SNAP BEANS IN THE DEVELOPING WORLD

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PREFACE

As the final decade of this century begins, we are observing rapid changes in the international agricultural research and development scene. New objectives such as those related to sustainable resource use and employment and income generation are complementing the traditional objectives of food security and a reduction of production costs. At the present time the CGIAR is considering adding several new research activities to its network that are considered to have high potential for contributing to these additional objectives. In addition, the centers already under the auspices of the CGIAR are reviewing their research portfolios, and this includes CIAT.

CIAT is satisfied with the excellent progress that is being made in realizing it traditional objectives. The benefits of focussed and highly prioritized research programs directed at laudable socio-economic outcomes have been obvious. While appreciating the merits of some shifts in focus, CIAT, with its responsibilities to both client and donor countries for the rational use of public funds, must make such changes very carefully.

The proceedings reported in this publication represent a collection of workshop papers prepared by CIAT staff and our collaborators, aimed at analyzing the potential for snap bean research within the international system. The depth and the range of papers provides an extremely useful example of the comprehensiveness with which research proposals can be evaluated prior to implementation. For three years we have been gathering information from around the world that could lead to a more objective judgement on the value of including snap bean research in our essential program.

The studies have defined quite clearly the most appropriate directions for CIAT involvement in snap bean research and have identified our comparative advantage in relation to others in the system.

The consensus achieved among the many participants in the study underlines a fundamental principle developed at CIAT over the last 20 years, that is "change with continuity". This center has always been able to maintain a clear focus and to change its objectives when evaluated. Decisions to modify the directions of our research efforts have never been unilateral. We have always looked to our collaborators to help us in defining the directions that CIAT should go.

The efforts by our many collaborators who have helped us to carry out these studies are greatly appreciated and we commend them for the excellence of their contributions.

CIAT must now evaluate the benefits of working on snap beans compared with the many other contenders for our attention. This is the more difficult task.

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Deputy Director General

INTRODUCTION

Vegetable research in the developing world is receiving increasing attention. Traditionally, international agricultural research has concentrated most of its resources and efforts on staple food commodities. However, it is evident that with the growth in incomes, population and urbanization in most developing countries, the role of vegetable crops has become more pronounced. Vegetables are a valuable source of vitamins and minerals, essential elements for a balanced diet. Yet studies on vegetables in the developing world show that vegetable output is limited due to complex production and marketing constraints.

The CGIAR system, advised by its Technical Advisory Committee (TAC), initiated discussions in the early 1970s on possible strategies for vegetable research in the developing countries. In 1984, at the suggestion of CIAT's External Review panel, TAC recommended that CIAT undertake a study of the potential of snap bean research in the developing world.

With financial support from the Ministry For International Development Cooperation (DGIS) of the Netherlands, CIAT initiated a two-year study in 1987. The objective of the investigation was to analyze the merits of investing resources in research on snap beans in the developing world. The strategy adopted by the Snap Bean Study included four major thrusts. These were to:

1) Identify the major snap bean production areas in the developing world and compile country level data.

2) Analyze trends in snap bean production, consumption, trade and prices.

3) Identify and analyze the importance of current snap bean production and marketing constraints.

4) Estimate the current economic value of snap beans and conduct an ex-ante assessment of potential research benefits for the developing world.

As primary information on snap beans is almost non-existent, and the reliability of official documentation is often questionable, it was decided to commission indepth case studies to amass a database of consistent, reliable and firsthand information across countries and themes. These studies were based on surveys, interviews and more local literature searches, and served as the backbone for subsequent analyses of the actual and potential status of snap beans in the developing world.

The mechanics of the study included the following activities:

1) Worldwide compilation of secondary macro-level data on snap beans and other vegetables.

2) An extensive literature search for relevant studies on snap beans.

3) Study trips within Latin America, Asia and the Middle East to collect data and identify appropriate institutions and individuals to undertake country case studies.

4) Implementation of nine country case studies and a number of specially commissioned reports by collaborating institutions, including universities, and national and regional research organizations.

5) Implementing pilot research projects in Colombia.

6) Organizing a Latin American snap bean workshop (1987) and an international conference on snap beans (1989). Publication of the conference proceedings highlighting the results and analyzing their implications for snap bean research.

The international conference was held October 16-20, 1989 at CIAT headquarters in Palmira, Colombia, with funding from DGIS. The conference's major objectives were to give international scientists an opportunity to report on snap beans in developing countries, to discuss current constraints, and to reach a consensus on future snap bean research strategies and target areas. The conference also provided a forum to discuss the international framework for future snap bean research, including the role of CGIAR centers and CIAT in particular.

The conference was attended by international scientists from 19 countries, representing a wide range of disciplines. Most participants had been involved in the snap bean study, either as authors of country case studies or as contributors of valuable information on snap beans.

We would like to thank all of the scientists and officials who participated in the study and the conference for their excellent cooperation and express our gratitude to the Ministry of International Development Cooperation of the Netherlands, for its generous financial support.

The Editors

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SNAP BEANS IN THE DEVELOPING WORLD: AN OVERVIEW

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Abstract

This paper evaluates the current and potential economic importance of snap bean in the developing world, both at the farm level and in the aggregate. In addition, it assesses the benefits that would accrue to producers and consumers from the adoption of new research-generated snap bean technology. Having established the economic potential of snap bean, a cross-country study was conducted to analyze snap bean production and marketing channels and to identify the principal constraints to productivity and availability. Among the most important constraints are: poor seed quality and inadequate seed distribution systems; heavy insect and disease pressure; fluctuating producer prices; labor requirements; and inaccessibility to credit.

Introduction

As countries develop and disposable incomes increase, people first satisfy their calorie needs before paying more attention to such quality aspects as protein, vitamin and mineral nutrition. In this process the role of vegetables, along with meats and fruits, increases in the human diet. The precise form of diet diversification depends on the country, traditions and health perceptions. In Asia, already at low levels of income, vegetables constitute the second most important component of the daily diet after rice. In Latin America, on the other hand, vegetables become important only after protein needs have been largely satisfied.

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Snap bean ranks among the more preferred vegetables, on a par with broccoli, cauliflower, eggplant, peas and tomato. A characteristic of these vegetables is that their demand is highly income dependent. Urban consumption is also much higher than rural consumption. As such, snap bean demand is driven by income and urbanization in addition to population growth.

Increasing urban demand for vegetables has created concentrations of small farm enterprises near urban centers, producing a large variety of vegetables in intensive "high-input, high-output" multicropping production systems. Aggregate demand projections for the developing world suggest that if current conditions prevail production may not keep up with the demand for snap beans in the developing world.

This paper assesses the current economic importance of snap beans in the developing world and the potential impact of snap bean research. It reviews snap bean production with the objective of identifying research strategies that can reduce the possible supply deficit. Marketing and consumption of snap beans are not treated in any detail, as these topics are discussed extensively in other papers. The first section of this paper presents data on the current value of snap bean production, estimated future demand and the potential impact of research. This is followed by a description of snap bean production and a discussion of the implications for developing snap bean production technology. Much of the information presented in this paper is drawn from a series of country case studies and surveys carried out specifically for the CIAT Snap Bean Project.

Economic Importance and Research Potential

The importance of a crop can be evaluated in various ways. In this paper the current importance of snap bean is analyzed by drawing comparisons with other crops. Research potential is assessed in terms of the benefits that might accrue from the adoption of improved production technologies.

Current economic importance

Snap bean production in developing countries (LDCs) is estimated at 4.0-4.5 million metric tons: Latin America produces 250,000-300,000 tons; Africa, 40,000 tons; the Middle East and Northern Africa, 600,000 tons; while total Asian snap bean production is 3.6-4.0 million tons, highly biased towards China's share of 3.0-3.5 million tons (Table 1). Since approximately 70,000-80,000 tons are exported from LDCs annually, domestic production is assumed to equal domestic consumption.

To make projections about future growth in LDC snap bean demand, the following approximations were made: 1) average population growth rate will be 1.3%-2.0%; 2) urban population growth rate will be 3%-4%; 3) income growth will be 0.5%-4.8%; and 4) the snap bean income elasticity of demand is 0.2-0.4 (World Bank, 1987). Consequently, demand for the year 2000 is expected to be about 6.5 million tons, as presented in Table 2 (Henry, 1989).

Presently, the monetary value of snap beans in LDCs is estimated at about US$1.2 billion at the farm level or about US$1.8 billion at the retail level. Under ceterus paribus conditions the farm gate value would be US$1.7 billion and the retail value US$2.7 billion by the year 2000.

To assess the economic importance of snap bean production, profitability needs to be compared with that of other crops. Colombian data (Pachico, 1987) show that labor and input requirements for snap bean cultivation are higher than for the production of maize/beans, potato, wheat or barley. However, the profitability of snap beans, calculated as the returns per month, is also higher (Table 3).

An important vegetable that competes with snap beans, both at the production and consumption level, is yardlong bean, *Vigna sesquipedalis* L., grown extensively in Africa and the Far East. Data from Indonesia (CGPRT, 1988) reveal that production methods for snap beans and yardlong beans are very similar except that snap bean labor requirements are higher than those for yardlong beans. However, snap beans yield at least twice as much per hectare (10.6 tons/ha) than yardlong beans (4.6 tons/ha) and snap bean production is almost twice as profitable. Net returns to the farmer are US$333/ha and US$175/ha for snap beans and yardlong beans, respectively.

An economic value can also be attached to post-harvest losses in vegetables. Although snap beans are considered highly perishable, in the tropics this is a relative measure. As Table 4 shows, post-harvest losses of 25%-28% for snap beans are comparable to that of green tomatoes, but much lower than for cabbage, cauliflower or sweet corn (Pantastico and Bautista, 1976). Another source (FAO, 1985) estimates post-harvest losses of snap beans as 5%-10% lower than those of lettuce, spinach, green onions or ripe tomatoes. Lower post-harvest losses translate into a lower marketing margin which benefits both consumers and producers.

Besides comparing the profitability of snap beans with other vegetables in a monetary sense, one can also make comparisons with respect to consumer preferences. Data from consumer surveys in Turkey and Taiwan (Erkal et al.,1989; National Pintung Institute of Agriculture, 1988) show that snap beans are well respected in both countries. They have an appeal similar to tomatoes, and are more favorably perceived than yardlong beans (Table 5). Snap bean and tomato prices are also within the same range (Table 6).

Potential impact of research

The potential economic impact of research is assessed by estimating the additional gains that would accrue to producers and/or consumers from using technological innovations. Later in this conference, the merits of specifc research thrusts will be discussed (Henry, 1990). At this point, however, it is assumed that a package of technologies could increase overall snap bean production by 10%. It is further assumed that a significant rate of adoption can only be expected after about five years.

Innovative snap bean farmers will be the first to adopt a new technology, increasing yields and decreasing production costs. In the short run, the relatively small number of farmers will not affect the market price with their increased supplies. Consequently, these innovators will reap maximum benefits. Eventually, though, more farmers will adopt the new technology. At the same time as the more innovative farmers may be increasing acreage, new farmers will enter the market. As a result, the new technology (under ceteris paribus conditions) will increase aggregate snap bean supply.

In the short term snap bean supply faces a relatively inelastic demand (about -0.5). However, in the intermediate to long run, this demand will become increasingly elastic by demand substitutions with other vegetables. Table 7 summarizes the benefits under different demand and supply shift scenarios. In the short run consumer gains are more than double producer gains. But in the longer run, when demand becomes more elastic, benefits are transferred from consumers to producers.

Ex-ante estimates of benefits from improved technology are based on many assumptions and vary according to the different scenarios. The intention here is merely to demonstrate that newly introduced technology does have a significant impact on both snap bean producers and consumers. Benefits would range from US$58 million to US$120 million, and accrue to producers largely. As shown later in this paper, the producers of snap beans are small farmers. Hence, technology that improves snap bean production generates extra income for the small farmers of the developing world.

Snap Bean Production

Given the economic potential of the crop, how then can it be realized? This requires an analysis of snap bean production and production constraints, and identification of research thrusts to overcome the constraints and boost production.

In the developing world snap beans are cultivated in different climatic zones, at varying altitudes and under a variety of management practices. Among and within countries they may differ in size, shape, taste and color, ranging from white to black pods. The common denominator is that snap beans are invariably produced by small farmers as a "high-input, high-output", market-oriented crop, close to urban centers.

Snap bean farming systems

Snap bean producing farms are small, on average. Farms are typically bigger in Latin America (2-20 ha) and smaller in Asia (.2-3 ha), basically reflecting population densities (Table 8).

The share snap beans have of total farm area differs considerably according to country and farm size. In this regard, a distinction needs to be made between export-oriented snap bean cultivation and production for local consumption. In South China, farmers are contracted by canning factories to produce large volumes of snap beans (Henry, 1988). The same is true for Rwanda, where farmers are contracted by French fresh-vegetable exporting companies to grow snap beans (Schasfoort and Westerhof, 1988). In these cases, farmers plant almost 100% of available land to snap beans. However, when snap beans are produced for the local market, only a portion of total farm area is used. In northeastern China, snap beans may account for only 5%-10% of the total farm acreage (Henry, 1989), while in Turkey they occupy 14%-60% of the farm (Erkal et al., 1989). In Colombia, snap bean farmers use on average 30% of the farm area to cultivate a snap bean crop (CIAT, 1989). It appears, moreover, that small farms are relatively more specialized in snap beans than large farms (Table 9). Farms with less than 6 ha devote almost 75% of the total area to snap beans. Perhaps because they have such limited resources, these small farmers must adopt highly risky production strategies simply to generate some income.

Multicropping and intercropping are of major relevance to most vegetables, including snap beans. Both bush and climbing type snap beans are intercropped with other vegetables, cereals and even fruit trees. The most sophisticated intercropping can be seen in the Far East. In China, some 10-20 different vegetables may be planted above, below, next to or alongside snap beans, often with intricate trellissing (Henry, 1988). Besides rotating with other vegetables, snap beans are popular for planting after a (wet-season) rice crop as practiced in China, Indonesia, Sri Lanka and India (Henry, 1988; CGPRT, 1988). Snap bean farms in Turkey seem to be more livestock oriented. A farm survey in the Marmara region found that snap bean farmers own on average 2 cows, 7 sheep and 1 goat (Erkal et al., 1989). In the same area, farmers have an interesting intercropping system in which irrigated maize and snap beans are planted between olive trees (Henry, 1988). Colombian snap bean farmers intercrop beans to a small degree only, with for example, tree tomatoes and maize. More often snap beans are rotated with dry beans, tomatoes, cucumbers, peas and onions (CIAT, 1988-89).

Climbing versus bush type snap beans

Snap bean farmers in most developing countries plant climbing varieties. Colombia only plants the climbing variety Blue Lake, while Costa Rica plants exclusively such imported bush type varieties as Guaria, Provider and Seminol (van Loohuizen, 1989). Other countries cultivate both climbing and bush varieties, but climbing varieties represent the largest share (Table 10). Still, bush types are becoming increasingly important in China, Sri Lanka, Indonesia and Turkey (Henry, 1988; CGPRT, 1988; Erkal et al., 1989). The main reasons for this are the rising costs of staking materials and local labor constraints. In Colombia snap bean farmers use illegally cut stakes made from protected tree species (Henry, 1988).

Snap bean seed

In the developing world most snap bean farmers rely on seed that has been produced on their own farm (Table 11). This seems to be more a necessity than a desire. Farmers are consistently concerned about the quality, reliability and price of seed purchased from shops. This applies to both imported and locally produced seed. When seed is produced on-farm farmers at least know what quality to expect. Both availability and prices of commercial seed can fluctuate substantially (Belt, 1989). In Costa Rica virtually all seed is commercially purchased, since distribution and availability seem to be adequate (Broekhoff, 1989). In Indonesia, however, imported seed in the shops is three times more expensive than local seed. This inhibits farmers from purchasing seed from shops (Table 11).

Management practices

Throughout the developing world land preparation, planting and weed control in snap bean cultivation differ only slightly. However, the quantity of seed planted per hectare varies considerably (Table 11). The major reasons for this are: 1) quality of the seed (germination rate); 2) local cultural practices; and 3) growth habit (bush or climbing type). In general weed control is by hand. Some chemical control of weeds takes place, but the cost ratio of labor versus chemical control in LDCs is low enough generally to warrant manual weed control.

Disease and insect control are major financial and labor drains. All the farmers surveyed agreed unanimously on the overriding importance of these issues. Major production-reducing diseases are rust, anthracnose, root rot and various blights. The major snap bean insect pests are whitefly, beanfly, leafminer, pod borer, aphids and mites (Table 12).

Weekly or twice-weekly fumigations with pesticides (insecticides and/or fungicides) are common. Table 8 shows the average number of fumigations by country. Frequency ranges from 5 to 17 applications per snap bean cycle. Besides the high frequency, the problem is exacerbated by the fact that several chemical products are applied per fumigation. Snap bean farmers in the Sumapaz area of Colombia apply "cocktails" of 1-2 insecticides and 3-5 fungicides to control leafminer, whitefly, rust and anthracnose (CIAT, 1989).

In most LDCs snap bean harvesting starts at 50 days after planting for bush type snap beans and at 60 days for climbing type snap beans (Table 13). The number of days required to harvest is also relatively consistent. However, the number of pickings per harvest differs significantly among the countries surveyed. For example, in Rwanda farmers harvest every day; in Costa Rica harvests occur only every 5-7 days (Broekhoff, 1989; Schasfoort and Westerhof, 1988). The frequency of pickings may be important. Francisco and Domingo found that snap bean yield was significantly higher with more frequent pickings.

Labor

Vegetable production in general and snap bean production in particular is highly labor intensive. Labor constitutes 1/3 - 1/2 of total production costs (Table 14). The breakdown of labor shows that harvesting may take as much as 67% of total labor, as in Taiwan. Other labor-consuming farm activities are weeding, tutoring and pesticide applications (Table 14). Small-farm snap bean production typically exploits on-farm labor resources, i.e. family labor. Family labor as a percentage of total labor may be as high as 90%-95%. Examples are Colombia and China (van Dijken, 1988; Henry and Li Peihua, 1988). Female and even child labor are used for weeding, defoliating and harvesting activities. This is partly because of the lower wage rates for these labor groups. In some countries like Turkey and Rwanda, women traditionally do most of the agricultural labor, except for some land preparation (Erkal et al., 1989).

Snap bean yields

Snap bean yields, as recorded in the country case studies, are presented in Table 13. The highest yields for the developing world have been reported for China (Henry, 1988). Yields for peri-urban Beijing are an estimated 15-20 tons/ha (Henry and Li Peihua, 1989). Data from the countries surveyed indicate that bush type snap beans yield typically less than climbing types. The yields reported in the case studies are always higher than the yields published in national or FAO statistics (Table 1), illustrating the problems with official statistics.

While bush type snap beans may yield less than climbing types, profitability is not necessarily inferior. As documented in Table 8, bush snap bean farmers in Costa Rica show a benefit to cost (B/C) ratio of 1.5. This is higher than the ratios for both Colombia and Turkey, where climbing types prevail. The highest returns from snap bean cultivation have been reported for Indonesia, 60% (CGPRT, 1988) and Taiwan, 70% (National Pintung Institute, 1988). In the case of Indonesia this is due in part to the large quantities of fertilizer applied, purchased at a relatively low (subsidized) price, in addition to relatively high producer prices (CGPRT, 1988).

Snap Bean Production Constraints

Snap beans are a "high-input, high-output" crop. To generate the potentially high returns on investment, the crop requires large amounts of fertilizer and pesticides. In addition, irrigation has been shown to have a significantly positive effect on production in several countries (Erkal et al., 1989; Francisco and Domingo, 1988). Table 8 summarizes snap bean production inputs and their contribution to total costs. Fertilizers and pesticides constitute 20%-30% of total costs. In some countries tutoring materials have recently become more expensive and may be an economic constraint in the near future. In this case a possible alternative might be the introduction of appropriate bush varieties.

Survey results show producers worldwide agreeing with surprising consistency on snap bean production constraints. The constraints most frequently cited are: labor; seed quality and seed distribution; insect and disease pressure (and the need for frequent pesticide applications); and farmgate price fluctuations. Inherent to high input usage is the problem of availability of capital. A survey in Colombia found that only 51% of snap bean farmers used commercial credit (CIAT, 1989). This is comparable to the Philippines (Table 15). The remaining half of the farmers in Colombia relied on their own resources (family/friends), were either unable to obtain credit, or found it too risky. In Indonesia, only 4% of snap bean farmers obtain credit (CGPRT, 1988).

Seed quality and distribution

Traditionally, vegetable seed production has been monopolized by major U.S. and European seed companies. Seed has been bred and selected for more temperate climates and targeted to the specific demands of developed-country consumers and canning/freezing industries. As a consequence, developing countries experience major problems with the adaptability of imported seed to their climatic conditions. Some of these LDC markets are viewed by the seed export companies as residual or monopoly markets and do not offer incentives for product improvement. Local commercial seed production is usually small scale and multiplies seed of the "adapted" imported variety. At least 50% of farmers rely on seed multiplied on their own farms (Belt, 1989). Hence, farmers face heavy disease pressure in addition to poor seed germination and vigor. Moreover, snap beans from imported seed often do not satisfy local consumer preferences as documented in Colombia, Turkey and China (CIAT, 1989; Erkal et al., 1989; Henry, 1988).

Chemical control practices

Pesticide management has serious repercussions on snap bean production in the developing world. Lab findings show that out of 22 insecticides commonly used for snap beans in Colombia, only four were effective against whitefly (Trialeurodes vaporium), an important production -limiting pest (Cardona and Pastor Coralles, 1989). It was also determined that the high rate of applications caused resistence among whitefly and leafminer and significantly decreased the natural enemy populations of these pests (CIAT, 1989). The numerous chemical products and frequency of their use reflect the risk averse behavior of the farmer. They are paying, in a sense, a "risk-premium" against possible insect and disease attacks (CIAT, 1989).

An analysis of expenditure for chemicals in various countries revealed a range of 7%-13% of total cost (Table 8). However, these shares can more than double when labor is included in the calculation of disease and insect control costs. Consequently the share of total costs may be between 15% and 30%. This clearly shows the financial drain resulting from current chemical control practices.

Besides the major monetary cost to the farmers, the alarmingly high frequency of pesticide applications has dangerous repercussions on human health and the environment. Blood samples from farm workers in the Sumapaz area of Colombia showed significant levels of contamination from organophosphates and carbamates (CIAT, 1989). However, lab tests on chemical residues in snap beans marketed from the same area do not suggest a health threat to consumers (ICA, 1989).

The labor constraint

Depending on the country, the labor requirement for a climbing snap bean crop with a 90-day cycle is on average 250-680 person-days/ha or 3-7 persons/ha/day (CIAT, 1988-89). Translated into a percentage of total costs (Table 8), labor ranges between 20% and 50%. Asian farmers typically use more than double the labor that African or Latin American farmers use. This is roughly comparable to the cultivation of such vegetables as tomatoes or peas. However, it is more than double the labor needed for a dry bean or potato crop (Janssen et al., 1988). The labor issue has a dichotomous nature. While individual snap bean farmers regard it as a major constraint, at the national level the labor intensity of vegetable farming in general and snap beans in particular constitutes a means of generating employment and encouraging economic growth and development.

Price fluctuation

Severe producer price fluctuations of snap beans are evident throughout the developing world. Colombian data show price variations of up to 200% within one week. In most other countries monthly fluctuations of 50%-150% are not uncommon (CIAT, 1988 and 1989). The extensive marketing channel absorbs much of the oscillations, with the consumer only facing the tailend. However, retail prices for snap beans do not differ markedly from other produce. The perishable nature of snap beans and the many pricing points in the marketing channel are largely responsible for the high marketing margin. Farmgate prices are largely a function of quantity supplied. The latter is influenced by farmers' price expectations and short-term and seasonal climatic conditions. Farmers, to a degree, "hedge" against the high risk created by price fluctuations. Some of the bigger farmers in Colombia deliver on contract directly to urban retail outlets. In the Philippines many farmers are on contract with input suppliers who pay on average a lower but more stable guaranteed price. For the same reason a small marketing coop was formed in Arbelaez, Colombia. In China a large number of peri-urban vegetable farmers sell their produce directly on the "free" retail markets (Henry and Li Peihua, 1989).

Besides marketing practices to reduce revenue instabilities, agronomic practices, like staggered planting, are widely employed. This increases the number of harvests and evens out the "high" and "low" prices. At the same time this method improves the farmer's cash flow. However, it may have an adverse effect on insect infestations of the crop. Clearly, not all farmers value the advantages of this practice. Data from Colombia show only 58% of farms staggering planting, with a significantly higher frequency among small farms (<.6 ha) and big farms (>6 ha) than intermediate-sized farms (CIAT, 1989). Another agronomic practice is irrigation. Under certain seasonal/ climatic conditions irrigating can be a means of spreading risk.

Implications for Future Research

Seed quality and insect and disease resistence appear to be of global concern among all the countries surveyed. Tackling these problems would appear to offer the best strategy for improving snap beans production. Such research should take into account existing farmer practices, such as frequent crop fumigations and production of own seed. This suggests the necessity of interdisciplinary collaboration, especially among social scientists, crop protectionists, breeders and seed production experts.

Distribution of income is a much debated topic in studies of technology impact in agricultural development. Large scale farmers sometimes are able to benefit relatively more from improved technologies than small farmers. This study has shown that snap bean production in the developing world is basically a small-farmer activity and that these small farmers are ultimately the major benefactors of improved snap bean production technology. In addition, scale-neutral technology for a highly labor intensive crop like snap beans will act as an employment generator, promoting economic development. Snap bean research would improve small farmers' incomes and stimulate rural employment opportunities.

The concept of sustainability in agricultural development in LDCs is now generally accepted, and the danger of an eroding germplasm base resulting from the diffusion of only a few improved crop varieties is well recognized. Yet the number of snap bean varieties currently grown in the developing world is alarmingly small. If breeding programs used more of the common bean germplasm available, this would help broaden the germplasm base. In addition, snap bean research should include investigations of Integrated Pest Management (IPM) practices, with the objective of reducing insecticide and fungicide use. This is critical, both to diminish the health threat to farmworkers and their families, and to sustain profitable snap bean cultivation. Nonetheless, snap beans will undoubtedly continue to require relatively high amounts of inputs. Thus, increased snap bean production will promote demand for inputs and contribute to economic growth in other sectors.

Increased snap bean research would also have an impact on vegetable research in general. Vegetable research in the developing world has lagged significantly behind research on other crops (FAO, 1987). Research methodologies developed for snap beans might be useful for other crops. Training scientists in snap bean research might develop their overall ability as vegetable researchers, and institutional arrangements, such as networks and nurseries, could serve as models for other vegetables. In this way, snap beans would be a pilot crop for vegetable research.

In conclusion, snap bean research may contribute significantly to equity and sustainability objectives, while enhancing the economic importance and expansion of the crop. Snap bean research fits well into a world where attention to present and future quality of life is becoming increasingly important.

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APPENDIX 1

In the case of snap beans, being a market oriented crop, it is safe to argue that virtually no home consumption takes place and therefor the perfect inelastic home demand will be zero and as such this curve is equal to the vertical axis. In the static analysis (at some fixed point in time), aggregate demand will be D (Graph 1A). As a consequence, the snap bean price will fall from P to P'and volume of snap beans produced will expand from Q to Q'. To analyze the wellfare effects of the technology impact on consumers and producers, there are to approaches. The first, and most convential, is based on Marshallian demand analysis. The second, is dereived from Hicksian, or compensated demand (Just et. al.,1982). For the sake of simplicity, the first approach will be used in this analysis. As such, the benefits from the new technology to consumers, or "consumer surplus" is given in Graph 1A, by the area a+b. Producers benefits, or "consumer surplus" is given by the area c-a. Society as a whole is gaining from this technology by area b+c. Depending on the elasticities of demand and supply curves the relative gains for consumers and producers can be assessed. In general, it can be said that if there is an inelastic supply, producers may face a net loss from the new technology (in the long run).

Instead of assessing the wellfare effects in a static framework, it is more realistic to view the impact of new technology over time, that is, in a dynamic framework. Over time, demand will not remain static, but will shift out and to the right, influenced by population growth, urbanisation, increased expenditures and other exogenous variables. It is wel-known that population growth is the major driving force behind this shift (Enstberger, 1989). As depicted in Graph 1B, aggregated demand shifts from D to D'. A parallel shift is assumed here again, although this may not be exactly true, if relative snap bean expenditure shares among the different income strata change over time (Ernstberger, 1989). Depending on the supply and demand elasticities, and on the magnitudes of the respective shifts, over time, the market may equilibrate at the quantity Q", which gives the original market price P. Consequently, consumer will gain by the shaded area above the priceline, while consumers will gain by the shaded area below the priceline. Thus, in time, society as a whole will benefit from the new snap bean technology by the amount of both shaded areas.

Table 1. Global snap bean indicators for production and consumption.

	Total production (t)	Production as % of total vegetable production	Yield (kg/ha)	Value of production (1000 US$)	Consumption (kg/cap/year)
LATIN AMERICA					
Argentina	41,900	1.7	9,300	12,570	1.3
Brazil	92,000	2.0	7,000	27,600	0.7
Chile	39,500	3.2	7,900	11,850	3.2
Colombia	76,000	5.8	7,000	22,800	2.7
AFRICA + MIDDLE EAST					
Turkey	400,000	6.2	2,000	200,000	8.0
Egypt	117,500	1.5	8,700	100,000	2.5
Morocco	17,880	1.3	10,200	8,000	0.9
Kenya	10,000	2.3	5,000	5,000	Export
Rwanda	1,000	0.6	2,000	800	Export
ASIA					
China	3,500,000	3.0	15,000	800,000	3.5
India	46,133	0.1	2,135	13,839	0.1
Indonesia	43,498	1.6	6,200	13,047	0.3
Philippines	19,500	1.2	3,250	5,850	0.2

Source: Data collected from National Statistics, Food Budget Surveys, FAO production yearbooks 1982-86, ITC and personal communications.

Table 2. LDCs projected snap bean demand growth for the year 2000.

	China	RODW*	Total
1989 demand (million tons)	3.00	1.50	4.50
2000 demand growth (%) from:			
population effect	15%	34%	21%
urbanization effect	8%	14%	10%
income effect	11%	2%	8%
2000 demand (million tons)	4.30	2.25	6.55

* RODW = Rest of Developing World

Source: Henry, 1989.

Table 3. Production parameters of snap beans and other crops, Colombia, 1980-1985.

	Labor days (ha)	Input costs (US$/ha)	Returns (US$/ha)	Returns (US$/ha/month)
Snap beans	241	1218	982	327
Maize/beans	108	156	155	16
Potato	119	625	1667	278
Wheat	30	221	32	5
Barley	35	192	209	42

Source: Janssen et al., 1988.

Table 4. Post-harvest losses in selected vegetables in the tropics.

		% Loss due to:					
Vegetable	Days held	Decay	Trimming	Mech. damage	Wt.loss	Other	Total
Snap beans	2	--	--	15	5-8	5	25-28
Cabbage	4	15-20	15-20	10	--	--	40-50
Cauliflower	7	10	2-4	2-4	5	15	34-38
Corn (sweet)	2	--	--	--	5	50	55
Tomato	4	1-12	--	4-6	2-4	15-12	22-32

Source: Adapted from Pantastico and Bautista, 1976.

Table 5. Urban consumer responses[1] on selected vegetables characteristics for Taiwan and Turkey, 1988.

	Vegetables				
	Snap Bean	Yardlong Bean	Tomato	Cucumber	Broccoli[2] Eggplant
	%				
1. Nutritious					
Taiwan	19	10	25	7	17
Turkey	71	--	15	--	9
2. Excellent taste					
Taiwan	11	5	18	7	21
Turkey	47	--	19	3	29
3. Nice appearance					
Taiwan	18	4	37	12	14
Turkey	7	--	82	--	9
4. Cannot be kept					
Taiwan	10	12	7	5	6
Turkey	32	--	36	16	12
5. Quality always the same					
Taiwan	19	10	1	14	16
Turkey	38	--	16	11	24
6. Chemically contaminated					
Taiwan	19	17	3	10	10
Turkey	14	--	56	8	9

1) Consumer responses as percentage of total. Responses may not add up to 100%, as some vegetables have been left out.

2) Responses from Taiwan are for broccoli, responses from Turkey are for eggplant.

Source: National Pintung Institute of Agriculture, 1988; Erkal et al., 1989.

Table 6. Relative consumer prices of selected vegetables for several countries.

Country	Snap Beans	Carrot	Tomato	Lettuce	Cabbage	Cauliflower
Brazil (1987)	100	85	57	124	28	63
Colombia (1986)	100	--	114	161	36	84
Venezuela (1983)	100	59	54	101	54	66
El Salvador (1982)	100	48	95	128	26	66
Indonesia (1984)	100	113	121	--	49	70
China (1988)	100	--	100	--	30	89
Turkey (1988)	100	--	100	85	--	75

Source: Janssen et al., 1988; Henry, personal communication, 1988.

Table 7. Estimated *ex-ante* consumer and producer benefits resulting from improved snap bean production technology in the short and long run.

Scenario	Benefits (million US$) Producer	Consumer	Total
Inelastic Demand (short run)			
A: Parallel Supply Shift			
Net gains	35.5	84.8	120.4
B: Pivotal Supply Shift			
Net gains	-20.7	78.9	58.2
Elastic Demand (long run)			
A: Parallel Supply Shift			
Net gains	125.0	0	125.0
B: Pivotal Supply Shift			
Net gains	62.5	0	62.5

Table 8. Snap bean production cost data for selected developing countries, 1988 - 1989.

	Colombia	Costa Rica	Brazil	Turkey	Rwanda	Philippines	Indonesia
Average farm price (US$/t)	270	357	200	350	120*	153	294
Production per person-day (kg/person)	43.0	54.5	-	31.5	6.1	26.2	33.6
% of total costs:							
Labor (%)	39	44	28	49	16	35	20
Seed (%)	7	20	8	5	10	-	-
Fertilizer (%)	12	5	20	4	14	20	46
Chemical control (%)	9	8	13	10	10	11	7
Number of chemical applications	11	14.8	16.5	5	7	6	12
Return to costs	1.2	1.5	-	1.2	1.2*	1.6	1.7

* Returns to costs for export firm.

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

Table 9. Snap bean area as % of total farm area according to farm size, Sumapaz, Colombia, 1989.

Farm Size	Snap Beans	Other Vegetables	Cattle/ Crops
	%		
Farm < 0.6 (ha)	72	20	8
0.6 ≤ Farm < 3 (ha)	28	36	36
3 ≤ Farm < 6 (ha)	41	16	42
Farm ≥ 6 (ha)	21	15	63
Average farm shares	29	20	51

Source: CIAT Internal Data, Snap Bean Project, 1989.

Table 10. Snap bean varieties for selected countries in the developing world, 1988 - 1989.

Country	Variety	Popularity[1]	Domestically produced	Imported
Colombia	Blue Lake (C)	20%		x
	Lago Azul (C)2	80%	x	
Costa Rica	Guaria (B)	61%		x
	Provider (B)	28%		x
	Semisol (B)	21%		x
Turkey	Seker (C)	--	x	
	Aysekadin (C)	--	x	
Philippines	Black Valentine (B/C)	89%		x
	Stonehill (C)	86%		x
	Blue Lake (C)	19%		x
	Contender (B)	43%		x
	Kentucky W.(C)	2%		x
	Canaya (C)	6%	x	
Indonesia	Bandung (C)	--	x	
	Lembang (C)	--	x	
Rwanda	Royal Nel (B)	100%		x

1) % refer to number of farms that use the variety and can add up to more than 100%.

2) Lago Azul is a domestically multiplied Blue Lake variety.

(B)= Bush type
(C)= Climbing type

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

Table 11. Snap bean seed purchasing and planting methods for selected LDCs, 1988-1989.

Country	Origin of Seed (% of total): Shop	Friends/ neighbors	Own-produced	Seed planted (kg/ha)	Average price (US$/kg)
Colombia	30	30	40	30	3.70
Costa Rica	97	--	3	90	2.85
Turkey	22	22	56	62	1.50
Philippines	27	16	57	72	1.80
Indonesia	--	44	56	34	1.34

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

Table 12. Major diseases and insects affecting snap bean production for selected LDCs, 1988 - 1989.

Countries	Diseases	Disease control methods	Insects	Insect control methods
Philippines	Root rot Rust	-	Thrips, Beanfly, Cutworm, Pod borer, Mites.	Endosulfan Metamidophos Monocrotophos Metomyl
Indonesia	Rust Angular leafspot	Antracol	Beanfly	Dursban Decis Tamaron
Costa Rica	Web blight, Rust, Botrytis, Anthracnose Angular leafspot, Cescospora leafspot.	Dithane Manzate Dacomyl	Cerotoma Agrotis ipsilon Aphids Estigmene Epinotia opposita	Tamaron Decis Ambush Metil
Colombia	Ascochyta, Anthracnose, Rust, Powdery mildew, Halo blight.	Manzate Dithane Ortocide Benlate Difolatan Plantvax Antracol Deosal	Whitefly Leafminer	Monitor Decis Cymbush Baytroide Curacron Lannate
Rwanda	Ascochyta Anthracnose	Peltar	Caterpillars Aphids Spider mite	Rogor Lannate Decis

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

Table 13. Snap bean harvesting systems for selected LDCS, 1988-1989.

Country	Snap bean type	Harvesting period (days)	Number of pickings	Average yield (kg/ha)	Total crop cycle (days)
Colombia	C	30	4-6	9,539	90
Costa Rica	B	14	2-3	7,634	75
Turkey	C	30	6	8,180	80-90
Philippines	C	30-33	8-10	10,406	80-90
Indonesia	C	30	10	11,600	90
Rwanda	B	14	10-14	3,780	65-75

B = Bush type varieties are planted.

C = Climbing type varieties are planted.

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

Table 14. Labor requirements and wage rates for snap bean cultivation in selected LDCs, 1988-89.

Country	Total labor (days/ha)	Harvesting	Fumigations	Labor as % of total cost	Wage rate (US$/hr)
		(% share of labor)			
Colombia	222	37	19	39	.43
Costa Rica	140	44	24	42	.50
Turkey	260	34	8	49	.46
Philippines	397	25	14	40	.16
Indonesia	345	22	10	52	.17
Rwanda	620	63	3	35	.28
Taiwan	325	67	15	48	1.50

Source: Broekhoff, 1989; CGPRT, 1988; CIAT, internal data, Snap Bean Project, 1988-1989; Erkal et al., 1989; Francisco and Domingo, 1988; Schasfoort and Westerhof, 1988;

Table 15. Irrigation and credit use in snap bean production for selected LDCs, 1988-1989.

Country	Irrigation (% farmers)	Credit (% farmers)
Colombia	75	51
Costa Rica	51	Low
Turkey	68	n.a.
Philippines	60	56
Indonesia	n.a.	4

Source: Francisco and Domingo, 1988; Broekhoff, 1989; Erkal et al., 1989; CGPRT, 1988; Schasfoort and Westerhof, 1988; CIAT, internal data, Snap Bean Project, 1988-1989.

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THE NUTRITIONAL VALUE OF SNAP BEANS VERSUS OTHER VEGETABLES

John F. Kelly and Marcia K. Scott 1/

Abstract

Existing analytical data for essential nutrients were compared among 33 commonly consumed vegetables. A single serving size of one cup of cooked vegetable was used in the comparisons except for those vegetables commonly consumed raw. The nutrient contributions were expressed as a percentage of the FAO/WHO and NAS/FNB Safe Practical Allowances and Recommended Dietary Allowances for 14-year-old males. A similar comparison was made using the Index of Nutritional Quality. Green snap beans can contribute exceptionally well to the ascorbic acid requirement (60% per serving), but less than most other green vegetables. Losses during handling and home preparation of this highly labile nutrient need to be considered, however, in making this comparison. Green snap beans contribute very significantly (11%) to the vitamin A requirement and can be moderate contributors of riboflavin (7.5%), thiamine (9%), calcium (6.9%) and iron (6.7%). Levels of niacin, protein and phosphorus contribute less than 5% of the requirement and the caloric contribution is less than 2%. It is concluded that green snap beans can contribute nutritionally in a mixed diet and that further research relative to maturity, handling and preparation along with variety development can result in their greater contribution.

Introduction

The nutritional contribution of any food is dependent upon the composition of the food and the quantity which is consumed. We have available various

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compilations of the average or typical nutrient composition of most foods from which we can readily compare the potential contributions of foods to a healthful diet. We measure a healthful diet using various guidelines such as those established by the U.S. National Academy of Sciences Food and Nutrition Board (1980) or the Food and Agricultural Organization and World Health Organization of the United Nations (Passamore et al., 1974). In this paper we have used these published data. Since we are interested in potential contributions of nutrients to an individual diet, we have not attempted to utilize per capita consumption or national production data. Instead we have made comparisons based on a common serving size of 33 prepared common vegetables, mostly cooked, and using non-severe preparation methods.

The nutrient contribution of a one-cup measure or (by conversion) a 150-gram serving was used as the basis for comparisons. The FAO/WHO Safe Practical Allowances, and for phosphorus the NAS/FNB Recommended Dietary Allowance (RDA), for a 14-year-old male were used as the standard for daily nutritional requirement. For ease of reading we have referred to both the NAS/FNB and FAO/WHO standards as RDA in all tables and discussion. Both comportional and dietary requirement figures were a result of interpolation from more than one source in some cases. This interpolation did not contribute to significant differences for making our comparisons, as we are not concerned with specific values but only with relative contributions.

Results

Data in Tables 1 through 10 reflect the quantities of individual nutrients in one cup of the 33 vegetables and the percentage contribution of each vegetable to the RDA. Because the basis for most diets is the total caloric contribution of foods to the diet we have calculated, using our compositional and nutrient requirement data, the Index of Nutritional Quality (INQ) (Hansen et al., 1979) for each vegetable (Tables 11-19). This index relates each of the vegetables on the basis of its contribution to the caloric requirement (2550 Kcal in our study). It is an expression of nutrient density in relation to calories. Thus, if any of the vegetables were the sole source of energy in the diet the INQ would express the fraction of the daily allowance of a particular nutrient contributed by the individual vegetable. For example, from Table 12, if sweet potato were the sole source of energy in a diet, the sweet potato would contribute 24.12 times more vitamin A than the daily requirement. Needless to say, such figures are of little practical value except to assist in evaluating the relative contribution of that food to a normal mixed diet.

The green bean is an excellent source of **ascorbic acid**; a one-cup portion yields 60% of the RDA. Caution must be exercised, however, in comparing the leafy vegetables with green beans, because the leafy vegetables are very susceptible to ascorbic acid losses in handling and preparation. This is true to some degree for green beans also. Numerous studies have been made to compare vitamin C losses in different vegetables prepared or handled differently. It is not uncommon for losses of 25%-50% to occur (Adams and Erdman, 1980; Erdman and Erdman, 1982; Fennema, 1982; Fennema, 1988; Lamb, Farrow and Elkins, 1982; Salumkhe and Desai, 1988). In areas with limited refrigeration and simple cooking facilities it may be unrealistic to expect recoveries to even approach losses already accounted for through analysis of the cooked products. Thus, the contributions of ascorbic acid per serving are likely to be significantly less than those reported herein. Because of their very small contribution of calories, green beans compare more favorably with the other vegetables when the INQ is utilized. This comparison is true for each of the nutrients evaluated.

The **vitamin A** dietary contribution by green beans can be very significant. Because of the higher perishability of leafy greens, green beans could represent a very major contributor of vitamin A in a mixed diet. Green beans can be handled over a relatively longer period but cannot match the handling advantages held by sweet potato, carrot, winter squash and tomato.

Thiamine and riboflavin are not likely to be lacking in mixed diets which include grains, legumes and vegetables. Green beans will contribute meaningful levels of these B vitamins in such mixed diets.

Calcium is commonly deficient in mixed diets lacking dairy products. Vegetables, especially leafy vegetables, then become extremely important sources of calcium in the diet. If leafy greens are lacking, green beans can contribute to overall calcium in a mixed diet.

Iron contributed to the diet by vegetables is difficult to evaluate on the basis of gross composition because of the low bioavailability of plant iron (non-heme) compared to iron originating from meat (heme). Few studies have been conducted to compare bioavailability of iron among various vegetables. Depending upon its bioavailability, green beans might contribute moderately to the iron in mixed diets but should not be counted upon as an important source.

Protein is contributed in small amounts by green beans. Taken in aggregate with other low protein components of the diet, the protein in green beans can contribute to the overall level of of protein intake. Because of the unfavorable amino acid balance of most plant proteins, the protein contribution by vegetables is exaggerated (See Table 7). The RDA assumes protein quality equal to egg or milk protein. If grown to the "mature green" seed stage, as are peas and lima beans, green beans could be a more important protein source and at the same time contribute as a green vegetable. At that stage of maturity, however, the pods of currently grown varieties become inedible, and easily shelled types are not available.

Phosphorus and niacin are minor components of green vegetables, including green beans. Green beans cannot be counted on as a phosphorus or niacin source.

Food energy is contributed in very small quantities by green beans. In mixed diets with adequate or excess calories the other nutrients in green beans can be supplied without adding to a caloric excess. This situation is more likely to prevail as a society becomes affluent.

Micronutrients and other vitamins and growth factors are mostly contributed in small to moderate amounts by the various components of mixed diets.

Copper, magnesium and manganese are supplied in moderate amounts (5%-10% of RDA per cup) by green beans. Zinc, vitamins B_6 and B_{12} and biotin are present at very low levels. Folic acid requirement can be met by four cups of green beans.

Leafy vegetables usually have high nitrate levels: 165 ppm (parts per million) for cabbage; 534 ppm for spinach; and 535 ppm for celery). This is a potential problem, especially for infants. In contrast, green bean nitrate levels are very low (35 ppm). There are no antinutritional or toxic factors in green beans and the potential for pesticide residues is reduced because the edible part develops over a very short time frame.

Discussion and Conclusions

The green bean can be a meaningful contributor of essential nutrients in a mixed diet, even if consumed at the modest level of one cup per day. Differences among varieties with respect to nutrient composition as influenced by stage of maturity, cultural practices and environment have not been studied in depth. Numerous studies have been conducted on the effects of handling, processing and preparation upon retention of nutrients. They indicate that consumer education will be an important part of the introduction of green beans and other vegetables into established diets.

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Table 1. Contributions of ascorbic acid to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Ascorbic acid Mgm	%RDA
Pepper, red	306	1020
Pepper, green	192	640
Broccoli	111	370
Turnip greens	87	290
Collards	84	280
Brussels sprouts	61	203
Kale	56	187
Spinach	54	180
Cabbage (cooked)	53	177
Cabbage (raw)	50	167
Sweet potato	43	143
Tomato	40	133
Asparagus	40	133
Cauliflower	34	113
Okra	32	107
Chinese cabbage	31	103
Cowpeas, green	29	97
Turnip root	28	93
Potato	25	83
Peas	24	80
Lima beans, green	24	80
Squash, summer	23	77
Parsnip	19	63
GREEN BEAN	18	60
Squash, winter	14	47
Eggplant	14	47
Sweet corn	14	47
Onion	13	43
Cucumber	12	40
Carrot (raw)	7	23
Celery (raw)	7	23
Carrot (cooked)	6	20
Lettuce	5	17

[1]13-15 year old male/30 milligrams (FAO/WHO).

Table 2. Contributions of Vitamin A to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Vitamin A Retinol equivalents	%RDA
Spinach	2120	292
Sweet potato	2015	278
Carrot (cooked)	1813	250
Turnip greens	1537	212
Collards	1450	200
Carrot (raw)	1312	181
Squash, winter	1269	175
Kale	922	127
Pepper, red	668	92
Broccoli	`510	70
Tomato	254	35
Aspargus	182	25
Sweet corn	152	21
Peas	115	16
GREEN BEAN	83	11
Okra	78	11
Pepper, green	63	9
Cowpeas	62	9
Squash, summer	55	8
Brussels sprouts	52	7
Lima beans	46	6
Cucumber	26	4
Chinese cabbage	26	4
Lettuce	25	3
Cabbage (cooked)	15	2
Cauliflower	11	2
Onion	11	2
Cabbage (raw)	8	1
Celery (raw)	0	0
Potato	0	0
Eggplant	0	0
Parsnip	0	0
Turnip root	0	0

[1]13-15 year old male/725 Retinol equivalents (FAO).

Table 3. Contributions of thiamine to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Thiamine Mgm	%RDA
Cowpeas	0.46	46
Peas	0.40	40
Asparagus	0.23	23
Sweet potato	0.23	23
Lima beans	0.22	22
Okra	0.21	21
Collards	0.15	15
Tomato	0.14	14
Potato	0.14	14
Spinach	0.14	14
Pepper, red	0.12	12
Pepper, green	0.12	12
Squash, winter	0.10	10
Eggplant	0.10	10
Broccoli	0.10	10
Turnip greens	0.09	9
Parsnip	0.09	9
GREEN BEAN	0.09	9
Cabbage (cooked)	0.08	8
Squash, summer	0.08	8
Kale	0.08	8
Sweet corn	0.07	7
Cauliflower	0.07	7
Carrot (cooked)	0.07	7
Carrot (raw)	0.06	6
Cabbage (raw)	0.06	6
Turnip root	0.06	5
Celery (raw)	0.05	5
Lettuce	0.05	5
Brussels sprouts	0.05	5
Onion	0.04	4
Chinese cabbage	0.03	3
Cucumber	0.03	3

[1]13-15 year old male/1.0 mgm (FAO/WHO).

Table 4. Contributions of riboflavin to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Riboflavin Mgm	%RDA
Turnip greens	0.59	36.9
Collards	0.46	28.7
Spinach	0.36	22.5
Squash, winter	0.31	19.4
Asparagus	0.30	18.7
Okra	0.29	18.1
Kale	0.25	15.6
Peas	0.22	13.7
Broccoli	0.22	13.7
Brussels sprouts	0.16	10.0
Parsnip	0.16	10.0
Squash, summer	0.15	9.4
Sweet potato	0.15	9.4
Lima beans	0.14	8.8
Sweet corn	0.13	8.1
Cowpeas	0.13	8.1
Pepper, green	0.12	7.5
Pepper, red	0.12	7.5
GREEN BEAN	0.12	7.5
Cauliflower	0.10	6.3
Turnip root	0.09	5.6
Cabbage (cooked)	0.08	5.0
Eggplant	0.08	5.0
Tomato	0.08	5.0
Carrot (cooked)	0.07	4.4
Onion	0.06	3.8
Potato	0.06	3.8
Carrot (raw)	0.06	3.8
Cabbage (raw)	0.05	3.1
Lettuce	0.05	3.1
Cucumber	0.04	2.5
Chinese cabbage	0.04	2.5
Celery (raw)	0.04	2.5

[1]13-15 year old male/1.0 mgm (FAO/WHO).

Table 5. Contributions of calcium to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Calcium Mgm	%RDA
Collards	473	72.8
Turnip greens	376	57.8
Kale	248	38.2
Spinach	223	34.3
Broccoli	195	30.0
Okra	147	22.6
Parsnip	88	13.5
Sweet potato	82	12.6
Cabbage (cooked)	78	12.0
Onion	67	10.3
Turnip root	62	9.5
Cowpeas	59	9.1
Celery (raw)	50	7.7
Squash, winter	49	7.5
Lima beans	46	7.1
Cabbage (raw)	46	7.1
GREEN BEAN	45	6.9
Brussels sprouts	44	6.8
Chinese cabbage	43	6.6
Carrot (raw)	43	6.6
Carrot (cooked)	38	5.8
Peas	35	5.4
Asparagus	33	5.1
Squash, summer	32	4.9
Tomato	27	4.2
Cucumber	26	4.0
Cauliflower	26	4.0
Eggplant	22	3.4
Pepper, red	20	3.1
Lettuce	15	2.3
Pepper, green	14	2.2
Potato	11	1.7
Sweet corn	10	1.5

[1] 13-15 year old male/650 mgm (FAO/WHO).

Table 6. Contributions of iron to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Iron Mgm	Iron %RDA
Cowpeas	4.0	29.6
Spinach	3.6	26.7
Turnip greens	3.5	25.9
Collards	3.0	22.2
Peas	3.0	22.2
Lima beans	2.7	20.0
Kale	2.4	17.8
Broccoli	2.0	14.8
Asparagus	1.8	13.3
Sweet potato	1.8	13.3
Brussels sprouts	1.7	12.6
Squash, winter	1.6	12.9
Tomato	1.5	11.1
Cauliflower	1.3	9.6
Sweet corn	1.3	9.6
Eggplant	1.2	8.9
Cucumber	1.2	8.9
Parsnip	1.1	8.1
Pepper, green	1.1	8.1
Onion	1.0	7.4
Chinese cabbage	0.9	6.7
Pepper, red	0.9	6.7
Potato	0.9	6.7
GREEN BEAN	0.9	6.7
Carrot (cooked)	0.9	6.7
Carrot (raw)	0.9	6.7
Okra	0.8	5.9
Turnip root	0.8	5.9
Squash, summer	0.8	5.9
Cabbage (cooked)	0.8	5.9
Cabbage (raw)	0.5	3.7
Celery (raw)	0.5	3.7
Lettuce	0.4	3.0

[1]13-15 year old male/13.5 mgm (FAO/WHO).

Table 7. Contributions of protein to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Protein Grams	Protein %RDA[2]
Cowpeas	11	23.2
Lima beans	8	16.8
Peas	8	16.8
Collards	7	14.7
Spinach	6	12.6
Brussels sprouts	6	12.6
Broccoli	5	10.5
Sweet corn	5	10.5
Kale	4	8.4
Sweet potato	4	8.4
Asparagus	4	8.4
Turnip greens	4	8.4
Squash, winter	4	8.4
Potato	3	6.3
Okra	3	6.3
Cauliflower	3	6.3
Cabbage (cooked)	2	4.2
GREEN BEAN	2	4.2
Pepper, green	2	4.2
Onion	2	4.2
Tomato	2	4.2
Pepper, red	2	4.2
Parsnip	2	4.2
Eggplant	2	4.2
Chinese cabbage	1	2.1
Celery (raw)	1	2.1
Cabbage (raw)	1	2.1
Squash, summer	1	2.1
Turnip root	1	2.1
Cucumber	0.9	1.9
Lettuce	0.7	1.5

[1]13-15 year old male/47.5 grams (FAO/WHO).

[2]Because of the lower efficiency of plant proteins the contributions are overstated. The FAO/WHO recommendation is based on a milk or egg protein quality equivalent.

Table 8. Contribution of phosphorus to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Phosphorus Mgm	Phosphorus %RDA.
Cowpeas	241	20
Lima beans	206	17
Peas	158	13
Sweet corn	147	12
Sweet potato	120	10
Brussels sprouts	112	9
Broccoli	104	9
Collards	99	8
Squash, winter	98	8
Parsnip	96	8
Asparagus	84	7
Potato	82	7
Tomato	77	6
Spinach	68	6
Okra	66	6
Kale	64	5
Onion	61	5
Turnip greens	54	5
Cauliflower	53	4
GREEN BEAN	46	4
Pepper, red	45	4
Carrot (cooked)	45	4
Eggplant	42	4
Carrot (raw)	40	3
Squash, summer	38	3
Turnip root	37	3
Celery (raw)	34	3
Pepper, green	33	3
Chinese cabbage	30	3
Cabbage (cooked)	29	2
Cucumber	28	2
Cabbage (raw)	23	2
Lettuce	17	1

[1]11-14 year old male/1200 mgm (USRDA).

Table 9. Contributions of niacin to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Niacin Mgm	Niacin %RDA
Peas	3.7	21.5
Collards	3.2	18.6
Sweet corn	2.4	14.0
Potato	2.3	13.4
Asparagus	2.1	12.2
Kale	1.9	11.0
Lima beans	1.8	10.5
Tomato	1.7	9.9
Sweet potato	1.5	8.7
Okra	1.4	8.1
Cowpeas	1.3	7.6
Squash, summer	1.3	7.6
Broccoli	1.2	7.0
Squash, winter	1.2	7.0
Spinach	1.1	6.4
Eggplant	1.0	5.8
Turnip greens	1.0	5.8
Pepper, red	0.8	4.7
Pepper, green	0.8	4.7
Carrot (raw)	0.7	4.1
Carrot (cooked)	0.7	4.1
Brussels sprouts	0.6	3.5
GREEN BEAN	0.6	3.5
Cauliflower	0.6	3.5
Turnip root	0.6	3.5
Cabbage (cooked)	0.5	2.9
Chinese cabbage	0.4	2.3
Celery (raw)	0.4	2.3
Onion	0.4	2.3
Cabbage (raw)	0.3	1.7
Parsnip	0.3	1.7
Lettuce	0.2	1.2
Cucumber	0.2	1.2

[1] 13-15 year old male/17.2 mgm (FAO/WHO).

Table 10. Contributions of food energy to the recommended daily dietary allowance[1] by one cup of selected prepared vegetables.

Vegetable	Food energy K cal	Food energy %RDA
Sweet potato	291	11.5
Sweet corn	170	6.7
Cowpeas	150	5.9
Lima beans	150	5.9
Potato	118	4.7
Peas	110	4.4
Parsnip	95	3.8
Squash, winter	95	3.8
Onion	80	3.2
Collards	75	3.0
Brussels sprouts	60	2.4
Pepper, red	47	1.9
Okra	46	1.8
Kale	45	1.8
Tomato	45	1.8
Broccoli	45	1.8
Carrot (raw)	45	1.8
Carrot (cooked)	45	1.8
Spinach	45	1.8
Turnip greens	45	1.8
Cabbage (cooked)	40	1.6
Turnip root	40	1.6
Eggplant	38	1.5
Squash, summer	35	1.4
Asparagus	35	1.4
Pepper, green	33	1.3
Cauliflower	30	1.2
Cabbage (raw)	25	1.0
GREEN BEAN	25	1.0
Celery (raw)	20	0.8
Cucumber	16	0.6
Chinese cabbage	15	0.6
Lettuce	10	0.4

[1] 13-15 year old male/2525 K cal (FAO/WHO).

Table 11. Index of nutritional quality (INQ)[1] for ascorbic acid in one cup of selected prepared vegetables.

Vegetable	INQ
Pepper, red	547.98
Pepper, green	489.70
Broccoli	207.61
Chinese cabbage	173.94
Cabbage (raw)	168.33
Turnip green	162.72
Cabbage (cooked)	111.52
Kale	104.74
Spinach	101.00
Asparagus	96.19
Cauliflower	95.39
Collards	94.27
Brussels sprouts	85.57
Tomato	74.81
Cucumber	63.13
GREEN BEAN	60.60
Turnip root	58.92
Okra	58.55
Squash, summer	55.31
Lettuce	42.08
Eggplant	31.01
Celery (raw)	29.46
Peas	18.36
Cowpeas, green	17.96
Potato	17.83
Parsnip	16.83
Onion	13.68
Lima beans	13.47
Carrot (raw)	13.09
Sweet potato	12.44
Squash, winter	12.40
Carrot (cooked)	11.22
Sweet corn	6.93

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 12. Index of nutritional quality (INQ)[1] for vitamin A in one cup of selected prepared vegetables.

Vegetable	INQ
Spinach	164.08
Carrot (cooked)	140.32
Turnip greens	118.96
Carrot (raw)	101.54
Kale	71.36
Collards	67.33
Pepper, red	49.50
Squash, winter	46.52
Broccoli	39.47
Sweet potato	24.12
Tomato	19.66
Asparagus	18.11
GREEN BEAN	11.56
Lettuce	8.71
Pepper, green	6.65
Chinese cabbage	6.04
Okra	5.91
Cucumber	5.66
Squash, summer	5.47
Peas	3.64
Sweet corn	3.11
Brussels sprouts	3.02
Cowpeas, green	1.44
Cabbage (cooked)	1.31
Cauliflower	1.28
Cabbage (raw)	1.11
Lima beans	1.07
Onion	0.48
Eggplant	0.18
Potato	0.00
Celery (raw)	0.00
Turnip root	0.00
Parsnip	0.00

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 13. Index of nutritional quality (INQ)[1] for thiamine in one cup of selected prepared vegetables.

Vegetable	INQ
Asparagus	16.59
Lettuce	12.63
Okra	11.53
Peas	9.18
Pepper, green	9.18
GREEN BEAN	9.09
Spinach	7.86
Tomato	7.86
Cowpeas, green	7.74
Eggplant	6.64
Pepper, red	6.45
Celery (raw)	6.31
Cabbage (raw)	6.06
Cauliflower	5.89
Squash, summer	5.77
Broccoli	5.61
Turnip greens	5.05
Collards	5.05
Chinese cabbage	5.05
Cabbage (cooked)	5.05
Cucumber	4.73
Kale	4.49
Carrot (cooked)	3.93
Turnip root	3.79
Lima beans	3.70
Carrot (raw)	3.37
Potato	3.00
Squash, winter	2.66
Parsnip	2.39
Brussels sprouts	2.10
Sweet potato	2.00
Onion	1.26
Sweet corn	1.04

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 14. Index of nutritional quality (INQ)[1] for riboflavin in one cup of selected prepared vegetables.

Vegetable	INQ
Turnip greens	20.69
Asparagus	13.53
Spinach	12.63
Okra	9.95
Collard	9.68
Kale	8.77
Lettuce	7.89
Broccoli	7.72
GREEN BEAN	7.57
Squash, summer	6.76
Pepper, green	5.74
Cauliflower	5.26
Squash, winter	5.15
Brussels sprouts	4.21
Chinese cabbage	4.21
Pepper, red	4.03
Cucumber	3.95
Turnip root	3.55
Eggplant	3.32
Peas	3.16
Cabbage (raw)	3.16
Cabbage (cooked)	3.16
Celery (raw)	3.16
Tomato	2.81
Parsnip	2.66
Carrot (cooked)	2.45
Carrot (raw)	2.10
Lima beans	1.47
Cowpeas, green	1.37
Sweet corn	1.21
Onion	1.18
Sweet potato	0.81
Potato	0.80

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 15. Index of nutritional quality (INQ)[1] for calcium in one cup of selected prepared vegetables.

Vegetable	INQ
Turnip greens	32.46
Collards	24.50
Kale	21.41
Spinach	19.25
Broccoli	16.83
Okra	12.41
Chinese cabbage	11.14
Celery (raw)	9.71
Cabbage (cooked)	7.57
Cabbage (raw)	7.15
GREEN BEAN	6.99
Cucumber	6.31
Turnip root	6.02
Lettuce	5.83
Carrot (raw)	3.71
Asparagus	3.66
Parsnip	3.60
Squash, summer	3.55
Cauliflower	3.37
Carrot (cooked)	3.28
Onion	3.25
Brussels sprouts	2.85
Tomato	2.33
Eggplant	2.25
Squash, winter	2.00
Pepper, red	1.65
Pepper, green	1.65
Cowpeas, green	1.53
Peas	1.24
Lima beans	1.19
Sweet potato	1.09
Potato	0.36
Sweet corn	0.23

[1]Using the data collected for this study and the method of calculation form Hansen, Wyse and Sorensen.

Table 16. Index of nutritional quality (INQ)[1] for iron in one cup of selected prepared vegetables.

Vegetable	INQ
Spinach	14.96
Turnip greens	14.55
Cucumber	14.03
Chinese cabbage	11.22
Kale	9.98
Asparagus	9.62
Broccoli	8.31
Cauliflower	8.10
Lettuce	7.48
GREEN BEAN	6.73
Pepper, green	6.23
Tomato	6.23
Eggplant	5.91
Brussels sprouts	5.30
Peas	5.10
Cowpeas green	4.99
Celery (raw)	4.68
Squash, summer	4.28
Turnip root	3.74
Cabbage (raw)	3.74
Cabbage (cooked)	3.74
Carrot (raw)	3.74
Carrot (cooked)	3.74
Pepper, red	3.58
Lima beans	3.37
Okra	3.25
Squash, winter	3.15
Onion	2.34
Parsnip	2.17
Collards	1.60
Sweet corn	1.43
Potato	1.43
Sweet potato	1.16

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 17. Index of nutritional quality (INQ)[1] for protein in one cup of selected prepared vegetables.

Vegetable	INQ
Spinach	7.09
Asparagus	6.08
Broccoli	5.91
Brussels sprouts	5.32
Cauliflower	5.32
Collards	5.00
Turnip greens	4.73
Kale	4.73
GREEN BEAN	4.25
Cowpeas, green	3.90
Peas	3.87
Lettuce	3.72
Chinese cabbage	3.54
Okra	3.47
Pepper, green	3.22
Cucumber	2.99
Lima beans	2.84
Eggplant	2.80
Cabbage (cooked)	2.66
Celery (raw)	2.66
Tomato	2.36
Pepper, red	2.26
Squash, winter	2.24
Cabbage (raw)	2.13
Sweet corn	1.56
Squash, summer	1.52
Potato	1.35
Onion	1.33
Turnip root	1.33
Carrot (raw)	1.18
Carrot (cooked)	1.18
Parsnip	1.12
Sweet potato	0.73

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 18. Index of nutritional quality (INQ)[1] for phosphorus in one cup of selected prepared vegetables.

Vegetable	INQ
Broccoli	4.86
Asparagus	4.39
Chinese cabbage	4.21
Brussels sprouts	3.93
GREEN BEAN	3.87
Cauliflower	3.72
Cucumber	3.68
Tomato	3.60
Lettuce	3.58
Celery (raw)	3.58
Cowpeas, green	3.38
Spinach	3.18
Peas	3.02
Okra	3.02
Kale	2.99
Lima beans	2.89
Collards	2.78
Turnip greens	2.52
Eggplant	2.33
Squash, summer	2.28
Squash, winter	2.17
Parsnip	2.13
Pepper, green	2.10
Carrot (cooked)	2.10
Pepper, red	2.01
Turnip root	1.95
Cabbage (raw)	1.94
Carrot (raw)	1.87
Sweet corn	1.82
Onion	1.60
Cabbage (cooked)	1.53
Potato	1.46
Sweet potato	0.87

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 19. Index of nutritional quality (INQ)[1] for niacin in one cup of selected prepared vegetables.

Vegetable	INQ
Asparagus	8.81
Collards	6.26
Kale	6.20
Tomato	5.55
Squash, summer	5.45
Peas	4.94
Okra	4.47
Chinese cabbage	3.91
Broccoli	3.91
Eggplant	3.86
Spinach	3.59
Pepper, green	3.56
GREEN BEAN	3.52
Turnip greens	3.26
Lettuce	2.94
Celery (raw)	2.94
Cauliflower	2.94
Potato	2.86
Pepper, red	2.50
Carrot (cooked)	2.28
Carrot (raw)	2.28
Turnip root	2.20
Sweet corn	2.07
Squash, winter	1.85
Cucumber	1.84
Cabbage (cooked)	1.84
Lima beans	1.76
Cabbage (raw)	1.76
Brussels sprouts	1.47
Cowpeas, green	1.27
Sweet potato	0.76
Onion	0.73
Parsnip	0.46

[1]Using the data collected for this study and the method of calculation from Hansen, Wyse and Sorensen.

Table 20. Adjusted[1] percent RDA contributions and index of nutritional quality totals of 9-10 essential nutrients in 33 vegetables.

Adjusted Tables

	150g		1 Cup		1 Cup	
	%RDA	Rank	%RDA	Rank	INQ	Rank
Pepper, red	236	8	236	8	620	1
Pepper, green	151	20	151	18	528	2
Turnip greens	356	1	350	2	365	3
Spinach	303	4	324	3	334	4
Broccoli	262	6	266	6	300	5
Kale	344	3	306	4	235	6
Chinese cabbage	159	16	130	24	223	7
Collards	344	2	383	1	216	8
Cabbage (raw)	151	19	127	25	195	9
Asparagus	217	10	214	11	177	10
Carrot (cooked)	154	17	156	17	131	11
Cabbage (cooked)	145	22	144	20	138	12
Carrot (raw)	178	13	158	16	133	13
Cauliflower	153	18	144	19	131	14
Tomato	140	23	192	14	125	15
GREEN BEAN	137	24	114	28	114	16
Brussels sprouts	170	15	170	15	114	17
Okra	193	11	200	12	113	18
Cucumber	97	30	68	31	106	19
Lettuce	104	29	38	33	95	20
Squash, summer	146	21	127	26	90	21
Turnip root	126	26	131	23	81	22
Squash, winter	190	12	223	10	78	23
Celery (raw)	63	32	50	32	62	24
Eggplant	67	31	89	29	58	25
Peas	219	9	233	9	53	26
Sweet potato	242	7	297	5	44	27
Cowpeas	264	5	257	7	44	28
Lima beans	172	14	195	13	32	29
Parsnip	118	28	122	27	31	30
Potato	136	25	141	21	29	31
Onion	61	33	85	30	26	32
Sweet corn	125	27	137	22	19	33

[1]All individual values greater than 100 were reduced to 100 in totaling.

SNAP BEAN CONSUMPTION IN LESS DEVELOPED COUNTRIES

Willem Janssen 1/

Abstract

Data on snap bean consumption are reviewed for Brazil, Colombia, Costa Rica, Indonesia, Philippines, Rwanda, Taiwan and Turkey to evaluate the present and possible future importance of snap beans in human diets, and the implication of consumption issues for snap bean research. Analyses of current consumption levels and their interaction with income, urbanization, prices and substitute vegetables are conducted. Price stability and market integration are also investigated. Snap bean quality preferences are described, including consumer attitudes to snap beans versus other vegetables. It is concluded that from a consumption point of view, snap beans are as worthy of research as any other vegetable. However, snap beans have the advantage of a complementarity with dry beans.

Introduction

Snap beans are consumed in many countries of the world. As noted by Kelly and Scott (1989) in the preceding paper, snap beans contribute very reduced amounts of calories and protein to the diet, but respectable amounts of vitamins and minerals. Snap beans can be rated as a vegetable of intermediate nutritional value. They are not as important for human nutrition as cereals and legumes, which do provide calories and protein, the most essential nutritional elements.

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By now many countries in the developing world have assured the supply of staple foods to their populations. The concerns for food security are less overwhelming and attention to less essential products is increasing. At the same time incomes have grown and the demand for animal proteins and for vegetables is increasing. Snap bean is one among many vegetables for which demand is growing. Demand prospects for snap beans are very good. (Henry and Janssen, 1989). Worldwide, some 4 million tons of snap beans are consumed at present. Demand will grow at about 4% a year. By the year 2000 the expected demand for snap beans will reach 6.5 million tons.

The Rationale for Studying Snap Bean Consumption

Food consumption patterns, including snap bean consumption, are highly variable among countries and over time. The share of vegetables in consumption expenditures is high in China and low in Latin America. Products that had reduced consumption levels 20 years ago, such as chicken, are now essential parts of the diet in many countries. The variability in consumption patterns is due to many causes. Tradition is one explanation; availability is another.

Behind such concepts as tradition and availability, a range of economic explanations are hidden. Tradition corresponds to a long-term comparative advantage for the production of certain goods. Availability reflects low production costs and a marketing system that makes the product available throughout most of the year. The economic analysis of food consumption patterns provides very useful insights into the reasons for variability in food consumption.

The objective of this paper is to analyze the economic issues influencing present snap bean consumption trends and future consumption. The present and future importance of the crop can thus be assessed more accurately. The analysis will also provide guidelines for future agricultural research. Policy guidelines will receive considerably less attention. Policy interventions are less common in the case of vegetables than in the case of staple foods. Vegetables are less essential than cereals or legumes and their poor storability strongly reduces the feasibility of price policies or other market interventions. Research in production and processing appears more appropriate in influencing vegetable consumption. Therefore this paper emphasizes how consumption issues influence agricultural research priorities.

Issues That Affect Snap Bean Consumption

The consumption of any single commodity is affected by a large number of variables. Economists typically use income, degree of urbanization, own - prices and availability of substitutes to explain consumption levels. Marketing specialists would point out the importance of spatial market integration, seasonality of supply and price stability. Specialists in consumer behavior, would be interested in understanding consumer attitudes towards the product, desired quality characteristics and preparation methods. The actual consumption of the crop can best be understood by analyzing all the different dimensions.

Among the variables just mentioned some are useful for assessing the present and future importance of the crop, while others have important implications for research strategies. For example, the effect of income on snap bean consumption has a bearing on expected future consumption levels, but does not shed much light on where to focus research efforts. On the other hand, knowing the desired quality characteristics of snap beans has important implications for genetic improvement, but does not provide any insight into the relative importance of the product.

Only by discussing variables that affect present and future importance as well as variables that have a bearing on research priorities, is it possible to design appropriately sized and focused research programs. Information on these variables, especially those related to research issues, is often not available from secondary sources, or is very unreliable. To overcome this lack of information, a number of country case studies were executed in close collaboration with national research programs and the CIAT Bean Program. The data which are reported in this paper are drawn largely on these country case studies: Colombia (Mulder, 1988); Costa Rica (Broekhoff, 1989); Indonesia (CGPRT, 1988); Philippines (Francisco and Domingo, 1988); Rwanda (Schasfoort and Westerhof, 1989); Taiwan (NPIA and AVRDC, 1988); and Turkey (Erkal et al., 1989). They are complemented by secondary data from Brazil, Colombia and FAO.

Snap Bean Consumption Levels

Snap bean consumption per capita differs considerably from country to country (Table 1). While in the Philippines and Indonesia consumption is less than 500 grams/person/year, annual per capita consumption is about 3 kg in China and 6 kg in Turkey. For Rwanda consumption of 16 kg/person/year was reported, but this refers also to green pods of dry bean cultivars that are eaten before the dry beans can be harvested (Schasfoort and Westerhof,1988).

Only in Turkey and Rwanda, are snap beans really important vegetables. In countries such as China, Colombia, Chile and Egypt, snap beans are a vegetable of intermediate importance. In many countries, including Brazil, India, Indonesia and the Philippines, snap beans are a vegetable of very reduced importance.

The relative importance of snap beans is to some extent related to production conditions. Snap beans are an intermediate to cool-season vegetable. Countries like Indonesia and the Philippines do not have large cool-weather production zones (highlands). The competition for the available highlands is so intense that only a limited amount of snap beans can be grown. In China, Colombia, Turkey and Rwanda, for example, the crop can be produced in various areas of the countries at different times of the year and consequently production is higher.

Care should be taken in interpreting these data, however. Some data were obtained from questionnaires on snap bean consumption and might be overestimated. Other data, from national production statistics, only consider commercial production and omit the large amounts of home-produced snap beans. Still, these data form the best available starting point for reviewing how different variables influence snap bean consumption.

Snap Bean Consumption and Income

Snap bean consumption appears to be income sensitive. In Colombia consumption among the lowest income strata was only one fifth of consumption among the wealthiest income strata. In Brazil, from the lowest to the highest income strata, consumption increased more than eight times. Snap beans are presently not an important food crop for the poor and equity considerations would not favor its research.

Income elasticities were estimated for various countries, in all cases on the basis of cross-section data. The estimated income elasticities were significantly positive in all cases, but varied strongly from country to country. For Iraq, FAO food budget survey data estimate a value of 1.06 (FAO, 1979), while for Rwanda the case study data produce an estimate of 0.24 (Schasfoort and Westerhof, 1988). The estimate for Brazil (0.65) falls between those for Iraq and Rwanda (ENDEF, 1976). For Colombia and the Philippines urban and rural income elasticities were estimated. The rural values were comparable: 0.33 in Colombia and 0.30 in the Philippines. The urban values were rather different: 0.23 in Colombia and 0.43 in the Philippines (Encuesta DRI-PAN, 1982; Arocena-Francisco and Domingo, 1988). The estimated values fall in the range of income elasticities for vegetables as prepared by FAO (1971). In Colombia, the low value contrasts with the fact that among a group of 10 important vegetables snap beans was the one with the highest changes in consumption relative to income.

Some estimation problems might have been caused by the peculiar nature of the data. In Colombia (but also in Indonesia), the percentage of consumers stating that they had consumed snap beans during the period specified by the survey grew strongly with income. This suggests that income increases lead to more frequent consumption, rather than to bigger portions. However, it is possible that because such a large number of respondents in the sample stated they had not consumed snap beans in the specified period, the conditions for ordinary estimation were violated and the outcomes were highly biased. In comparison with dry beans the income elasticities for snap beans are high. For dry beans, income elasticities tend to be around zero (Janssen, 1988). While dry bean consumption will not grow with rising income, snap bean consumption will still experience considerable increases.

Urbanization and Snap Bean Consumption

For Brazil, Colombia and Indonesia, data that distinguish between urban and rural consumption are available. In all three countries urban consumption is considerably higher. In Brazil and Colombia, people in the city eat three times as many snap beans as people in the country. In Indonesia, urban consumers eat twice as many snap beans as rural consumers.

What causes these differences in consumption levels? First let's consider availability. In many rural areas snap beans are not produced because of lack of adaptation or because more profitable crops can be grown. In other rural areas snap beans are available only in certain months of the year. Rural-rural marketing channels are often not well developed and when snap beans are not produced in one region, neither are they brought in from other rural areas. In contrast, in urban areas availability is ensured throughout the year by supplies from different areas.

Secondly, urban consumers have different dietary needs. Hard, physical labor is less frequent in urban than in rural areas. Consumers adapt their diet by exchanging calorie sources for vegetables. Thirdly, urban incomes are higher than rural incomes. The effect of the higher urban incomes, however, should not be overestimated. The data for Colombia were used to separate the income effect from the pure urbanization effect. Among urban consumers snap bean consumption was still more than two times higher than among rural consumers with comparable incomes. These data suggest that urbanization represents an independent factor driving increased snap bean consumption. For Latin America, most of the urbanization process has already taken place, but for Asia and Africa it will imply rapid demand increases.

While vegetable marketing is better organized towards urban than towards rural areas, it is still subject to improvements. To the extent that these improvements increase availability, urban snap bean consumption will probably increase. Nevertheless, these consumption changes are probably not unique for snap beans, but apply equally to other vegetable crops.

Prices and Snap Bean Consumption

Prices for snap beans at retail level are around US$.50/kg. In some countries, such as China, snap beans are cheaper (Henry and Li Peihua, 1989). Prices fluctuate strongly from month to month.

Snap beans are rather expensive in comparison with many other vegetable crops. Table 2 provides some information on relative price levels in different countries. Cabbage, cauliflower and carrots are considerably cheaper in most countries. Tomatoes are more comparably priced but are still cheaper. Only lettuce is more expensive than snap beans in almost all cases.

Price levels are strongly related to production and marketing costs. Snap beans have a reference yield of 10 tons/ha and are not particularly easy to market. A cabbage crop easily yields 25 tons/ha and can be marketed with equal or more ease than snap beans. Carrots yield 15/ha and can also be marketed easily. On the other hand, lettuce yields 20 tons/ha but faces extreme marketing problems. (For reference yields, see Agricultural Compendium, 1981.)

The high price levels of snap beans reduce the feasibility of processing. Both canning and freezing add considerable costs that are passed on to the consumer. In tropical or semi-tropical environments, at present income levels, such processing does not appear justified. It would be better to eat other vegetables instead of processed snap beans.

The available data do not suggest a direct relation between relative price and consumption. For example, relative prices in Indonesia are very comparable to Colombia. However consumption levels are ten times lower in Indonesia. This would suggest that continuous production and availability, which is more possible in mid-and-high elevation Colombia than in lowland Indonesia, is very important for stimulating consumption.

Reliable price elasticities of supply were estimated for Brazil, Colombia, Indonesia, the Philippines and Taiwan. In the case of Brazil, a time series estimation for the market of Rio de Janeiro yielded an elasticity of -0.42. For Colombia, Indonesia, the Philippines and Taiwan, cross-section price elasticities were calculated resulting in somewhat higher figures than for Brazil. Urban elasticities estimated were: Colombia, -0.74; Indonesia, -0.53; Philippines, -0.84; and Taiwan, -0.84. Rural price elasticities for Colombia, Indonesia and the Philippines were: -0.42; -0.89 and -1.15, respectively.

These price elasticities are high and would indicate that snap bean consumption is sensitive to price changes. Such a conclusion, however, does not coincide with the previous conclusion on the unimportance of relative price levels. A possible explanation might be that given a <u>certain degree</u> of availability, snap bean consumption is price sensitive.

Substitutes and Snap Bean Consumption

Are there any specific crops that are substituted for snap beans in consumption patterns? For three countries specific crops were hypothesized as potential substitutes. These were tomatoes in Brazil, because of their importance as a vegetable, and yardlong beans for the Philippines and Indonesia, because of their similarity to snap beans. For all three cases substitution effects were not significant. In the case of Indonesia, the effect of the yardlong bean price on snap bean consumption was negative. This might suggest complementarity.

In Colombia, another statistical procedure was followed to explore possible substitution effects. Prices of other vegetables were included in demand equations for snap beans and other vegetables for different income strata, according to the increase in explanatory power that they would cause (forward stepwise regression, see SAS, 1985). Except for some weak effect of onion prices on tomato consumption, this exercise did not reveal any structure in substitution among vegetables. For snap beans on a national scale, the stepwise regression analysis points to some weak substitution with carrots in the urban areas and cabbage in the rural areas.

Snap bean consumption, then, does not appear to be specifically affected by any vegetable, nor do snap beans affect the consumption of any particular vegetable. However, price reductions for one crop relative to others would trigger an increase in the consumption of that vegetable at the cost of other crops. This conclusion is as true for most other vegetables as for snap beans.

Seasonality and Price Stability

Snap bean prices are more unstable than prices of other vegetables, according to consumers in Taiwan, Turkey and Rwanda. Average retail prices are 60% higher in the off-season than in the harvest period in the Philippines and more than double in Brazil. In comparison, dry bean prices in Brazil are less than 20% more expensive in the months with reduced supply than in the months with ample supply.

Apart from the seasonal price variability, snap beans experience considerable random price fluctuation. Prices change from day to day; after a week with ample supplies prices might fall by more than 50% (Henry, 1989).

Price series analysis for Brazil suggests that seasonality is the biggest source of price instability. In a comparative analysis of 12 towns, 56% of the price variability was caused by seasonality. In comparison, for dry beans only 22% of price fluctuations was caused by seasonality (Table 3).

One would expect seasonality to be stronger in the temperate climates, where snap bean production is bound by seasons than in tropical highland regions. Although there are no data available to support this hypothesis, this would suggest that seasonality is an important issue in countries such as China.

What is the value of overcoming this seasonality? Certain authors argue that it is not useful to stabilize the price of vegetables (Shalit, 1984). If one considers the aggregate supply of vegetables, such a conclusion might easily find support: while one vegetable is expensive others are cheap and widely available. From the point of view of snap bean research, improving availability might be an important way of increasing consumption and improving "crop loyalty" (see Engel and Blackwell, 1982, for the concept of brand loyalty).

At present most snap beans are marketed in fresh form. Freezing or canning have not made their way into snap bean marketing in developing countries. Overcoming seasonality will have to be achieved primarily by spreading production over the year, to the extent possible. For the more random short-term price fluctuations, refrigeration might provide a partial solution. The economics of such storage need to be studied with great rigor before any investments are made.

Market Integration and Snap Bean Consumption

For Brazil, market integration parameters for dry beans and snap beans were calculated on the basis of monthly wholesale data for a five-year period. A summary of this data is provided in Table 4. This shows that price movements for snap beans in different towns are very unrelated. An average correlation coefficient of 23% was found, versus 76% for dry beans. It was difficult to define clusters of cities that appear to operate similarly. Only two clusters resulted. The correlation between cities within these clusters was still lower than the correlation for dry beans between cities classified as belonging to different clusters.

These data suggest very reduced integration of snap bean markets. This implies that most cities are probably supplied by their own production region, with little flow of produce from town to town. If this is the case, research focused on a single region where impact is expected to be highest will increase availability in the town that the region services, but not in other towns. Research strategies have to take into account all major production areas of a country.

Consumer Attitudes

In a number of case studies consumers were asked their opinions about snap beans and some other vegetables. Results for Taiwan, Turkey, Colombia and Rwanda are presented in Table 5. The general impression is that consumers consider snap beans a valuable vegetable. Its quality is highly praised. Judgements as to its nutritiveness, taste and healthfulness are also generally favorable, though snap beans are not considered to have an especially attractive appearance.

Regarding nutritional qualities, the consumer impressions actually conflict with technical evaluations of beans. Snap beans are not particularly rich in vitamins or minerals in comparison with other vegetables. Consumers, however, do not base their opinion on nutritional parameters, but on a more complex set of subjective perceptions.

With respect to the convenience of snap beans, views are less favorable. Availability has below average scores. Storability is not considered a great asset either. Opinions with respect to waste in preparation are divided. Finally, many consumers do not think that snap beans are a very versatile food.

Future research should recall these attitudes. Quality characteristics should be maintained and availability and versatility improved. If yields are increased at the cost of quality, these increases may be worthless.

Quality Preferences and Snap Bean Consumption

Snap beans can be flat or cylindrical, curved or straight, yellow, green or almost black. Seed size can range from small to big and pod length from less than 10 cm to more than 20 cm. Nevertheless, a review of qualities sought by consumers and producers in different countries shows more uniformity than one would expect. In most countries, cylindrical, straight green pods about 15 cm long with intermediate seed size and no fiber would be very acceptable. While in most developed countries the desirable seed size is small, in most developing countries medium-sized seed is appreciated. As suggested by Mulder (1988), this might be because snap beans with medium-sized seeds satisfy people's appetite more than beans with smaller seeds. Seed color, which is especially important in case of canning (Silbernagel, 1986), was not investigated as a quality characteristic. The variation in preferred qualities is considerably less than in dry beans. This has very positive implications for snap bean breeding strategies.

In Taiwan consumers expressed concern about chemical contamination. When consumers do not know exactly how heavily a product has been treated with chemicals, they will often avoid consuming the product. Laboratory data from Colombia, where chemical control is repeated up to 15 times, suggest that levels of chemical contamination in snap beans are still below critical levels for consumers.

A peculiar finding with respect to quality preferences is that they are least defined in some of the countries with the highest consumption levels. In Turkey, curved snap beans are accepted and presence of fiber is less penalized than would be expected given the level of consumption in that country. Also, it should be noted that quality preferences are not clearly defined for China, the major snap bean producer and consumer of the world.

Methods of Preparation and Snap Bean Consumption

Although snap beans are not praised for their versatility, a spectrum of preparation methods was identified in the different case studies. They range from ordinary boiling to frying with egg white. Snap beans consumed in soups, salads or mixed with meat appear to be most popular. There is no relation between preparation method and pod type.

Conclusions

From a consumer's point of view snap bean is not a particularly outstanding vegetable. It is slightly more appreciated than average for its intrinsic qualities and slightly less for availability and versatility. It is not a very important vegetable, but then, there are few very important vegetables. Consumption levels vary from country to country and vary from less than 500 grams to more than 6 kg. This suggests considerable expansion potential in countries with low present consumption.

How might this consumption expansion be achieved? Relative prices in different countries do not show strong relation with existing consumption levels. Substitute products for snap beans cannot be defined very clearly. Snap beans tend to be included or excluded from the diet at the cost or benefit of other vegetables. Price elasticities for snap beans (estimated in the short run) are high. Available data suggest that in the long run increased availability of snap beans would be absorbed with minor price reductions, at the cost of a decreased relative importance of most other vegetables. The critical factor for snap bean consumption appears to be, not production costs, but availability throughout the year. Continuous widespread availability creates something of a "crop loyalty", similar to the concept of "brand loyalty" used in commercial marketing. Consumers need a certain degree of familiarization before they buy snap beans more frequently.

Due to the fluid substitution in vegetable consumption, consumer- price decreases as the result of successful research will be less than estimated given known short-term price elasticities. That implies that present estimations of benefit distribution within a partial equilibrium framework would be biased. The benefits to snap bean producers, as estimated by Henry (1989) are probably only the lower limit. Small-scale snap bean growers will be, in fact, the principal beneficiaries of successful snap bean research, probably at some cost to vegetable producers that do not produce snap beans.

Another aspect of the fluid substitution in vegetable consumption should be discussed. This is the expected value of research. If one crop can improve its consumption share considerably at the cost of other crops, then the initial market value of the crop is a bad approximation for the expected impact. If research is successful market value would increase rapidly and the effect on the production and availability of that vegetable might be considerably more than initially expected. However, if all vegetable crops are the subject of research, the effect of the fluid substitution would cancel the potential impact and the expected impact would have to be calculated on the basis of the initial market value.

Thus, snap bean research can be expected to have a high pay-off as long as a limited number of vegetable crops are being researched. Moreover, research efforts on a restricted number of vegetables would be more efficient than on a wide range of vegetable crops. Careful selection of the target crops, as recommended by TAC (1988), is warranted. Since research on snap beans would benefit considerably from the work done on dry beans, inclusion of snap beans would be justified. Snap bean research would be a cost-effective investment, more so than expected on the basis of its present market value.

Snap bean research would be coordinated by CIAT's Bean Program. The question arises how snap bean and dry bean research compare to each other. From a consumer's point of view, the two crops are very complementary. The fact that dry beans are more important than snap beans for the nutrition of poor consumers favors dry bean research. Snap bean consumption, however, is more responsive to income growth and will increase more rapidly over time than dry bean consumption. Price levels appear to be rather high for both products, warranting further research on both. Whereas substitution possibilities in dry beans are limited, in snap beans they widen considerably the expected value of research. Urbanization favors snap bean research, but current market integration suggests more potential impact for dry beans than for snap beans.

It is difficult to justify snap bean research on income distribution, market integration and dependency of producers and consumers. However, these are exactly the issues where dry bean research is justified. On the other hand, income growth, substitution possibilities and urbanization do not favor dry bean research. Here snap bean research balances the equation.

Snap bean research is also complementary to dry bean research in its regional focus. Snap bean research should focus on West Asia and China, while dry bean research focuses on Latin America and Africa. Within the target regions improved availability on a year-round basis should be the principal research goal. In order not to lose consumer acceptance of the crop, existing quality standards must be maintained. Ongoing attention to consumption issues will thus be a cornerstone for building successful snap bean research programs.

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Table 1. Consumption levels of snap beans in selected LDCs.

	Amount (kg/person/year)	Importance in context of total vegetable consumption	Source of information
<u>Latin America</u>			
Argentina	1.3[2]	-	C
Brazil	0.7[2]	-	C
Chile	3.2	±	C
Colombia	2.7	±	B
Costa Rica	n.a.	-	A
Peru	0.4[2]	-	C
<u>Africa</u>			
Egypt	2.5	±	C
Morocco	0.9[2]	-	C
Rwanda	16.7[1]	+	A
<u>Asia</u>			
China	3.0	±	E
India	0.1[2]	-	D
Indonesia	0.3	-	B
Philippines	0.4	-	B
Taiwan	8.0[1]	-	A
Turkey	6.5	+	C

1/ Data from snap bean consumption survey, probably an overestimation.
2/ Data from national production survey, probably an underestimation.

Sources: A = Case studies B = National food budget surveys, as mentioned in case studies. C = Availability as calculated from production statistics (for sources see Janssen et al., 1988). D = FAO E = Henry and Li, 1989.

Table 2. Snap bean prices relative to other vegetables.

Countries	Snap bean	Carrot	Tomato	Lettuce	Cabbage	Cauli-flower	Source of information
Brazil 1987	100	85	57	124	28	63	A
Colombia 1986	100	-	114	161	36	84	A
Costa Rica 1988	100	30	67	75	25	65	B
El Salvador 1982	100	48	95	128	26	66	A
Indonesia 1984	100	113	121	-	49	70	A
Peru 1985	100	55	87	-	-	-	A
Rwanda 1988	100	113	101	-	54	-	B
Venezuela 1983	100	59	54	101	54	66	A

Note: In each country, the snap bean price has been set at 100. Prices of other vegetables are calculated relative to the snap bean price.

Sources: A = See Janssen et al., 1988.

B = Case studies

Table 3. Dry bean and snap bean wholesale price variability, 12 towns, Brazil, 1980 - 1985.

	Dry beans	Snap beans
Variability explained by seasonality	22%	56%
Number of towns with stable seasonality patterns	7	10
Average monthly deviation of prices caused by seasonality	4%	18%

Source: Snap bean prices: COBAL
Dry bean prices: Ministerio de Agricultura, Brazil
Calculations by the author.

Table 4. Market integration parameters for dry beans and snap beans in Brazil, 1980 - 1985.

	Dry bean prices	Snap bean prices
Average correlation between towns	76%	23%
Number of market clusters	3	2
Number of towns included in the clusters	11	9
Average correlation between towns within clusters	0.91	0.66
Average correlation between towns in different clusters or outside clusters	0.68	0.05

Source : Snap beans: COBAL

Dry beans: Ministerio de Agricultura. Precoz nos mercados atacadistas, various years, Brasilia, Brazil.

Calculations by the author.

Table 5. Consumer attitudes to snap beans in selected countries.

Perceptions	Taiwan	Turkey	Colombia	Rwanda
This product always has high quality	+ 11%	+ 24%	+ 5%	+ 12%
This product is nutritious	+ 24%	+ 63%	n.a.	- 20%
This product has excellent taste	- 2%	+ 33%	+ 16%	+ 7%
This product is healthful	+ 19%	n.a.	+ 4%	+ 4%
This product has an attractive appearance	+ 12%	- 16%	n.a.	- 16%
This product is readily available	- 5%	- 5%	n.a.	0%
This product can be kept well	+ 7%	+ 15%	- 22%	0%
Little of this product is wasted in preparation	+ 11%	+ 4%	- 13%	n.a.
This product is useful in many dishes	+ 32%	- 15%	n.a.	- 31%

The % indicates for how many more consumers the statement is true in the case of snap beans than in the case of other vegetables.

Source: Case studies

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QUALITY CHARACTERISTICS OF SNAP BEANS IN THE DEVELOPING WORLD

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Abstract

Pod quality requirements in snap beans vary from region to region. Characteristics related to pod shape, length, color and fiber content, among others, determine the degree to which snap beans are accepted by consumers and processors. The snap bean program at CIAT screens accessions from the germplasm collection and breeding lines for these characteristics, as well as adaptation and disease susceptibility. Information about the quality requirements of some Latin American countries is provided. Research on environmental and agronomic factors affecting snap bean pod quality is also discussed.

Introduction

The principal quality-determining factors for snap beans are low fiber content in the pod walls and absence of string in the suture. Characteristics such as shape, color, curvature and pod length are other qualities taken into account by consumers in developing countries, where snap beans are usually consumed fresh. Consumer requirements for snap beans are diverse throughout the developing world. Table 1 shows consumer preferences for some Latin American countries.

There is presently no detailed information at CIAT for other areas of the world, even for countries such as Taiwan and China which rank among the major consumers of snap beans.

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Quality Characteristics

The snap bean improvement project at CIAT evaluates quality characteristics, adaptation and disease resistance of accessions from CIAT's collection of bean germplasm (Table 2). The same evaluation system is used for the breeding nursery: segregating populations and progeny. However, for breeding purposes, selection for round, medium length, green pods is given the highest priority.

Shape

Shape refers to the pod's cross-section. It may be flat, round or an intermediate type such as semi-flat, oval or slightly oval.

Color

Pods can vary in color from dark green and light green to yellow. Accession G 15300 of CIAT's germplasm bank has a good quality purple pod which is round in shape. This accession has been used as a male parent in crosses done at CIAT and produces progeny with excellent architectural traits and uniform high yield.

Length

The length of pods may range from 10 cm to 20 cm or more.

Curvature

A curved pod is not a desirable trait for most snap bean consumers. Curved pods generally result from poor adaptation of a cultivar to a particular environment. They also cause problems in the packaging and shipment at harvest since they are more susceptible to breakage.

Seed size and color

Cultivars which have small, light-colored seed are preferred. However, white-colored seeds are associated with a tendency to increased susceptibility to root rots.

Pod Quality Characteristics in Snap Beans and their Relation to Ambient and Agronomical Factors

Interlocular cavitation

Interlocular cavitation (IC) is the cavity formation in soft cells of the parenchymatous endocarp between seed locules. Cavity formations appear 6-10 days after anthesis and persist until pod senescence. Cavities are considered a defect, may cause additional unwanted characteristics and lower processed pod quality (Lee et al., 1975).

Environment and cultural practices have a marked effect on the amount of IC. An excess of rain or irrigation before flowering, low temperatures in the pod formation period, and excess nitrogen increase IC (Lee, 1973).

Fiber and temperature

The cultivar "Wade" was planted in greenhouse trials with high temperatures (85 ^{o}F-95 ^{o}F) and optimum temperatures (60 ^{o}F-70 ^{o}F). It was found that pods grown at high temperatures had a higher content of fiber than those grown at optimum temperatures. The study concluded that fiber content may be estimated if ambient temperatures during the growth cycle are known (Rico, 1965).

Fiber and soil moisture

Two cultivars, Oregon 1604 and Galamor, were planted in trials where the soil's water potential was measured. It was found that fiber content was the same for both varieties when grown in soil with a water potential of -.06 bars (40%-45% water elimination). Fiber content was higher when the cultivars were planted in soil with a water potential of -2.5 bars (65%-70% water elimination) (Mack et al., 1982).

Fiber and row spacing

Three varieties, Early Gallatin, Gallagreen and Lakette, were used in trials where the distance between rows was 9 inches (high population) and 40 inches (low population). it was found that pods from high populations had slightly longer seeds and higher fiber content that those from low populations (Tompkins et al., 1972). The seed index (seed weight x seed length) is highly correlated with the percentage of fiber in snap bean pods and can be used to determine the fiber content in fresh and processed products. This is an easier and more efficient method to determine fiber content (Silbernagel et al., 1978).

Summary

Consumer requirements for snap beans are diverse and include aspects related to the bean's pod and the plant's growth habit (determinate or indeterminate). In Colombia, for example, pods which are round in shape, have a medium length (8-15 cm) and a light green color are preferred over others. CIAT is searching for these characteristics in bush and climbing type varieties. More than 6,000 hectares, with an average yield of 10.5 t/ha, have been planted in Colombia with the climbing variety Blue Lake. This variety is susceptible to many pathogens. Chemical control of these pathogens increases farmers' production costs. It is one of CIAT's priorities to offer farmers new, productive alternatives by developing lines which suit market requirements and are resistant to pathogens in the field.

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Table 1. Quality requirements in different Latin American countries.

	Argentina	Brazil	Peru	Ecuador	Colombia
Pod size (cm)	15	17	13	15	13
Pod cross-section					
- flat	x	x			
- semi-flat		x		x	x
- round		x	x	x	x
Seed size					
- small		x	x		x
- medium	x	x		x	x
- large		x			
Pod color					
- light green	x	x		x	x
- dark green			x		x
- yellow	x				
Pod curvature					
- straight	x	x	x		x
- curved				x	
Fiber acceptable	No	Yes	No	Yes	Yes
Growth habit of cultivars	4	4	1	1	4

Source: Janssen, W. 1987.

Table 2. Pod color (PC) and pod cross-section (PCS) of some snap bean germplasm accessions.

# CIAT	Identification	Origin	Proc.	Growth habit	PC[1]	PCS[2]
G 10214	Pole as Stringless-Kent	PTC	PTC	4A	G	R
G 15779	Paracido	SPN	UTK	3B	G	F
G 15801	--	ZBA	ITL	4A	G	SF
G 17647	OSU 4852	USA	USA	4A	G	R
G 17723	Pole Blue Lake	USA	COL	4A	G	R
G 18179	Llico	CLE	CLE	4A	G	F
G 5760	Golden Gate Wax	USA	USA	4A	Y	SF
G 17862	Tottosi-TF 2663	HGY	HGY	3B	Y	F
G 18215	--	SPN	SPN	3B	Y	R
G 18826	Sable Amarillo	SPN	USA	4A	Y	F
G 18848	Jeruzalemcm	VUG	USA	4B	Y	F
G 15300	--	ZBA	ITL	4A	p	R
G 8978	Saxa	GFR	NLD	1	G	R
G9189	Favarnel	-	FRC	1	G	F
G9308	Provider	-	FRC	1	G	SF
G 7654	Golden Age	-	GDR	1	Y	R
G 18023	--	HGY	HGY	1	Y	F
G 7632	Butter	-	GDR	1	Y	SF

[1] G = Green, Y = Yellow, P = Purple

[2] R = Round, F = Flat, SF = Semi-flat

SNAP BEAN INTERNATIONAL TRADE: PRESENT STATUS AND FUTURE PROSPECTS

Wesley Peterson and Guy Henry 1/

Abstract

International trade in fresh and processed vegetables has expanded considerably over the last 20 years. The volume of fresh vegetables traded is about three times the volume of processed vegetables. More than half of total world trade originates in Europe, in particular the EEC, and two thirds of world trade is between industrialized countries. The European demand for fresh snap beans appears to be strong. Significant increases in imports have occurred in the EEC, especially France, during the last five years. Little data exists on the trade of canned or frozen snap beans between developing and developed countries. However, China is a major exporter of canned beans. Several other countries, like Kenya and Turkey are also attempting to capture a share of this trade. Developing countries may enjoy a comparative and competitive advantage as snap bean exporters, based on relatively lower wages and geographic location. Snap bean production trends for importers and exporters are discussed to shed light on the prospects for growth in import demand and the potential of the snap bean trade for developing countries. It is expected that most of the demand growth will occur in the Middle East, Far East and in Europe.

Introduction

International trade in fresh and processed vegetables has expanded considerably over the past two decades (Sparks). The reasons for

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this expansion can be related to changes in the nature of both supply and demand. With respect to supply, widespread use of genetically improved varieties and technological innovations in transportation, storage, packaging, processing and production have increased the supply and cut the costs of delivering fresh and processed products to distant markets (Bale). An important aspect of these changes is the increased homogeneity and standardization of the traded products. As Bale notes, greater standardization allows traders to reach agreement on the basis of written or verbal descriptions rather than through personal inspection (p. 2). Historically, fresh vegetables were only available from local producers at certain times of the year. The changes noted above have made it possible for the highly perishable fresh products to be traded widely. Of particular importance in these developments is the ability of countries in the southern hemisphere to supply fresh products to industrialized countries during winter months.

Demand for vegetables has also been growing over time. The main factors influencing demand are population and income growth. If per capita consumption remains constant, total demand will grow at the same rate as the population is growing. For most types of food, increases in income lead to only moderate increases in per capita demand. In some cases, income growth can lead to a decline in per capita consumption. In these cases the increased income is used to purchase products seen as more desirable, so the amount of food purchased increases only slightly, stays the same or declines. For some food products, however, income increases may stimulate much greater per capita consumption because these products are seen as desirable by consumers. This may be the case for some kinds of fresh vegetables, particularly in the industrialized countries, where food consumption patterns appear to be shifting toward healthier foods. Islam and Subramanian found that in industrialized countries demand for fresh tomatoes imported from less developed countries (LDCs) tends to increase at a rate that is higher than the rate of income growth. The implication of this is that consumers in Europe, Japan and North America perceive some types of fresh vegetables as superior products, purchasing proportionately more of them as their incomes increase.

The purpose of this paper is to outline the current situation in world vegetable trade with particular reference to international trade in snap beans. Following an overview of world trade in vegetables, the main economic considerations related to trade in perishable products are outlined. Based on these considerations the state of international trade in snap beans is assessed, with emphasis on the potential for growth of trade between developing and industrialized countries.

International Vegetable Trade

Both fresh and processed vegetables are traded internationally. Tables 1 through 6 contain basic data for the period 1975-1985 on vegetable trade. Fresh vegetables are included in the Standard International Trade Classification (SITC) category 054. More precisely, this SITC code includes fresh potatoes, dry beans, peas and lentils, fresh tomatoes, other fresh vegetables and miscellaneous vegetables or vegetable products preserved temporarily (Sparks). Processed vegetables (mostly canned or frozen) are included under SITC 056. As can be seen from the tables the value of trade in fresh vegetables is almost three times the value of trade in processed vegetables. Since 1975 the real value of trade in vegetables has fallen, although the nominal value has increased substantially. Sparks reports statistics that indicate substantial growth in the quantities of fresh vegetables traded between 1962 and 1982. According to her figures the volume of trade increased from around 6 million metric tons in 1962 to more than 23 million tons in 1982. The decline in the real value of trade in vegetables in the early 1980s was probably due to a combination of depressed prices and smaller quantities traded due to the worldwide economic recession of that period.

It is not clear why the recorded values for world exports are consistently less than the values of world imports. It is likely that the recorded data are somewhat unreliable, although they may be sufficiently close to the true values to draw some general inferences. For both SITC codes trade is dominated by the industrialized countries. Although the share of developing countries in world exports of fresh vegetables appears to have increased slightly since 1975, about two thirds of the total is still controlled by the developed countries (DC). In fact, about half of total world exports originates in Europe, which is also the region purchasing the largest share of world imports. Within Europe the greatest amount of vegetable trade takes place within the European Community (EC). Between 1982 and 1987, annual fresh vegetable trade within the EC (excluding Spain and Portugal) averaged 2.8 million tons while net imports from countries outside the EC averaged slightly more than 1 million tons (Ag. Sit.). In 1986 the value of fresh vegetables imported by the EC (including Spain and Portugal) was over US$ 6 billion (58% of world imports), compared with exports worth about US$ 4.6 billion (55% of world exports) (U.N.). Although the bulk of EC trade in vegetables takes place among EC members, this block of countries is an important market for exporting countries outside the EC.

Among Third World countries, the region experiencing the greatest increase in fresh vegetable exports is Asia, including the Middle East, Far East and Southeast Asia (Table 2). The value of Latin American exports has increased enough to maintain that continent's share of world exports. The value of fresh vegetable exports from Africa has remained constant while its share of world exports has declined. Similar trends are apparent for processed vegetable trade although the industrialized countries play a much greater role in this market than in the market for fresh vegetables.

An interesting characteristic of world trade in vegetables is that trade tends to be concentrated within hemispheric regions. Thus, there is significant trade between Latin America and North America as well as between Africa and Eurasia (Sparks). It was noted above that intra-European trade is extensive and may account for over half of the total volume of fresh vegetable trade. Much of the remaining trade consists of exports from LDCs in the southern hemisphere to northern, industrialized countries. These north-south flows tend to take place within the Americas or within the African and Eurasian regions. Sparks suggests that the main link between the Americas and Africa/ Eurasia is through U.S. and Canadian exports to Eurasia. It is difficult to quantify the magnitude of fresh vegetable trade between southern LDCs and northern, industrialized countries, but there is some evidence that these trade relations have been increasing in importance (ITC). On the other hand, the area where demand for imported vegetables appears to be growing the most rapidly is the Middle East, although significant further growth in demand may also occur in the industrialized country markets of North America, Europe and the Far East.

There are no readily available statistics on international trade in snap beans and it is difficult to identify the nature and evolution of trade patterns in this product. However, some observations can be made to set the stage for further analysis of snap bean trade. As in the case of other vegetables, it is possible to distinguish markets for fresh and processed snap beans. The market for snap beans in the United States is primarily a market for canned and frozen snap beans with some local supply of fresh products during the growing season (USDA). In addition, the U.S. imports fresh snap beans from northern Mexico and Haiti (CIAT, 1989). Mexican exports to the southern U.S. have increased significantly. Whereas snap bean supplies in 1974/75 were about 4,000 tons, in 1984/85 exports had doubled to 8,000 tons for a total value of US$ 5.5 million (Buckley et al., 1986).

In western Europe, on the other hand, demand for fresh snap beans is quite strong. This is particularly true in the EC where trade barriers are applied during the growing season to protect EC producers from foreign competition. These barriers, and the fact that fresh produce can only be produced during part of the year, mean that a major part of EC snap bean imports consists of fresh beans imported during the European winter. Annually some 102,000 tons of snap beans are traded in the EC (ITC, 1987). Of this about 62,000 tons are supplied by Spain, France and Italy. The other 40,000 tons are supplied by African countries. Table 7 shows the volume of snap bean exports by country for specific seasons. To put this in perspective, the EC's aubergine trade is 47,000 tons and the volumes traded annually in capsicum and courgettes are 302,000 tons and 82,000 tons, respectively (ITC, 1987). That the EC snap bean trade is growing is evidenced by the fact that from 1982-86 the total volume of trade increased by 35%. France, which is Europe's major snap bean importer, importing some 30,000-32,000 tons a year, showed an increase in snap bean imports of 40% in volume and 55% in value for this period.

The nature of these markets is extremely important for exporting countries. Processed vegetables are generally perceived as normal goods for which demand grows only moderately as income increases. Many varieties of fresh vegetables on the other hand are superior goods, and it is likely that demand for these products will increase more rapidly in the future. This is probably the case for snap beans exported to Europe during the winter months.

The situation is somewhat complicated by the fact that European consumers, particularly those in France, distinguish between three grades of snap beans. Fine and extra fine snap beans are seen as superior to "Bobby" beans. As such, the former are more income elastic than the latter. Bobby beans are typically produced in France, Italy, Spain, Egypt and Morocco. The major producer of fine and extra fine beans is Kenya. The price difference between fine and extra fine is 20%. However, the unit value of extra fine beans is double that of Bobby beans. To the extent that these consumer preferences are translated into market demand, consumption of fine and extra fine is more likely to increase than consumption of Bobby snap beans.

Not much information exists about the processed snap bean trade. China annually exports about 30,000 tons of canned snap beans under the brand names "Ma-Lin" and "White Elephant" to Europe and the Middle East (Henry and Li, 1989). In addition, Turkey has attempted to initiate some canned exports. However, this has not exceeded 300-500 tons (Henry, 1988). Kenya, traditionally a fresh snap bean supplier, is currently investigating the possibilities for expanding into the processed (canned and frozen) market (Grisley, 1989).

Economics of the International Vegetable Trade

The fundamental factor determining the origins and flows of traded goods is referred to as comparative advantage. This economic concept is based on comparing the amount of resources used to produce different goods within a country. Assume, for example, that climatic and other conditions in a country mean that a small amount of resources is required to produce vegetables compared to the amount of resources needed to produce radios. In this case radios are expensive to produce in terms of the amount of resources that have to be withdrawn from vegetable production. In other words, this country has to give up a great deal of vegetables to produce radios. In some other country, conditions may be such that the amount of vegetables given up to produce a radio is much less than the amount given up by the first country. In this case, the first country is said to have a comparative advantage in vegetable production while the second has a comparative advantage in the production of radios.

A country's comparative advantage depends on its basic resource endowment. If labor is abundant, for example, the country is likely to have a comparative advantage in the production of goods that require large labor inputs. Another way of explaining this phenomenon is to note that the cost of a resource such as labor is likely to be relatively low where that resource is abundant. Alternatively, scarce resources are likely to be expensive. Thus, a country generally has a comparative advantage in the production of goods that are intensive in the factors for production (labor, capital, weather, raw materials, etc.) that are abundant and, hence, inexpensive relative to other factors.

To illustrate these concepts, consider the production of fresh snap beans, an extremely labor intensive crop. A 90-day climbing snap bean crop requires 360-500 person-days of labor per hectare (Henry, 1989). In addition, sorting and packing of snap beans is a labor intensive activity. Given these observations, it can be inferred that production of snap beans for export is likely to take place in countries with abundant labor. Of course, this conclusion may be altered by other considerations such as the possibility of substituting machinery for labor, thereby, shifting comparative advantage to countries where capital and energy are cheap.

While the overall conclusion that countries will tend to produce and export goods that require relatively large amounts of the abundant factors and relatively small amounts of the scarce factors offers a fairly robust explanation of trade flows, it is generally impossible to develop a detailed account of each country's comparative advantages. As a practical matter, economists frequently refer to competitive advantage. A country has a competitive advantage in a given product if it can deliver that product to a foreign buyer at a price less than the prices charged by other exporters. Many factors, including comparative advantage, may contribute to the ability of a country to compete on a foreign market. For example, countries in the southern hemisphere have a competitive advantage in supplying fresh fruits and vegetables to the winter market in northern industrialized countries. Producers in Chile, for example, are able to supply the U.S. market at times when Mexican producers cannot. This is an example of competitive advantage conferred by the accident of geographic location. Other influences on the relative competitive positions of different countries include such elements as the level of development of the transportation system, infrastructure and facilities for handling the traded products.

The most important influence on competitive advantage is the actions of governments. A country that has a comparative advantage in the export of a particular commodity may find itself excluded from a market if another country employs export subsidies or if the importing country has a preferential tariff system that favors other countries. The EC, for example, applies tariffs to imported vegetables during the part of the year when EC farmers are producing temperate-zone vegetables. These tariffs are eliminated during the European winter allowing the development of an important fresh vegetable market for African producers who have a locational advantage. In recent years, the United States has been able to establish a competitive advantage in rice exports through the use of export subsidies.

The preceding comments suggest that the importance of economic considerations related to international vegetable trade include production costs, transportation and marketing costs, consumer preferences and effective demand, and all of the coordination and logistical aspects of moving perishable products over long distances. In the following paragraphs, these considerations are discussed in terms of their relation to developing country exports of fresh vegetables and, more particularly, snap beans. A survey of these issues requires discussion of production and supply in LDCs, vegetable demand in the industrialized countries, and international marketing activities related to the assembly, handling and transportation of perishable products such as snap beans.

Fresh Vegetable Supply in LDCs

LDC snap bean production systems geared towards exports can vary significantly. In most cases state-owned enterprises or private companies are in charge of production and exports. Some show further vertical integration by relying on their own marketing and/or retail systems in the importing country. In Kenya there are some 10,000 licensed vegetable and fruit exporters, of which only 20-30 handle the majority of volume (Grisley, 1989). The export companies contract local farmers to grow snap beans. Farmers are supplied with seed and technical assistance and product prices are fixed beforehand. Seed supplied by the exporting firms are typically of varieties preferred by consumers in the importing countries. For example, snap beans produced for French, Dutch and British markets are mostly of the Monel variety (Grisley, 1989). Besides local export companies, foreign companies handle snap bean production in several LDCs. In Rwanda, a French fruits and vegetables marketing firm is in charge of the entire snap bean production, as well as transportation and marketing of the products to retail outlets (super and hyper-markets) in France (Schasfoort and Westerhoff, 1988). In this case the Rwandan government taxes the exported produce in order to capture some of the earnings that would otherwise largely accrue to the foreign company.

As noted earlier, LDCs often enjoy competitive advantages in vegetable production because of relatively lower production costs as well as seasonal aspects. Snap bean production in Mexico is an example of this advantage. Table 8 shows that snap bean production costs in Mexico are 32% lower (on a per kilogram basis) than a comparable cultivation in the U.S. (Buckley et al., 1987).

As a consequence, Mexican imports to the southern United States will be profitable as long as Mexico-U.S. transport costs are less or equal to US$ 0.16/kg. An interesting observation is that packing and harvesting costs for Mexico are 78% higher than in the U.S. In the U.S. snap beans are harvested mechanically, which is not the case in Mexico or any other LDC. The current cost advantage for the U.S. in carrying out these activities could disappear if energy prices were to increase significantly. This would allow Mexico to compete more easily for U.S. fresh snap bean markets.

When the European winter begins, retail prices start to increase. Urban consumers continue to demand fresh vegetables during seasons when they cannot be produced locally. Prices may reach a level that makes it profitable to airfreight snap beans from African countries. According to Dardel's estimates, production costs in Mali constitute only 18% of the wholesale price for Malian snap beans in France. If a retail mark-up of 50%-60% is assumed, the production-cost share is only about 10% of the consumer price. Consequently, more than 90% is taken up by transport and marketing costs.

Demand for Imported Vegetables

The amount of vegetables people consume depends on such economic variables as prices and incomes as well as individual tastes and preferences. The quantities of vegetables imported by a region is the difference between the consumption and production in that region. From the perspective of exporting countries, the rates at which consumption and production grow in importing countries are critical in determining the size of the market. In addition, the share of this market that can be captured by a particular exporting country is influenced by the ability of exporters in that country to deliver high quality products at competitive prices. Thus, the economics of consumer demand in importing regions, the production potential of these regions, and the quality of products shipped from exporting regions are three important factors in assessing the future of trade in vegetables, including snap beans. A fourth factor, government policies, conditions all of the other considerations. Governments frequently intervene in agricultural markets to alter the prices received by producers or those paid by consumers. In the extreme, governments can prevent trade in a particular good if this action appears to be in the interests of domestic producers and/or consumers. In the following paragraphs these four influences are discussed with reference to trade in snap beans.

The problem faced by any consumer is deciding how to allocate his/her disposable income for different kinds of goods. Economists generally argue that consumers allocate their budgets so as to maximize their sense of well-being. If is useful to think of this allocation process as a sequence of budget divisions. Consumers first determine the proportion of their budget to be allocated to broad categories such as food, clothing and housing. In subsequent stages these broad categories are sub-divided until the level of individual goods is reached. This image of consumer behavior implies that consumers develop a rough estimate of what they wish to spend on food categories such as fresh vegetables, meat or dairy products and then choose the individual items within these categories on the basis of prices and other factors. The important result following from this description is that demand for fresh snap beans depends on relative prices within the fresh vegetable category. Thus, if snap bean prices are low relative to the prices of other fresh vegetables, consumers will shift their food expenditures to include more snap beans and less of other vegetables. Of course, it is also true that non-economic factors such as tastes, customs, and product quality influence the demand for particular products. Nevertheless, continued reductions in the price of snap beans relative to other fresh vegetables is one of the most effective ways to stimulate demand.

Other economic factors influencing demand for fresh vegetables include income and population. As incomes grow consumers can spend more for products perceived as desirable. Income elasticities of demand for fresh vegetables are estimated to be around 0.7 in Greece and France (Fulponi et al.). Taking this value as a reasonable estimate for western Europe as a whole, demand for fresh vegetables can be expected to grow by about 20% over the next ten years, assuming incomes continue to grow at 2.5%/yr, the average rate for industrial economies registered between 1980 and 1986 (IBRD). (2.5% compounded continuously for 10 years leads to total growth of 28%. Seven tenths (0.7%) of 28% is approximately equal to 20%.)

In 1985/86, about 37 million tons of fresh vegetables were consumed in the EC (Ag. Sit.). With a population of 322 million in that year, this represents a per capita consumption of about 115 kg/yr. If income growth does lead to a 20% increase in fresh vegetable demand, per capita consumption can be expected to increase to 138 kg/yr. Therefore, even if population does not grow at all in the next 10 years, total demand could still increase to 44 million tons solely on the basis of the projected income growth. If population grows at the rate projected for industrialized countries of 0.4% (IBRD), reaching a level of 335 million after 10 years, total demand for fresh vegetables will be about 46 million tons by the year 2000.

The preceding discussion highlights the importance of income growth, population growth and relative prices as factors determining demand in importing regions. It is likely that incomes will continue to grow throughout the world although the existence of business cycles means that the rate of growth will not be constant. Population growth, on the other hand, will probably vary greatly from region to region with the industrialized countries growing very slowly (0.4% /yr) relative to the LDCs (about 2% /yr as projected by the IBRD). Low rates of population growth may mean that the markets for fresh vegetables in Europe, North America and Japan grow much less rapidly than elsewhere in the world. However, even if overall growth of demand for vegetables slows in these markets, demand for snap beans could still expand significantly if the price of snap beans falls relative to the prices of other vegetables. These results suggest that snap bean producers would benefit from reduced costs of production, marketing and transportation that would allow profitable sales of snap beans at lower prices. In addition, markets such as those in the Middle East, where both income and population are growing, should be targeted for increased sales of snap beans.

So far we have focused on the overall growth in demand for fresh vegetables in importing countries. However, total demand is not the only factor that determines the market for imported vegetables. Even if total demand expands by 10%, there will be no growth in demand for imports if internal production also increases 10%. Thus, the potential for increased production of fresh vegetables in current import markets is important in assessing the likely evolution of markets for vegetable exports by LDCs. The most important factor in the expansion of production in countries that currently import fresh vegetables is technological innovation. In the absence of technical change, these countries will continue to import these products from lower cost foreign suppliers.

However, technological changes can reduce the costs of production so that producers in these countries are able to expand output and compete with imports.

An example of technical change that can reduce the market for imports is the use of greenhouses to extend the period of time during which producers in temperate climates can supply the local market. If effective greenhouse production is developed in Europe, for example, it will remove the special advantage of African producers in supplying fresh snap beans in the off-season. Of course, greenhouse production is likely to be quite costly because of the large amounts of energy required. If the costs of greenhouse production are high enough, it may still be cheaper to import fresh snap beans from Africa by air. The danger, however, is that European greenhouse producers will either find methods to keep costs down or succeed in convincing their governments to put on trade barriers such as tariffs or import quotas. Because the EC has a special arrangement with African, Caribbean and Pacific (ACP) countries, the likely form for such restrictions would be some kind of voluntary export restraint or market-sharing arrangements. Any developments along these lines could reduce the growth in north-south snap bean trade.

Another factor of importance in developing international trade in snap beans is the quality of the delivered product. Developing countries will probably always have a cost advantage in producing snap beans and exporting them to the north. However, consumers in Europe, North America and Japan will not purchase produce that does not appear fresh and of good quality. This points to the difficulties producers in many developing countries face in organizing the exportation of fresh fruits and vegetables. These products must be handled with care at all stages of the export process, including production, assembly, packing and shipping. According to one informant, the state-owned enterprise responsible for snap bean exports in Mali encountered organizational and logistical problems that led to delivery of low quality products and loss of market share (personal communication).

A final factor conditioning all aspects of supply and demand is government policies. Governments frequently intervene in import markets to protect domestic producers. The most common interventions include import tariffs and quantitative restrictions such as import quotas. The EC, for example, applies tariffs to imported snap beans during certain periods of the year (Table 9). Between May and October, snap beans are produced throughout Europe and there is no cost advantage for LDC producers. However, even during the EC growing season there is a market for imported snap beans of very high quality (ITC). The EC tariffs are applied during the off-season and are designed to favor the ACP countries under the Lome Convention. In addition to tariffs and quotas, countries often apply strict regulations on quality to imported products. These quality regulations often appear to be alternative barriers to trade designed to protect producers from competition rather than to protect consumers from low quality or unsafe products. The use of quality regulations as barriers to trade is one way the EC could circumvent the rules agreed on in the Lome Convention if it is ever decided to restrict imports to protect greenhouse producers.

Logistical and Other Coordination Issues

The importance of maintaining quality during shipment was alluded to in the previous section. Problems associated with delivering products of high quality to distant markets are undoubtedly the greatest barrier to the rapid development of LDC snap bean exports. These problems begin with planting, which must be done at a particular time in order to insure that the harvest will take place at the optimum time for shipment and sale on foreign markets. In addition to timing, the choice of variety is critical in assuring quality products. Throughout the period of plant growth, careful cultivation practices must be followed to prevent damage to the plants and their fruit.

Clearly, it is not a simple matter to produce quality snap beans. Yet production is only the first problem to overcome. Harvest, assembly, packing and shipping must all be done in a manner that preserves quality until the products reach their destination. These are complex problems, but they are not insurmountable. Countries such as Kenya have been able to develop production and distribution systems that generate year-round production and sale of very high quality snap beans (ITC). On the other hand, lack of attention to these issues is a certain recipe for failure.

Concluding Remarks

Most of the preceding discussion has focused on trade in fresh vegetables with particular reference to snap beans. Processed vegetable trade is of somewhat less importance, although there may be some scope for expanding trade in canned snap beans in certain markets. Most of the snap beans consumed in the U.S., for example, are either frozen or canned. One possibility for developing countries would be to sell fresh snap beans for processing to processors in the U.S. Depending on the resource endowment it may be more profitable to can the snap beans in the country itself. Because processed snap beans are probably a normal good, it may not make sense to attempt to enter the frozen market where transportation costs are likely to be high. It appears that some countries are considering the feasibility of exporting canned snap beans (Grisley). The problems associated with trade in canned snap beans are quite different from those related to the fresh product. In particular, the quality concerns are most intense at the production and processing levels rather than at the levels of packing and shipping. Processing plants will have to satisfy the highest standards of hygiene and product safety. In addition, processed vegetable production is much less labor intensive than production and export of fresh products. This fact removes some of the cost advantages developing countries have in production and export of fresh vegetables. Finally, the processed vegetable market is not seasonal, so the particular climatic advantages of developing countries are of no importance.

In general, it appears that developing countries would be better off targeting for the fresh snap bean market than the processed market, at least initially. The market for fresh snap beans in Europe is large, but may not grow rapidly in the future. While smaller, the markets in the Middle East appear to be growing rapidly. The main factors contributing to the further growth of demand for fresh snap beans are increases in income and greater preference for foods seen as healthy. These factors affect demand for all fresh vegetables. Consequently, growth in demand for snap beans requires that prices for this product remain low relative to prices of other fresh vegetables. The importance of maintaining competitive prices illustrates the need for research and technological innovation aimed at lowering both the costs of production and the costs of assembly, packing and transportation.

One issue that could prove important for developing countries wishing to enter export markets for snap beans is the potential for market saturation. The population of Europe, for example, is not growing. This means that the size of the market for fresh snap beans may grow very slowly despite income growth and competitive snap bean prices. In these circumstances, if too many developing countries attempt to export snap beans to Europe, the market could become saturated. This would result in substantial price decreases making snap bean exports less profitable for all producers. Developing countries might be able to insulate themselves at least partially from the negative effects of this potential situation by promoting domestic snap bean consumption. While much can be gained by taking advantage of the opportunities for profit offered by international trade, dependence on foreign markets means that producers are subject to the volatility of these markets. Unforeseen developments can be particularly devastating if there is no home market to fall back on in times of declining demand.

In summary, there appears to be some potential for growth in trade of fresh snap beans and this means that there are opportunities for developing countries to initiate or expand snap bean production for export. If developing countries wish to design policies to promote the production and export of snap beans it will be important to pay particular attention to logistical and transportation issues that may affect the quality of the final product. For CIAT and other research institutions, the critical need is for continued technological innovation aimed at reducing costs.

It cannot be emphasized enough that the relevant costs are not limited to those associated with production. To keep snap bean prices low, it will also be necessary to develop innovative post-harvest and marketing techniques. Finally, governments in developing countries should not limit their efforts to international snap bean trade. Development of the internal market is important as a way of protecting producers from the vicissitudes of the world market and providing consumers with a wholesome food.

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able 1. Trade in fresh vegetables (SITC 054) in millions of nominal U.S. dollars, 1975-1985.

	Exports					Imports				
ear	LDCs	(Share) %	DCs	(Share) %	World	LDCs	(Share) %	DCs	(Share) %	World
975	957	(29)	2367	(71)	3324	756	(18)	3414	(82)	4170
976	1268	(30)	2927	(70)	4195	769	(15)	4502	(85)	5271
977	1514	(33)	3007	(67)	4521	913	(16)	4743	(84)	5656
978	1709	(35)	3157	(65)	4886	1026	(17)	5040	(83)	6066
979	2031	(33)	4101	(67)	6132	1295	(17)	6126	(83)	7421
980	2393	(32)	4993	(68)	7386	1806	(21)	6937	(79)	8743
981	2547	(32)	5314	(68)	7861	2130	(23)	7211	(77)	9341
982	2826	(36)	4968	(64)	7794	1975	(22)	7076	(78)	9051
983	2448	(35)	4522	(65)	6970	1775	(22)	6449	(78)	8224
984	2634	(36)	4748	(64)	7382	6165	(19)	6909	(81)	8574
985	2310	(34)	4550	(64)	6860	1295	(16)	6770	(84)	8065
verage Values										
975-980	1645	(32)	3425	(68)	5070	1095	(18)	5127	(82)	6221
981-985	2353	(35)	4820	(65)	7373	1768	(20)	6883	(80)	8651

DC Export Growth:

$$\frac{981/1985}{975/1980} = \frac{2553}{1645} = 1.55$$

orld Export Growth:

$$\frac{981/1985}{975/1980} = \frac{7373}{5070} = 1.45$$

LDC Import Growth:

$$\frac{1981/1985}{1975/1980} = \frac{1768}{1094} = 1.62$$

World Import Growth:

$$\frac{1981/1985}{1975/1980} = \frac{8651}{6221} = 1.39$$

Table 2. Regional export in fresh vegetables (SITC 054) in millions of nominal U.S. dollars, 1975-1985.

Year	Africa (Share %)*	Latin America (Share %)	Asia (Share %)
1975	385 (12)	243 (9)	279 (8)
1976	482 (11)	322 (8)	464 (11)
1977	467 (10)	506 (11)	541 (12)
1978	355 (7)	598 (12)	756 (16)
1979	427 (7)	659 (11)	909 (15)
1980	496 (7)	719 (10)	1178 (16)
1981	344 (4)	757 (10)	1446 (18)
1982	399 (5)	890 (11)	1537 (20)
1983	413 (6)	776 (11)	1259 (18)
1984	390 (5)	873 (12)	1371 (19)
1985	428 (6)	669 (10)	1213 (18)
Averages (shares %)*			
1975-1980	435 (9)	522 (10)	687 (13)
1981-1985	395 (5)	793 (11)	1365 (19)
1981/1985 ÷ 1975/1980 =	.91	1.52	1.99
1985 ÷ 1975 =	1.11	2.28	4.35

* Share of World Exports - see Table 1.

ble 3. Trade in processed vegetables (SITC 056) in millions of nominal U.S. dollars, 1975-1985.

	Exports					Imports				
ar	LDCs	(Share) %	DCs	(Share) %	World	LDCs	(Share) %	DCs	(Share) %	World
75	210	(16)	1088	(84)	1298	257	(16)	1363	(84)	1621
76	283	(17)	1414	(83)	1697	317	(16)	1641	(84)	1958
77	356	(20)	1471	(80)	1827	417	(18)	1918	(82)	2345
78	398	(20)	1576	(80)	1974	486	(19)	2049	(81)	2535
79	418	(18)	1875	(82)	2293	577	(20)	2287	(80)	2864
80	434	(18)	1990	(82)	2424	698	(22)	2446	(78)	3144
81	600	(23)	1967	(77)	2567	724	(23)	2369	(77)	3093
82	566	(22)	1983	(78)	2549	745	(23)	2463	(77)	3208
83	676	(26)	1973	(74)	2649	856	(26)	2444	(74)	3300
84	612	(23)	2073	(77)	2685	765	(23)	2619	(77)	3384
85	454	(18)	2057	(82)	2511	564	(18)	2562	(82)	3190
erage Values										
75-80	350	(18)	1569	(82)	1919	459	(19)	1951	(81)	2410
81-85	582	(22)	2011	(78)	2593	731	(23)	2484	(77)	3215

C Export

$$\frac{81/1985}{75/1980} = 1.66$$

LDC Import

$$\frac{1981/1985}{1975/1980} = 1.59$$

rld Export

$$\frac{81/1985}{75/1980} = 1.35$$

World Import Growth:

$$\frac{1981/1985}{1975/1980} = 1.33$$

Table 4. Processed vegetables (SITC 056) in millions of nominal U.S. dollars, 1975-1985.

Year	Africa (Share %)*	Latin America (Share %)	Asia (Share %)
1975	105 (8)	47 (4)	58 (4)
1976	98 (6)	64 (4)	121 (7)
1977	147 (8)	85 (5)	124 (7)
1978	158 (8)	97 (5)	143 (7)
1979	163 (7)	94 (4)	161 (7)
1980	161 (7)	71 (3)	202 (8)
1981	133 (5)	177 (7)	290 (11)
1982	129 (5)	75 (3)	362 (14)
1983	154 (6)	202 (8)	320 (12)
1984	144 (5)	159 (6)	309 (12)
1985	154 (6)	78 (3)	222 (2)
Averages Values			
1975-1989	139 (7)	76 (4)	135 (7)
1981-1985	143 (6)	138 (5)	301 (11)
1981/1985 / 1975/1980 =	1.03	1.82	2.23
1985 / 1975 =	1.47	1.66	3.83

e 5. Fresh vegetable (SITC 054) trade in millions of real U.S. dollars (1980 = 100).

	Exports						Imports		
	Africa	Latin America	Asia	All LDCs	DCs	World	LDCs	DCs	World
	674	513	489	1676	4145	5821	1324	5979	7303
	766	512	738	2016	4653	6669	1223	7157	8380
	677	733	784	2194	4358	6552	1323	6874	8197
	478	805	1017	2300	4249	6549	1381	6783	8164
	502	817	1068	2387	4819	7206	1522	7199	8721
	496	719	1178	2393	4993	7386	1806	6937	8743
	304	669	1279	2252	4698	6950	1883	6376	8259
	318	709	1224	2251	3955	6206	1572	5634	7206
	295	555	900	1750	3232	4982	1269	4610	5879
	245	549	862	1656	2984	4640	1047	4343	5390
	242	378	685	1305	2568	3873	731	3821	4552
age Values									
0	599	683	879	2161	4536	6697	1430	6822	8252
5	281	572	990	1843	3487	5330	1300	4957	6257
5 - = 0	.47	.84	1.13	.85	.77	.79	.91	.73	.76

World Wholesale Price Index

	57.1
	62.9
	69.0
	74.3
	85.1
	100.0
	113.1
	125.6
	139.9
	159.1
	177.2

ble 6. Processed vegetable (SITC 0564) trade in millions of real U.S. dollars (1980 = 100).

	Exports						Imports		
ar	Africa	Latin America	Asia	All LDCs	DCs	World	LDCs	DCs	World
75	184	82	97	368	1905	2273	450	2387	2837
76	156	102	192	450	2248	2698	504	2609	3113
77	213	123	180	516	2132	2648	604	2780	3384
78	213	131	192	536	2121	2657	654	2758	3412
79	192	110	189	491	2203	2694	678	2687	3365
30	161	71	202	434	1990	2424	698	2446	3144
31	118	156	257	531	1739	2270	640	2095	2735
32	103	60	288	451	1579	2030	593	1961	2554
33	110	144	229	483	1410	1893	612	1747	2359
34	91	100	194	385	1303	1688	481	1646	2127
35	87	44	125	256	1161	1417	318	1426	1744
erage Values									
-80	187	103	175	465	2100	2565	598	2611	3207
-85	102	101	219	422	1438	1860	529	1775	2304
-85 --- = -80	.54	.98	1.25	.91	.68	.73	.88	.68	.72

e 6A. Partial comparison of trade using USGDP deflator and world wholesale price index.

orld Wholesale Price U=USGDP Deflator

	Exports						Imports					
	LDCs		DCs		World		LDCs		World			
	W	U	W	U	W	U	W	U	W	U		
1.054												
	1676	1383	4145	3421	5821	4804	1324	1092	5979	5428	7303	6520
	2016	1723	4653	3977	6669	5700	1223	1045	7157	6117	8380	7162
	2393	2393	4993	4993	7386	7386	1806	1806	6937	6937	8743	8743
	1656	2092	2984	3771	4640	6732	1047	1322	4343	5488	5390	6810
	1305	1775	2568	3497	3873	5272	731	995	3821	5204	4552	6199
2.056												
	368	303	1905	1572	2273	1875	450	371	2387	2167	2837	2538
	450	385	2248	1921	3698	2306	504	431	2609	2230	3113	2661
	434	434	1990	1990	2424	2424	698	698	2446	2446	3144	3144
	385	486	1303	1647	1688	2133	481	608	1646	2080	2127	2688
	256	349	1161	1581	1417	1766	318	434	1426	1942	1744	2376

P Deflators

69.2
73.6
78.5
84.3
91.7
100.0
109.6
116.7
121.2
125.9
130.1

Table 7. International snap bean trade (1985-1986).

Exporter	Volume (t)	Value (1000 US$)	Importer
Fresh/Off-season			
Burkina Faso	3,437	25,777	
Cameroon	771	2,700	
Kenya	8,845	28,330	E.C.
Mali	351	700	
Senegal	3,959	9,896	
Rwanda	1,000	3,000	
Turkey	284	450	E.C., Middle East
Egypt	12,608	15,000	
Mexico	10,000	6,000	USA
Canned/All-year			
China	30,000	120,000	E.C., Middle East, Asia

Source: ITC, 1987.

Table 8. Comparative snap bean production costs for Mexico and U.S., 1984-1985.

Item	USA[a] (US$)	% of[c] total cost	Mexico (US$)	% of[c] total cost
Land Rent	360	14%	167	5%
Machinery	460	18%	229	7%
Fertilizer	233	9%	103	3%
Pesticides	298	11%	53	2%
Labor	236	9%	259	7%
Interest	38	1%	23	1%
Harvesting and Packing	760	29%	2,239	66%
Other Inputs	222	9%	286	9%
Total Costs/ha	2,607	100%	3,359	100%
Total Costs/kg	.66		.50	
Yields	3,297		6,624	

Source: Adapted from Buckley et al., 1987.

a Florida data

b Sinaloa data

c Percentage total costs

Table 9. EEC common external tariff (CET) on selected fresh fruits and vegetables as of 1 January 1986 (Rates in percentages ad valorem).

Vegetable	CET	Cyprus	Israel	Maghreb	Mashraq[a]	Turkey	ACP[b]	GSP[c]
Green beans								
1-31 October 1 May-30 June	13 with a minimun of 2 ECU per 100 kg net	13	13	13	13	13	0	13
1-November-30 April	13 with a minimun of 2 ECU per 100 kg net	5.2 with a minimum of 0.8 ECU per 100 kg	13	5.2 with a minimum of 0.8 ECU per 100 kg net	5.2 (Egypt and Jordan only)	0	0	13
1 July-30 September	'17 with a minimum of 2 ECU per 100 kg net	17		17	17	17	0	17

[a] Lebanon, Jordan, Egypt and Syrian Arab Republic.

[b] African, Caribbean and Pacific countries associated with the EEC.

[c] Generalized System of Preferences.

Source: Tropical and off season fresh fruits and vegetables: a study of selected European markets. 1987. Market Study. International Trade Center UNCTAD/GATT, Geneva, Switzerland.

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THE POTENTIAL FOR SNAP BEAN PROCESSING IN TURKEY

Suleyman Erkal 1/

Abstract

Turkey produces 13% of the world's production of snap beans. Although the government has allocated priority to the processing industry, only half of the available capacity is used. Of the 400,000 tons of snap beans produced annually in Turkey, only 5,500-6,000 tons are processed. Some of the reasons include: 1) prolonged availability of fresh snap beans in the market; 2) the wide range of vegetables that compete with snap beans; 3) the strong competition between processed and out-of-season fresh snap beans; 4) price differences between fresh and canned snap beans; 5) the difficulty processors have in obtaining enough of the type of snap bean they need; and 6) the lack of a strong relationship between processors and snap bean producers.

Introduction

Beans, in dry or fresh forms, are appreciated and consumed as a staple food in almost all countries. Along with other vegetables, beans are widely produced for their mineral and vitamin attributes.

According to FAO statistics, 3 million metric tons of fresh snap beans were produced in the world in 1987. Total production of fresh beans increased by 13.2% and acreage increased by 7% in the period 1980-87. World population also increased by 12.3% in the same period. The difference between the increase in production and the increase in population is minimal. However, bean producing countries should intensify

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efforts to avoid a major gap between production and population increases occurring in the future.

Forty-one and a half percent (41.5%) of snap beans are produced in Asian countries; 40% are produced in European countries. The major snap bean producing countries are: China in Asia; Turkey, Italy, Spain and Romania in Europe; and Egypt in Africa. The United States is one of the most important producers of snap beans as well.

Turkey's share in the world's total snap bean acreage and total production are about 10% and 13%, respectively. This paper looks at the demand for snap beans in Turkey and the snap bean processing industry in particular.

Overview of Turkey's Vegetable Processing Industry

Recent state development plans have given priority to supporting growth in the processing industries. However, despite all the supports and interventions, the processing industry in Turkey has not grown as expected. Extra processing capacity created is not fully utilized. Development of vegetable processing as a whole has been very slow, with tomatoes being the exception. This slow development includes snap bean processing. While the total capacity of all vegetable processing plants is 57,715 tons/year, only half of this capacity is currently utilized. In Turkey, demand for canned snap beans is estimated at 7,000 tons/yr. Snap bean ranks second with a 25% share of canned vegetables. Peas rank first with a 40% share. Peas have a very short growing period and limited availability in the fresh market. Processing peas has gained advantage over other vegetables. Snap beans are mixed with other vegetables such as peppers, eggplant, tomatoes, squash and carrots and canned together. This is called "turlu" (mixed) and ranks third, represent 18.7% of all canned vegetables. Okra represents 15.5% and other vegetables 0.7% (Bingol, 1985).

Turkey produces 400,000 tons snap beans annually, of which only 6,000 tons are processed. The export of canned snap beans is very limited.

Generally snap beans are consumed fresh locally. Only 24% of Turkish families consume canned vegetables. Per capita consumption of canned snap beans is 125 g/yr (Erkal et al., 1989).

Production of frozen vegetables was about 13,000 tons in 1988. Frozen snap beans amounted to only 105 tons, less than 1% of all frozen vegetables. Consumption of frozen snap beans is very limited in the domestic market because of inadequate freezing capacity from processors to consumers. Frozen vegetables are prepared mainly for export to European countries (Table 1).

There are many reasons why only 30,000 tons of vegetables are canned when 16 million tons are produced yearly in Turkey (Table 2).

Major Factors Limiting Demand for Processed Snap Beans

Extended availability of fresh snap beans

Fresh snap beans are available in the market for a relatively long period because there are several ecologically different production regions in Turkey. This makes it possible to produce successive crops of fresh vegetables that are more competitive than canned products. Figure 1 shows the snap bean supply by month. The supply of snap beans increases after April and peaks in July and August. In the months of September, October and November the supply stabilizes when beans are produced in the fields as secondary crops. Snap bean production is not possible in the open fields between December and April, except in the Mediterranean region where production is possible on a limited scale under plastic. In the period 1987-1988, 725 tons of snap beans were produced under plastics (Ghersi, 1978).

Fresh snap beans are consumed regularly by all families during July and August. They are consumed regularly by only 2% in December and 1% in the period of December to March (Erkal et al., 1989). Consumption of some important vegetables by months is shown in Table 3.

Availability of other vegetables

Another factor limiting demand for processed snap beans is the availability of many other competitively priced vegetables. Turkey has a very suitable ecology for growing vegetables, in general. Thirty-two vegetable species are grown commercially. Consumers have a wide choice depending on their income and taste. Competition and substitution exists among fresh vegetables as well as processed ones. Price is the most important factor determining consumer preference in Turkey.

Prices of different vegetables are shown in Table 4. Between January and April, when fresh snap bean supplies are low and prices are high, the consumer can buy 12 kg of cabbage or 9.5 kg spinach or 4 heads of cauliflower instead of 1 kg of snap beans at retail prices.

Processed and out-of-season fresh snap beans

There is also strong competition between processed and out-of-season fresh snap beans. In the region where the climate is favorable enough to grow beans under plastic the price of snap beans is lower than that of canned beans.

Table 4 shows these price differences by months. Consumers' preferences towards fresh out-of-season vegetables encourages more glasshouse production.

Additional Cost of Processing Snap Beans

Processing snap beans consists of the following steps: sorting; grading; blanching; cooling; filling the containers; sterilizing; and labeling. All these steps are labor intensive and costly. If processors' revenues do not exceed the processing costs they discontinue investing in the industry and growth in the sector slows down. The cost of the raw material (or fresh produce) constitutes 18%, while tins and labeling constitute 36% of the total cost of canning (CNCE, 1972).

Inadequate Quantity and Quality

Processors find it difficult to obtain enough beans with the desired qualities. Different varieties are grown from one region to another. Processors prefer varieties that are flat, stringless, dark green, white-seeded and straight. Generally, climbing bean varieties, grown in only limited areas, have these characteristics. In recent years, with the promotion of the seed industry by foreign investors, introduced varieties have gained popularity in the country. Growers produce 400,000 tons of snap beans, but canning plants complain that they cannot purchase an adequate supply of the bean varieties they need for canning. Contracting with growers is necessary to get enough beans at reasonable prices for the canning industry. Varieties should be selected and planted to meet the canneries' demands. Production plans must suit both consumer and processor preferences. Otherwise, overall large supplies do not necessarily serve the canning industry.

Export of Processed Snap Beans

Export of processed snap beans has not reached a satisfactory level. This is due in part to Turkey's inability, thus far, to provide preferred type beans at competitive prices to countries importing beans. An "Export promotion law" creates some incentives for growers, investors and exporters with various subsidies. However, the processing industry is excluded from these supports. The tomato processing industry is the most attractive area presently for domestic and foreign investors. Snap bean processing has the character of being a secondary activity in tomato processing plants.

Future Demand for Processed Foods

Demand for processed foods varies according to the stage of economic development of a country. In general, demand for processed food depends on, among other things, per capita disposable income, income distribution, food preferences, prices of substitute goods and the structure of the population.

Families living in the countryside and urban families with low incomes generally eat few processed foods or vegetables. On the whole, low-level incomes in Turkey limit development and consumption of processed food. Nor is the pace of urbanization progressing at a rate fast enough to encourage consumption of canned vegetables. The increase in the number of people eating-out is not satisfactory either for the processing industry.

Feeding the growing world population is the prime concern of agriculturists around the world. It is imperative that especially Third World countries increase their production to compensate for population growth and the gradual decline in agricultural lands. Processed foods are of strategic importance in exploiting this potential.

Turkey in particular, along with other countries, has an important production potential due to its suitable labor and topographic properties. With the benefit of international cooperation this potential could be realized more quickly.

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(Translation from Turkish pending.)

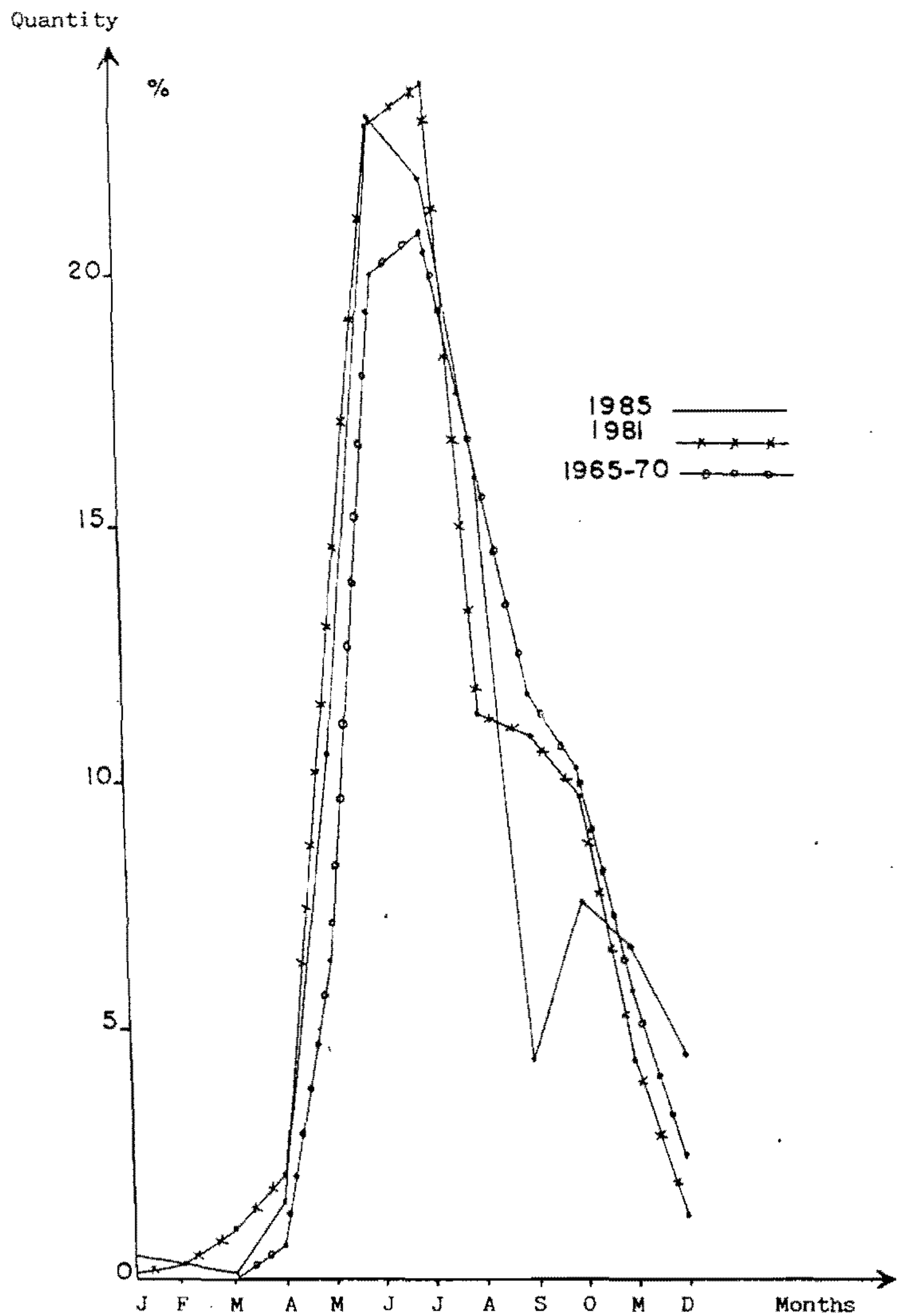

Figure 1. Supply Distribution of Snapbeans by Months.

Table 1. Amount and value of frozen snap beans exported, 1988.

Country	Amount (t)	Value (US$)
To:		
Greece	78.9	49,558
Lebanon	25.0	14,200
England	.7	939
W. Germany	.5	272
Other Countries	.5	435
Total	105.6	65,404

Source: State Statistics Institute, "Foreign Trade Statistics".

Table 2. Turkey's vegetable production 1985 and 1987.

Vegetables	1985	1987
Total area (ha)	661,638	608,971
	(t)	(t)
Fruit-bearing vegetables	12,969,000	13,013,000
Melon	2,077,913	1,927,146
Watermelon	3,422,087	3,422,854
Pumpkin	70,000	80,000
Squash	310,000	300,000
Cucumber	780,000	800,000
Eggplant	680,000	710,000
Okra	24,000	23,000
Tomato	4,900,000	5,000,000
Bell pepper	490,000	500,000
Green pepper	235,000	250,000
Leafy or stem vegetables	1,238,950	1,235,280
Cabbage	721,000	655,000
Artichoke	10,000	13,000
Celery	17,000	14,000
Lettuce	69,500	112,000
Spinach	136,000	130,000
Leek	310,000	300,000
Others	5,480	11,250
Leguminous vegetables	542,000	535,000
Green bean	400,000	400,000
Green pea	36,000	40,000
Green broad bean	56,000	60,000
Calavance	50,000	35,000
Root, bulb and tuberous vegetables	380,450	375,200
Green garlic	20,000	25,000
Green onion	150,000	150,000
Carrot	150,000	150,000
Radish	50,000	50,000
Others	450	200
Other vegetables	58,025	64,016
Cauliflower	58,000	64,000
Asparagus	25	15
	15,258,456	15,222,465

Source: (Translation from Turkish pending.)

Table 3. Percentage of families consuming some important vegetables regularly by month (Turkey, 1988).

Vegetable	J	F	M	A	M	J	J	A	S	O	N	D
Green bean	1	1	1	3	1	59	100	100	84	54	19	2
Tomato	12	12	15	23	55	91	100	100	97	73	45	16
Eggplant	1	1	1	4	11	68	97	100	80	60	16	1
Cabbage	100	81	41	6	6	-	-	-	7	22	87	96
Spinach	91	88	61	25	17	2	-	-	20	55	96	94
Cauliflower	81	61	34	3	-	-	-	-	7	33	74	81

Source: (Translation from Turkish pending.)

able 4. Wholesale prices of some vegetables by months.

egetables	J	F	M	A	M	J	J	A	S	O
reen bean	1350	1620	1725	1910	1000	576	625	580	515	780
ggplant	1410	1540	1605	1840	935	445	385	270	285	335
omato	415	575	625	580	365	360	270	250	175	230
epper	1220	1500	1560	1550	885	435	450	270	300	440
abbage	130	145	150	120	–	–	–	210	175	155
pinach	170	190	180	155	210	–	–	–	335	300
auliflower (Heads)	360	345	305	470	–	–	–	–	–	345

ource: Records of Istanbul Wholesale Market, 1988.

FRESH SNAP BEANS FOR URBAN MARKETS: THE PERFORMANCE OF SOME VEGETABLE MARKETING SYSTEMS IN DEVELOPING COUNTRIES

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Abstract

In developing countries, marketing of fresh produce, such as vegetables, fruits and fish, to urban centers becomes more critical as urbanization accelerates and people with rising real incomes seek a more diversified diet. If possible, vegetables and fruits are cultivated near urban areas, because their perishability requires short marketing channels. The marketing of snap beans is analyzed in four countries: Colombia; Indonesia; the Philippines; and Turkey. Investigated are market structures, the strategies pursued by the various actors in the marketing channels and the performance of the markets. Two major types of market organization are distinguished: the conventional marketing channel (CMC); and the vertical marketing system (VMS). To improve the marketing of snap beans, more research into price instability, matching of supply and demand, more rapid turnover, and post-harvest handling would be warranted.

Introduction

This paper presents the analysis of domestic snap bean marketing systems in four countries. The aim is to understand better the channels used to

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market vegetables from centers of production to urban areas and how their performance might be improved. A main question is whether, in the case of perishable foods like vegetables, the speed with which the produce moves through tne marketing channel must be improved, or if measures must be taken to improve the "keepability" of the produce.

The paper is organized as follows. A brief introduction of some relevant concepts for organizing and measuring the performance of marketing channels is followed by the results of four case studies on snap bean marketing in Colombia, Indonesia, Philippines and Turkey. The outstanding features in the structure of the marketing channels and the conduct of the actors, from farmers to retailers, are discussed next. The final section assesses the opportunities and constraints for the marketing of vegetables to urban centers in developing countries, suggesting some topics for further research.

Principal Dimensions of Market Structure, Conduct and Performance Analysis

Market structure analysis (Hill and Ingersent, 1982) assumes that the structure of a market and the strategies of actors in the marketing channel affect market conduct and performance. The principal dimensions of market structure are the degree of buyer and seller concentration (competition), the degree of product differentiation and the conditions of access to the market. Market conduct consists of the following factors: mechanisms for setting price and output; product and promotion policies; market coordination; and the presence or absence of predatory tactics.

Market performance is the outcome of structure and conduct and forms the principal subject of market evaluations. The following criteria can be used to evaluate the performance of marketing channels (Stern and El-Ansary, 1988, completed with de Morree).

Effectiveness of Delivery is a measure of how well the marketing channel meets the needs of end-users for certain services. L.P. Bucklin specifies four service outputs (Stern and El-Ansary, 1988): spatial convenience or market decentralization (should be high); lot size (should be small); waiting or delivery time (should be low); and product variety or choice (should be high). Marketing channels that provide higher levels of service outputs reduce consumers' search, waiting time, storage and costs. For developing countries another service output may be of interest. The opportunity to obtain produce on credit (de Morree, 1985).

Effectiveness of Stimulation measures how well actors in the channel stimulate latent demand in order to achieve optimal levels of demand for service outputs.

Equity is the extent to which marketing channels reach markets that are more difficult to service.

Productivity refers to the efficiency in use of resources.

Profitability is the financial efficiency of the channel as measured by return on investment, liquidity, profit and growth potential for members participating in the channel.

Degree of Unpredictable Variation in Prices and Income assumes that actors in the marketing channel are better off the smaller the unforeseen variation in supply and demand, prices and income (de Morree, 1985).

Conventional Marketing Channels and Vertical Marketing Systems

A main distinction in the structure of marketing channels (Stern and El-Ansary, 1988; Meulenberg, 1989) exists between conventional marketing channels (CMC) and vertical marketing systems (VMS). The question is which type of marketing system, CMC or VMS, delivers fresh vegetables in the best condition to end-users. Or, more specifically, which best ensures: a) daily delivery of reasonably priced fresh vegetables of required quality to users, including low-income groups; and b) farmers a daily outlet and reasonable prices (de Morree, 1985).

There are three types of VMSs: administered systems (informal collaboration), contractual systems (contractual agreements), and corporate systems (one organizations owns and/or operates channel members at different levels of distribution).

Each type of VMS limits open-market activities so that transaction costs, costs associated with the allocation of marketing activities and the establishment of the terms of trade among channel members are held to reasonable levels. VMS's attempt to capitalize on programmed organization, economies of scale and standardization that exist within activities at the various levels of distribution.

Vertical integration is often an extremely costly undertaking (Stern and El-Ansary, 1988, p.211) and involves a number of trade-offs, not the least of which is bureaucratic inflexibility. Therefore, it may not be justified in a wide variety of circumstances.

In CMCs, coordination of activities in the marketing channel is achieved primarily through bargaining and negotiation among actors. CMCs rely heavily on market forces to bring about a division of labor among channel members. Large numbers of decisionmakers tend to be preoccupied with cost, volume, and investment relationships at a single stage of the marketing process.

In CMCs producers or middlemen concentrate on activities within their specific areas of expertise. Thus functions that can be performed more effectively and efficiently by specialized institutions are assigned to those particular members. This division of labor may result in lower overall distribution costs than a vertically integrated system.

The choice of a channel structure is determined by the interaction between a set of human factors (bounded rationality and opportunism) and a set of environmental factors (uncertainty/complexity and the number of market agents). For environments typified by small numbers and uncertainty, the hazards of opportunism can be confronted more efficiently by using more administratively (as opposed to market-) coordinated channel structures.

Domestic Vegetable Marketing Systems: Some Case Studies

Colombia: Marketing Snap Beans from Sumapaz to Bogota

Bogota, the capital of Colombia, is a city of about 4 million inhabitants (1985). The main vegetables consumed in Bogota are carrots, fresh peas, onions, snap beans and tomatoes. In 1987 the weekly consumption of snap beans in Bogota households (n=120) was estimated to be about 1800 tons in December 1987. On average, each person consumes weekly almost half a kilo in soups, salads and dishes with rice and meat (Mulder, 1988).

About 10% of consumers purchase vegetables at CORABASTOS, the city's main wholesale market; 48% purchase at other markets; 22% at supermarkets and 20% at neighborhood shops (Table 1). Freshness, price, distance, and choice are the main criteria for buying at a particular outlet.

The Sumapaz region, in the southwestern part of the department of Cundinamarca is Colombia's main snap bean producing area. The distance from Fusagasuga, the assembly market of the region, to Bogota is 60 km. The principal economic activity of the region is agriculture, especially coffee, sugar cane, potato, and cattle breeding. Traditional crops like coffee and potato are being increasingly replaced by vegetables because of the rising demand in Bogota (van Dijken, 1987).

Marketing channels for snap beans

The different alternatives for marketing snap beans from Sumapaz to Bogota are shown in Figure 1. The main marketing channel is from farmers (individual marketing) to the assembly market in Fusagasuga, to the wholesale market in Bogota, and finally to the permanent or mobile markets in the different neighborhoods.

Farmers in the Sumapaz region. Most farmers in the Sumapaz region (n=130) sell their produce to traders at the assembly market in Fusagasuga. They are usually paid the same day. Farmers in the municipality of San Bernardo, who deliver snap beans of high quality, sell their snap beans directly to wholesalers at CORABASTOS. Sometimes farmers sell snap beans to traders visiting their farms. Generally, though, they dislike this alternative because of the lack of price information.

Farmers are reluctant to market their produce through cooperatives since a number of coops have been mismanaged in the past. An exception is the farmers' cooperative in the village of Arbelaez, with 50 members. The farm size of 90% of its members is less than 5 hectares (ha). The cooperative purchases vegetables and fruit from its members and sells these to supermarkets in Bogota. The cooperative sells weekly about 1400 kg of snap beans to supermarkets in Bogota. If their supply is greater they sell the extra beans elsewhere. They purchase snap beans from other farmers when they cannot deliver the required quantity from their own farms. The cooperative accepts only beans of good quality.

Members of the cooperative obtain higher prices than those selling at the Fusagasuga assembly market or at CORABASTOS. Results of a survey among members of the cooperative show that 78% of the members thought there were fewer risks to selling beans since they entered the cooperative and 64% thought their income had improved (van Dijken, 1988).

Fusagasuga assembly market. Color, freshness, size and form of the snap beans affect the price farmers receive. Traders pay most for bright green, fresh, large and straight beans. During the first hours of trading the price level is influenced by the prices paid at CORABASTOS early in the morning. Later in the morning the supply of vegetables determines the price. Vegetable prices fluctuate considerably during market days. As yet, no clear explanations for these price variations have been found (van Dijken, 1988). Seasonality in the supply of snap beans also causes seasonal price variation.

At the Fusagasuga market, some 45 traders buy about 37.5 tons of snap beans daily from farmers. (van Dijken, 1988). About 88% of the snap beans purchased by traders at Fusagasuga are sold the next day at CORABASTOS, the wholesale market in Bogota. Another 8% are sold on contract to supermarket chains. The remaining 4% are sold to other cities. About 20% of the traders give credit fo farmers they know well.

The wholesale market CORABASTOS. CORABASTOS, the principal Colombian wholesale market, provides the city of Bogota daily with all types of food, including fresh fruit and vegetables. The market consists of a wholesale and a retail section. About 125 wholesalers trade in snap beans. They sell, on average, about 1800 kg of snap beans per day. The large wholesalers purchase mainly at markets in the production regions. Most beans are supplied from the Sumapaz region (Fusagasuga and San Bernardo) and the Caqueza region (Oriente). San Bernardo in the Sumapaz region delivers the best quality beans. However, the wholesalers' margins do not differ much for beans from different production centers. In 1987 margins were about 18% for beans from Fusagasuga, about 16% for beans from San Bernardo (no transport costs), and about 19% for beans from Caqueza.

The market area is covered with large sheds. Each of these sheds specializes in one or more products. Snap beans are sold in the same shed as peas and green shelled beans. Wholesalers sell sacks of 62.5 kg, but in periods of extreme shortages 12.5-kg bags can be obtained. Snap beans are stored at most 3-4 days with price reductions of up to 40%.

Farmers who sell often at CORABASTOS obtain better prices than farmers who are unknown to the wholesalers.

Retail trade in vegetables in Bogota

In 1987 there were in Bogota about 3000 retail stallholders at CORABASTOS, about 20,000 market stallholders elsewhere in the town, about 6,000 neighborhood shops and about 1000 supermarkets (Table 1).

Neighborhood shops. Neighborhood shops are popular among consumers because of their proximity. The turnover in vegetables is low, though, compared to that of market stalls.

Mobile markets. In several quarters of Bogota a "mobile market" is held once a week. There are about 80 stallholders belonging to mobile market organizations. The oldest mobile market, founded in 1980, is managed by CORABASTOS. The second one, COOMERCUN, founded in 1982, is a cooperative of retail traders. The third, MERCASO, founded in 1984, is a private enterprise. The CORABASTOS organization trades with fixed prices; the others set maximum prices. The organizations do not differ much in their trade policies. They are popular because of their clean appearance and relatively low fixed prices.

Supermarkets. There are five supermarket chains in Bogota and many independent ones. They often purchase vegetables directly from farmers in the production areas surrounding Bogota. The largest chains are CARULLA AND CAFAM. CARULLA has its own delivery system and purchases directly from farmers or farmers' organizations. It sold about 325 tons of snap beans in 1987. CAFAM contracts out purchase and delivery to a distribution agent, and sells about 300 tons of snap beans. Every Friday the supermarket chains set their purchase policy for the next week for fruits and vegetables. They accept only vegetables of very good quality. Sometimes they purchase vegetables at CORABASTOS when their regular channels can not deliver enough. Consumer prices are adjusted daily.

Strategies of wholesalers and retailers

Although large and small wholesalers have distinct strategies their gross margins are similar (Table 2). Gross margins are highest when supply is neither excessively small or excessively large. The principal price strategy of traders is to add a fixed amount to the purchase price. If the price increases, wholesalers adjust their sales price as soon as possible. If the price decreases they wait as long as possible to adjust their prices.

Small wholesalers try to avoid the high costs incurred when they can not sell all of their purchased supply. They buy snap beans only when they are sufficiently sure of demand and price. If snap bean prices are relatively high they buy snap beans of lower quality. When prices of snap beans increase further they switch to other vegetables.

Wholesalers who buy and sell large volumes of snap beans are inclined to take more risks by buying large quantities in the production areas. They manage to realize a high turnover rate because of their ability to estimate the quantities demanded. They avoid losses due to deterioration by buying beans of good quality. Still, perished produce is one of their major costs.

Neighborhood shops have a low turnover rate for snap beans, but also low costs. They purchase snap beans only when prices are low and they purchase less than they expect to sell. Supermarkets and mobile market traders have a high turnover of vegetables but also high costs. Costs to supermarkets are high because of the quality they offer. The costs of mobile markets are high because of transport, membership fees, hired labor and deterioration.

Market performance

If the major criteria for judging the performance of snap bean marketing are: delivery time; market decentralization; a wide choice of outlets; and granting of credit, then we can conclude that the marketing channel operates satisfactorily.

Indonesia: Marketing Snap Beans in West Java

This case study is based on information provided by the Economic and Social Commission for Asia and the Pacific (ESCAP, 1988) and the Coarse

Grains, Pulses, Roots and Tubers Crops Center (CGPRT, 1988). Data were collected at rural assembly markets and the central wholesale market in Jakarta: Pasar Induk Kramat Jati (PIKJ).

Snap beans ('buncis') are cultivated on Java, Indonesia, in the mountainous areas of Lembang and Pangalengan near Bandung. The assembly market of snap beans for the Lembang production area is Pasar Ahad. From there snap beans are traded to Bandung, Bogor, Cirebon, Semarang and Jakarta. Snap beans are harvested in the morning and delivered to, for example, Jakarta later that night. They would be traded at PIKJ from the early morning to the late afternoon of the next day.

Farmers sell snap beans unsorted. Assembly traders sort them into three grades, weigh, pack and transport the produce to a wholesaler. Snap beans are packed in bamboo baskets of 50-70 kg capacity. About 10% of the snap beans are lost due to transportation damage.

Snap beans are marketed to major cities in large volumes, involving only assembly agents and wholesalers, an advantage for fresh produce. The process of marketing snap beans to smaller cities involves more steps, including small local assembly agents, interregional traders, wholesalers and subwholesalers.

Before 1974, there were several wholesale markets in Jakarta. The main reasons local authorities opted for one wholesale market was to bring supply and demand together for optimum price formation, to establish a price information system, to improve trade practices, and to banish big trucks from the overcrowded roads in the center of Jakarta (van Tilburg, 1981). Fruits and vegetables have to enter Jakarta through PIKJ according to government regulation. The inflow of snap beans to PIKJ has decreased considerably from about 2600 tons monthly in 1984 to about 1400 tons in 1985 and about 900 tons in 1986/1987. Due to high handling costs, time-consuming procedures and increased losses, PIKJ has become less attractive to traders. Main cost-incurring items are: losses (13%); the extra handling costs of entering the market (2.3%); 5 hours waiting time; and the commission for wholesalers at PIKJ (Table 3).

Prices of snap beans are normally low from October to February and high from April to July. This is the case in both the small assembly and the urban wholesale markets reflecting the integration of snap bean markets in West Java.

Deflated prices of snap beans both at the farm level and at retail level did not keep pace with the price index for horticultural produce. The ESCAP-CGPRT study does not provide information on the causes of this price reduction. It might have been caused by more efficient marketing but as well by reduced demand.

Marketing Snap Beans in the Philippines

This study is based on data collected in Benguet Province and the adjoining lowland areas of the Ilocos region. The Ilocos region was, in 1986, the major snap bean producing area in the Philippines (Francisco and Domingo, 1988).

In the Philippines farmers have a wide variety of marketing strategies. Some farmers bring their crop to the market and sell it directly to traders or to consumers (40%). Other farmers sell to middlemen at the farm gate or at a trading post (25%). The remaining farmers have no choice but to become contract farmers (30%-35%). They sell their crop to the trader who provides them the inputs to grow snap beans. Farmers not bound by contract are better off bringing their produce to the market rather than selling it at the farm gate, even when the farmer's time spent at the market is taken into account. At the market they realize a better price.

The timing of production is an important variable for farmers. Prices are high from September to December. Prices are low between January and May, when all winter-season crops are harvested. About two thirds of the farmers interviewed mentioned price fluctuations as a problem in marketing their crop. Price fluctuations coupled with high input needs make snap bean cultivation a risky investment, increasing the attractiveness of producing the crop on contract. Farmers who had no problems marketing snap beans timed their production so that harvesting and selling occurred when prices were high. Usually, they did not rely on borrowed capital and their farms were situated near the market.

Three types of traders were included in the study: 6 truckers, 15 retailers-wholesalers and 5 retailers (Table 4). The first two types of traders obtain their snap beans directly from farmers. Three of the five retailers had regular suppliers for snap beans. Some of them purchased from farmers: The majority purchased from wholesalers. Traders want to have regular suppliers in order to offer snap beans in all seasons. Vegetable traders usually purchase a mixture of crops from vegetable farmers. Truckers usually pick up the crop at the farm gate, whereas retailers and wholesalers get the crop delivered by the farmers. When prices are high farmers are paid cash. When prices are low farmers have to wait some time before being paid. Table 4 highlights traders' main marketing problems. Like farmers, their principal complaint was the instability of prices.

Marketing Snap Beans in Turkey

This analysis draws on a preliminary report by the Ataturk Central Horticultural Research Institute (1989). Turkey is one of the main snap bean producing countries in the world. It cultivates about 400,000 tons of snap beans, predominantly in coastal areas. The data presented were gathered in the southern Marmara region, one of the major snap bean producing areas and in Istanbul, the largest city of the country.

Common places to sell snap beans are markets in villages and towns (52%) and wholesale markets (30%). Grading and sorting of snap beans is not a common practice. About 86% of the farmers interviewed were not satisfied with the prices obtained for their snap beans. Prices vary a lot for snap beans compared to other vegetables and their quality is difficult to control. Still, with snap beans, farmers can generate a high income from little land.

Consumers are sensitive to price changes. They seem to react more quickly to decreases in snap bean prices than to increases. Consumers prefer to buy snap beans at the local market because of a relatively low price. Snap beans of higher quality are purchased at greengrocers or supermarkets.

Most fresh vegetables in Turkey are marketed through wholesale markets in the production areas. At the retail level, local markets and greengrocers are important outlets. The supply of snap beans is high from June to August. During the winter, snap beans are only produced in greenhouses in the southern part of Turkey. Prices are considerably lower from June to August than from November to February, when the supply of snap beans is low.

About 10% of all snap beans are sold directly from farmer to consumer. At the wholesale level, four principal buyer categories can be distinguished: comissioners, greengrocers, supermarkets, and the processing industry. Commissioners trade snap beans at wholesale markets on behalf of urban distributors or retailers at a commission of 7%-8%. Supermarkets are quite popular, especially in big cities, but usually purchase snap beans directly from the producer. Their gross margin is 20%-25%. Greengrocers have a considerable share in fruit and vegetable marketing and usually purchase at wholesale markets. Their gross margins need to be higher than for supermarkets because of a lower turnover rate and higher losses of produce.

About 10% of the snap bean production is purchased by the processing industry. Canneries obtain snap beans mainly on contract, but they also purchase at the wholesale market. Contract farmers receive seed, fertilizer and chemicals from the canneries.

Observations About Market Structure

The following similarities in market structure can be observed in the four case studies on domestic snap bean marketing systems.

Degree of public intervention

No parastatals operate in the marketing systems of vegetables studied. Vegetable marketing is a highly risky operation requiring a high degree of flexibility, more suited to private entrepreneurs than to parastatals. Usually, the organization of public markets is regulated by local authorities.

Distance

Distance between the locations of supply and demand have important implications for prices and costs. It is essential for assembly traders and wholesalers to get supply information at rural markets in order to set the price. For example, assembly traders in Fusagasuga, Colombia, buy snap beans in the morning at prices based on wholesale prices in Bogota ealier that morning, but adjust their prices when the supply of snap beans becomes known. Large traders try to guarantee their share by buying already early in the morning. Time constraints often result in quick unsatisfactory agreements between farmers and large traders. When snap beans are scarce, large traders purchase a very high share of the supply. Small traders buy few beans, if any, in that case. Damage to vegetables in transport is another major risk.

Degree of vertical integration

Snap bean marketing channels mostly resemble CMCs but have elements of VMSs. Examples of vertical integration are contract farming in the

Philippines and cooperative marketing of snap beans from farmers to supermarkets in Bogota.

Perishability

A main risk in marketing snap beans is decay or perishability. Losses depend on the distribution channel. Decay rates are inversely related to he turnover rate: the lower the turnover the more decay. Decay rates are lower in supermarkets because they purchase first quality beans, have high turnover rates and refrigeration. In a study on the marketing of highland vegetables to Jakarta (van Tilburg, 1981), it was estimated that 15% to 40% of the weight of several vegetables was removed as waste at the wholesale market in Jakarta. In a similar way, considerable amounts of snap beans are lost in the marketing channel.

Observations About Market Conduct

Volume vs. margin strategies

Do traders follow a high volume and low margin policy or a low volume and high margin policy? Snap bean marketing takes place in an environment of fluctuating prices. This offers traders the opportunity to make considerable profits, but also incur considerable losses. Snap bean assembly traders in Colombia adapt their margins to the quantities supplied. Their margins are relatively low in periods of very small or large supply. When supply is low competition among traders results in high prices that cannot be passed on to the consumer without substantial reductions in demand. In times of plentiful supply, prices have to fall far in order to clear the market. At those prices margins stay low, but the volume of sales compensates, allowing traders a satisfactory income.

How traders assure the supply of produce

Generally, large wholesalers try to assure their supply, irrespective of price. Small wholesalers do not buy snap beans when prices are high.

They are not prepared to assure a stock when both margins and volumes are low. In Colombia a tendency to more vertical integration can be observed. Snap bean wholesalers took over several assembly functions, while supermarkets bypassed the wholesale trade by concluding contracts with farmers. Similarly, the boards of the companies managing mobile markets intended to organize the supply of fruit and vegetables themselves.

Size of margins

To maximize the welfare of consumers, trade margins should be as low as the required set of marketing functions (grading and sorting, transport, storage and financing) allow. Studies on the marketing of agricultural produce usually attempt to identify the levels of gross and net margins. The difference should be at least equal to the value that consumers attribute to those marketing functions. Some authors (Torres and Lantican, 1977) state that criticism of middlemen in fruit and vegetable marketing for high profit margins may be unjustified if the gross margins include more costs than profits. From the point of view of the trader, a particular income might be obtained with different strategies: a high turnover of vegetables at a low net margin, or a small turnover at a high net margin. The choice of strategy depends on the market structure. There may be a segment in the market that requires high quality vegetables, best supplied by specialized outlets with high prices. The evidence on gross and net margins in the vegetable trade as reported in this paper does not point to exploitation of farmers or consumers, or excessive incomes for traders.

Observations About Market Performance

Price fluctuations

Snap bean prices vary considerably during the year and during the cropping season. Harvesting in the off-season or early in the main season appear to be attractive to farmers. Many snap bean farmers in the Philippines prefer to grow snap beans on contract because of the relatively high investment needed and because of fluctuating prices.

Delivery of services

In the four cases analyzed traders were aware of the need to provide market services, but only in a few cases was this the result of vertically integrated planning. Each entrepreneur appeared to be optimizing his or her own interests. This highlights the question whether in a developing country, highly perishable produce is marketed more effectively in a CMC or VMS.

To recall the criteria for successful development of VMSs, for environments typified by small numbers of agents and uncertainty, the hazards of opportunism can be confronted more efficiently by using more administratively coordinated channel structures. In vegetable marketing, there is usually frequent interaction among actors, the number of traders is usually considerable, the level of uncertainty in the environment varies, and hardly any specific investments are required. These factors do not point to a need for more vertical integration in vegetable marketing channels.

Conclusions and Implications for Research

Perishability and post-harvest technology

Post-harvest technology seeks to maintain the quality of agricultural produce from harvest until consumption. Post-harvest technology is particularly relevant for highly perishable produce such as vegetables, fruit and fish. In the tropics traders of perishables usually try to avoid losses by aiming at a high turnover rate. Ideally, all produce harvested during the night or in the early morning has to be sold on the same day.

Snap beans are not as vulnerable as leafy vegetables, but shriveling and rotting threaten their shelf life. Mulder (1988) asked consumers in Bogota to specify the maximum conservation time of some vegetables. Answers ranged from 3.6 days for spinach, 3.8 days for lettuce, 4.2 for fresh beans and 4.5 for snap beans, to 5.1 for red beets and 5.2 for onions.

In the tropics cooling vegetables is a rather costly operation, usually only practiced by supermarket chains. It is difficult to use cold rooms at public markets in an optimal way when many clients want to use them. Cooling of vegetables seems to be more feasible in vertical marketing systems than in conventional marketing channels.

Grading and sorting of snap beans takes place particularly in case of export marketing (Schasfoort and Westerhof, 1988; van Bergen and Warner, 1989). The best quality beans are selected for export. The remaining beans are usually sold at local markets. The case studies show that first quality snap beans usually have a longer shelf life than other beans. Proper handling of snap beans during transport is essential. The question can be raised whether it is effective and efficient to transport snap beans in baskets containing 60-70 kg of produce. More research and exchange of experiences on the optimal packing procedures is required. There is a need for effective, efficient, but especially simple and cheap technologies that can be easily applied and maintained. One possible post-harvest measure is to increase the turnover rate in all stages of the marketing channel.

Whether more vertical integration in vegetable marketing could reduce post-harvest losses of vegetables is another issue. At the retail stage, the occurrence of losses depends largely on the ability of the retail outlets to assess the demand for the next day(s). A VMS would have to develop methods to forecast both supply and demand. In a CMC, each trader is responsible for selling the quantities of vegetables purchased. The success or failure of their enterprise depends on their purchase policy in relation to the expected demand. What are their strategies to take or to avoid the sales risk? Do they know their clients better than those who operate in a VMS? This is an area that needs more research.

Alternative market arrangements

The introduction of mobile markets in new middle and high income neighborhoods of Bogota in the 1980s is an interesting innovation in which a new marketing channel with a different approach gained a significant share in vegetable marketing in Bogota. No public markets were built in these new areas. Once a week the mobile markets sells produce of good quality in a clean environment with good service sprang up to fill the gap. The market share of mobile markets in the fresh vegetable trade increased considerably in the 1980's. The approach of the mobile market organizations differs from that of the permanent markets. Their policy and service outputs are more adapted to the needs of the middle class than the public market. By selling once a week, they concentrate the demand for their produce on a particular day. In this way, their turnover rate of fresh vegetables is considerably higher than that of public markets. Costs are also higher, but their policy usually results in higher profits. The exact impact of such alternative market arrangements on product quality, consumer satisfaction and traditional outlets forms another interesting field of research.

Price instability

What can be done to control the price instability of snap beans? In theory measures can be taken to: 1) spread cultivation over the year; 2) process snap beans to improve their keepability; and 3) support the price of vegetables when the supply is higher than the current demand. Irrigation, or developing more drought resistant beans can lead to production throughout the year. Spreading crops over the year would benefit both low and high income consumers. Processing vegetables generally results in a canned product sold in supermarkets, a marketing channel that is a relatively expensive. Processed vegetables taste different than fresh vegetables and are more accessible to the rich than to the poor. The price of snap beans can be supported in times of oversupply by opening additional outlets in lower income neighborhoods where demand is assumed to be very price elastic. Or lower quality produce can be taken out of the market, a practice of the Dutch auction system.

Improving the matching of supply and demand

Actors in the marketing channel use external information on expected supply, demand and prices to take their decisions. In the interest of farmers, traders and consumers there is a need for reliable and timely market information on: 1) quantities of snap beans to be supplied at markets; 2) quantities demanded by consumers in different market segments; and 3) prices in different stages of the marketing process and in different outlets. Also, 'early warning systems' on the expected result of snap bean harvests in different seasons may guide farmers in their decisions to grow or not to grow snap beans. Analysis of trends and seasonality in demand, substitution patterns of consumers, and alternative uses of snap beans in case of oversupply are helpful in this respect. Snap bean varieties with a short cropping cycle could perhaps be used to respond quickly to expected shortages and price rises.

Another option may be to improve the keepability of the harvested snap beans. Snap beans varieties that are less sensitive to fungi may result in better harvests and a longer shelf life of the fresh produce. Decreasing or controlling the temperature during transport, in wholesalers' stalls and in retail outlets is an example.

The sales policy of retailers may contribute to a higher turnover of stocks of fresh vegetables purchased one or more days previously. Are 'fresh' snap beans purchased several days earlier sold at lower prices? Do consumers buy snap beans of lower quality for certain dishes and beans of higher quality (or longer shelf life) for others? Do snap beans with a longer shelf life attract another market segment (the poor?). Restaurants in Bogota for example, purchased beans of lower quality at relatively low prices for use in the dishes they prepare.

Accelerating the turnover rate of vegetables in CMCs and VMSs

An outstanding conclusion from this study is the importance of the turnover rate for effective and efficient snap bean marketing. For many of the problems discussed, faster turnover rates would provide partial or complete solutions. Strategies to accelerate the turnover rate, however, are different for CMCs and for VMSs. It is essential for CMCs that local authorities responsible for the organization of public wholesale and retail markets take measures to ensure a smooth flow of fresh produce from rural areas to consumers in urban centers. The case study of West Java, Indonesia, illustrates how a single wholesale market in a very big city can hinder this flow. Significant reductions in delivery time and vegetable and fruit marketing costs could result from supplying this produce directly to the main public markets and to supermarket chains. There is also the example of the Bogota mobile markets concentrating the demand for vegetables in middle and higher class neighborhoods to one day of the week. By contracting backwards now to suppliers, such mobile markets could obtain more VMS characteristics.

For VMSs other alternatives should be considered, based on the ability of market agents to communicate effectively. If orders were placed in advance, market demand could be estimated and used for productions purposes. The drawback here is that the actors in the marketing systems described are not used to purchasing snap beans without seeing them.

Which market structure increases its relative importance will depend on the structures' ability and agility to react to the challenge of improved vegetable supply. No clear predictions can be made on the outcome of the evolutionary processes in vegetable marketing structures.

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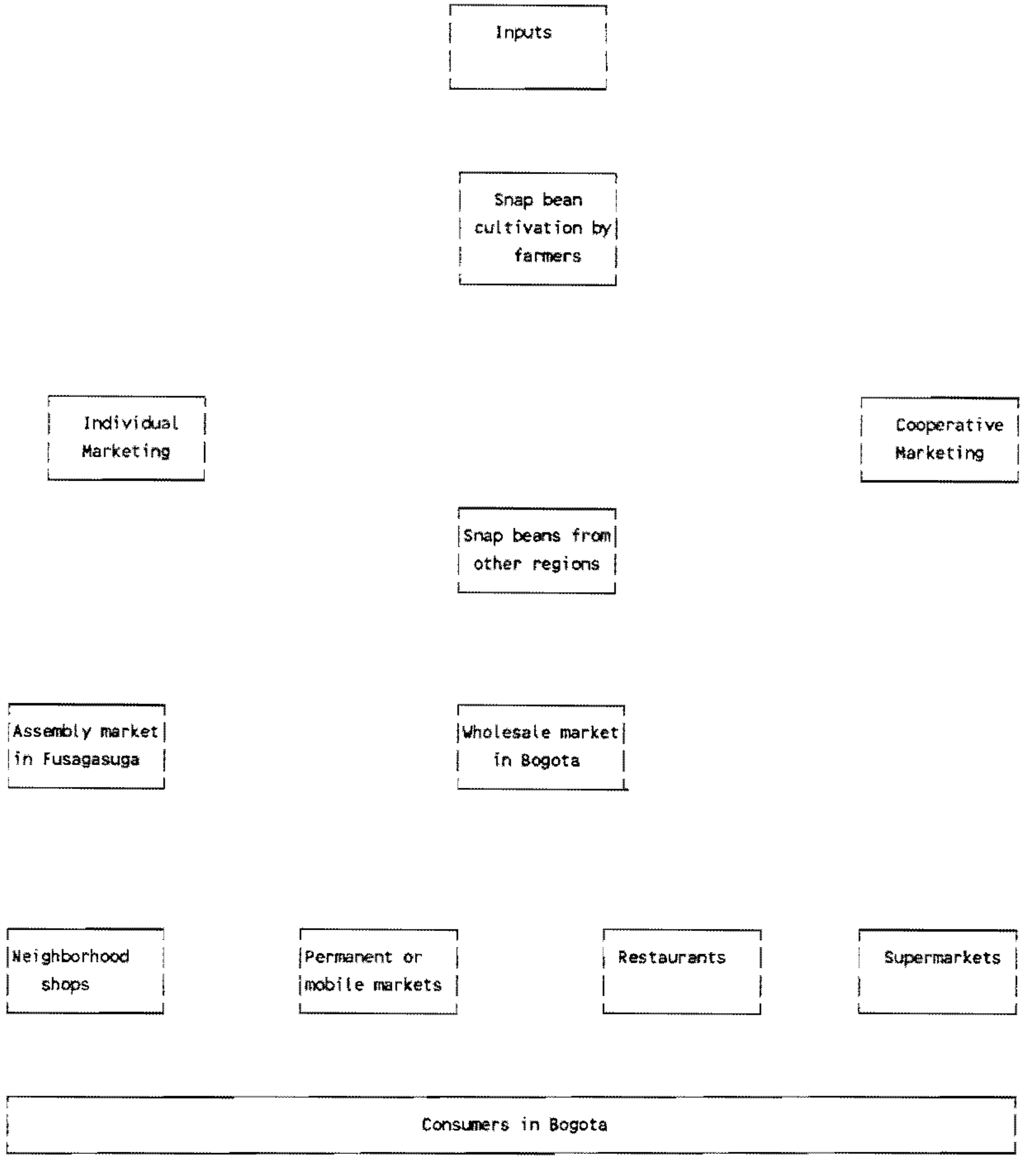
FIGURE 1. THE MAIN MARKETING CHANNELS FOR SNAP BEANS FROM THE SUMAPAZ REGION TO BOGOTA



Source: Mulder, 1988; van Dijken, 1988.

Table 1. Daily purchases of snap beans by consumers at retail outlets in Bogota, December 1987.

Outlets	All inhabitants		Per capita
	(t)	(%)	(g)
Neighborhood shops	64	22	16
CORABASTOS	19	6	5
Mobile markets	9	3	2
Market place	135	46	34
Supermarkets	61	21	15
Restaurants	6	2	1
Total	294	73	

Source: Mulder (1988)

Note: At the end of the survey it was concluded that the figures in Table 1 were probably too high in relation to the daily supply of about 37.5 tons of snap beans from Fusagasuga to CORABASTOS. It is more likely that around 200 tons of snap beans are purchased daily in Bogota.

Table 2. Productivity and profitability of the marketing system of snap beans, Sumapaz-Bogota.

Markets	Gross margin (%)	Decay losses(*) (%)	Daily sales (kg)	Daily transactions costs (US$)	N
Assembly traders (Fusagasuga)	20	?	830	500	21
Wholesalers	16-19	70	1800	5420	5
Neighborhood shops					
*vegetables	17	3	38	1451	20
Market stalls (vegetables)					
*vegetables	16	18	313	1113	11
*snap beans			44		
Mobile markets					
*vegetables	17	7	442	11,048	9
*snap beans			29		
Restaurants					
*vegetables	?	small	61	4644	20
*potatoes			32		
*snap beans			2		

* Decay losses as a percentage of total daily transactions.

Note: Table does not include transportation costs, nor rent of warehouse or shop.

Table 3. Cost of marketing snap beans from Lembang to Jakarta (West Java, Indonesia), February 1988.

	Price	Cost	Price	Cost
	(Rp/kg)		(%)	
Price of produce, ready for harvest	235		42.7	
Cost of harvesting		15		2.7
Local transport costs		10		1.8
Selling price to assembly traders	260		42.7	
Labor costs of sorting and packing		3		0.4
Costs of packing material		8		1.4
Costs of loading		2		0.3
Transport costs to Jakarta		16		2.9
Losses of produce		29		5.3
Commission for wholesalers		40		7.3
Gross profit of assembly traders		44		7.9
Wholesale selling price to retailers	400		72.7	
Costs of transport and (un) loading		12		2.3
Other costs		10		1.8
Losses		43		7.7
Gross profit of retailers		85		15.5
Retail selling price at Pasar Minggu	550		100.0	

Source: ESCAP, CGPRT (1988)

US$ 1 = 1660 Rp

Table 4. Traders' marketing problems, Benguet Province, Philippines.

Problem	Type of trader		
	Retailer	Wholesaler-retailer	Trucker
		(%)	
Price fluctuations	100	80	17
Non-fulfillment of contract	40	-	
Poor transport facilities	20	20	33
Poor grading standards	40	13	-
Unstable supply	20	13	16
Buyers too selective	20	13	-
Low quality	20	-	33
No problems	-	13	-
(n)	5	15	6

Source: Francisco and Domingo (1988).

Table 5. Urban price elasticities of the demand for snap beans in Colombia, 1981.

Socio economic Stratum	Price elasticity	Abs. t-value
Very low	-1.37	4.6
Low	-0.75	7.2
Middle	-0.51	2.5
High	-0.46	4.0
Very high	-0.38	2.1

Source: CIAT, cross-sectional analysis of the DANE DRI 1981 household survey.

THE BEANFLY PEST COMPLEX OF SNAP BEAN IN THE TROPICS

Narayan S. Talekar 1/

Abstract

Beanfly, Ophiomyia phaseoli (Tyron) and two other agromyzids, O. centrosematis (de Meijere) and O. spencerella (Greathead) are the most destructive pests of snap bean (Phaseolus vulgaris L.) during the seedling stage. The formers two are found in tropical to subtropical regions of Africa, Asia, Australia and the Pacific. The latter species is confined to Africa. Insect larvae feed inside the plant stem which results in severe weakening of and, at times, mortality of the snap bean plant. Insects are more serious during the dry season. The critical period of damage is within four weeks after germination. Certain cultural practices, like ridging seedlings, reduce insect damage. A large number of hymenterous parasites attack all three beanfly species, but these parasites alone cannot control the pests. The present use of broad-spectrum insecticides on commerical farms is not sustainable due to their toxicity to parasites and the development of insecticide resistance in the beanfly species. Newer chemicals with insect growth regulatory (IGR) activity, which are toxic to the pest but safer to parasites, are being developed. Two CIAT accessions, G35023 and G35075, show high levels of resistance to beanfly. An integrated pest control approach, based on the use of a resistant cultivar, seed treatment with insecticides, and occasional use of selective insecticides, will allow full exploitation of natural enemies and has a potential for sustainable control of beanflies.

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Introduction

Among all the insect pests that infest snap bean (*Phaseolus vulgaris* L.) in the tropics, tiny flies belonging to the dipteran family Agromyzidae, commonly called "beanflies", are the most destructive. Six species: *Ophiomyia phaseoli* (Tryon), *Ophiomyia spencerella* (Greathead), *Ophiomyia centrosematis* (de Meijere), *Melanagromyza sojae* (Zehntner), *Melanagromyza phaseolivora* Spencer, and a *Japanagromyza* sp. attack snap bean. The first three species are the most destructive, whereas the latter three are either minor or only occasional pests of snap bean in isolated areas. As such very little published information exists on the biology, damage and control of the latter three species.

Among the three *Ophiomyia* species, *O. phaseoli* and to some extent *O. centrosematis*, are by far the most destructive and widespread in Africa, Asia, Australia and the Pacific. Damage due to *O. spencerella* is confined to Africa only. These agromyzids do not occur in Europe, North and South America or the Caribbean islands. In addition to snap bean, they also feed on such economically important legumes as soybean (*Glycine max* (L.) Merrill), cowpea (*Vigna unguiculata* (L.) Wasp.) mungbean (*Vigna radiata* (L.) Wilczek) and pea (*Pisum sativum* L.) and several wild legumes. In all cases, the larvae of *Ophiomyia* feed inside the stem and kill or seriously weaken the plant. This results in considerable yield loss.

In Indonesia, Australia, Vietnam and East Africa, these insects are major limiting factors to successful cultivation of snap bean. Although these insects occur in the tropics and subtropics, their damage is generally greater at latitudes closer to the equator.

Identification

Adults of all three *Ophiomyia* species are tiny black flies which look alike. They are agile and difficult to observe in the field. Their larvae and pupae have characteristic morphological features which, coupled with their oviposition and feeding sites within snap bean, can be used to identify these pests on the spot in the field. The morphological features of O. phaseoli and O. centrosematis larvae and pupae are depicted in Figure 1. The easily distinguishable morphological features of larvae and pupae of O. spencerella are practically identical to those of O. phaseoli. In full grown larva and pupa of O. phaseoli, the posterior spiracles closely adjoin on conical projections, usually with 10 minute bulbs. Oviposition takes place in unifoliate and early trifoliate leaves. The morphological features of posterior spiracles of O. spencerella are identical with those of O. phaseoli. The only external characteristic that distinguishes O.spencerella from O. phaseolli is the shiny black pupae of the former as against the pale yellow to brown pupae of the latter. The shiny black feature of the pupae of O. spencerella can be seen even underneath the stem epidermis where the larvae feed and pupate. In addition, O. spencerella lays eggs in the hypocotyl whereas O. phaseoli lays them in the foliage. The full grown larvae and pupae of O. centrosematis can be distinguished from the two other Ophiomyia species by the presence of three conical structures on the distal end of the posterior spiracle with one opening on each (Figure 1).

The pupal color of O. centrosematis and O. phaseoli is practically identical. Like O. spencerella, O. centrosematis lays eggs in the hypocotyl. At times, and only in East Africa, all three Ophiomyia species can attack a single snap bean plant. Under such circumstances the above described morphological and oviposition characteristics can be exploited in identifying these pests easily. Publications by Kato (1961), Greathead (1968) and Spencer (1973) describe the morphology of most economically important agromyzids and can be utilized for the identification of adults.

Geographic Distribution and Seasonality

All three Ophiomyia species are pan-tropical and their damage increases as one goes closer to the equator. The names of countries/states which have reported infestation of these species on various legumes are listed in Table 1. Among the three, O. phaseoli is the most widespread and occurs practically in every country or territory in tropical to subtropical Asia, Africa, Australia and the Pacific. In contrast, O. spencerella is confined to Africa, mainly East Africa. O. centrosematis occurs both in Africa and Asia.

The seasonality of Ophiomyia species varies from location to location depending upon climate and presence of host plant. Although these pests can occur throughout the year, their damage is more serious during the dry season. Since the occurrence of the dry season varies from location to location in a calendar year, so does the occurrence of the pest. For example: in Indonesia it is between June and September (van der Goot, 1930); in the Philippines, from January to April (Otanes, 1918); in Taiwan between September and February (Talekar and Chen, 1983); in Australia, from March to May (Morgan, 1940); in Egypt from July to October (Abul-Nasr and Aseem, 1966b); in Tanzania, from November to February (Swaine, 1968); in Kenya, between October and December (Okinda 1979); and in India, during October and November and March and April (Pandey, 1962; Singh, 1982). If snap bean planted in these seasons is not protected the loss can be total.

Biology of Ophiomyia Species

Ophiomyia phaseoli

Mated females are active fliers and seek tender foliage for oviposition. They lay oval, milky white, opaque or translucent eggs, often near the midrib close to the petiole, on both sides, only during the day time. Eggs are inserted between the epidermis and spongy parenchyma. Eggs are found in 10% to 15% of the leaf punctures made with the ovipositor by O. phaseoli female. The remaining holes are empty feeding holes. The numbers of eggs laid vary from as low as 16 (van der Goot, 1930) to as high as 1,106 (Raros, 1975). The egg incubation period varies from 2 to 4 days depending upon temperature; shorter duration at high temperature and vice versa.

The newly hatched, pale yellowish white, first instar larva mines through the lamina to the midrib and constructs a tunnel along the midrib where it completes the first instar. It continues to mine through the petiole and eventually reaches the stem, feeding in the cortex underneath the midrib. The larval period lasts from 10 to 22 days depending upon the ambient temperature. During this period the larva undergoes three instars. The first instar larvae generally suffer more natural mortality than other instars, egg or pupa.

Pupation takes place in the feeding tunnels from the root-shoot junction in the seedling stage to up to the junction of the leaf lamina and petiole or even in the midrib (Raros, 1975) in older plants. The pupa is barrel shaped, 2.25 - 2.30 mm long and 0.95 - 1.05 mm wide. The color changes from yellowish brown initially to a much darker color just before adult emergence. In the tropical lowlands the pulpal period lasts 7 - 13 days and in the highlands 13 - 20 days (van der Goot, 1930).

Soon after emergence, adults fly off in search of food sources such as water droplets on the leaves, natural secretions of plants, or sap exuding from feeding and oviposition holes made by females. Adults generally mate two days after emergence, usually in the morning hours. In the tropical lowlands there are between 9 and 14 generations a year.

Ophiomyia centrosematis

Adult females, three days after emergence from the pupae, lay an average of 63 eggs in the hypocotyl just underneath the epidermis (Talekar and Lee, 1988) in young plants. Newly hatched larvae feed on the cortex just underneath the epidermis. In the 11 days of the larval period the larva undergoes three instars (at 28 ^{o}C). Pupation takes places in the feeding channels. The 2.30 mm long and 0.89 mm wide golden yellow pupae emerge into tiny black adults in 11 days. After 2-3 days, adults mate and start laying eggs in 3 - 4 days. The oviposition continues for up to 18 days. Adults make oviposition and feeding holes in the hypocotyl and feed on sap oozing from such holes. There are usually 3 - 4 generations in one cropping season lasting 3 - 4 months.

Ophiomyia spencerella

Females make punctures in the leaf tissue but rarely oviposit in them. Oviposition occurs in the hypocotyl at ground level in the first 2 - 3 days after the plants emerge above ground. A few eggs are also laid in stems just above the cotyledons. Larvae mine in the cortex downwards feeding in the hypocotyl and tap root and return to the ground level or above for pupation. In a laboratory study at 21 ^{o}C, Greathead (1968) found that eggs take 28 - 37 days to develop into adults followed by a pre-oviposition period of about 2 days.

Nature and Extent of Damage

The major damage comes from the feeding of Ophiomyia larvae inside the stems; adult feeding damage, although visible, is insignificant. Although infestation can occur throughout the plant growth, in general, the plants are more heavily damaged in their seedling rather than more mature stage. The consequences of insect attack in the seedling stage, if the plant survives, are manifested even in older plants. Whether the plant is young or old, the Ophiomyia species are cortex feeders and feed in only that part of the plant in either the stem or the petiole.

Ophiomyia phaseoli

In general, adult beanfly damage is negligible. The most serious damage by adults, if it occurs, takes place when snap bean plants are at the unifoliate leaf stage. The unifoliate leaves show a large number of feeding and oviposition punctures (Figure 2) on the upper side with corresponding light yellow spots, especially on the basal portion of the leaf. Sometimes the feeding holes progressively enlarge and the damaged unifoliate leaves become prematurally yellow and usually drop off (van der

Goot, 1930). This type of damage, however, does not affect the physiology of the plant or the seed yield.

The larval feeding starts in the leaf lamina where newly hatched larva, from the point where the adult laid eggs, mines through the lamina into the midrib and eventually in the petiole and stem. The numerous mines are most visible on the underside of the leaves just beneath the epidermis and appear as silvery, curved stripes. Larval mines in the stems can be easily seen under the epidermis as wide, straight, white stripes (Figure 3).

The larva spends most of the first instar feeding in the leaf lamina. By the time it reaches the petiole, it molts to the second instar. The second instar larva mines downwards into the stem, where the third molt occurs. The larva in the third instar feeds voraciously, mining in the cortex just underneath the stem epidermis. In some cases when the population is very high, it even feeds on the woody portion of the stem. Initially, the presence of the insect in the field can be noticed by the stunting of the plants. This symptom, however, usually goes unnoticed since in snap bean the infestation is usually total and all plants are stunted. The third instar larva continues feeding downwards into the tap root, and returns to pupate close to the soil surface. As several larvae feed in a localized area the cortex tissue is often devoured around the root collar. This, at times, results in a swollen and brown collar with raised and cracked skin, and in the formation of a gall with a rather cankerous surface (Figure 4). The cortex tissue is totally destroyed which weakens the stems and such plants are easily lodged during moderate winds. Lodged plants do not recover and this results in a considerable yield loss. In many cases this damage results in plant mortality within 3 to 4 weeks after germination. If part of the cortex tissue remains intact, the plant continues growing and develops a new root system above the point of injury by forming adventitious roots (Figure 5). In wet weather the lowest adventitious roots can reach considerable lengths and can compensate for the loss of a large part of the root system (van der Goot, 1930).

The extent of damage and the yield loss fluctuates with season, time of planting within a season and weather factors, such as rainfall. In general the yield loss during the rainy season is much less than in the dry season (van der Goot, 1930; Okinda, 1979). This is because the rain interferes with the movement of adult flies, which affects oviposition, and also because adequate soil moisture promotes vigorous growth, which can compensate for insect damage. In Indonesia in the dry season, van der Goot (1930) found high plant mortality in fields showing up to 100% of plants affected. In Tanzania, Wallace (1939) reported a 50% yield loss. In later studies, Swaine (1968) found plant damage ranging from 10% to 92% and yield loss up to 35%. In the Gosford district of New South Wales in Australia, Morgan (1940) found it impossible to grow snap bean, indicating that 100% of the plants were damaged and the yield loss was total. In Kenya, except for April plantings, Okinda (1979) found significant yield loss due to O. phaseoli (and possibly O. spencerella) due to fewer pods per plant and fewer seeds per pod. At AVRDC in Taiwan, a yield loss of about 35% was observed in one experiment (Talekar, 1989).

The nature of damage by O. centrosematis and O. spencerella is similar to O. phaseoli. However, the extent of damage by these two agromyzids is not as high and widespread as that by O. phaseoli. O. centrosematis is a distinctly minor pest, both in Asia and Africa. O. spencerella, which occurs only in Africa, can at times be as serious as O. phaseoli and may even surpass damage by the latter. The identical seasonality and nature of damage in snap bean makes it impossible to judge the contribution of O. spencerella and O. centrosematis independent of O. phaseoli.

Control of Beanflies

Host-plant resistance

Attempts have been made in the past to screen snap bean germplasm to find a cultivar resistant to O. phaseoli (Otanes) 1918; Hutson et al., 1929; van der Goot,1930; Raros, 1975; Rogers, 1979; Reddy et al., 1983). However, these attempts involved only a few cultivars with a narrow genetic base, and other than noting differences in beanfly infestation of various cultivars included in such tests, no serious efforts were made to breed beanfly resistant cultivars.

At AVRDC, a large collection of CIAT's Phaseolus germplasm was screened to identify O. phaseoli-resistant cultivars. Among 588 accessions of Phaseolus spp. screened between 1977 and 1983, three accessions, G05478, G35023 and G35075, were significantly less damaged in tests at AVRDC. A multilocation screening within Taiwan of these three accessions and a local susceptible check revealed that only G35023 and G35075 are consistently less damaged (Table 2). Both accessions belong to P. coccineus. Further screening of additional P. coccineus accessions showed that only G35023 and G35075 are consistently resistant. These accessions are now actively used in CIAT's snap bean breeding program. Crosses between G35023 and susceptible agronomic cultivars of P. vulgaris are made at CIAT and the progeny are screened and selected for beanfly resistance at AVRDC. With the establishment of CIAT's regional program in southern Africa, the breeding for resistance to O. spencerella and O. phaseoli is expected to be expedited.

Biological control

Despite the hidden mode of existence of eggs, larvae and pupae, several species of parasites have been reared from each of the three Ophiomyia species. In most cases, parasitic insects lay eggs in the late larval instars and the parasite adults emerge from the pupae. Table 3 lists all recorded parasites from each of the three Ophiomyia species from various locations. Information on the biology of these parasites is adequately covered elsewhere (Talekar, 1989).

Among various parasite species, Opius phaseoli Fischer is the most effective in checking the population of O. phaseoli. It is widespread in eastern Africa, and Greathead (1968) reports a parasitism between 70% and 90%. This parasite, along with a related species Opius importatus

Fischer, was introduced from Uganda to Hawaii to control Ophiomyia phaseoli (Davis, 1971). Initial studies by Davis (1972) showed 100% parasitism of Ophiomyia phaseoli on Kaui and 25% - 83% on Maui islands. In later observations Raros (1975) found peak parasitism of only 8.3% - 23.5% by Opius phaseoli and Ophiomyia phaseoli assumed a pest status. Greathead (1975) observed a weak density dependence parasitism. Under such circumstances, sporadic outbreak of the pest is to be expected. Nonetheless the parasites were able to achieve a useful degree of control during most months.

Cultural control

As all three Ophiomyia species cause serious damage in young plants and are confined to the part of the stem closer to the ground, several attempts have been made to minimize insect damage by devising cultural methods to protect the plants soon after germination. These include ridging the plants, using mulch to cover the planted area, fertilizers to encourage vigorous growth, intercropping and adjusting the planting date. Many of these methods were actually practiced on the farms for O. phaseoli control before the introduction of synthetic organic insecticides, and some of these are still practiced, especially by Javanese farmers in Indonesia. The most common of these practices, ridging, derives its usefulness from the fact that beanfly-damaged stems of snap bean plants produce adventitious roots which hang in the air. Covering these plant parts with soil, besides giving physical support, allows them to absorb moisture and nutrients to sustain the growth of damaged plants (Otanes, 1918; van der Goot, 1930). This technique is not practical on a commercial farm but has potential in home gardens or subsistence farming.

Intercropping is a common practice on small farms in the tropics. Van der Goot (1930) was able to reduce O. phaseoli damage to snap bean by intercropping with maize. However, it is necessary to sow maize ahead of snap bean, as simultaneous planting of both crops did not reduce damage by O. phaseoli. In a trial at AVRDC, snap bean, soybean and mungbean were intercropped with 60 crop species belonging to 14 botanical families. The intercrops were planted four weeks ahead of snap bean. None of the intercrops significantly reduced O. phaseoli or O. centrosematis infestation of snap bean compared to monocrop snap bean control (AVRDC, 1981a, 1981b).

In most locations, even in the tropics, agromyzids are not serious in the rainy season compared with the dry season. Thus the rainy season can be utilized to plant snap bean to reduce O. phaseoli damage. However, in most locations in humid tropical Asia, snap bean is a secondary crop and is always grown in the dry season; in the rainy season rice and other staples receive preference. Within a cropping season, van der Goot (1930) found that planting delayed by three weeks resulted in higher plant mortality. The delay allows the beanfly population to build up on earlier sown crops and causes serious damage to late sown snap bean.

Fertilization has an indirect effect on O. phaseoli damage. It reduces plant mortality and yield loss by promoting luxuriant plant growth (van der Goot, 1930). Fertilization should, however, be timed so that the nutrients are available for vigorous plant growth in the early stages when insect infestation can kill plants.

Chemical control

Both preventive and curative insecticide treatments show promise in the control of beanflies, however, due to the concealed nature of larval feeding, preventive measures are more likely to provide control. Since all three Ophiomyia species attack mainly young plants, an early application of a suitable chemical, in most cases simultaneously with crop sowing, acts as a good control measure.

Since the introduction of modern synthetic organic insecticides in the mid-1940s, a large number of chemicals in a variety of formulations have been tested to obtain adequate control of the beanfly. The chief modes of application of these chemicals are seed treatment, incorporation in soil at sowing, and post-planting foliar sprays.

Seed treatment: The treatment of seeds with insecticides ensures the presence of insecticide residues in the seedlings, when the plant is most vulnerable to damage by the beanfly. In addition to being relatively inexpensive, this mode of insecticide application can help protect predators and parasites. Under field conditions this treatment also does not seem to affect nitrogen-fixing organisms. In the initial stages persistent organochlorine insecticides, such as aldrin, dieldrin, lindane, endrin, etc. were recommended for the control of beanfly (Taylor, 1958, 1959; Walker, 1960; Wickramasinghe and Fernando, 1962; Jones, 1965; Swaine, 1968). Although all of these chemicals have very low water solubility and systemic activity, their physical proximity to the plant facilitates sufficient quantities of active ingredients to move within the plant and protect against invading larvae in the stem. Most of these chemicals have now been replaced with less persistent but more systemic organophosphorus and carbamates. Among these chemicals, trichlorphon, thiometon, malathion, diazinon, phorate, triazophos and carbofuran have been widely tested and recommended (Wickramasinghe and Fernando, 1962; Abul-Nasr and Aseem, 1968b; Sepswasdi and Meksongnsee, 1971; Sudarwohadi and Eveleens, 1974; Saxena et al., 1975; Babu, 1977; AVRDC, 1979; IRRI, 1981). In most cases these treatments are effective for up to three weeks after germination and one or two additional foliar sprays are usually required to provide optimum control of beanfly.

Soil application: In this method of insecticide application, organophosphorus and carbamates are applied to the soil, generally in close bands, but not touching the seeds, at the time of planting. In this type of application the insecticide is not too close to the root to cause phytotoxicity but is still close enough for the developing roots to absorb and translocate enough quantity of active ingredient to kill the invading beanfly larvae when seedlings have formed enough roots. This strategy, made possible by the 2-3 day incubation period of beanfly eggs, avoids phytotoxicity and at the same time translocates the insecticide within the plant to provide adequate control. Several insecticides such as phorate, disulfoton, dimethoate, carbofuran and aldicarb have been tested and recommended (Chang, 1969; Sepswasdi and Meksongsee, 1971; Naresh and

Thakurs, 1972; Saxena et al., 1975; Babu, 1977; AVRDC, 1981b). In all cases the chemicals are formulated in granules which are relatively easy to apply. A large portion of the chemical is complexed with the soil organic matter or clay colloidal complexes. Hence dosages far in excess of the actual amount of chemical required to kill the insect are needed. Soil property, mainly pH, has considerable influence on the persistence of these chemicals in the soil and thus their effectiveness in killing the insects over a period of time. At pH levels approaching 6.5 and above, organophosphorus and carbamates are degraded rapidly (AVRDC, 1981b). Under such circumstances, foliar application of a suitable insecticide 2-3 weeks after germination becomes necessary.

Both seed treatment and soil application of insecticides are especially valuable in the case of frequent rains, which make it difficult to enter the waterlogged field to apply foliar insecticides. Under such conditions foliar-applied chemicals are also washed off by frequent rains.

Foliar application: In this mode of application, the chemicals are dispensed as high volume sprays, ultra-low volume formulations or dusting directly on the plants. Foliar sprays of the insecticide affects the agromyzid adult population which is not affected either by seed treatment or incorporation of insecticides in the soil. In addition insecticides with a local systemic activity are absorbed in the plant tissue, where larvae, possibly pupae and even eggs could be killed. The insecticide spray application thus provides much quicker results than the seed dressing or soil treatments. The major drawback of insecticide spray in controlling beanfly is its adverse effect on predators and parasites, most of whom tend to be more susceptible than the pest to the insecticides. In all cases the chemicals are contact poisons ranging from the old organochlorines, organophosphorus, carbamates and synthetic pyrethroids to newest phenylurea-type insect growth regulators.

Among the plethora of chemicals tested and recommended, three, monocrotophos, dimethoate and omethoate, demonstrate consistently superior toxicity than most others on a wide variety of beanfly hosts (Table 4).

All three are O, O-dimethyl phosphates or phosphorothionates with a N-methyl carbamoyl group in the 'tail' part of the molecule. This means that if the beanfly becomes resistant to one it will have cross resistance to the remaining chemicals (Talekar, 1987).

In a search for alternative chemicals a fungicide, pyrazophos, was found to be as effective as any of the insecticides in controlling the beanfly (AVRDC, 1989). Earlier, cyromazine, a phenylurea-type insect growth regulator, proved to be very effective in controlling the beanfly (AVRDC, 1988). This chemical is selectively toxic to beanfly but not to its parasites. It makes an ideal candidate for integrated control of the beanfly. No matter what chemicals are used, spraying must start within the week of germination and continue for 4 - 5 weeks at once-a-week intervals. In fact, during the first week, two sprays, one at 3 days and the other at 7 days after emergence followed by four weekly sprays of any one of the above cited effective chemicals are essential to obtain complete control of the beanfly.

Integrated control

Although insecticides presently still seem to give adequate control of the beanfly, overdependence on chemical insecticides alone will lead to the insect becoming resistant as well as the negative environmental consequences so frequently documented in literature for other insects. The beanfly already shows resistance to dimethoate and even to monocrotophos, the most commonly used chemicals for beanfly and other agromyzid control in Asia. If used judiciously, insecticides can play a leading role on a sustainable basis in the control of beanfly. In order to protect parasites and predators so that their full potential in controlling the beanfly can be utilized, it is necessary to use only a seed treatment or soil application of a suitable chemical before sowing. This will protect the plant without harming the natural enemies for up to three weeks. At this juncture, if the beanfly population is still too high, the insect growth regulator cyromazine, which is relatively safe to the parasites, can be utilized. The introduction of beanfly resistant cultivars, when they become available, will reduce, but not eliminate the need for insecticides, as it is unlikely that a highly resistant cultivar can be developed by conventional breeding. O. phaseoli already has two biotypes: one is prevalent in Indonesia where it is a deadly pest of soybean; the other is found in the rest of Asia and barely damages soybean. To keep the beanfly population low, thereby minimizing the possibility of beanfly developing further biotypes and prolonging the utility of a resistant cultivar, use of a seed treatment where feasible will be very useful. The low insect population due to the introduction of a beanfly resistant cultivar in turn will postpone the inevitable development of insecticide resistance in the beanfly and allow the presently available chemicals to realize their full potential. In the meantime, introduction of such effective parasites as Opius phaseoli, where it does not exist, will provide an additional natural enemy to combat the pest. Because of the concealed feeding habit and high population during the peak period of activity, the use of action threshold or other similar measures is of no use in beanfly control where the insect is endemic.

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Figure captions

Figure 1. Morphological characters of larvae and pupae of O. phaseoli and O. centrosematis. (The above morphological characters in O. phaseoli and O. spencerella are practically identical).

Figure 2. Feeding and oviposition punctures of _O. phaseoli_ in snap bean.

Figure 3. Larval feeding mines of _O. phaseoli_ in the snap bean seedling stem.

Figure 4. Swelling at the root-shoot junction due to _O. phaseoli_ larval feeding in the snap bean stem.

Figure 5. Formation of adventitious roots on stems above _O. phaseoli_ larval feeding damage in snap bean.

Table 1. Geographical distribution of three *Ophiomyia* species.

Species	Location	Reference
Ophiomyia phaseoli	Australia	Jones (1965)
	Burma	Ghosh (1940
	Burundi	Dieudonne (1981)
	China (Guangdong)	Campbell (1925)
	Egypt	Abul-Nasr and Assem (1966a)
	Ethiopia	De Lima (1983)
	Fiji	Lever (1946)
	Guam	Peterson (1957)
	Hawaii	Raros (1975)
	India	Singh (1982)
	Indonesia	van der Goot (1930)
	Israel	Avidov and Harpaz (1969)
	Japan	Kato (1961)
	Kenya	Khamala (1978)
	Libya	Hammand (1974)[a]
	Malaysia	Ho (1967)
	Malawi	Edje et al. (1981)
	Mali	De Lima (1983)
	Mauritius	Moutia (1932)
	Micronesia	Spencer (1959)
	Nepal	Singh and Ipe (1973)[a]
	New Hebrides	Sasakawa (1963b)[a]
	Nigeria	De Lima (1983)
	Pakistan	Khan and Shafique (1974)
	Papua New Guinea	Young (1984)
	Philippines	Otanes (1918)
	Rwanda	Nyabyenda et al. (1981)
	Senegal	De Lima (1983)
	Singapore	Mathieu (1920)
	South Africa	Spencer (1959)[a]
	Sri Lanka	Wickramsinghe and Fernando (1962)
	Sudan	De Lima (1983)
	Taiwan	Chen (1953)
	Tanzania	Swaine (1968)
	Thailand	Arunin (1978)
	Uganda	Greathead (1968)
	Vietnam	Huynh (1981)
	Zaire	Spencer (1959)
	Zambia	Naik et al. (1981)
	Zimbabwe	Taylor (1958)

Table 1. Geographical distribution of three Ophiomyia species (Contd.)

Species	Location	Reference
Ophiomyia spencerella	Kenya	Greathead (1968)
	Nigera	Spencer (1973)
	Rwanda	Trutmann (1986)
	Tanzania	Spencer (1973)
	Uganda	Greathead (1968)
	Zambia	EPADP (1986)
Ophiomyia centrosematis	Australia	Spencer (1973)
	China (Fujian)	Sasakawa and Fan (1985)
	India	Singh et al. (1981)
	Indonesia	De Meijere (1940)
	Japan	Spencer (1962)[a]
	Kenya	Greathead (1968)
	Malaysia	Spencer (1973)
	Micronesia	Singh and Ipe (1973)
	Taiwan	AVRDC (1984)
	Tanzania	Spencer (1961)
	Thailand	Sasakawa (1981)
	Uganda	Greathead (1968)

a From taxonomic literature, no definite information on the host plant is available.

Table 2. Response of four Phaseolus accessions for agromyzid[a] resistance at four locations in Taiwan[b].

CIAT	AVRDC		Feng Shan		Pingtung		Shin She	
Acc No	No. L+P[c] per plant	Damaged plants (%)	No. L+P per plant	Dead plants (%)	No. L+P per plant	Damaged plants (%)	No. L+P per plant	Dead plants (%)
G05478	5.66a	100.0a	2.20a	90.3a	1.57a	92.7a	10.47a	61.7b
G35023	0.96b	63.3c	0.57b	13.3b	0.18bc	29.3b	6.13a	11.1c
G3075	0.96b	80.0b	0.40b	18.3b	0.06c	52.7b	5.73a	7.5c
Local	4.70a	96.7a	1.67a	94.3a	1.24ab	94.3a	9.33a	87.6a

[a] Mainly <u>Ophiomyia phaseoli</u>. [b]Planting dates: AVRDC, 13 September; Shin She, 29 September; Pingtung, 8 October; Fengshan, 8 October 1982. [c]Larvae+pupae. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

able 3. Parasites of *Ophiomyia* species at various locations.

arasite species	Host plant	Location	Reference
	Ophiomyia phaseoli **(Tryon)**		
ulophidae			
nrysomotomyia (=*Achrysocharis*) *douglasi* Girault	Cowpea	Australia	Kleinschmidt (1970)
emiptarsenus semialbiclavus (Girault)	Cowpea	Australia	Kleinschmidt (1970)
emiptarsenus (=*Neodimmockia*) *agromyzae* (Dodd)	Cowpea	Australia	Kleinschmidt (1970)
emiptarsenus sp.	Cowpea	Australia	Kleinschmidt (1970)
emiptarsenus sp.	Cowpea	Philippines	Litsinger (1987)
etrastichus sp	Soybean	India	Gangrade (1974)
ı eulophid	Snap bean	Hawaii	Raros (1975)
ı eulophid	Cowpea	Thailand	Burikam (1980)
raconidae			
osteres sp.	Cowpea	Thailand	Burikam (1980)
aenetiella rapae (Curtis)	Snap bean, Cowpea	Egypt	Abul-Nasr and Assem (1968a)
ius importatus Fischer	Snap bean	Hawaii	Raros (1975)
ius liogaster Szepliget	Snap bean	Mauritius	Moutia (1932)
ius liogaster Szepliget	Cowpea	Zimbabwe	Jack (1942)
ius liogaster Szepliget	Snap bean	Zimbabwe	Taylor (1958)
ius oleracei Fischer	Cowpea	Australia	Kleinschmidt (1970)
ius phaseoli Fischer	Snap bean	East Africa[a]	Greathead (1968)
ius phaseoli Fischer	Cowpea, garden pea	India	Singh (1982)
ius phaseoli Fischer	Snap bean	Hawaii	Raros (1975)
ius phaseoli Fischer	Snap bean	Ethiopia	Negasi (1986)

Table 3. Parasites of Ophiomyia species at various locations (Contd.)

Parasite species	Host plant	Location	Reference
Opius sp.	Snap bean	East Africa	Greathead (1968)
Opius sp.	Soybean	Taiwan	Chu and Chou (1965)
A braconid	Snap bean	Zimbabwe	Jack (1913)
Pteromalidae			
Callitula yasudi Yasuda	Snap bean	Japan	Yasuda (1982)
Callitula sp.	Snap bean	Ethiopia	Negasi (1986)
Cryptoprymna sp.	Soybean	Taiwan	Chu and Chou (1965)
Cryptoprymna sp.	Snap bean, cowpea	Egypt	Abul-Nasr and Assem (1968a)
Cyrtogaster sp.	Snap bean	Ethiopia	Negasi (1986)
Eurydinotellus viridicoxa Girault	Cowpea	Australia	Kleinschmidt (1970)
Halticoptera patellana Dalman	Snap bean	Hawaii	Raros (1975:28)
Halticoptera sp.	Snap bean, Cowpea	Egypt	Abul-Nasr and Assem (1968a)
Halticoptera sp.	Soybean	Taiwan	Chu and Chou (1965)
Norbanus sp.	Snap bean	East Africa	Greathead (1968)
Polycystomyia benefica Dodd	Cowpea	Australia	Kleinschmidt (1970)
Polycystus propinquus Waterston	Cowpea	Sri Lanka	Waterston (1915)
Polycystus sp.	Snap bean	India	Babu (1977)
Metacolus (Pterosema) subaenea (Dodd)	Cowpea	Australia	Kleinschmidt (1970)
Sphegigaster hamygurivara	Snap bean	Japan	Yasuda (1982)
Sphegigaster sp.	Snap bean	Japan	Yasuda (1982)

ble 3. Parasites of Ophiomyia species at various locations (Contd).

rasite species	Host plant	Location	Reference
hegigaster sp.	Soybean	Taiwan	Chu and Chou (1965)
hegigaster (=Trigonogastra) agromyzae (Dodd)	Cowpea	Australia	Kleinschmidt (1970)
hegigaster (=Trigonogastra) agromyzae (Dodd)	Snap bean	Java	van der Goot (1930)
hegigaster (=Trigonogastra) agromyzae (Dodd)	Snap bean	Egypt	Hassan (1947)
hegigaster sp.	Cowpea	Philippines	Litsinger (1987)
ratrigonogastra rugosa Waterston	Cowpea	Sri Lanka	Waterson (1915)
ratrigonogastra rugosa Waterston	Cowpea	Philippines	Otanes (1918)
ntomopus sp.	Snap bean	Japan	Yasuda (1982)
pteromalid	Cowpea	Thailand	Burikam (1980)
nipidae			
nipoide sp.	Snap bean	Java	van der Goot (1930)
colidea sp.	Soybean	Taiwan	Chu and Chou (1965)
cynipid	Cowpea	Thailand	Burikam (1980)
pelmidae			
pelmus gravi var revicinctus Girault	Cowpea	Australia	Kleinschmidt (1970)
pelmus urozonus Dalman	Snap bean, Cowpea	Egypt	Abul-Nasr and Assem (1968a)
rytomidae			
rytoma larvicola Girault	Snap bean, cowpea	Egypt	Hassan (1947)
rytoma larvicola Girault	Cowpea	Australia	Kleinschmidt (1970)
rytoma poloni Girault	Snap bean	Java	van der Goot (1930)

Table 3. Parasites of Ophiomyia species at various locations (Contd).

Parasite species	Host plant	Location	Reference
Eurytoma poloni Girault	Cowpea	Philippines	Otanes (1918)
Eurytoma sp.	Cowpea	Australia	Kleinschmidt (1970)
Eurytoma sp.	Snap bean	Java	van der Goot (1930)
Eurytoma sp.	Cowpea, garden pea	India	Singh (1982)
Eurytoma sp.	Snap bean, Cowpea	Egypt	Abul-Nasr and Assem (1968a)
Eurytoma sp.	Soybean	Taiwan	Chu and Chou (1965)
Plutarchia sp.	Mungbean	Malaysia	Ooi (1973)
Plutarchia sp.	Cowpea	Philippines	Litsinger (1987)
Plutarchia sp.	Soybean	Taiwan	Rose et al. (1976)
Plutarchia sp.	Cowpea	Thailand	Burikam (1980)
Chalcididae			
Menismonella shakespearei Girault	Cowpea	Australia	Kleinschmidt (1970)
Chalcids	Cowpea	Sri Lanka	Rutherford (1914)
A tetracampid	Snap bean	Ethiopia	Negasi (1986)
	Ophiomyia spencerella (Greathead)		
Cynipidae			
Eucoilidea sp.	Snap bean	East Africa	Greathead (1968)
Braconidae			
Opius phaseoli Fischer	Snap bean	East Africa	Greathead (1968)

Table 3. Parasites of *Ophiomyia* species at various locations (Contd).

Parasite species	Host plant	Location	Reference
	Ophiomyia centrosematis (de Meijere)		
Pteromalidae			
Crytoprymna sp.	Soybean	Taiwan	Chu and Chou (1965)
Halticoptera sp.	Soybean	Taiwan	Chu and Chou (1965)
Sphegigaster sp.	Snap bean	Taiwan	Chu and Chou (1965)
Cynipidae			
Eucoilidea sp.	Snap bean	East Africa	Greathead (1968)
Eurotomidae			
Eurytoma sp.	Soybean	Taiwan	Chu and Chou (1965)
Braconidae			
Opius phaseoli Fischer	Snap bean	East Africa	Greathead (1968)

Table 4. Evaluation of selected insecticides on yield[a-h] and beanfly populations in soybean, mungbean, snap bean and cowpea.

Insecticides	Rate (kg ai/ha)	No. of beanfly maggots+pupae per 20 plant samples				Damaged plants (%)				Yield (t/ha)		
		Soybean	Mungbean	Snap bean	Cowpea	Soybean	Mungbean	Snap bean	Cowpea	Soybean	Snap bean	Cowpea
Monocrotophos 55EC	0.5	8.75c	0.00b	0.00b	0.00b	38.75b	10.00c	20.00b	15.00c	1.33a	1.51ab	2.82a
Dimethoate 44EC	0.5	34.25b	3.25ab	1.25b	2.25b	92.50a	40.00b	30.00b	61.25b	1.18ab	1.44ab	2.54a
Omethoate 50EC	0.5	1.25c	0.00b	0.00b	0.00b	17.50c	10.00c	13.75b	16.25c	1.54a	1.82a	2.70a
Control	-	54.50a	8.75a	38.00a	31.50a	100.00a	75.00a	95.00a	95.00a	0.83b	1.19b	1.91b

[a]Cultivar: Soybean (KS9), Mungbean (VC1628 Sel.A), Snap bean and cowpea (local).
[b]Date planted: 9/27/83.
[c]Insecticides sprayed: 10/3, 10/7, 10/14, 10/21, 10/28, 11/4.
[d]Date of sampling: 11/3.
[e]Date harvested: 12/28.
[f]Data shown are means of four replicates. Means in each column, if followed by the same letter, are not significantly different at the 5% level according to Duncan's multiple range test.
[g]Plot size: 10x2m.
[h]Mungbean was severely damaged by root disease complex and low temperatures.

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SNAP BEAN PESTS AND DISEASES IN SUMAPAZ, COLOMBIA: THEIR PRESENT STATUS AND IMPLICATIONS

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Abstract

Initial studies on snap bean production in Sumapaz, Colombia, indicated excessive use of pesticides in the region. A more in-depth investigation of how chemicals are used to control insects and diseases, and the economic and agroecological implications was thus initiated in 1989. It was found that reliance on pesticides was largely related to the disease susceptibility of the most popular variety grown, Lago Azul. Of the farmers surveyed, 90% sprayed their crops once a week with a mixture of 1-2 pesticides, 2-3 fungicides and a foliar fertilizer. Indiscriminate application of insecticides appears to have little, if any, effect on yields, but a destructive effect on natural enemies of leafminer. So far, though, snap beans tested for chemical residues from the region have shown no appreciable levels of contamination.

Introduction

An economic evaluation of snap bean production in the Sumapaz region of Colombia (van Dijken, 1987) revealed that the use of agrochemicals might be excessive. Consequently, a more detailed investigation of the phytosanitary conditions and practices in Sumapaz was undertaken in 1989. The results are presented in this paper.

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Study Objectives

The study included the following objectives:

1) Identify the production-limiting factors for snap beans and determine their relative importance.

2) Identify farmers' practices to control their production problems.

3) Analyze the implications of control methods used for farmers, consumers and the environment.

The Sumapaz region is the major snap bean producing area in Colombia (Federacion Nacional de Cafeteros, 1985). Located 45 km from Colombia's capital, Bogota, Sumapaz is characterized by an average temperature of 20 ^{o}C and annual rainfall of 1150 -1600 mm, which occurs in two rainy seasons per year. It lies 1500-1900 meters above sea level in the western range of the Andes.

Methodology

The investigation consisted of the following activities:

1) On-farm visits with snap bean producers to identify the nature and severity of their production problems.

2) Farmer surveys to identify the actual practices farmers employ to overcome their current production constraints.

3) Field trials on farmers' fields to confirm the importance of each problem.

4) Collection of blood samples from farmers and their families to determine the degree of their contamination by pesticides based on the presence of the enzyme cholinesterase.

5) Analyses snap beans produced in the region for pesticide residues.

6) Trials with farmers to appreciate the factors they consider in making farming decisions and how they might be convinced to alter their practices.

Results

The imported, climbing type snap bean, Blue Lake, is the only variety planted by farmers in the region. However, farmers themselves have selected two Blue Lake lines known for their medium-large and extra-large pod size. It appears as if the Blue Lake variety may be the key to farmers' crop protection problems. It is very susceptible to diseases and insects. The variety's popularity is mainly due to its pod qualities that are much in demand in the Bogota markets. Most farmers (81%) produce seed for their own use, or for exchange with or sale to other farmers. This facilitates the spread of seed-borne diseases. Up to 47% of farmer-produced seed samples collected in the Sumapaz region were contaminated with seed-borne diseases (Table 1).

Problems Identified

During the first survey in 1989, 75 snap bean plots were visited. In each one 20 plants were evaluated for the presence of various insects and diseases and the damage they caused. A scale for the visual identification of insects and diseases was developed with "1" corresponding to the first signs of attack and "9" corresponding to the highest level of infection (Tables 2 and 3) This scale represents a subjective measure only of the infection and probable yield loss. Tables 4 and 5 list the broad range of insects and disease identified.

The two most important insect pests are whitefly, <u>Trialeurodes vaporariorum</u> (Westwood), and the leafminer <u>Liriomyza huidobrensis</u> (Blanchard). These were found on 82%-90% of the farms visited. Based on the visual scale used, somewhat more damage was inflicted by whitefly

(3.49) than by leafminer (3.00). Occurrence of the slug, Sarasinula plebeia (Fisher), was only minor, as was the damage it caused.

Diseases appear to be the more serious problem. More diseases than insects attack snap beans and, in general, the severity of infection is greater. At least three diseases were found on more than 60% of snap bean fields visited (Table 4).

In the trials conducted to quantify the effect of individual diseases and insects on yield and pod quality, it was found that the existing whitefly and leafminer populations did not cause significant yield reductions. In plots where whitefly infestation was the equivalent to "7" on the visual scale, yields were the same in plots sprayed only once with pesticides during the cropping cycle as in plots sprayed weekly (10 times a cropping cycle) against whitefly (Table 6). Moreover, the pesticides appear to have a destructive effect on the natural predators of leafminer. Their populations were lower in treated plots than in untreated plots or in those snap bean fields where pesticides had been previously applied. Fields treated with the maximum number of pesticide applications or just recently sprayed evidenced much higher populations of leafminer pupae. (Table 7). These data are preliminary, however. The trials are being repeated to verify the results.

In the trials conducted to quantify the importance of diseases, rust ranked first in terms of incidence and severity. Despite some methodological problems, it can be concluded that if effective chemicals are not applied on time, yields will be reduced by more than one third. Currently, farmers apply dithiocarbamates to reduce rust infection, with generally good results in controlling the disease. Additional trials are being developed to solve the methodological problems encountered and to measure the effect of other important diseases, such as anthracnose, Ascochyta blight and rust, on snap bean yields.

Farmers' Current Crop Protection Practices

In Sumapaz, farmers' production strategy is based on a schedule of preventative chemical treatments. According to the survey of farmers, 90% apply chemicals once a week. Only 2.6% of farmers apply chemicals every two weeks, depending on the season. While farmers generally apply chemicals to control the diseases, they often mix insecticides with the fungicides to prevent insect damage, without evaluating the actual incidence of insect pests or understanding their impact on yields.

The agrochemicals used most often are listed in Tables 8 and 9. A typical weekly crop treatment, mixed together in one tank, includes 1-2 insecticides, 2-3 broad spectrum fungicides and 1 foliar fertilizer. An analysis of the efficacy of the chemicals used by farmers has not yet been done, but a preliminary evaluation of the effect of the insecticides used in Sumapaz on adult whiteflies was carried out in greenhouse trials at CIAT, using insects from the Sumapaz area.

Of 22 commercial products mixed to approximate the average dosage used in Sumapaz, four products were efficient in controlling whitefly adults: monocrotophos (1.5 cc/li); dimethoate (1.5 cc/li); metamidophos (1.5 cc/li); and acephate (2.5 cc/li). The remaining products showed only intermediate to ineffective control of whitefly adults. For controlling whitefly first instar nymphs, monocrotophos (1.5 cc/li) and metamidophos were the most effective. These results suggest that monocrotophos and metamidophos are the most effective insecticides for controlling whitefly in general.

No results are yet available on the relation between pesticide use and leafminer or the effectiveness of various fungicides on snap bean diseases.

Environmental Impact

In evaluating the potential environmental consequences of insecticide and fungicide use it is useful to distinguish among producers, consumers, and the agroecosystem.

Farmers

During two rallies in Sumapaz, blood samples were taken from 197 and 75 persons, respectively, in five municipalities. Five blood-sample collections are planned in all. The results of the first sample showed only 2% of the people evidencing higher levels of intoxication from chemical contamination, while the second sample registered 17%. Those most affected were farmers and people in the farm household. The presence of individuals (36% in the first sample) with cholinesterase levels slightly depressed (87.5% using the Lovibond method) but still in the normal range, suggests the possiblity of exposure to organophosphorus and carbamates. In the surveys conducted, 76 farmers cited 43 cases of people (themselves or neighbors) becoming intoxicated while spraying the crop. No accurate statistics exist on the number of chemical intoxications. Victims usually do not go to hospitals, but try to cure themselves. Nor do hospitals include a classification for chemical intoxication in their list of the 10 most frequent causes for hospital admittances.

Consumers

Snap bean samples taken both directly from the Sumapaz area and from Bogota markets showed no appreciable levels of insecticide residues in laboratory analyses. Samples will continue to be taken for one year to monitor all climatic conditions. Some doubts exist as to the reliability of the analysis techniques. The tests will be repeated using different techniques in a different laboratory.

Agroecosystem

Natural enemies of both whitefly and leafminer were found in commercial snap fields treated weekly with pesticides. Leafminer parasites identified include braconids of the genera Oenonogastra sp. and Opius sp.; Platygasteridae of the genus Amitus sp.; and the eulophids Chrysocharis sp., Diglyphus sp., Encarsia sp. and Closterocerus sp. Information is not available on their ability to reduce the insect pest populations. However, if indiscriminate application of insecticides continues it may reduce the population of natural predators and thus eliminate a potential form of biological control.

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Table 1. Contamination of snap beans by seed-borne diseases, Sumapaz, 1989.

Contaminating agent:	% contamination
Anthracnose	18
Halo blight	50
Ascochyta blight	32
Overall contamination level	47

Table 2. Visual scale of disease damage in snap beans.

1-	First symptoms.
3-	Very distinct symptoms on 1/3 of the plant.
5-	Symptoms on 1/2 of the plant; disease damage could lead to yield losses.
7-	Symptoms on 2/3 of the plant; production is clearly affected.
9-	Disease damage induces plant death.

Table 3. Visual scale used to estimate infestation levels of whitefly and leafminer on snap beans.

1-	Presence of newly laid whitefly eggs or leafminer adult feeding and oviposition punctures.
3-	Populations are established, colonizing upper 1/3 of the plant (whitefly) or lower 1/3 of the plant (leafminer).
5-	First generation of adults produced in this field or pupape ready to hatch. Immatures and adults of either whitefly or leafminer found on 2/3 of the plant. First signs of whitefly-produced honeydew.
7-	Overlapping generations. Insects occupy the entire plant. Honeydew production by whitefly is abundant.
9-	Very high overlapping populations. Leaves are covered by honeydew and sooty mold (whitefly) or severe defoliation has occurred (leafminer).

Table 4. On-farm presence and damage caused by most important[1] insects and other invertebrate pests.

Insect/Pest	Presence %	Mean[2] Intensity
Leafminer	90.7	3.00
Whitefly	82.9	3.49
Leaf-feeding caterpillars	26.0	2.53

1 Liriomyza sativae (another leafminer), aphids, mites, lacebugs, leafhoppers, thrips, cutworms, and slugs were present in less than 15% of the fields sampled.

2 On a 1-9 visual scale (see Table 3).

Table 5. On-farm occurence and intensity of the most important diseases.

Disease	Presence %	Intensity[1]
Ascochyta blight	92.1	4.14
Rust	72.4	3.77
Anthracnose	61.8	4.07
Sclerotinia	39.5	4.3
Root rot	26.3	8.22
Halo blight	26.3	2.72

1 On a 1-9 visual scale (see Table 2).

Table 6. Yields of snap bean plots sprayed at different insect (whitefly and/or leafminer) infestation levels.

Insect infestation level[1]	No. of sprays	Yield (t/ha)[2]
1	10	17.7
3	4	17.2
5	2	15.1
7	1	15.7
9	0	13.5
Check (unsprayed)	0	15.4
Farmer's practice	10	15.1

1 On a 1-9 visual scale (see Table 3). Plots were sprayed when infestations reached respective infestation levels.

2 No statistical differences were found at the 5% level (Duncan).

Table 7. Leafminer pupae populations found in snap bean plots sprayed at different insect (whitefly and/or leafminer) infestation levels.

Insect infestation level	No. of sprays	No. of leafminer pupae/ 5 plants
1	10	13.4 a[1]
3	4	3.1 c
5	2	8.8 b
7	1	3.1 c
9	0	2.5 c
Check (unsprayed)	0	3.0 c
Farmer's practice	10	18.4 a

1 On 1-9 visual scale (see Table 2). Plots were sprayed when infestations reached respective infestation levels.

2 Means followed by the same letter are not significantly different at the 5% level (Duncan).

Table 8. Insecticides most frequently used to control leafminer and whitefly in snap bean cultivation in Sumapaz, Colombia.

	Number of times mentioned	Dosage (cc or g/liter)	Range
Leafminer			
Monitor	16	0.73 cc	0.25-1.5
Decis	13	0.82 cc	0.16-2.5
Cymbush	5	1.03	0.30-2.5
Baytroide	4	0.95	0.25-2.5
Curacron	4	0.62 cc	0.32-0.5
Metamidofos	3	0.92 cc	0.45-1.5
Tamaron	4	2.47 cc	1.05-6.0
Whitefly			
Triton	14	1.26 cc	0.23-4.16
Lannate (powder)	10	0.69 g	0.42-1.26
Lannate (liquid)	6	1.03 cc	0.32-1.67
Tamaron	13	1.18 cc	0.50-2.50
Monitor	12	1.17 cc	0.32-1.67
Curacron	6	0.87 cc	0.32-1.60
Azodrin	4	1.50 cc	0.95-2.56
Lorsban	3	1.13 g	0.63-1.50
Baytroide	3	0.50 g	0.25-0.625
Furadan	3	2.19 cc	0.63-5.00
Mavric	3	0.45 cc	0.25-0.60
Nudrin	3	1.67 cc	0.50-2.00

Note: 16 other products were mentioned, though less than 3 times.

Table 9. Fungicides most frequently used to control ascochyta blight, anthracnose and rust in snap bean cultivation in Sumapaz, Colombia.

	Number of times mentioned	Dosage (cc or g/liter)	Range
Rust			
Plantvax	11	1.82 g	0.60-0.90
Baycor	5	0.75 cc	0.50-1.25
Elosal	4	4.31 cc	1.00-10.0
Topas	4	0.58 cc	0.50-0.60
Saprol	3	0.75 cc	0.60-0.90
Tedion* (acaricide)	1	5.00 cc	--
Ascochyta blight and Anthracnose			
Manzate	29	3.46 g	1.50-4.00
Dithane	28	4.16 g	1.25-7.50
Orthocide	27	3.00 g	0.40-13.75
Benlate	23	0.57 g	0.50-0.84
Difolatan	23	1.83 g	0.32-5.00
Antracol	10	3.68 g	1.00-7.50
Derosal	8	0.88 cc	0.33-2.50
Ridomil	8	0.83 g	0.42-1.68
Elosal	7	2.86 cc	2.50-5.00
Cobretane	4	1.90 g	0.84-3.00
Ronilan	3	0.83 g	0.80-0.84

Note: There were 20 other products mentioned, though less than 3 times.

* Tedion is misused by some farmers who believe rust damage is the same as mite damage.

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STRATEGIES FOR MANAGEMENT OF PESTS AND DISEASES OF SNAP BEANS IN LATIN AMERICA

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Abstract

Pests and diseases are important production constraints of snap beans in tropical and subtropical regions of the world. Among the most important conditions favoring their development are climate, planting susceptible varieties in monoculture over entire regions, staggered planting dates, and planting infected seed. In addition, indiscriminate use of chemicals kills beneficial insects and induces resistance. Among the most important pests are whiteflies, leafminers, leafhoppers, pod borers, chrysomelids, cutworms, crickets, mites and bruchids. In highland regions with cool climates, anthracnose, ascochyta blight, halo blight, and white and gray mold are the most important diseases during rainy growing cycles. Rust, powdery mildew and southern blight are prevalent during the drier cycles. At lower altitudes with warmer climates, rust, bacterial blight and powdery mildew are the most important diseases. However, in the rainy, tropical lowlands, web blight is the most important disease. Disease and insect control should pursue an integrated approach that includes: a broadening of the genetic base; more rational chemical control; the use of clean seed; and rotations with crops that are not hosts for snap bean pests and diseases.

Introduction

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Integrated Pest Management (IPM) is defined as a pest control strategy that uses all available methods to reduce pest populations below economic thresholds. At present, IPM uses resistant varieties, cultural practices, biological control and chemicals to suppress pest populations. This strategy has been used with success in various crops in temperate and a few tropical regions but little emphasis has been placed on IPM for snap beans.

In general, snap bean growers in Latin America rely on preventive chemical applications to reduce losses to pests and diseases. This is likely to change in the future due to the high cost of pesticides, resistance and resurgence of organisms harmful to the crop, environmental contamination, and unacceptable residue levels on the crop. It is obvious that pests and diseases of snap beans are more prevalent, severe and economically important in many developing countries of tropical and subtropical regions (e.g. Colombia, Costa Rica, Mexico, Indonesia, Taiwan and Tanzania) than in developed countries in temperate areas (e.g. USA, Canada, Holland and France).

The greater importance of pests and diseases in many developing countries is exacerbated by the following factors:

1. Climatic conditions (temperature, relative humidity, rainfall) that allow year-round planting of snap beans and survival and dissemination of pest and disease causal agents.

2. Cultural practices that favor disease development:
   a) Staggered planting dates;
   b) Planting of infected seed;
   c) Monoculture of one variety over entire area.

3. Planting of very susceptible varieties developed for temperate regions.

4. Presence of a much greater number of pathogens with greater

pathogenic variation in the tropics and subtropics than in temperate regions.

5. Occurrence of multivoltine, polyphagous insect pests which can develop throughout the year and reach high levels of resistance to chemicals.

To the climatic and biological factors stated above, we could add that in our limited experience with snap beans, it is becoming increasingly evident that a human factor is of consequence to the success or failure of IPM programs that have been developed or are likely to be implemented in the future. We have observed that grower-adoption rates are often very low even when appropiate, simple tactics or tools are being disseminated. Generally, though, an effective IPM strategy is based on implementing a rather complex package of practices. These might include the use of clean seed and resistant varieties that introduce more genetic diversity, rotating crops and perhaps applying some chemicals. This makes it a difficult strategy for farmers to use on a day-to-day basis. In tropical regions, where snap bean growers are usually smallholder farmers with limited education, adoption rates of non-chemical methods are low because farmers are likely to prefer easier, quicker results obtained with routine sprays.

In addition, consumer preferences for a perfect, unblemished final product dictate the need for absolute control of organisms. This is not easily attained with IPM strategies, which usually rely on a combination of control tactics. Some are also supposed to tolerate a certain level of damage to the beans.

The Case of Latin America

Diseases

The most economically important diseases of beans in Latin America vary according to:

- Climate and location
- Time of the year (rainy/dry)

In most mid-altitude valleys the following diseases are the most important during the rainy season:

Disease	Causal agent
Anthracnose	Colletotrichum lindemuthianum
Ascochyta blight	Phoma exiqua var. diversispora
White mold	Sclerotinia sclerotiorum
Gray mold	Botrytis cinerea
Halo blight	Pseudomonas syringae pv phaseolicola
Rhizoctonia root rot	Rhizoctonia solani

During the dry (less rainy) season in mid- to high-altitude valleys as well as in lower altitude areas, other diseases are more important:

Disease	Causal agent
Rust	Uromyces appendiculatus
Powdery mildew	Erysiphe polygoni
Southern blight	Sclerotium rolfsii

In the rainy and lowland areas of Central America, Web blight caused by thanatephorus cucumberis (asexual: Rhizoctonia solani) is the most important disease of snap beans.

Pathogenic Variation in Snap Beans in Colombia

Results of work conducted at CIAT with the rust pathogen obtained from a mid- (Palmira) and from a high-altitude area (Fusagasuga) show that the isolates (races) prevalent in snap beans are fairly uniform in pathogenicity and different from the populations prevalent in dry beans. Table 1 shows the reaction of a snap bean variety and of a dry bean variety to two isolates of the rust pathogen obtained from a snap bean and a dry bean isolate, respectively.

Similarly, anthracnose pathogen isolates from Colombia tested, which have been tested on a series of 12 differential varieties that are used in Latin America for pathogenic studies of Colletotrichum lindemuthianum, are very uniform in the reaction they elicited on these varieties. All isolates obtained from the snap bean variety Blue Lake grown in Fusagasuga attack only the snap bean varieties Michelite and Cornell 49242. No other comparisons have been conducted for other snap bean pathogens.

Insects

Several of the major insect species affecting dry beans in Latin America have also been recorded for snap beans. These include cutworms, crickets, leafhoppers, cabbage loopers, slugs, chrysomelids, leafminers, whiteflies, pod borers, mites and bruchids, among others. However, it has become evident that two are the major insect pests of snap beans in Latin America: The greenhouse whitefly, Trialeurodes vaporariorum (Westwood), and the leafminer, Liriomyza huidobrensis (Blanchard).

The greenhouse whitefly is a polyphagous insect that causes mechanical damage to the plants and affects the quality of the snap beans as a result of honeydew secretion and development of sooty mold. Few insecticides are efficient to control this insect at present. Work in progress at CIAT suggests that the whitefly has developed resistance to pyrethroids and organophosphates. The occurrence of some natural enemies and the possibility of handling pest populations with some selective pesticides are important factors in the development of strategies to implement an IPM system for this insect.

The leafminer represents a classic example of a secondary pest raised to a primary pest status as a result of the intensive, indiscriminate use of insecticides to control the whitefly. Research at present is aimed at measuring the true economic impact of this insect and at reestablishing its natural equilibrium in the agroecosystem.

IPM strategies

When considering strategies to manage snap bean pests and diseases in developing countries, several factors must be considered:

1. At present, the cash crop status of the crop makes it profitable to rely completely on chemical control strategies.

2. High market demand favors planting of a single variety.

3. Lack of a certified seed industry means that in many areas clean seed is not used.

4. Abuse of chemical control and cultural practices that exacerbate pests and pathogens will probably result in higher and increasingly less efficient use of fungicides and insecticides.

The following alternatives must be considered and researched:

1. A more rational chemical control as one of the components of an IPM strategy that includes:

    a) Broader genetic base
    b) Resistant varieties
    c) Clean seed
    d) Rotations

2. Establishment of economic thresholds and critical periods of control for the major insect pests of the crop.

3. Demonstration of alternative control methods and judicious use of pesticides.

4. Development of appropiate communication channels. This will require highlighting the advantages of IPM over other pest management strategies, the ease with which it can be implemented and the likely end results.

5. The most difficult task will be to integrate extension personnel and growers into a team with researchers.

Table 1. Reactions of a dry bean and snap bean variety to rust pathogen isolates.

Bean variety	Rust Pathogen Isolates: Pradera (SB) (Mid altitude)	Fusagasuga (SB) (High altitude)	CIAT (DB) (Mid altitude)
Blue Lake (SB)	S	S	S
BAT 338 (DB)	R	R	S

SB= Snap bean; DB= Dry bean

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TOXICOLOGICAL IMPLICATIONS OF PESTICIDE USE ON SNAP BEANS IN SUMAPAZ, COLOMBIA

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Abstract

CIAT and Colombia's national agricultural research institution, ICA, are involved in a collaborative study of the toxicological effects on farm workers and their families from using pesticides on snap beans. Between June and August 1989, blood samples were collected on three occasions from persons directly and indirectly (families) involved in snap bean cultivation in the Sumapaz area of Colombia. As an indicator of contamination by pesticides, the level of the enzyme cholinesterase was measured, using both the Lovibond and monotest methods. Preliminary results suggest the possibility of liver and kidney damage from excessive use of insecticides among male farm workers in Sumapaz.

Introduction

Pesticide use carries a number of risks. In both their original and transformed states, pesticides can have a negative impact on the biology of agricultural regions and the health of the regions' populations. Pesticides are among the synthetic substances most produced in the world. Currently about 1500 different substances with a pesticide action are used around the world. These substances are combined with other ingredients or dissolvents, which vary from country to country, to create innumerable chemical compounds.

Improved methods of analysis for pesticide residues make it possible to demonstrate the persistence of compounds that were originally thought to

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be nonpersistent or unstable in the environment. A problem is that all tests, for both persistence and biotransformation, are carried out with the active compound. Manufacturing impurities, isomers and products of degradation or biotransformation are not taken into consideration.

The persistence of a substance facilitates its transportation by natural means to sites remote from the one where it was originally used. This process is enhanced when the substances are soluble in fats and can be accumulated in human tissue. Once these substances have entered the environment they are subject to a range of chemical transformations that can lead to more 'toxic or persistent substances of the original compound.

The greatest harm to people comes not from immediate, dramatic effects but from long-term damage. In exposed populations, different effects on reproduction and on the central nervous system have been verified, and the risk of cancer has been established not only for those directly exposed, but also the wives and children, who wash contaminated clothes and take food to the field, and for those people who help with field tasks. The exposed population includes all those people who are involved with production, transportation, importing, storage or use of these substances, and there are undoubtedly people exposed indirectly through pesticide residues.

The problems caused by the excessive use of pesticides are much more serious and complex than what is normally believed. In developing countries, information is generally lacking. Information does reach authorities from the chemical- producing companies, but only a small amount from international health organizations. Legislation for environmental protection and health is insufficient in general. Provisional permits are issued and control over treated foods that are sold is lost.

Pesticides That Inhibit Cholinesterase

Most traditional insecticides (organophosphates and carbamates) function by inhibiting the cholinesterase enzyme in the nervous system of insects. This is effective to kill insects, but can also influence human beings since their nervous systems also rely on cholinesterase (McEwen and Stephenson, 1979). Toxicity from organophosphates can be very acute and the cases of human intoxications are frequent. Organophosphates can also have long-term effects, even though the average life of organophosphates and derivatives is relatively short (hours or days). Their biotransformation occurs through oxidase, hydrolase and transferase enzymes, principally hepatic. Elimination occurs through the urine, and to a lesser extent through feces and exhaled air.

The first effect associated with toxicity of organophosphates is inhibition of acetylcholinesterase. In the change of membrane potential, the acetylcholine acts as a mediator of the nerve impulse. It is the chemical transmitter of the nerve impulse in the terminals of the parasympatic postganglionic nerve fibers, neuromuscular joint, sympatic and parasympatic preganglionic fibers, and certain synapses of the central nervous system. Organophosphates compete with acetylcholine for acetylcholinesterase in the following chemical reactions:

I. Acetylcholine + acetylcholinesterase => choline + acetylated acetylcholinesterase

II. Acetylated acetylcholinesterase + H_2O => acetylcholinesterase + acetic acid + choline

Results from a Case Study in the Sumapaz Valley

Snap bean farmers in the Sumapaz region apply mixtures of insecticides and fungicides weekly (Henry and Janssen, 1989). Their production technology is based on the use of agrochemicals, which they apply without adequate protective measures. According to a survey, the most common products are organophosphates, carbamates and synthetic pyrethrins (Velasquez et al., 1989). The CIAT Snap Bean Project considered it important to know the effect of these chemicals on agricultural workers and their families. CIAT's Staff Medical Office was requested to sample the level of cholinesterase in people working with snap beans, to detect the level of intoxication caused by the most frequently used pesticides.

Exposure to agrochemicals

Three series of tests were conducted between February and September 1989. On February 13, 1989, the first meetings with farmers from five municipalities were held. The farmers had received written invitations to visit the municipal center, where they were advised about the safe use of agrochemicals. A cholinesterase test was also done and a survey was carried out to collect relevant data on the farm families, their use of agrochemicals and general clinical histories.

Of the persons surveyed, 48 worked in farm-related jobs (farmers, day laborers, assistants), and 6 had other occupations, such as distributors, homemakers and teachers (Table 1). Crops most frequently planted by the farmers are snap beans, tomatoes and peas, in that order (Table 2). These crops have similar pesticide-application patterns.

Forty-eight of the people surveyed responded that they personally applied agrochemicals, mainly using backpack sprayers. They usually apply chemicals once a week, without personal protection equipment (74%), although some put a cloth or handkerchief over their mouth and nose (11%). In general, they wash themselves (74%) and change clothes after treating the crop with chemicals, and these clothes are then washed (66%). But some continue wearing the same clothes throughout the week.

Of the 54 people surveyed, 18 responded that they drank and 40 said they ate during the process of applying pesticides, indicating their lack of awareness of the danger (Table 3). Farmers say that the children do not participate in chemical applications, but personal observations and photographic records show they are present. Containers and pesticide leftovers are generally piled up and kept (74%) and are not destroyed.

When asked about incidences related to chemical use, 29.6% of farmers admitted to having experienced intoxication at least once.

Cholinesterase test: first sample

For the first test, farmers and other interested people met in the municipal centers of the region. The method used for the cholinesterase test was the Lovibond tintometer, easily carried out with a drop of capillary blood, an indicator (bromthymol blue) and a substrate (acetylcholine perchlorate), followed by a reading. Contrary to what was expected, the proportion of individuals with some contamination or with significant contamination was not high (Table 4). Also, students and women dedicated to the household, who are apparently less exposed, constituted a large proportion (Table 5) of the group evidencing contamination.

Having analyzed and reviewed this information, it was decided that the test should be made directly on farms and not in the municipal center.

Cholinesterase test: second sample

In the second sample in June 1989, the reliability of the Lovibond method was verified as compared to the cholinesterase monotest method. Seventy - five samples were taken, and the analysis was contracted out to a private laboratory in the region (Table 6).

The samples were taken with an anticoagulant, and processed at 37 ^{o}C. The normal values are expected to be:

women over 40 and men (5400 to 13,400 U.)
women not pregnant and aged 16-39 (4300 to 4500 U.)
pregnant women were not tested

Samples for the Lovibond method should be taken from capillary blood without an anticoagulant. Seventeen were taken (Table 7). Thirteen people had results showing cholinesterase levels lower than normal: ten men and three women. None was younger than 18. The Lovibond and monotest methods produced similar results.

Third sample from Sumapaz farmers

In August 1989, it was decided to take, besides cholinesterase, a urine exam and blood tests that measure the kidney and liver functions, for the purpose of detecting chronic damage. As noted earlier, pesticides are eliminated primarily by the urine and they can cause liver injury.

All the samples were gathered on farms, with 72.6% coming from males and 27.4% from females. Of these people, 64.5% were spraying at the time the sample was gathered. Table 8 specifies the occupations of the people included in the sample.

In this sample, using the Lovibond method for detecting cholinesterase, over half of the 62 people tested evidenced significant or very significant levels of contamination (Table 9). Moreover, for 31.2% of the farmers that had very significantly reduced cholinesterase, the additional urine and blood exams indicated possible kidney damage. With cholinesterase at significantly reduced levels, the percentage of people with possible kidney damage was 44%.

Other results show 41.9% of the people tested evidencing alkalinization of the urine. In the urine exams done, 31% of the farmers showed loss of protein through the urine (proteinuria) and 37.1% showed a loss of blood through the urine (hematuria). Although not all of these lesions are necessarily attributable to the use of agrochemicals, some may be. More than half of the farmers who showed proteinuria had lower levels of cholinesterase. Of the four farmers with liver deficiencies, three sprayed chemicals; and 75% of the farmers with alkaline urinary pH had reduced or very reduced cholinesterase.

Conclusions

So far, no conclusive evidence can be offered concerning the health risks to farmers and farm families in Sumapaz from the misuse of agrochemicals. Additional exams need to be conducted. It should also be noted that besides snap beans, farmers cultivate and chemically treat other crops as well. To generate a complete picture of the situation, a more holistic approach needs to be taken. In fact, it may not be correct to attribute all clinical effects to agrochemical use. Other causes may influence these tests. Nonetheless, these preliminary results lead us to think about the possibility of chronic liver and kidney damage due to the use of agrochemicals.

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Table 1. Sumapaz region: occupation of people surveyed, February 1989 diagnostic study.

Occupation	Number	%
Landowner	41	75.9
Foreman	6	11.1
Day laborer	1	1.9
Other	6	11.1
Total	54	100.0

Table 2. Sumapaz region: most frequently planted crops among farmers surveyed, February 1989 diagnostic study.

Crop	% of Farms	Frequency (times cited)
Snap bean	74	35
Tomato	68	32
Pea	28	13
Cucumber	21	10
Potato	21	10
Onion	17	8
Coffee	17	8
Curuba	11	5
Plantain	11	5
Livestock	4	2

Table 3. Sumapaz region: habits during pesticide application, February 1989 diagnostic study.

Response	Habits Smoking	 Eating	 Drinking
Yes	20	40	48
No	20	10	4
No data	14	4	2
Total	54	54	54

Table 4. Sumapaz region: number of people contaminated by pesticides by district according to cholinesterase exams, February 1989.

Cholinesterase Activity	Silvania	Arbelaez	Fusa	S. Bernardo	Pasca	Total	%
Normal	9	34	22	34	26	125	63.5
Some contamination	11	14	14	10	13	68	34.5
Significant contamination	1	1	1	1	-	4	20

Table 5. Sumapaz region: distribution by activity of those with some contamination, February 1989.

Activity	Number of people contaminated	Total number of people examined	% with some contamination
Farmers	41	140	29.3
Housewives	5	6	83.3
Students	12	19	63.2
Distributors	3	11	27.3
Others	7	21	33.3
Total	68	197	

Table 6. Sumapaz region: cholinesterase monotest results, second sample, June 1989.

Results	Number of People	%	Classification
-5400	13	17.3	Abnormal
5401-7400	38	50.7	Low normal
7401-9400	21	28.0	Medium normal
9401-11,400	3	4.0	High normal
11,400-13,400	0	-	
Total	75		

Table 7. Sumapaz region: Lovibond cholinesterase results, second sample, June 1989.

Cholinesterase amount	Number of people	%
Normal	4	24
Some contamination	11	64
Significant contamination	2	12

Table 8. Sumapaz region: occupation of those examined in the third sample, August 1989.

Occupation	Number of People	%
Landowner	9	14.5
Day laborer	30	48.4
Housewife	13	21.0
Minor	5	8.1
Other	5	8.1
Total	62	100

Table 9. Sumapaz region: results of the Lovibond cholinesterase test, August 1989.

Results	Number of people	Sex		% of those examined
		Male	Female	
Normal	6	3	3	9.7
Some contamination	22	14	8	35.5
Significant contamination	16	13	3	25.8
Very significant contamination	16	15	1	25.8
No data	2	-	-	3.2
Total	62	45	15	

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PRODUCTION OF SNAP BEANS VERSUS YARDLONG BEANS IN INDONESIA

Irlan Soejono 1/

Abstract

Snap beans and yardlong beans are two of the many popular vegetables featured in Indonesian diets. Except for seed, almost all crop production is sold in the form of green pods for fresh vegetable consumption. Between 1981 and 1986, these vegetables represented about 2% and 7%, respectively, of total vegetable production in Indonesia. Results of a study analyzing the production of snap bean and yardlong bean, as a close competitor, to appreciate the advantages, constraints and profitability associated with both vegetables, are presented. Cultivation practices appear to similar, and are labor intensice. Both crops are usually grown as a monocrop, and a a second or third crop after rice.

Introduction

In Indonesia, beans (*Phaseolus vulgaris* L.) are mainly consumed as green vegetables (snap beans or french beans). Snap beans may be substituted by many other vegetables; the most important is yardlong beans (*Vigna unguiculata* or *Vigna sesquipedalis*). Consumption of the dry, mature beans is known, but the quantities consumed are negligible. The relative importance of snap beans and yardlong beans among the 18 major vegetables produced in Indonesia is shown in Table 1.

Production data from 1981 indicate that snap beans ranked thirteenth among the 18 major vegetables in Indonesia, while yardlong beans occupied sixth rank. After five years in 1986, these relative positions had hardly

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changed. Increases in their production during that period were mainly due to population increases rather than significant shifts in vegetable consumption patterns.

The objective of this paper is to understand the production systems of both snap beans and yardlong beans. It discusses farm and household characteristics of the producers, cultivation practices, yields, and access to production inputs and services. In addition to the secondary sources used for macro-level data, detailed information was collected through interviews with 100 farmers selected at random in villages of West Java Province.

Regions of Production in Indonesia

Vegetable production in Indonesia, including snap beans and yardlong beans, is concentrated on the densely populated island of Java, where some 100 million people presently live. Java has a land area of 132,174 km^2, but constitutes only 7% of the total land area of Indonesia.

As shown in Table 2, a total of 63,322 tons of snap beans, 63% of the total national production, were produced on Java in 1986. Among the three provinces of Java, most vegetable production is in the province of West Java. Tables 2 and 3 show that in 1986, West Java alone produced 47% of the snap beans and 60% of the yardlong beans of all Java. For this reason it was decided to conduct the farm survey of snap bean and yardlong bean producers, in the production areas of West Java.

Trends in Annual Production

From 1981 to 1986 annual production of snap beans in Indonesia increased by 20% on average, from 49,722 tons in 1981 to 99,698 tons in 1986 (Table 2). For Java, where two thirds of the population lives, the estimated annual growth rate was higher, 35%. While small declines in production occurred in West Java in 1982 and in 1986, normally increases were recorded.

Table 3 presents the annual production of yardlong beans, on average three to four times more than snap beans. With a production of 152,270 tons in 1981 increasing to 286,140 tons in 1986, the average annual rate of growth was 18%, a little less than that of snap beans (20%). On Java island the difference in the rate of growth between snap bean and yardlong bean production was larger, with average annual rates of 35% and 12%, respectively. It also appears that yardlong beans were more subject to yearly fluctuations than snap beans.

Trends in Average Yields

In general, snap beans yielded twice as much as yardlong beans per hectare (ha). However, average yields recorded in different administrative units fluctuated from 2.6 to 4.3 tons/ha for snap beans, and 1.1 to 2.0 tons/ha for yardlong beans. In fact, no consistent increases in average yields of snap beans were reported from 1981 to 1986 (Table 2). Small increases, if any, occurred in the average yields of yardlong beans on Java (Table 3).

Regarding the potential for increasing farm yields of snap beans and yardlong beans, Tables 2 and 3 show the highest average yield reported by a province in Indonesia during 1983 to 1986. Thus, under present farm practices, the feasible potential yield for snap beans appears to be 4.6 - 6.3 tons/ha and 5.2 - 8.7 tons/ha for yardlong beans. This suggests that there is little difference in the potential yields between snap beans and yardlong beans.

Monthly Distribution of Production

The monthly supply of snap beans and yardlong beans in the three provinces of Java during 1987 are presented in Tables 4 and 5. Roughly speaking, production of snap beans is more evenly distributed than yardlong beans. Pronounced variations are found at the provincial level for both crops.

In the case of snap beans, low production figures were reported in the months of August to December for West Java, January to March for Central Java and February to April for East Java, with monthly production levels ranging from 4% to 6% of the total for 1987. High production occurred in the months of January to June in West Java, July to October in Central Java and August to January in East Java, with monthly production ranging from 9% to 15% of the total. Given the good transport facilities throughout Java, the seasonal patterns of provincial production smoothed out the average supply and the monthly market price fluctuations.

In the case of yardlong beans, with the exception of East Java where monthly production fluctuated more frequently than the other two provinces, low production was found in the months of November and December. Production levels of only 4%-7% of the total for 1987 were reported in those two months. It could be expected that prices were the highest during those months.

Characteristics of the Study Areas and Farmers

In the study of the production systems of snap beans and yardlong beans, the two subdistricts in West Java Province with the largest total production for the two crops were selected. The locations of the two study subdistricts, Pacet (for snap beans) and Ciomas (for yardlong beans), are shown in Figure 1. Samples of 50 snap bean farmers were drawn at random from lists of crop growers in Pacet and Ciomas. Thus a total of 100 sample farmers were interviewed.

The study areas

The subdistrict of Pacet, which is one of the major snap bean producing centers in West Java, is situated 45 kilometers east of Bogor or 105 kilometers southeast of Jakarta, the capital of Indonesia. Pacet is mountainous and hilly, a part of the shoulder of Mount Gede-Pangrango ($\pm$

3,000 m). High-altitude vegetables are usually grown, including snap beans. It has 13,505 ha of agricultural land.

The subdistrict of Ciomas, selected to represent yardlong bean production areas, is located about 15 kilometers southwest of Bogor and 75 kilometers south of Jakarta. With about 7,303 ha of agricultural land, Ciomas has undulating plains, where low - altitude vegetables, including yardlong beans, are grown.

Soil types of both subdistricts are similar, mainly latosols, andosols and regosols. The two areas have good access to public transport, and both are fairly close to urban centers where consumer markets for vegetables are abundant.

Harvested areas and crop yields

Table 6 shows harvested areas and yields of various food crops in Pacet and Ciomas. Rice is clearly the dominant crop in both sites. Maize, soybean, cassava, sweet potato, tomato and chili are also commonly grown in both areas. It appears that snap beans, carrots, leeks, cabbage, potatoes, garlic, chayote and chinese cabbage are typically found in high altitude areas like Pacet. Low altitude areas, such as Ciomas, are the better place for growing peanuts, yardlong beans, eggplants and cucumbers.

Since Pacet farmers are able to grow more varied kinds of vegetables than farmers in Ciomas, they tend to be more responsive to price changes. Table 6 lists the many alternative vegetables cultivated in the snap bean area. This flexibility, together with better access to price information and less risk aversion, makes the Pacet farmers generally more responsive to price fluctuations.

Although Pacet is the major snap bean production area, snap bean is not the major crop grown. The area devoted to snap beans was only about 6% of the total area planted to vegetables in 1986. Carrots, leeks and cabbage were the major vegetables in terms of area harvested. In Ciomas, however, more area was planted to yardlong beans than to any other single vegetable.

Household characteristics

In general, household data for the two study areas are similar. Over half of the heads of household have more than four years of schooling and can read and write. The average number of household members is 5.5 in Pacet and 5.3 in Ciomas. The number of adults (more than 15 years of age) is larger (3 persons) than that of the dependent members (2.4 persons in both). However, the average number of farm family laborers per household in Pacet is 2.2 and 2.4 in Ciomas. Perhaps some of the adults are still in school.

Ownership of land and other assets

On average the total land area per farm in Pacet is .5 hectares (ha), and .4 ha in Ciomas. This includes: (i) low lands ("sawahs"), which are technically irrigated; and (ii) uplands, including home gardens and housing sites. Ownership of other assets in 1987 included livestock, farm implements and vehicles.

No mechanized farm implements were found in the study areas. In addition to traditional tools, 55% of snap bean farmers own a sprayer worth Rp 25,000 (US$15). Some 16% also have a weighing scale estimated at Rp 29,000 (US$18). In Ciomas 32% of farmers own one sprayer worth Rp 20,000 (US$12). Another 22% also have a weighing scale costing Rp 11,000 (US$7).

Sources of family income

According to Table 7, most farmers do not rely on farming as a sole source of income. However, it is the main source of income for the majority of farmers (63% of farmers in Pacet and 82% of farmers in Ciomas).

Cultivation Practices

This section describes farmers' production activities, including land preparation, planting, fertilizer application, weeding, spraying and harvesting. For analytical purposes, farmers' reponses are expressed in percentage terms (Tables 9 to 14).

Snap bean cultivation practices

When snap beans are planted as a second crop after rice, the land is usually first prepared by breaking up the soil and crushing it into small particles. Raised beds are then formed. Regardless of the length, raised beds measure 80-100 cm wide and are separated by a of 30-cm wide furrow between the beds. When planted as a third crop after rice and other vegetables, no specific land preparation is required. Plant holes are made along both sides of the raised beds and two seeds are placed in each hole. Seeds are either from a farmer's own stock or purchased from neighbors.

Most farmers (84%) in the study area apply manure as a basic fertilizer one or two days before planting (Table 9). Almost all farmers (98%) apply inorganic fertilizers as well. Urea and Triple super phosphate (TSP) are most common. In addition to these subsoil fertilizers, some farmers also apply leaf fertilizers such as Gandasil B or D. Most farmers apply two or more types of inorganic fertilizers. During the growing period weeding is done manually once or twice.

Plant diseases commonly found are leaf blights due to <u>Cercospora canescen</u> and rusts due to <u>Uromyces appendiculatus</u>. The most common insect pest is beanfly, <u>Ophiomyia phaseoli</u>. On the whole, farmers have succeeded in controlling the pests and diseases. Data in Table 10 indicate that most farmers (98%) spray. Most of these farmers (94%) apply pesticides three or more times. It is interesting to note that crops are only sprayed before harvest.

Cropping Patterns and Cultivation Practices

Cropping patterns described in the following paragraphs are based on information obtained from farmers who grew snap beans and yardlong beans in 1986/87. Since great variation exists among villages, they may not represent the subdistrict as a whole. Nevertheless, certain "patterns" based on the most common practices can be identified.

It should be noted that in both study areas all farm activities are done manually, despite the fact that the number of hand tractors and threshers has increased rapidly during the last decade. The machines are, however, concentrated in the major rice-producing centers.

The common varieties of snap beans grown in Indonesia are climbing varieties. Upright or bush types are not popular, because their green pods are rather stiff and not easily broken. Although the pods command the same price, some believe that bush types have a low yield compared to climbing types.

Cropping patterns

The cropping patterns for the agricultural year 1986/87 in both Pacet and Ciomas are presented in Table 8. Patterns are listed and ranked according to the frequency of farmers' responses. When less than 4% of farmers followed a particular pattern they were grouped together as "others".

No dominant cropping pattern seems to exist in the snap bean area. Most farmers appear to monocrop snap beans, planting them as a second or third crop after rice. This makes it almost impossible to specify any seasonal production pattern since both rice and snap beans may be grown any time of the year.

On the other hand, a dominant cropping pattern is evident in Ciomas. More than half of the farmers follow a rice-rice-cucumbers-yardlong beans pattern. Some examples of intercropping with yardlong beans were also reported, which are included in "others".

Two methods of harvesting were identified (Table 11). Either the farmer himself harvests the green pods, assisted by his family and/or hired labor (78%), or he sells the standing crop at harvest time (22%). Of the farmers who harvest their own crop, 47% required 10 pickings. The first harvest is generally 50-55 days after planting, followed by further harvests at three-day intervals. Usually the entire crop is sold, although some farmers (47%) set aside plants for seed purposes.

Yardlong bean cultivation practices

Since yardlong beans are usually planted as a third crop after rice and other vegetables (Table 8), no particular land preparation is considered necessary. The method of planting is similar to snap beans, where spacing is 20 cm between holes along both sides of the 80 cm-wide beds. Seed originates either from previous crops or is bought from neighbors.

Fertilizer is commonly applied in two stages. Before planting, a basic fertilizer consisting of manure and inorganic fertilizers (Potassium chloride (KCL), TSP, and urea) is applied. If the crop follows cucumbers, most farmers consider the basic fertilizers applied before or during the land preparation for cucumbers as sufficient. Fertilizer is not always applied after planting. This depends very much on cash availability. Nonetheless, data in Table 12 show that most farmers (90%) apply basic fertilizers and do fertilize after planting.

The frequency of weeding depends on the stage of plant growth and weed population in the plot. Most farmers (78%) only weed once and a few of them (12%) do not weed at all.

The longer harvest period of yardlong beans makes it necessary to spray pesticides before and after the first harvest. Pesticide applications and related aspects are presented in Table 13. It appears that spraying during the harvest period tends to be more intensive than during the pre-harvest period. Many farmers (52%) spray more than four times during the harvest period, while some (28%) do not spray at all. In effect, farmers engage in preventive measures by spraying regularly regardless of any pest and disease infestation. The high cash cost incurred compels some farmers to sell their standing crops and leave the harvesting (and the spraying) to the buyer.

As in the case of snap beans, however, most farmers (72%) harvest the crops themselves (Table 14). Only 28% sell their standing crops using the tebasan system. Yardlong beans require a longer, extended harvest of 50-60 days. The proceeds can only be realized in small portions and over an extended period. For farmers who wish to cash in on the full expected returns at the earliest possible time, the tebasan system offers the better choice. Many of the small farmers argue that yardlong beans require relatively large amounts of capital and the harvesting method does not suit their needs.

Financial Analysis of Snap Beans

Table 15 shows the total cost of current inputs is Rp 311,167/ha (US$189/ha). Pesticides represent 35%, fertilizers 27%, seed 24% and manure 14% of the total cost. The total labor cost is Rp 614,443/ha (US$373.50/ha), including the imputed cost of family labor (Table 16). Land preparation comprises 24%, harvesting 23%, weeding 16%, staking 12%, spraying 11%, fertilizing 8% and planting 6% of the total labor cost.

The yield of snap beans is relatively high, averaging 11.6 tons/ha. The subdistrict average is only 6.2 tons/ha (Table 6). With an average price of Rp 150/kg (US$.09/kg) the value of production or total revenue is Rp 1,733,753/ha (US$1,054.00/ha).

Table 17 shows a total production cost of Rp 1,185,980/ha (US$721/ha). Labor represents the major (52%) cost, followed by current input costs (26%) and other costs (22%). The profit from snap bean production, defined as revenue minus total cost, is Rp 547,773/ha (US$333/ha). Since some of the inputs come from the farm family itself, the gross family income (defined as revenue minus total paid-out costs) is actually Rp 1,135,064/ha (US$690/ha).

Financial Analysis of Yardlong Beans

The total current input cost of yardlong bean production is Rp 133,968/ha (US$81/ha), less than half that for snap beans (Table 18). The ranking of costs reflects the importance of fertilizers (36%), followed by seed (29%), pesticides (25%) and manure (10%). As shown in Table 19, the total labor cost of Rp 326,850/ha (US$198/ha) is also half that for snap beans. The most labor-consuming activity is harvesting (18%), followed by spraying (26%), land preparation (14%), weeding (11%), staking (10%), planting (7%) and fertilizing (4%).

The average yield of yardlong beans is 4.7 tons/ha, comparable to the Ciomas subdistrict average in Table 6. The average price received by farmers was Rp 213/kg (US$0.13/kg), resulting in an estimated value of production or total revenue of Rp 997,282/ha (US$606.25/ha).

The total production cost, then, of yardlong beans is Rp 709,673/ha (US$ 431/ha) (Table 20). The major expense is labor (46%), followed by other costs (35%) and current input costs (19%). The imputed land rent is even higher than in Pacet. This could be explained by Ciomas' proximity to Bogor, a city with expanding urbanization. The profit of yardlong been production is estimated at Rp 287,609/ha (US$175/ha).

The results of the financial analyses for both snap beans and yardlong beans are very sensitive to the assumed yield levels. In the case of snap beans, yield levels in the survey were almost double the subdistrict average. For yardlong beans they were only slightly higher. If subdistrict averages are used instead of survey yields, then yardlong beans would be more profitable than snap beans and would also produce a higher family income (Table 21).

It is difficult then to evaluate the attractiveness of snap beans versus yardlong beans. For snap beans, the high cost of inputs is notable and may be related to the elevated yield levels reported in the survey. In this case a comparison of profitability by subdistrict averages would be incorrect. Snap beans appear to be more input demanding than yardlong beans, but the high yields should not be attributed to the input use only. Thus the profitability of snap beans versus yardlong beans remains subject to further study.

Farmers' Access to Services

According to A.T. Mosher (Getting Agriculture Moving: Essentials for Development and Modernization, Praeger, New York, 1966.), rural institutions are an accelerating factor in agricultural development, in that they supply services which have economic values. The availability of such institutions, and the farmer's awareness of them, will have an impact on his management options and on the returns from farming. The accessibility to services is presented in Table 21.

Access to inputs

In both study areas local varieties of crops are generally grown. Farmers believe that yields do not show marked differences from improved varieties. Seeds are either from the farmer's own crops (47% for snap beans and 52% for yardlong beans), or purchased from neighbors. No farmers reported buying seeds from stores, although available nearby. They argued that the store price was about three times more than the price of seed sold by neighbors.

More than half of the farmers purchase fertilizers and pesticides from local village stores. Apparently there is very little price difference (about 8%) between local and distant stores, and they only buy small quantities each time. Some farmers reported that they can buy fertilizers and pesticides on credit without interest, as long as payments are made within a week.

Access to extension service

With 45% of snap bean farmers and 94% of yardlong bean farmers reporting "no-access" to extension services, it can be concluded that the local extension service is not very effective. The apparent extension gap may be due to: 1) not enough agents for too many farmers (in one of the study areas, an agent was responsible for around 6,000 farm households); and 2) insufficient training in vegetable production for the extension agent.

The better access to extension services among snap bean farmers (55%) as compared to yardlong bean farmers (4%), could explain the more intensive production methods among snap bean farmers.

Access to credit

Data from Table 22 show that most farmers, 96% in Pacet and 86% in Ciomas, use their own financing for crop production. The total number of farmers who borrowed in the two study areas was only nine out of 100 sample farmers. Apparently the three farmers who borrowed from the cooperatives were exceptional cases, as borrowers are supposed to be small vendors with very limited capital. The traders lending money to farmers in Ciomas were presumably moneylenders, who provide "flexible" credit services at a rather high interest.

Summary

The production of snap beans and yardlong beans contributed only about 2% and 7%, respectively, to total vegetable production in Indonesia during the years 1981-1986.

Size of farms is relatively small (less than .5 hectares) and most farmers have two or more sources of incomes, although farming is their major source. Both crops are usually grown as a monocrop, and as a second or a third crop after rice. Cultivation practices are similar, and are labor intensive.

Farmers generally use their own-produced seed or buy seed from neighbors. Manure, urea and TSP are the popular fertilizers. Farmers usually spray with several types of pesticides. The average yield of snap beans is 6.2 tons/ha and 4.1 tons/ha for yardlong beans.

Farmers have no problem in obtaining fertilizers and pesticides, although extension services and credit facilities appear to be much in need of improvement.

Figure 1. Location of survey areas, Province of West Java, 1987

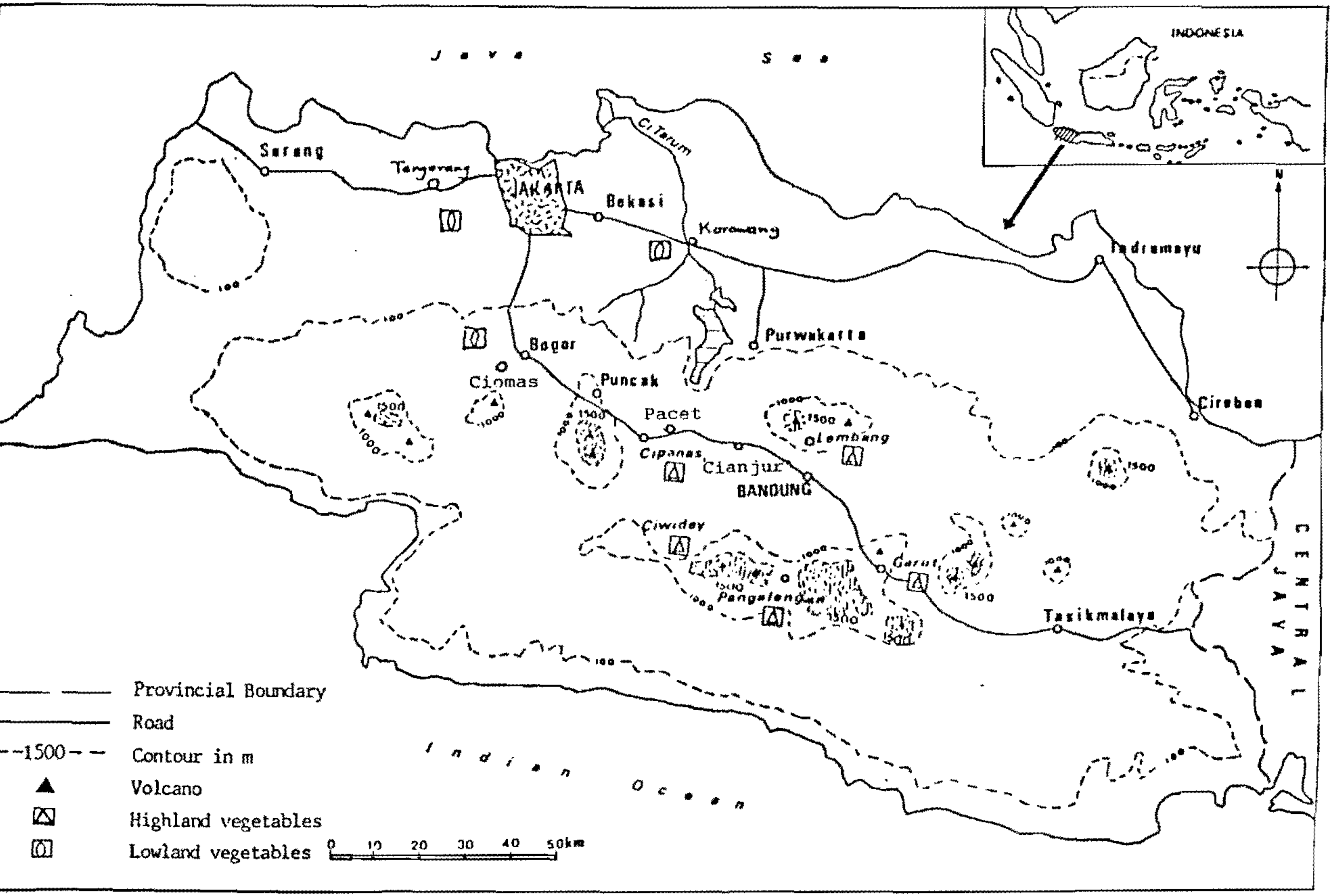

Table 1. Production of major vegetables in Indonesia, 1981 and 1986.

Major Vegetables	1981 Tons	1981 %	1986 Tons	1986 %
1. Shallot	176,031	8.66	382,117	9.16
2. Garlic	17,366	0.85	85,096	2.04
3. Leek (green onion)	79,405	3.91	150,675	3.61
4. Potato	216,713	10.66	446,295	10.70
5. Cabbage	349,013	17.17	820,357	19.67
6. Carrot	54,859	2.70	108,408	2.60
7. Chinese cabbage	123,552	6.08	212,435	5.09
8. Chinese radish	24,617	1.21	26,267	0.63
9. Red kidney bean	43,414	2.14	77,139	1.85
10. Chili	211,618	10.41	438,699	10.52
11. Tomato	108,764	5.35	189,406	4.54
12. Eggplant	135,219	6.65	181,521	4.35
13. Cucumber	152,228	7.49	298,930	7.17
14. Cayote (Sechium edule)	33,707	1.66	159,094	3.81
15. Kangkong (Ipomoea aquatica)	58,520	2.88	129,103	3.10
16. Spinach	45,810	2.25	78,136	1.89
17. Snap bean	49,722	2.45	99,698	2.39
18. Yardlong bean/cowpea	152,270	7.49	286,140	6.86
Total	2,032,828	100.00	4,170,116	100.00

Source: 1) Harvested areas, yields and production of horticultural crops, Directorate of Food Crop Program, Ministry of Agriculture, Jakarta, 1983.

2) Production of vegetables and fruits in Indonesia, 1986, Agricultural Survey, Central Bureau of Statistics, Jakarta, 1988.

able 2. Production and average yields of snap beans in the province of West Java, the island of Java and Indonesia as a whole, 1981-1986.

ear	1981		1982		1983		1984		1985		1986	
nit Area	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha
est Java	13,278	3.5	12,003	na	18,008	4.1	25,571	3.4	29,926	4.3	29,911	3.6
ava island	23,167	2.9	24,009	na	31,463	3.0	43,765	2.7	48,158	2.9	63,322	2.8
ll Indonesia	49,722	3.0	53,178	2.7	66,558	3.5	83,275	3.0	89,740	3.0	99,698	2.6
igest reported average rovincial yield		5.9		na		6.0		6.3		5.8		4.6

ource: 1) Harvested areas, yields and production of horticultural crops, Directorate of Food Crop Program, Ministry of Agriculture, Jakarta, 1983.

2) Production of vegetables and fruits in Indonesia, 1986, Agriculture survey, Central Bureau of Statistics, Jakarta, 1988.

le 3. Production and average yields of yardlong beans in the province of West Java, the island of Java and Indonesia as a whole, 1981-1986.

r	1981		1982		1983		1984		1985		1986	
t Area	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha	Production (tons)	Yield t/ha
t Java	49,682	na	46,422	na	64,495	2.0	72,153	1.2	95,917	1.7	103,588	1.9
a Island	107,496	na	87,542	na	133,694	1.2	157,74	0.8	170,956	1.3	173,863	1.4
Indonesia	152,270	na	133,401	na	181,814	1.1	355,807	1.5	272,431	1.5	286,140	1.5
hest reported average vincial yield		na		na		5.2		8.7		6.1		5.7

rce: 1) Harvested areas, yields and production of horticultural crops, Directorate of Food Crop Program, Ministry of Agriculture, Jakarta, 1983.

2) Production of vegetables and fruits in Indonesia, 1986, Agriculture survey, Central Bureau of Statistics, Jakarta, 1988.

ble 4. Monthly distribution of snap bean production in Java, 1987.

	Total Production 1987		Monthly distribution of production in 1987 (%)											
it area	(tons)	(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
st Java	26,294	100	14	11	10	10	10	10	7	6	5	6	5	6
ntral Java	21,787	100	6	6	6	8	8	7	10	15	8	9	8	9
st Java	11,923	100	10	6	6	4	8	6	5	13	14	9	11	7
. Indonesia	60,372	100	11	8	7	8	9	8	7	11	8	7	7	7

urce: Agricultural Survey: Production of Vegetables in Java, 1987.
Central Bureau of Statistics (CBS), Jakarta.

able 5. Monthly distribution of yardlong bean production in Java, 1987.

	Total Production 1987		Monthly distribution of production in 1987 (%)											
nit area	(tons)	(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
est Java	98,354	100	13	11	8	7	9	9	9	8	8	7	5	6
entral Java	31,065	100	10	8	9	9	8	9	8	9	9	10	4	7
ast Java	25,703	100	8	8	10	16	5	8	6	9	10	8	8	4
ll Indonesia	161,911	100	12	10	8	9	8	9	8	9	9	8	5	6

ource: Agricultural Survey: production of Vegetables in Java, 1987.

Central Bureau of Statistics (CBS), Jakarta.

Table 6. Harvested areas and yields of food crops in the sub-districts of Pacet and Ciomas, 1986.

Crops	Harvested areas (ha)	Yield (t/ha)
<u>Snap bean site (Pacet)</u>		
Cabbage	649	15.8
Carrot	2977	21.4
Cassava	3366	18.2
Cayote	134	16.2
Chili	459	3.2
Chinese Cabbage	364	17.6
Corn	926	2.3
Garlic	106	4.8
Leek	2066	17.7
Potato	313	13.2
Rice	4185	4.3
Snap bean	426	6.2
Soybean	146	1.2
Sweet potato	435	81.1
Tomato	109	14.3
<u>Yardlong bean site (Ciomas)</u>		
Cassava	177	12.2
Chili	81	2.1
Corn	255	6.3
Cucumber	129	31.4
Eggplant	47	9.3
Peanut	146	1.3
Rice	3949	6.7
Soybean	46	1.2
Sweet potato	191	23.0
Tomato	79	3.7
Yardlong bean	258	4.1

Source: Agriculture Extension Service, Cianjur and Bogor, 1987.

Table 7. Sources of family income, 1987.

Farmers' statement	Snap bean site (Pacet)	Yardlong bean site (Ciomas)
1. Number of sources of income (% household)		
- One	24	12
- Two	65	82
- Three	12	6
2. Kind of sources (% household)		
- Farming	98	100
- Farm labor	14	20
- Non agr. labor	10	6
- Trade	12	56
- Others	22	10
3. As the main source (% household)		
- Farming	63	82
- Farm labor	-	2
- Non agr. labor	24	-
- Trade	22	14
- Others	10	2

Source: Farm Survey Data, 1987.

Table 8. Cropping patterns in the study areas, 1986/1987.

Cropping patterns	Percentage of respondents
Snap bean site (Pacet)	
Rice- Pea -Snap bean	16
Rice - Snap bean - Snap bean	12
Snap bean - Carrot/celery - Carrot/celery	10
Rice - Snap bean - Carrot/celery	8
Rice - Snap bean - Daisy flowers	6
Rice - Chili - Snap bean	6
Rice - Snap bean - Rice	6
Rice - Celery - Pea - Snap bean	6
Rice - Tobacco - Snap bean	4
Rice - Snap bean - Carrot	4
Snap bean - Carrot - Carrot/celery	4
Carrot - Chinese cabbage - Snap bean	4
Carrot -Chili - Snap bean	4
Others (5 types)	10
Yardlong bean site (Ciomas)	
Rice - Rice - Cucumber - Yardlong bean	26
Sweet potato - Rice - Cucumber - Yardlong bean	12
Rice - Cucumber - Yardlong bean - Yardlong bean	4
Yardlong bean - Yardlong bean - Rice - Sweet potato	4
Rice - Yardlong bean - Yardlong bean	4
Others	22

Note: "/" means intercroping
Source: Farm Survey Data, 1987.

Table 9. Fertilizer application and weeding of snap beans, 1987.

Activities and related aspects	%of respondents	Application (DAP)* 1st	2nd	3rd
A. Fertilizing				
1. Use manure	84			
2. Use inorganic fertilizers	98			
3. No. of types of fertilizers used:				
- One type	10			
- Two types	51			
- Three types	39			
4. Fertilizers used:				
- Urea	98			
- TSP	84			
- ZA	18			
- KCL	6			
- NPK	4			
- Gandasil	31			
5. Frequency of application after planting:				
- Once	-			
- Twice	75	15	32	
- Three times	24	13	26	41
B. Weeding				
Frequency:				
- None	4			
- Once	43	23		
- Twice	53	16	33	

* DAP = Days After Planting.
Source: Farm Survey Data, 1987.

Table 10. Pesticide application on snap beans, 1987.

Activities and related aspects	% of respondents	Application (DAP)*					
		1st	2nd	3rd	4th	5th	6th
1. Use pesticides	98						
2. No. of type of pesticides used							
- One type	12						
- Two types	45						
- Three types	27						
- > three types	14						
3. Pesticides used:							
- Antracol	75						
- Dursban	57						
- Desis	18						
- Tamaron	12						
- Fandozed	4						
- Rohastic	8						
- Bayrusil	8						
- Elsan	4						
- Others	29						
4. Frequency of application:							
- Once	2	45					
- Twice	4	16	34				
- Three times	31	16	28	40			
- Four times	14	11	20	31	48		
- Five times	27	10	19	28	37	53	
- Six times	20	11	21	31	40	48	53

*) DAP = Days After Planting.
Source: Farm Survey Data, 1987

Table 11. Harvesting of snap beans,

Activities and related aspects	% of respondents
1. Self harvesting	78
2. "Tebasan" method*	22
3. Frequency of harvesting:	
- Five times	5
- Six times	12
- Seven times	13
- Eight times	18
- Nine times	5
- Ten times	47
	Average days
4. First harvest (DAP) **	50-55
5. Harvest interval	3

* Tebasan means the farmer sells the standing crop at harvest time and the buyer is responsible for harvesting.

** DAP = Days After Planting.

Source: Farm Survey Data, 1987.

Table 12. Fertilizer application and weeding of yardlong beans, 1987.

Activities and related aspects	% of respondents	Application (DAP)*		
		1st	2nd	3rd
A. Fertilizing				
1. Use manure	100			
2. Use inorganic fertilizers	90			
3. No. of types of fertilizer used:				
- One type	20			
- Two types	46			
- Three types	28			
4. Fertilizers used:				
- Urea	74			
- TSP	48			
- ZA	40			
- KCL	6			
- NPK	6			
- Gandasil	74			
5. Frequency of application after planting:				
- Once	56	13		
- Twice	34	12	28	
B. Weeding				
1. Frequency:				
- None	12			
- Once	78	20		
- Twice	10	16	29	

* DAP = Days After Planting.

Source: Farm Survey Data, 1987.

Table 13. Pesticides application on yardlong beans, 1987.

Activities and related aspects	% of respondents	Application (DAP)* 1st	2nd	3rd	4th	>4th
1. Apply pesticides	96					
2. No. of types of pesticides used						
- One type	34					
- Two types	38					
- Three types	20					
-> three types	4					
3. Frequency of application:						
a. Pre-harvest spraying:						
- None	2					
- Once	14	20				
- Twice	36	17	32			
- Three times	32	17	27	40		
- Four times	6	15	22	29	37	
- More than four times	10	10	22	28	35	45
b. Spraying during harvest:						
- None	28					
- Once	4	48				
- Twice	0	-				
- Three times	4	60	70	80		
- Four times	12	56	65	75	85	
- More than four times	52	52	56	61	66	79

*) DAP = Days After Planting

Source: Farm Survey Data, 1987.

Table 14. Harvesting of yardlong beans, 1987.

Activities and related aspects	% of respondents
1. Self harvesting	72
2. "Tebasan" method*	28
3. Frequency of harvesting:	
- Six times	3
- Seven times	5
- Eight times	3
- Nine times	-
- Ten times	39
- More than ten times	50
	Average days
4. First harvest (DAP) **	48
5. Harvest interval	5

* Tebasan means the farmer sells the standing crop at harvest time and the buyer is responsible for harvesting.

** DAP = Daya After Planting.

Source: Farm Survey Data, 1987.

Table 15. Current inputs per hectare of snap beans, Pacet, 1987.

Input	Quantity	Value (Rp)
1. Seed (liters)	33.7	73,792
2. Fertilizers (kg):		
- Urea	398.7	51,472
- TSP	194.7	25,101
- Others	69.0	8,936
3. Manure	-	43,151
4. Pesticides	-	108,715
Total (Rp)	-	311.167 (US$189.16)

Source: Farm Survey Data, 1987.

Table 16. Labor use per hectare of snap beans, Pacet, 1987.

Activities	Family labor				Hired labor				
	Male		Female		Male		Female		Total Cost (Rp)
	Hours	Imputed cost (Rp)	Hours	Imputed cost (Rp)	Hours	Actual cost (Rp)	Hours	Actual cost (Rp)	
1. Land preparation	291	75,967	-	-	279	72,834	-	-	148,801
2. Planting	70	16,994	49	6,698	22	5,341	43	5,878	34,911
3. Installing bamboo stakes	177	52,175	29	3,702	58	17,097	3	383	73,357
4. Fertilizing	119	32,161	74	8,425	23	6,216	33	3,757	50,559
5. Spraying	197	48,610	-	-	77	19,000	-	-	67,610
6. Weeding	107	28,676	204	25,815	41	10,988	267	33,787	99,266
7. Harvesting	271	98,060	300	35,631	13	4,704	13	1,544	139,939
Total	1,232	352,643	656	80,271	513	136,180	359	45,349	614,443
		(US$214.37)		(US$48.80)		(US$82.78)		(US$27.57)	(US$373.52)

Sources: Farm Survey Data, 1987.

Table 17. Costs and returns analysis of snap beans (Rp/ha), Pacet, 1987.

Item	Paid-out cost	Imputed cost	Total
A. Cost			
1. Current input			
a. Seed	36,442	37,350	73,792
b. Fertilizer	85,509	-	85,509
c. Manure	43,151	-	43,151
d. Pesticide	108,715	-	108,715
e. Total	273,817	37,350	311,167
2. Labor	181,529	432,914	614,443
3. Other costs			
a. Land rent	49,732	99,730	149,462
b. Implement rent	1,980	12,110	14,090
c. Land tax	20,254	4,490	24,744
d. Bamboo/Plastic	64,394	-	64,394
e. Others	6,983	697	7,680
f. Total	143,343	117,027	260,370
4. Total Cost	598,689	587,291	1,185.980 (US$720.96)
B. Revenue (value of production)			1,733,753 (US$1,054.00)
C. 1. Profit (B minus A4 Total)			547,773 (US$333.00)
2. Gross family Income (B minus A4 Paid-out cost)			1,135,064 US$690.00)

Source: Farm Survey Data, 1987.

Table 18. Current inputs per hectare of yardlong beans, Ciomas, 1987.

Input	Quantity (kg)	Value (Rp)
1. Seed	8.5	37,483
2. Fertilizers:		
- Urea	185.8	29,947
- TSP	40.6	5,600
- Others	-	17,636
3. Manure	-	14,341
4. Pesticides	-	33,961
Total (Rp)		133,968
		(US$81.44)

Source: Farm Survey Data, 1987.

Table 19. Labor use per hectare of yardlong beans, Ciomas, 1987.

Activities	Family Labor		Hired Labor		Total cost (Rp)
	Hours	Imputed cost (Rp)	Hours	Actual cost (Rp)	
1. Land preparation	79	19,661	111	27,625	47,286
2. Planting	54	12,094	48	10,741	22,835
3. Installing bamboo stakes	60	13,587	80	18,116	31,703
4. Fertilizing	34	7,912	28	6,516	14,428
5. Spraying	262	72,093	43	11,832	83,925
6. Weeding	56	13,946	82	20,421	34,367
7. Harvesting	101	49,762	86	42,554	92,316
Total	646	189,045 (US$114.92)	478	137,805 (US$83.77)	326,850 (US$198.69)

Source: Farm Survey Data, 1987.

Table 20. Costs and returns analysis of yardlong beans (Rp/ha), Ciomas, 1987.

Item	Paid-out cost	Imputed cost	Total
A. Cost			
1. Current input			
a. Seed	10,671	26,812	37,483
b. Fertilizer	48,183	-	48,183
c. Manure	2,581	11,760	14,341
d. Pesticide	33,961	-	33,961
e. Total	95,396	38,572	133,968
2. Labor	137,805	189,045	326,850
3. Others costs			
a. Land rent	12,800	147,200	160,000
b. Implement rent	8,342	3,926	12,268
c. Land tax	16,132	10,754	26,886
d. Bamboo/plastic	49,761	-	49,701
e. Others	-	-	-
f. Total	86,975	161,880	248,855
4. Total Cost	320,176	389,497	709,673 (US$431.41)
B. Revenue (value of production)			997,282 (US$606.25)
C. 1. Profit (B minus A4 Total)			287,609 US$174.84)
2. Gross family income (B minus A4 Paid-out cost)			677,106 (US$411.61)

Source: Farm Survey Data, 1987.

Table 21. Profitability of snap bean versus yardlong bean production (US$).

	Snap beans	Yardlong beans
Survey yields		
yields (tons)	11.6	4.7
gross revenues/ha	1054	606
profit/ha	333	175
family income/ha	690	412
Average subdistrict yields		
yields (tons)	6.2	4.1
gross revenues/ha	563	529
profit/ha	-158	98
family income/ha	199	335

Table 22. Accessibility to rural institutions, 1987.

Kinds of services	Pacet	Ciomas
	(% Respondents)	
A. <u>Farm inputs</u>		
1. Source of seed:		
a. From own crop	47	52
b. Bought from other farmers	53	48
2. Fertilizer/ pesticides:		
a. Bought in village	57	76
b. Bought outside village	43	24
-Average distance (km)	3.7	18
B. <u>Extension service</u>		
1. No access	45	94
2. Accessible	55	6
a. Frequency of contact:		
- Every week	(4)	-
- Every two weeks	(14)	-
- Once a month	(43)	(33)
- Once in several months	(39)	(67)
b. Place of meeting:		
- At home	(64)	
- In the village hall	(32)	(100)
- In the field	(36)	
C. <u>Accessibility to credit</u>		
1. Source of farm expenses:		
a. Self - financing	96	86
b. Credit	4	14
2. Source of credit:		
a. Cooperative	100	14
b. Trader	-	86
- Amount (Rp'000)	50	75
- Period (month)	4	4
- Interest (% month)	4	5

Source: Farm Survey Data, 1987.

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COMPARATIVE ADVANTAGES OF CLIMBING VERSUS BUSH TYPE SNAP BEANS

Tamer Turkes 1/

Abstract

Due to suitable climatic conditions, snap beans are produced in all regions of Turkey. The most important production area is along the Black Sea coast. The most popular climbing and bush type snap beans grown are described and the cultivation systems for the two types of beans discussed. Due to consumer preferences, predominantly climbing snap beans are grown, however, they have a longer production cycle, and are more labor and input intensive. This tends to limit the area a farmer can devote to climbing snap beans. The average area per farm planted to climbing snap beans is only 2.2 decars (10 decar = 1 hectare), while the average area devoted to bush snap beans is 8.6 decars.

Bean Production in Turkey

According to FAO statistics Turkey produced 190,000 metric tons of dry beans on 179,000 hectares (ha), and 400,000 tons of snap beans on 49,000 ha in 1987 (FAO, 1988). Turkey's share of world production in snap beans is 13%. Turkey is self-sufficient in both dry and fresh beans. Limited quantities of fresh, frozen and canned beans are exported to different countries.

Turkey's ecology is such that snap beans can be produced in all regions of the country (Figure 1). This map shows production by region and as a

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percentage of total production. Snap bean farming is common in coastal regions where irrigation is feasible. The most important production area is along the Black Sea coast. Snap beans alone comprise 2.5% of total vegetable production. In the smaller classification of leguminous vegetables, snap bean production dominates, representing 77% of total production (Erkal et al., 1989).

Major Snap Bean Varieties Grown in Turkey

Many local varieties are grown in the different regions of the country, although it is likely that different names are used for the same varieties of snap beans. Among the various programs currently carrying out research on snap beans in Turkey, Ataturk Horticultural Research Institute (AHRI) is one of the institutions with an established program in snap bean breeding. Research efforts have produced important snap bean varieties now used on a large scale. As shown in Table 1 the following are some of the more important bush and climbing snap bean varieties.

Bush Snap Bean Varieties

Karaayse

Due to its earliness this variety is especially popular in coastal areas. It was bred in Yalova by AHRI. Harvest begins about 40 days after planting and lasts about 30-40 days. Plant height varies between 40 and 50 cm and flowers are light red. Pods are light green and flat and contain 5-7 grains. Pods are 8-10 cm long, 1.5 cm wide and the weight per 1000 grains is 300-350 grams (g).

Yalova 5-17

Yalova 5-17 is a hybrid bush snap bean produced by AHRI's breeding program. Based on a cross between a stringless climbing bean and a high yielding bush variety, Yalova is high yielding and suitable for the fresh market as well for consumption as a dry bean. It is grown throughout the country and is used by the canning industry. This white-seeded bean is harvested 45-55 days after planting, with 4-5 pickings over 30-40 days. Plant height is 40-50 cm; flowers are white. Pods are about 10-12 cm long, 1.5 cm wide and contain 5-7 seeds. Pods are flat and stringless. The 1000-grain weight is 450-500 g.

Romano 26

Recently, this American variety was introduced to Turkey for use in the canning industry. The industry has made seeds available to small growers and it is particularly found in the area of the Marmara Sea. Its growing cycle is somewhat longer than that of Yalova 5-17. Harvesting starts 55 days after planting and continues 45 days approximately, with 3-4 pickings. Plant height is 50-60 cm. Flower color is white. Pods are 14-16 cm long, 1.6-1.8 cm wide and contain 5-6 grains. Weight per 1000 grains is 300-350 g.

Climbing Snap Bean Varieties

Seker or "Sugar"

This so-called "sugar" variety is used for canning, for fresh market purposes and as a dry bean. Small intensive farm enterprises cultivate Seker throughout the country. Days from planting to harvest vary from 55 to 60 days with a harvest period of 60-70 days. It can be harvested at least 10 times. Bush beans by comparison are harvested only 3-5 times. It has a flat pod and is stringless. Plants grow 2.4 -2.7 m high. Flowers are white. Pod length is 15-17 cm and pod width, 1.7-1.8 cm. There are about 7-9 seeds per pod. Weight per 1000 grains is 550 g.

Ferasetsiz

This is a flavorful flat, stringless bean cultivated especially in higher elevations. It is used for fresh consumption and by the canning industry. Its production period is comparable to Seker. Plant height is shorter:

2-2.3 m. Flowers have a pink-red color. Pods are 16-17 cm long and 1.7 cm wide, containing 7-9 grains. Weight per 1000 grains is 500-515 g.

Boncuk

Another product of the Ataturk varietal improvement program, Boncuk is a very flavorful bean planted for the fresh market in spring and fall. Pods are flat and grains are white-beige. Pods are harvested 10-12 times over a period of 60-65 days. Plant height is 2-2.2 cm. Flowers are pink-red. Pod length is 12 cm and pod width is 1.3 cm. Weight per 1000 grains is 300-350 g.

4F-89

Popular along the Black Sea coast 4F-89 is intended for fresh consumption. Plants grow to 2.2-2.5 m high. Grains are dark red. Pods are harvested 10-12 times 50-55 days after planting. Pods are 15 cm long and 1.6 cm wide and contain 7-9 grains. The 1000-grain weight is 500 g.

Comparison of Climbing Versus Bush Snap Beans

Farmers prefer to grow climbing beans rather than bush beans for fresh consumption in Turkey. In Marmara 61% of snap bean producers grow climbing snap beans while only 39% grow bush varieties (Erkal et al., 1989). Farmers' reasons for choosing one type of snap bean over the other are shown in Table 2. According to growers bush beans are easy to grow and have a shorter production period, but they do not suit consumer preferences and thus command a lower market price.

Generally, cultural practices vary according to the type of bean grown. The factor most affecting cultural practices is the length of the vegetative period. For bush beans the production period is 70-95 days from planting to the end of harvesting . For climbing beans the period is 110-133 days. Although climbing beans yield more, they require more intensive cultivation. In addition to the stakes, farmers need to irrigate and weed more often and need more labor for the longer harvest. To produce climbing snap beans 116 more hours of labor are needed than to produce bush types. Table 3 clearly shows how differences in irrigation, chemical treatments, weeding and harvesting affect labor use.

Snap bean farming is especially suited to small family enterprises in which family labor can be easily used. Because of the high labor demand, growers of climbing snap beans are restricted in the expansion of their bean area. In the Marmara region, the average area devoted to climbing snap beans is 2.2 decars (10 decar = 1 hectare). The average area per farm devoted to bush beans is 8.6 decars. Hence, with an increase in land, the area planted to bush beans also increases while the area set aside for climbing snap beans does not change (Table 4).

Comparing costs and returns on the production of climbing versus bush snap beans, it was found that when the yield of climbing snap beans was 3110 kg/ha more than bush beans the profitability was equal. If the yield difference is larger, it is more attractive to grow climbing beans than bush beans.

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FIGURE 1.

TARIM BÖLGELERI – AGRICULTURAL REGIONS

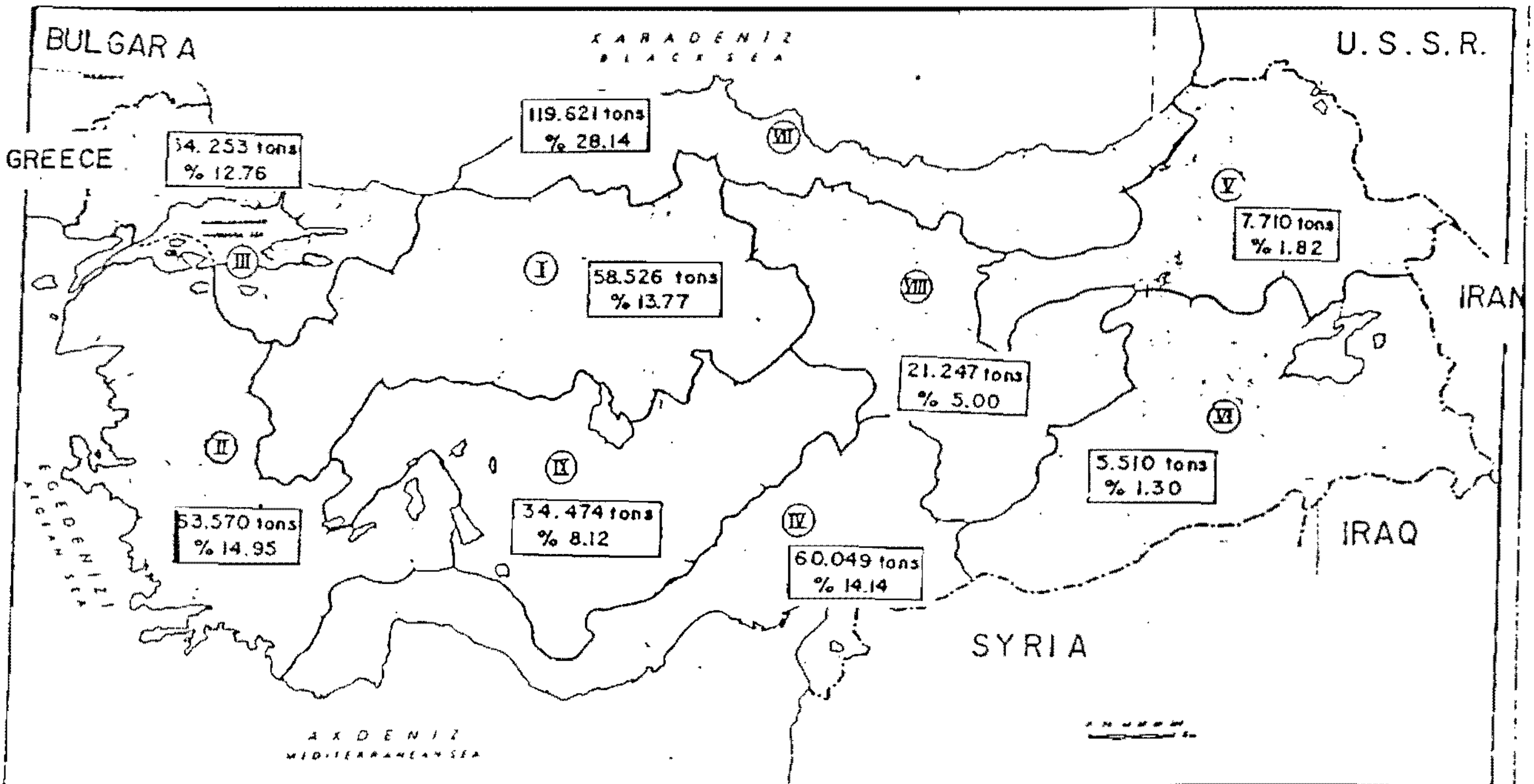

Table 1. Characteristics of some snap bean varieties grown in Turkey.

Name of variety	Seker (Sugar)	Boncuk	Ferasetsiz	4 F-89	Karaayse	Yalova 5	Romano 26
CHARACTERISTICS							
Breeding Institute	AHRI*	AHRI	AHRI		AHRI	AHRI	Harris Moran
Year, location	1989, Yalova	1989, Yalova	1989, Yalova	France	1987, Yalova	1978, Yalova	USA
Breeder	Dr. T. Turkes	Dr. T. Turkes	Dr. T. Turkes	-	Dr. T. Turkes	H. Akgun	Harris Moran
Breeding method	Selection	Selection	Selection	-	Selection	Crossing	Selection
Planting to harvest	55-60 days	55-60 days	55-60 days	50-55 days	35-40 days	45-55 days	55 days
Harvesting period	60-70 days	60-65 days	60-65 days	55-60 days	30-40 days	30-40 days	45 days
Number of harvests	10	10-12	10-12	10-12	4-5	4-5	3-4
Plant height	240-270 cm	200-220 cm	200-230 cm	220-250 cm	40-50 cm	40-50 cm	50-60 cm
Flower color	White	Red	Red	Red	Pink	White	White
Pod width	1.7-1.8 cm	1.3 cm	1.7 cm	1.6 cm	1.5 cm	1.5 cm	1.6-1.8 cm
Pod length	15-17 cm	12 cm	16-17 cm	15 cm	8-10 cm	10-12 cm	14-16 cm
Pod shape	flat	flat	flat	flat	flat	flat	flat
Number of seeds	7-9	5-7	7-9	7-9	5-7	5-7	5-6
Weight per 1000 seeds	550 g	300-350 g	500-515 g	500 g	300-350 g	450-500 g	300-350 g

* Ataturk Central Horticultural Research Institute, Yalova.

Table 2. Farmers' preferences for bush vs. climbing type snap beans.

Reasons for Preference	Percentage (%) of farmers preferring:		
	Bush	Climbing	Total
Easy to produce	100	-	100
Profitable	13	87	100
Easy to sell	-	100	100
Difficult to find poles	100	-	100
Others	17	83	100

Table 3. Production differences for bush and climbing type snap beans.

	Bush beans	Climbing beans
Area sown per farm	8.6 da *	2.2 da
Planting method	in row	in group
Days planting to harvest	70-95 days	110-133 days
Weed control frequency (by hand)	2	3
Frequency of chemical control	2	3
Frequency of irrigation	6	10
Frequency of harvests	3	8
Stakes used	-	1500/da
Labor used		
Weed control	5.6	8.4
Chemical control	1.4	2.1
Irrigation	1.5	2.5
Harvesting	4.9	10.9
Staking	-	4.0
TOTAL	13.4	27.9
Yield	460.0 kg	1,014.0 kg

* 10 decar (da) = 1 hectare

Table 4. Changes in bean areas on different sized farms.

Farm size (da)	Land for bush beans (da/farm)	Land for climbing beans (da/farm)
less than 10	3.5	1.6
11-20	3.7	2.1
21-30	1.8	2.2
31-40	4.7	1.3
41-50	18.0	3.9
More than 50	20.2	1.8

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PRODUCTION DIFFERENCES BETWEEN LOWLAND AND HIGHLAND SNAP BEAN CULTIVATION

Herminia A. Francisco 1/

Abstract

Snap bean production systems under lowland and highland conditions in the Philippines are analyzed to identify ways to increase production. In the cool highland environment, snap beans are grown with or rotated with other vegetables or upland rice. In the lowlands, the warmer climate limits snap bean cultivation to the cool-dry season. Snap beans are mostly grown in harvested rice paddy fields. The average area devoted to snap beans is .25 ha in the highlands and .33 ha in the lowlands. Yields tend to be higher in the highlands (11 t/ha) than in the lowlands (9 t/ha), but lowland farmers realize a higher benefit-to-cost ration because snap bean cultivation is more labor and input intensive in the highlands. Yields at both altitudes, though, are well below experimental-site yields of 15-18 t/ha. Major production constraints include susceptibility to insects and diseases, insufficient water, lack of production capital, and unpredictable prices.

Introduction

The majority of Filipino farmers are classified as poor. Farm incomes are low vis-a-vis soaring prices of all inputs and consumer goods. Past efforts to increase farm income through technological improvement appear inadequate as poverty continues to beset the rural sector of the country. In Benguet, the major vegetable producing province in the Philippines, the incidence of poverty among the population is estimated to be about 56% (Francisco and Consolacion, 1988). However, in the vegetable growing

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communities there is far less poverty (23%) than in predominantly rice growing areas (74%). This suggests that diversification from rice farming to the more profitable production of vegetables, such as snap beans, can improve the standard of living of families.

Snap bean (Phaseolus vulgaris L.) is a leguminous crop that supplies important minerals and vitamins. Besides its food value it is also an important cash crop for a large number of farmers, particularly in the province of Benguet and the nearby lowland areas of La Union. Together, these two provinces accounted for 58% of the country's total snap bean production of 6,281 metric tons in 1986 (Baecon, 1987).

Benguet province is a mountainous region more than 1200 meters above sea level and is characterized by upland cultivation. Snap beans are generally grown on the hillsides in combination or rotation with other crops. They are also grown in some valley areas. In the warmer, lowland environment of La Union snap beans are grown as a second crop in the paddy fields after rice.

Over the years, the land devoted to snap beans in these traditional snap bean growing areas has declined due to limited government attention. Although the government has identified priority commodities, legumes are grouped as one general commodity. This group, in which snap bean is just one among many crops, is given the least priority. Therefore, it has been appropriated less funds for research and development. In spite of this neglect snap bean is a major crop among many farmers, indicating that snap bean production is profitable. This was substantiated by the findings of the study presented in this paper.

The support for snap beans is minimal. Yet the crop's adaptability to both highland and lowland conditions and its income potential are factors favoring development support. To propose increased government support would appear justified. This paper presents an analysis of snap bean production systems in highland and lowland environments with the objective of identifying ways in which income to snap bean producers can be increased.

The data presented and discussed in this paper were collected in a survey of 200 farmers. The survey included a random sample of 100 highland farmers and 100 lowland farmers in the provinces of Benguet and La Union in the northern Philippines.

Snap Bean Producers

There are two types of snap bean producers depending on the environment in which they farm: highland or lowland farmers. An average highland farmer is 40 years old with 14 years experience in snap bean cultivation. His lowland counterpart is four years older, though with less experience in snap bean farming. Both have only a primary level education. The highland farmer belongs to an ethnic tribe called the "Igorot". Some 36% of those interviewed in the lowland area are also members of the Igorot but immigrated into the area.

In terms of land tenure, most highland farmers are owner operators. Most of their farms are untitled, however. This is because technically Benguet is classified as forest land and hence public land. Therefore, although farmers have undisputed ancestral claims to this land, very few actually own a document officially recognized as a land title. This inhibits their access to credit from the formal sector. Some 86% of those who rely on credit borrow under a contract-financing scheme from input suppliers and traders, who charge P.50-1.00 per kg of snap beans produced. Though exhorbitant, most farmers rely on the traders. Unlike formal institutions, they are always ready to extend credit.

In the case of lowland farmers, 32% are owner-operators, 33% lease land, 22% are tenants and 13% are part-time owners. Although relatively more farmers have land titles, not many of them (only 40% as compared to 71% of highland farmers) rely on credit to finance farm operations. Those farmers who borrow money from traders probably belong to the Igorot ethnic tribe. These farmers are generally observed to be risk averse. Due to the high cost of inputs and the wide fluctuation in the price of snap beans, cultivating snap beans is a risky venture. One way to minimize the risk is to share it with traders.

The Farm and Cropping System

Average farm size in the highlands is .93 hectare (ha). A large percentage (76%) of farmers interviewed, however, own only .33 ha, of which about 59% is devoted to snap beans. Among medium and large farmers the area devoted to snap beans, about 0.33 ha, is small compared to their farm holdings. This demonstrates the low priority given to snap beans as well as the potential for expanding the snap bean area. The same observation can be made of lowland farmers. The proportion of area cultivated to snap beans, an average of 34% of the total area farmed, is also low.

On highland farms, snap beans are always grown in combination with other crops like sweet pea and chinese cabbage in the cool-dry and hot-dry seasons and with upland rice in the hot-wet season. Among lowland farmers, the dominant crops cultivated are rice with legumes like string beans and cowpeas. Other characteristics of snap bean farms at both elevations are presented in Table 1.

Seed and varietal selections

Seed is either purchased from outside sources (neighboring farmers and local stores), produced on the farm, or comes from a combination of these two sources. The majority (57%) of farmers in both study areas produce their own seed. About 27% use both their own and purchased seed. Of those relying completely on an outside source for seed, other farmers serve as their major source.

Due to higher prices only a small proportion of farmers buy from a local store. In one case, farmers could buy seed at a trading center, but the center is inaccessible to most farmers. Except for one place in La Union where producers of snap beans specialized in producing seed for sale at P90.00/ganta or US$4.50 (1 ganta = 2.5 kg), no other source of seed was identified. The use of own seed by most farmers explains in part the low yields and highlights the need for better quality seed.

The popular cultivars in both highland and lowland environments are Black Valentine (89%) and Stonehill (86%). Other cultivars grown include Kentucky Wonder, Blue Lake Prime Pak and Contender, with the last two said to be the most promising snap bean varieties in the country (Atos, 1987).

A comparison of their yield performance shows the cultivar Blue Lake Pak producing the highest yield at 13.4 tons/ha. Stonehill follows with an average of 10.5 tons/ha at both elevations. Kentucky Wonder yields the least with only 7.85 tons/ha for highland farmers and 4.0 tons/ha for lowland farmers. For all types of cultivars, a higher yield is obtained in the colder Benguet-growing environment.

In terms of varietal mixtures, the use of more than one snap bean variety per season is more popular under lowland conditions, with 54% of farmers using mixtures, as compared to only 15% of farmers in the highlands. Though most highland farmers (85%) prefer to plant one variety per season, it is a common practice to change varieties from one season to another. This is because some varieties, such as Black Valentine, are more suited to the rainy season, whereas others like Stonehill are more adapted to the dry season.

In addition to its suitability to the rainy season, Black Valentine is also preferred by most farmers at both elevations because it is readily available and has a longer production cycle. Its high yielding quality was ranked only fourth in a list of factors farmers consider.

Insect and disease control

All farmers surveyed use insecticides, applying an average of 19.4 liters/ha (Table 2). The most common insects attacking snap bean crops are: pod borer, beanfly, cutworm and thrips. More lowland than highland farmers report attacks by these insects. Insecticides are generally applied from the vegetative to reproductive stages, with an interval of nine days between applications. Some farmers (15%) apply insecticides only in the reproductive stage.

Among highland farmers, 92% use fungicides compared to only 75% of lowland farmers. Fungicides are applied to control primarily stem rot and bean rust at the rate of 16.5 kg/ha on highland farms and 6.4 kg/ha on lowland farms. The higher dosage used in the highlands is probably because the colder, rainier environment is more conducive to the growth and multiplication of disease pathogens. About 68% of highland farmers and 53% of lowland farmers apply fungicides from the vegetative to reproductive stages at nine-day intervals as well. Others apply fungicides either in the vegetative or reproductive stage only (Table 2).

Fertilizer application

Farmers in both study areas use a combination of fertilizers. These include: organic (chicken manure, ash or compost); complete (14-14-14); urea (46-0-0), ammonium sulfate (21-0-0); ammonium phosphate (16-20-0); and foliar fertilizers.

Only 4% of lowland farmers use organic fertilizer compared to 41% of highland farmers. The use of chicken dung is more popular among highland farmers. On the average, they spend P793/ha on chicken dung as against only P45/ha among lowland farmers. The sloping topography of highland farms is susceptible to erosion and the soil demands constant nutrient replenishment. Lowland farmers do not generally use manure because snap beans are planted right after rice in the paddies, which have been enriched by burned rice straw reincorporated in the soil.

Not much difference was observed among farmers from both areas in their use of inorganic fertilizers. A farmer needs about 769 kg/ha/cropping season of inorganic fertilizers, valued at P3,088 (about US$154). Urea is used by 73% and 91% of highland and lowland farmers, respectively. It is usually applied as a sidedress at the pre-flowering stage. Some 53% of lowland farmers also apply it during the fruit development stage. Generally, though, urea is applied only once during the growing period. After urea, complete fertilizer is applied once basally before planting. Some, however, apply it at pre-flowering as a sidedress.

Other cultural practices

Planting is at the rate of 3 seeds/hill with an average planting depth of 5.4 cm on highland farms and 3.6 cm on lowland farms. On the sloping farmland in the mountains deeper planting allows for soil erosion. Distance between rows is similar in both growing environments, an average of 18.6 cm.

Irrigation practices vary substantially in the two environments. In the lowlands most snap beans are produced in rice paddies. About 64% of farmers irrigate once a week by flooding the field. Snap bean farmers in the highlands irrigate more often. About 62% irrigate twice a week using a sprinkler method.

Half of the highland farmers practice land rotation, fallowing the land to improve its fertility and to control soil-borne diseases. The other half do not have enough area to practice land rotation. Almost 70% of lowland farmers do not practice land rotation because snap beans are planted in the same rice paddies immediately after the rice is harvested.

Harvesting snap beans on lowland farms normally occurs 44-49 days after planting. In the highlands snap beans have a longer production period. About 29% of farmers harvest their crops after 44-49 days, 38% harvest after 50-55 days and 33% harvest their crop 56-61 days after planting. Most lowland farmers (90%) harvest twice a week, while only 37% of highland farmers harvest this often. Among lowland farmers, the practice of applying a small quantity of urea fertilizer during pod development results in faster pod development and a higher yield, thus enabling more frequent harvesting. It will be shown later that more frequent harvesting contributes positively and significantly to crop yield.

Economics of Snap Bean Production

Use of material inputs

Expenditure on inputs such as seeds, trellises and insecticides are similar at both altitudes. The average quantity and value of materials used per hectare are: seeds, 72 kg/ha valued at US$124.60/ha; insecticides, 19.4 li/ha at US$91.60/ha; and trellises worth about US$239.40. Since the trellis is useful to farmers for four cropping seasons, the actual cost per cropping season is only about US$60/ha. Expenditure on organic fertilizer is only US$2.25/ha in the lowlands as compared to US$39.70/ha on average among highland farmers. Highland farmers also spend more for fungicides: US$52.00/ha. Lowland farmers spend only US$33.00/ha.

Labor utilization

Table 3 provides a detailed breakdown of labor input per hectare according to farm operation and type of worker (hired, operator or family). Highland farms require more labor for land preparation (71 person-days/ha), hilling-up (25 person-days) and irrigation (43 person-days). In contrast, lowland farmers use only 21, 7 and 15 person-days/ha for these three farm activities, respectively. The difference in labor input is largely due to the topography of hillside farms. They require more intensive manual cultivation and more frequent application of irrigation water. On lowland farms the animal drawn plow is used for cultivation and the flooding system for irrigation, both of which require less labor. Highland farms also require more labor for harvesting. This can be explained in part by the higher per hectare yields.

Not much variation between the two elevations is observed in such labor-consuming activities as planting (22 person-days/ha), fertilizing (22 person-days/ha), insect and disease control (54 person-days/ha), trellising (21 person-days/ha), and post-harvest operations (36 person-days/ha). Weed control seems to be a major activity on snap bean farms in the lowlands, as illustrated by the higher labor input of 72 person-days/ha against 53 person-days on highland farms. This is because weeds are more abundant in rice paddies.

On the whole, snap bean production is a very labor intensive activity, requiring 440 person-days/ha on highland farms and 355 person-days/ha on lowland farms. With a growing period of less than 100 days this means that about four persons are needed to work fulltime on a hectare of snap beans. Even a small plot of snap beans would require full-time tending by a farmer and his family.

As such, snap bean production offers full-time employment to a farm family. This, however, could be a constraint to expanding snap bean farming. As observed by some of the farmers, cultivating snap beans is so taxing that, at times, they even have to work at night. If a farmer has a high preference for leisure or an easier life, he may not opt to produce snap beans. And even if a farmer is willing to work, the labor available on the farm may not be sufficient. Most farmers said they had to hire more workers at certain times of the cropping season.

It is worth noting that in the highland areas women were as involved as men in practically all farm operations. Some women on lowland farms also work in the field but not as a high a proportion as in the highlands. Women of the Igorot ethnic group are known to be hardworking.

Cost and return analysis

A comparison of the costs and returns on snap bean production in the two environments is summarized in Table 4. The data shows that in spite of a P9,072.84/ha (US$454) difference in gross revenue between the highlands and the lowlands, the returns after costs do not differ significantly: P20,080.13/ha (US$1004) for highland farms and P19,480.26/ha (US$ 974) for lowland farms. The high levels of input used by highland farmers offset their yield advantage. Some of them may be using inputs above and beyond what are considered economically efficient levels.

The benefit-cost ratio (B/C) among lowland farmers is more favorable: 1.93 as compared to a ratio of 1.68 among highland farmers. Taken together, a B/C ratio of 1.78 is obtained. This means that for every one peso invested in snap bean production, the farmer gets P1.78 in return or a 78% earning on his investment. This return is higher than for the major crops grown in the highlands, which include potato and cabbage.

The lower B/C ratio for highland farmers is caused by their high labor cost, two thirds of which is non-cash family, valued at P13,412.55. This represents 45.6% of the total cost of production. The cost of labor in the lowlands is only P7,200.27 or 34.4% of total costs. The high labor costs on highland farms is due to the greater number of person-days required to cultivate snap beans in the mountainous terrain. Moreover, the labor intensive nature of vegetable production results in a higher wage rate compared to the wage rate for farm workers in lowland areas.

In both environments, however, the profitability of snap bean production is evident, even when non-cash costs are considered. It costs P2.40 to produce one kg of snap beans. To realize a profit, snap beans must command a market price higher than P2.40/kg. Since the average price received by the farmers during the study was P4.73/kg, they realized a profit. Considering all cash and non-cash costs, a grower may earn an average of US$988/ha/cropping season. Highland farmers earn a profit of

US$1455/ha/cropping season when only cash costs are considered. This is more than the $1134/ha/cropping season earned by lowland farmers.

Production function analysis

A production function relates output (yield/ha or total production/farm) to inputs of production. Using a Cobb-Douglas production function equation, inputs significantly affecting the level of production in the highlands are: farm size (0.8809); levels of nitrogen (0.1262) and phosphorus fertilizer (.1328); age of farmer (-0.4610); and number of years in snap bean farming (0.1305). The 0.88 regression coefficient for land means that a 100% change in unit of land will increase output level by 88%, ceteris paribus. In other words, among the factors of production, a snap bean farmer's production is largely delimited by the land available.

With regards to other inputs, assuming other factors remain constant, a 100% change in the level of nitrogen and phosphorus fertilizers would result in a 25% increase in crop yield. Surprisingly, labor and chemicals, like insecticides and pesticides, do not significantly affect snap bean yield. This means these inputs are being used in excess of economically efficient levels and can be reduced without a detrimental effect on yield.

Among the management variables, the negative coefficient for age suggests that the younger farmers are better managers of snap bean farms. This could be due to more exposure to modern farming methods.

Under lowland conditions, the only significant physical input affecting snap bean yields is farm size (0.7759). Here cultural and management factors significantly affect snap bean yields. These factors include frequency of harvesting (0.2918), frequency of fertilizer application (0.2590), number of years in snap bean farming (0.1155) and depth of planting (-0.1266). The first three variables positively affect snap bean yield.

The production function analysis shows that the more frequent harvesting practiced by lowland farmers positively and significantly affects crop yield. In addition, use of a small dose of fertilizer during fruit development enables farmers to harvest more frequently and to get more pods per harvest.

The negative regression coefficient for depth of planting indicates that the current planting depth needs to be changed to enhance crop yield. The recommended planting depth of snap bean seeds is 2-3 cm (PCARRD, 1983), which is shallower than the average planting depth of 3.6 cm in the low elevation areas.

Among lowland farmers the use of insecticides also positively and significantly contributes to yield, with a production regression coefficient of 0.0873. With the marginal factor cost of insecticides being less than its marginal value product, it would pay for lowland farmers to invest more in these chemicals.

Efficiency analysis

Among the physical inputs included in the production function, only a few factors significantly affect snap bean yields: the size of the area devoted to snap beans (at both elevations); and nitrogen (N) and phosphorous (P) fertilizers, in the highlands only.

The level of N and P fertilizers made available to plants with the application of inorganic fertilizers like urea and complete fertilizers, significantly affects yields of snap beans at higher elevations. Use of inorganic fertilizers heavy on N and P contents may be increased further to enhance bean yields. For low elevation farmers, the use of organic and inorganic fertilizers has no significant effect on yield.

Results of the efficiency analysis show that these inputs are still below the efficient level as indicated by a ratio of MVP (Marginal value product) to MFC (Marginal factor cost) that is greater than 1. This means that an added unit of each of these inputs contributes more to returns than to cost and can be increased (For more details see table on "Efficiency analysis of significant inputs affecting snap bean production" in the full project report, Francisco and Domingo, 1988.)

Problems and Prospects for Specializing in Snap Bean Production.

With a net profit of US$ 988/ha/cropping season, most farmers interviewed consider snap bean production a profitable enterprise. Moreover, 39% of highland farmers and 25% of lowland farmers inferred they would specialize in the crop if favorable conditions prevailed. Of the highland farmers not wanting to specialize in snap beans (61%), 36% prefer to maintain a diverse cropping system, primarily to minimize the occurrence of soil-borne diseases. Another 23% consider snap beans only as a seasonal crop, while 20% regard heavy price fluctuation as a constraining factor, and 11% cite the input intensive nature of snap bean production their reason for not specializing in snap beans.

Among the lowland farmers, 31% of the 75% who would not specialize in snap bean production base their decision on its high input requirements. Some 24% think of snap beans as only a seasonal crop and 17% would not give up rice farming, as they need rice for home consumption. Almost all of the key farmers in the lowland areas cited snap beans as a very risky enterprise due to price fluctuations. Thus, farmers prefer to use only a small amount of land for snap beans and would not readily give up rice farming, despite the potential for more profits from snap beans. Rice is a buffer crop, ensuring farmers of something to eat in case the price of snap beans drops too low to make a profit.

While only few farmers expressed interest in specializing in snap bean production, 90% in the highlands and 85% in the lowlands are in favor of planting snap beans on a regular basis.

Production and Marketing Problems

In addition, a number of other specific production and marketing problems were mentioned by farmers as inhibiting their decision to specialize in or expand snap bean production. In the highlands the problem cited most often was the inadequacy of water supply, especially during summer. This was followed by the crop's susceptibility to insect pests and diseases, unavailability of seed and lack of capital.

Among lowland farmers, the major production problems are insect and disease control (82%) and inadequate water supply (58%). Other problems mentioned are lack of capital (48%), unavailability of seed (15%) and the poor quality of purchased seeds (5%). The fluctuating prices for snap beans also ranks as the top marketing problem.

While the major marketing problem experienced by farmers are the considerable price fluctuations[2] of the crop, other marketing problems include the failure of some contract buyers to pay the agreed price (on the pretext of a decline in price), and poor transportation facilities in the highlands, resulting in high transportation costs.

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2 According to the seasonal price index, the retail price of snap beans in Greater Manila and in the Ilocos region does not vary considerably. The reoccuring claim of fluctuating prices among snap bean producers, traders and even some government technicians was so frequent, however, it casts some doubt on the reliability of the BAS data collected. The average lowest price received by the farmers was P1.98/kg, while the average highest price was P9.72/kg. The average lowest price paid by consumers was P4.49/kg while the highest price was P13.15/kg. (See Table 19 and Appendix Tables 9 and 10 of the full report, Francisco and Domingo, 1988.)

Summary

1. Snap bean farmers generally rely on seeds produced on their own farms and/or purchase seed from other farmers.

2. The most popular snap bean cultivars are Black Valentine and Stonehill. Blue Lake Pak is gaining wider popularity due to its high yield.

3. The most common insects attacking snap beans are pod borer, beanfly, cutworm and thrips. Farmers use chemical sprays to control them. The most commonly used chemicals are Thiodan (endosulfan), Tamaron (metamidophos) and Lannate (methomyl). The average amount applied is 19.4 li/ha/cropping season. Insecticide is generally applied using an atomized spray during the vegetative to reproductive stages at nine-day intervals.

   Fungicides are used by 92% of highland and 75% of lowland farmers. The most common diseases attacking snap beans are stem rot and bean rust. These are controlled by mancozeb-containing fungicides.

4. Snap bean farmers use a combination of organic and inorganic fertilizers.

5. Cultural practices include planting at the rate of 3 seeds per hill with an average depth of 5.4 cm and 3.6 cm for high and low elevation farms, respectively. Plant spacing between rows averages 18.6 cm. Irrigation is by sprinkler method in the higher elevations while flooding prevails under lowland conditions. Plants are harvested once or twice a week.

6. The most favorable climatic condition for snap beans is the cool-dry season. Yields range from 9.8 to 12.6 tons/ha. The hot-wet season is the least favorable, with yields of 9.1-10.9 tons/ha.

7. Snap bean production is a profitable enterprise. The net return to highland farmers is US$1.004/ha (P20,080.13) and US$974/ha (P19,480.26) to lowland farmers. Despite a difference in snap bean yield between the two growing areas, the high cost of inputs and labor to highland farmers reduced their net returns to the same level as lowland farmers.

8. Producing snap beans is very labor intensive. In the highlands 440 person-days/ha are required and in the lowlands 355 person-days/ha. This offers full-time employment to a household of 3-4 members for the entire cropping season.

9. In deciding whether to expand or specialize in snap bean production, farmers are put off by the heavy price fluctuation and high input requirements of the crop. Production and marketing problems most often cited are: water supply, especially during summer; the crop's susceptibility to insects and diseases; lack of capital to finance the high cost of inputs; lack of seed; and the poor quality of seed.

Conclusions

Snap beans offer a profitable, alternative source of income to farmers at both high and low altitudes. Its high labor requirement offers farm families full-time employment, especially if snap beans are grown throughout the year. With varieties available for wet or dry conditions and warm or cold climates, snap beans can be planted for more than one cropping season. The high demand potential for snap beans adds to its promising future as a major cash crop.

In spite of the crop's profitability, snap bean farmers at both elevations can be helped in a number of ways. These measures would improve the economic potential of the crop:

1. Help farmers obtain high quality seed, particularly of the cultivars Blue Lake Pak, Stonehill and Black Valentine.

2. Provide more effective control of insects such as pod borer, beanfly, cutworm and thrips. These are still prevalent in despite heavy insecticide use. Current use of these chemicals in the colder, high-elevation areas is more than economically efficient. Farmers need more effective disease and insect control measures. In addition, farmers must be educated on the adverse and uneconomic effects of using more pesticides than recommended.

3. Encourage farmers to use more fertilizers containing nitrogen and phosphorus; these contribute positively to snap bean yields.

4. Encourage farmers to apply small doses of urea at the fruit-development stage to encourage more frequent harvesting. This practice contributes positively to yield.

5. Educate lowland farmers on the proper planting depth of snap bean seeds. The current depth of 3.6 cm results in yield reductions. Recommended planting depth is 2-3 cm.

6. Provide financial assistance to farmers to reduce their reliance on input suppliers. This is a critical factor, especially for highland farmers.

7. Assist farmers in marketing snap beans to areas far from the production sites. This should include creating consumer awareness about the value of the crop. Promoting demand for snap beans is necessary if production is to be encouraged. Without a corresponding increase in demand, an increased snap bean supply cannot be sustained.

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Table 1. Characteristics of snap bean farmers by elevation, Philippines, 1987-88.

FARM CHARACTERISTICS	HIGH ELEVATION				LOW ELEVATION				ALL AREAS			
	No. of farmers (%)	Avge. farm size (ha)	Bean area (ha)	% of farm	No. of farmers (%)	Avge. farm size (ha)	Bean area (ha)	% of farm	No.of farmers (%)	Avge.farm size (ha)	Bean area (ha)	% of farm
Land Area												
Small (< 1 ha)	76	0.34	0.20	59	38	0.40	0.24	60	57	0.36	0.22	61
Medium (1-2 ha)	16	1.15	0.31	27	55	1.33	0.42	31	35	1.29	0.40	31
Large (>2 ha)	8	6.06	0.28	5	7	3.64	0.89	24	8	4.93	0.57	12
All farms	100	0.93	0.23	25	100	1.14	0.39	34	100	1.03	0.31	30
Number of parcel												
1 parcel	39				62				51			
2 parcels	33				28				30			
3 parcels	19				5				12			
4-5 parcels	7				5				6			
6-7 parcels	2				-				1			
Slope of the farm												
Hillside	53				15				34			
Level	21				73				47			
Terraced	5				-				2			
Hillside and level	20				12				16			
Level & terraced	1				-				1			
Soil type												
Clay loam	40				13				26			
Sandy loam	11				18				14			
Loam	38				41				49			
Silty loam	1				-				1			
Sandy clay loam	-				28				14			
Source of water												
Rainfed	45				36				41			
Irrigated	55				64				59			

Table 2. Insect and disease control in snap bean production by elevation, Philippines, 1987-88.

CONTROL METHOD	HIGH ELEVATION		LOW ELEVATION		ALL AREAS	
	Insecticide	Fungicide	Insecticide	Fungicide	Insecticide	Fungicide
Control farmers use (%)	100	92	100	75	100	84
Moment of application (%)						
Vegetative stage only	-	9	4	40	2	23
Reproductive stage only	13	23	17	7	15	15
Veg. to reproductive stage	87	68	79	53	83	62
Purpose of application (%)						
Stem rot control	-	80	-	79	-	80
Bean rust	-	70	-	67	-	68
Thrips	47	-	63	-	55	-
Beanfly	58	-	79	-	68	
Cutworm	60	-	67	-	64	-
Pod borer	65	-	84	-	75	-
Mites	6	-	-	-	3	-
Other minor diseases	-	-	-	-	-	4
Quantity applied per cropping season						
(li/ha)	19.6		19		19.4	
(kg/ha)		16.5		6.4		11.5
Interval (days)	9	9	10	9	9.5	9

Table 3. Per hectare labor use in snap bean production by farm operation and elevation, northern Philippines, 1987-88.

FARM OPERATION	HIGH ELEVATION (person-days)	%	LOW ELEVATION (person-days)	%	ALL AREAS (person-days)	%
1. Land preparation						
operator	22		9		15	
family	11		5		8	
hired	38		7		22	
Total	71	16	21	6	46	12
2. Fertilizing						
operator	5		5		5	
family	7		4		6	
hired	8		15		11	
Total	20	5	24	7	22	5
3. Planting						
operator	4		2		3	
family	7		3		5	
hired	11		18		14	
Total	22	5	23	7	22	5
4. Hilling-up						
operator	10		3		6	
family	10		2		6	
hired	5		2		4	
Total	25	6	7	2	16	4
5. Insect and disease control						
operator	39		17		28	
family	10		8		9	
hired	2		31		17	
Total	51	12	56	16	54	14
6. Weed control						
operator	8		8		8	
family	19		9		13	
hired	26		55		41	
Total	53	12	72	20	62	16

Table 3. Cont.

FARM OPERATION	HIGH ELEVATION (person-days)	%	LOW ELEVATION (person-days)	%	ALL AREAS (person-days)	%
7. Irrigation						
operator	29		10		20	
family	12		4		8	
hired	2		1		1	
Total	43	8	15	4	29	7
8. Trellising						
operator	10		7		9	
family	8		4		6	
hired	2		10		6	
Total	20	5	21	6	21	5
9. Harvesting						
operator	24		14		19	
family	33		14		24	
hired	40		55		47	
Total	97	22	83	23	90	23
10. Post-harvest operation						
operator	16		14		14	
family	12		6		9	
hired	10		16		13	
Total	38	9	33	9	36	9
ALL OPERATIONS						
operator	167		86		127	
family	129		59		94	
hired	144		210		177	
TOTAL	440	100	355	100	397	100

Table 4. Cost and return analysis of snap bean production, northern Philippines, 1987-88.

	HIGH ELEVATION		LOW ELEVATION		ALL AREAS	
	Per ha	Per kg	Per ha	Per kg	Per ha	Per kg
YIELD (t)	11.4		9.4		10.4	
GROSS RETURN (P)	49,481.26	4.38	40,408.42	4.28	44,963.14	4.32
COST OF PRODUCTION (P)						
A. Material Inputs						
1. Seeds	2,580.48	0.23	2,402.85	0.25	2,491.66	0.24
2. Organic fertilizer	793.21	0.07	45.00	0.00	419.11	0.04
3. Inorganic fertilizer	3,272.29	0.29	2,903.28	0.31	3,087.78	0.30
4. Insecticide	1,743.63	0.15	1,921.59	0.20	1,832.61	0.18
5. Fungicide	1,040.14	0.09	660.95	0.07	850.50	0.08
6. Trellis (Depreciation)	1,223.97	0.11	1,165.10	0.12	1,194.54	0.12
7. Packing materials	133.12	0.01	340.48	0.04	263.80	0.02
Sub-Total	10,786.84	0.95	9,439.25	1.00	10,113.00	0.97
B. Labor Cost						
1. Non-cash labor	9,016.46	0.79	3,201.31	0.33	6,108.90	0.56
2. Cash labor	4,396.09	0.39	3,998.96	0.42	4,232.54	0.41
Sub-total	13,412.55	1.18	7,200.27	0.76	10,341.44	0.97

Table 4. (Cont.)

C. Others						
1. Irrigation fee	32.06	0.00	81.00	0.01	56.53	0.01
2. Tax/rent on land	137.59	0.01	989.85	0.10	563.72	0.06
3. Transport cost	2,490.78	0.22	1,830.56	0.19	2,160.67	0.21
4. Food for laborer	656.09	0.06	240.10	0.02	430.10	0.04
5. Depreciation	1,885.22	0.17	1,183.13	0.13	1,534.18	0.15
Sub-total	5,201.74	0.46	4,228.64	0.45	4,745.20	0.46
TOTAL COST	29,401.13	2.59	20,928.16	2.21	25,199.64	2.40
RETURNS ABOVE CASH COST	29,096.59	2.59	22,681.57	2.41	25,872.39	2.48
RETURNS ABOVE ALL COST	20,080.13	1.80	19,480.26	2.07	19,763.49	1.92
RETURN TO LABOR	2.50		3.70		2.91	
RETURN TO CURRENT MATERIAL INPUT	2.53		2.87		2.71	
B/C RATIO	1.68		1.93		1.78	

US$1 = P20.00

Table 5. Production function estimates for snap beans in the northern Philippines, 1987-88 (per farm and by elevation).

INDEPENDENT VARIABLES	ELEVATION High	Low	ALL AREAS
Area	0.8809***	0.77589***	0.8464***
Pre-harvest labor (person-days)	-0.0065	0.0349	0.0234
Seeds (kg)	-0.0419	-0.0525	-0.0468
Insecticides	-0.0709	0.0873	-0.0042
Fungicides	-0.0167	-0.0136	-0.0015
Organic fertilizer	0.0067	0.0143	0.0092
N-inorganic fertilizer	0.1262**	0.0450	0.0667
P-inorganic fertilizer	0.1328***	-0.0156	0.0499
K-inorganic fertilizer	-0.0112	0.0155	-0.0117
Foliar fertilizer	-0.0060	-0.0258	-0.0077
Dummy for variety used			
D_1 = 1 if new, 0 otherwise	0.0208	-0.0097	0.0141
D_2 = 1 if old, 0 otherwise	-0.0156	-0.0643	-0.0375
Frequency of fertilizer application (no. of times/cropping season)	-0.1399	0.2590**	0.1726**
Frequency of harvesting (no. of times/cropping season)	0.0418	0.2918***	0.1694***
Distance between rows in planting (cm)	0.1067	0.0164	-0.0101
Depth of planting (cm)	-0.0549	-0.1266*	-0.0209
Age of farmer	-0.4610***	-0.0445	-0.2872***
No. of years in snap bean farming	0.1305**	0.1155**	0.1221***
No. of years in school	0.0133	0.0215	-0.0024
Constant	4.4408	3.0898	3.9071
R^2	0.8536	0.8848	0.8455
Multiple R	0.9239	0.9406	0.9195

*** significant at 1% level
** significant at 5% level
* significant at 10% level

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SNAP BEANS IN THE EUROPEAN ECONOMIC COMMUNITY

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Abstract

Within the EEC, Italy, Spain and France are the major producers of snap beans, based on area cropped. While the area planted to snap beans has decreased slightly over the last years, yields have increased. Round-podded climbing and bush type snap beans represent the bulk of production. Climbing types are preferred for the fresh market, though bush types are gaining in popularity among producers. Recently, an increase in the area planted to snap beans in greenhouses, especially in Greece, Italy, Portugal and Spain, has extended the crop's commercialization period. The major problem affecting snap bean production is diseases, in particular anthracnose, BCMV and bacterial blight. The priority research objective is to introduce genetic resistance to these diseases.

Introduction

Snap bean cultivation is widespread throughout the world, occupying an outstanding position within horticultural production in many countries. The most important production areas are in Europe and Asia, which account for 80% of world production. Table 1 provides data on the area planted to snap beans, production and yields (FAO, 1986).

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Within the European Economic Community, Italy, Spain and France, in that order, are the largest snap bean producing countries based on the surface area cropped. However, the highest yields have been obtained in the F.R.Germany, Belgium and the Netherlands (Table 1).

An analysis of the data for the EEC between 1981 and 1986 shows a slight reduction in total surface area cultivated (9%) and in total production (3%), but an increase in yields (6.7%). The increase in yields is a result of the use of cultivars resistant or tolerant to diseases, less losses during mechanical harvesting, and a better knowledge and application of production techniques. It also reflects changes in the structure of farming and shifts in varietal preferences among farmers, consumers and the processing industry.

Concerning farm structure and cropping systems, small plots are being substituted for larger plots. An increase in surface area cropped in greenhouses has come about in Greece, Italy, Portugal and Spain. This extends the crop's commercialization period, resulting in a longer available supply. An increase in the surface area planted to bush type varieties adapted to mechanical harvesting has also occurred. Industrial demand for these varieties at competitive prices is increasing due to growing consumer preference for these products. Climbing varieties too, preferably with a flat pod, have good acceptance when grown in greenhouses. Besides their popularity in the fresh market, their higher yield per unit of area and prolonged harvesting period permits growers to obtain an adequate average price.

Development of New Varieties

The priority objective has been and continues to be the introduction of genetic resistance to the principal diseases that affect snap beans in Europe. The biggest problem is anthracnose, followed by BCMV and bacterial blight.

The discovery of the Are gene, described in 1960 (Fouilloux, 1979), capable of controlling all the races of anthracnose then known, allowed the obtention in 1968 of the first resistant cultivars, coming from the Netherlands and France (some also with resistance to BCMV). Starting in 1974, all the French cultivars destined for processing combined the two resistances, replacing the old cultivars. Since the appearance (after 1974) of new races of anthracnose capable of overcoming the Are gene and the identification of new sources of resistance against them (Fouilloux, 1976), the effort to obtain cultivars with complete resistance has been maintained.

With regard to BCMV, the scarce incidence of black root, and thus its minor economic importance, has caused resistance sources with the I gene to have been the ones primarily used up to now.

Work on the introduction of resistance to bacterial blight was begun in 1965. In 1978, a highly tolerant cultivar was obtained at the Institut National pour la Recherche Agronomique (INRA). In spite of the greater complexity of the genetic determination of this resistance (Fouilloux, 1975), several cultivars have genes against all three principal diseases mentioned.

Regarding other diseases, caused by Bean Yellow Mosaic Virus (BYMV), Fusarium, Sclerotinia, Botrytis and Rhizoctonia, improvement work has been much less intensive due either to the minor economic importance of the disease or to the lack of sources of resistance or variability.

A second objective pursued has been cultivar tolerance to herbicides, although the effort has concentrated principally on developing new, more selective and less phytotoxic herbicides.

Another important objective relates to the improvement of pod quality, both for those varieties destined for fresh consumption and those destined for industry. Until now, quality, apart from the phytosanitary aspects, has focused on the external characteristics. These include: pod color, shape, straightness, length and diameter, and uniformity of pod size, color and bean size (Fouilloux, 1979).

Finally, progress has also been made in an area of major economic and social significance — adaptation of the snap bean crop to mechanical harvesting. Different aspects related to plant architecture, root development, physiology of fruiting and other factors have been taken into account in developing the most appropriate strategy based on the type of snap bean and the existing availability of machinery (Bouvy, 1979).

Of all the types of green snap beans grown in the European Economic Community, the one that has merited greatest attention up to now has been the haricot type (pods without string or sidewall fiber) Other types, with a notable commercial demand and of excellent quality, lack resistance and other agronomically useful features and should be taken into account in future improvement work.

Most Important Current Varieties

The following is a classification of market needs for green snap beans in the European Common Market. Specifications for very select markets would increase the complexity of these classifications, thus discussion is limited to those snap bean types listed.

Flat-podded varieties: fresh market

Bush:	yellow, green
Climbing:	yellow, green

Round-podded varieties: fresh market, industry

Bush:	yellow, green
Climbing:	green

Snap Beans with Yellow Pods (Wax Beans)

These varieties represent only 5% - 8% of total production. While some countries, such as France, England and Germany, do have a tradition in their consumption, generally they are only of interest to the fresh market. Industry shies away from light colors. The most popular varieties do not have many characteristics in common,as they are adapted to the needs of local markets. However, high production, uniformity in pod type, and uniformity in pod color are universally sought. The most commonly grown climbing type wax bean varieties are: Rocquencourt Wax and Oro del Rhin. Kinghorn, Sungold, Saxa Gold and Dorina are the most commonly grown bush type wax beans.

Snap Beans with Green Pods

Flat-podded varieties

Varieties with flat pods are basically intended for the fresh market. However, when there is an excess of production and the fresh market cannot absorb them they are used by the processing industry. For processing the pods are always cut lengthwise or in cross-section, copying the industrial process used in the United States).

Bush types. Mechanical harvesting is not yet possible for these varieties. Therefore, production costs are high. These varieties cannot be produced competitively enough for industry. Only the fresh market can absorb the higher production cost.

Selection characteristics are as follows:

- pod length of 10-25 cm;
- absence of suture string and sidewall fiber;
- tolerance to transporting;
- uniformity of color;
- uniformity of pod size and shape;

- high productivity;
- resistance to pests and diseases.

Varieties most commonly grown are: Garrafal Enana, Romano and Plano. In general, these types of snap beans are receding in importance due to the excellent production and quality improvements achieved with green, round-podded bush varieties.

Climbing types. Improvement programs focusing on green, flat-podded climbing snap beans have produced excellent varieties, combining good quality and high productivity in types sought by the market. In particular strides have been made in adapting those varieties grown in greenhouses. Pods reach lengths of 25-30 cm and a width of 3 cm. In general, the pods are very fleshy and of an excellent cooking quality.

Varieties with dark-colored mottled pods have important markets, although very selective ones, that do not permit changes in varieties even when these varieties are very similar.

Selection characteristics include:

- pod length of 25-30 cm;
- absence of stuture string and sidewall fiber;
- tolerance to transporting;
- uniformity of color;
- uniformity of pod size and shape;
- high productivity;
- resistance to pests and diseases.

The most commonly grown varieties are: Garrafal Oro, Buenos Aires, Jiménez, Semilarga, Helda, Femira, Precoces, Selka and Zondra.

Round-podded varieties

This classification of snap beans represents the bulk of snap production.

Market demand emphasizes these types of beans. Genetic improvements achieved make it possible to provide the market with a quality product at competitive prices.

Bush types. Green, round-podded bush snap beans are produced for industry. These bush type snap beans as opposed to the flat-podded bush types can be mechanically harvested resulting in an excellent-quality product and competitive prices and supply.

Selection characteristics are:

- grouped production;
- adaptation to mechanical harvesting;
- erect, cylindrical and shiny, dark-green colored pods;
- uniformity of thickness;
- high productivity;
- resistance to pests and diseases.

With regard to thickness, the processing industry tends to prefer extra fine beans (5-8 mm).

A change with regard to seed color is also occurring. In the beginning, the most popular varieties had a dark seed color, but later they were substituted by white-seeded varieties, since the quality obtained after industrial processing was superior to that of the dark-seeded varieties.

Most popular varieties are: Eagle, Strike, Gator Green-15, Gallatin 50, Greencrop, Bush Blue Lake, Fin de Bagnols, Harvester, Michelet, Mistral, Prelude, Delinel (black seed), Camile (black seed) and Triomph de Farcy. The varieties mentioned are of American or French origin.

Climbing types. These are varieties are intended primarily for the fresh market and are grown mostly in greenhouses. Delivery to industry occurs only when a production excess allows the industry to obtain low-cost snap beans. The impossibility of mechanization impedes a regular supply at competitive prices.

Selection characteristics are:

- round and long pods (12-25 cm);
- dark-green uniform color;
- high productivity;
- resistance to pests and diseases.

The most commonly grown varieties are Blue Lake FM and Emerite (black seed).

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le 1. Comparative data on surface area, production, and yield of snap beans around the world.

	Surface area (x 1000 ha)				Production (x 1000 t)				Yield (kg/ha)			
	1979-81	1984	1985	1986	1979-81	1984	1985	1986	1979-81	1984	1985	1986
ld	429	448	446	445	2,697	2,937	2,927	2,991	6,289	6,560	6,568	6,724
frica	27	31	33	39	170	192	201	269	6,227	6,100	6,021	6,895
orth America	39	36	35	35	219	210	202	203	5,588	5,878	5,764	5,781
outh America	26	30	22	23	107	111	70	79	4,088	3,720	3,251	3,375
sia	164	187	196	189	1,002	1,221	1,258	1,248	6,127	6,516	6,429	6,602
ceania	8	8	8	8	46	43	42	42	5,709	5,614	5,021	5,052
urope	164	156	152	150	1,153	1,161	1,155	1,151	7,022	7,451	7,609	7,662
opean EEC-12	111	118	104	101	931	943	928	904	8,387	7,991	8,923	8,950
. Germany	4	4	4	4	44	37	41	46	10,022	10,459	11,165	11,478
elgium-Luxembourg	3	5	4	4	28	47	41	44	9,578	9,782	11,081	11,474
enmark	--	--	--	--	1	1	1	1	5,526	5,278	5,278	5,278
rance	14	14	14	14	81	85	86	88	5,735	6,103	6,106	6,119
pain	25	27	26	26	225	258	280	244	9,020	9,555	10,572	9,385
reece	10	9	5	8	78	75	74	74	8,095	8,333	9,250	9,188
etherlands	6	5	6	6	69	54	56	57	11,898	10,000	9,333	9,845
ngland	9	7	7	7	80	77	67	68	8,760	10,416	9,040	9,444
taly	37	34	32	29	295	280	252	263	8,011	8,347	7,946	8,669
ortugal	3	3	3	3	30	29	30	29	9,781	9,667	10,000	9,063

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SNAP BEAN BREEDING IN CHINA

Li Peihua 1/

Abstract

China is classified as a secondary center of genetic diversity for snap bean. It is also the major producer of snap beans in the developing world. Although farmers' local cultivars are most often used in commercial production, China has an active program to introduce and breed new cultivars. Selection criteria include early maturity, high yield, disease resistance and good quality, with emphasis on disease resistance. Yunfeng and Chunfeng 4 are just two of the varieties developed and successfully extended for commerical production. Snap beans suitable for processing are also being developed.

Introduction

Phaseolus vulgaris L. is used in China both as a pulse (dry bean) and as a vegetable (snap bean). Estimating the bean production area is difficult due to lack of reliable data. Teng Pingya et al. (1982) estimated the total dry bean area in China at 4.3 million hectares (ha) in 1979. However, it is not certain if this includes other pulses besides Phaseolus vulgaris. The area planted to snap bean has been estimated to be as little as 50,000 ha and as much as 250,000-300,000 ha (Henry and Li Peihua, 1989). The difference between these estimates is typical of the lack of agriculture data in China. The area planted to snap beans year round in the Beijing municipality is between 2,200 and 2,500 ha. Spring plantings use half of this area and summer plantings 40%. In the fall and winter snap beans are grown in greenhouses (Li Mingyuan et al., 1987).

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Snap beans have a medium-nutritional value, good taste and are a favorite vegetable in the Chinese diet. Snap beans are planted widely in China, especially in the north. In the northeast provinces of Heilongjiang, Jilin and Liaoning snap bean occupies 90% of the total bean area (Wang Su et al., 1989). In the northeast and northwest of China, beans are generally sown in the spring. Other areas sow in spring and autumn.

Snap Bean Cultivars in China

According to the literature P. vulgaris was introduced into China at the end of the 16th century (VRI/CAAS, 1987). Hundreds of years of natural evolution and artificial selection have resulted in a rich genetic diversity. Vavilov's Origin of Species identifies China as a secondary center of origin for snap bean (P. vulgaris L. var. chinesis). Chinese snap bean varieties are diverse, indeed, with different growth periods and growth habits, pod colors and pod shapes (CAAS, 1959; Wu Kiqing et al., 1985). Recently, more than 2000 local bean accessions were collected nationwide, evaluated and put into long-term storage.

China is a large country with a wide range of climates, production conditions and consumers preferences. Generally, local climbing type snap beans suitable for fresh consumption are used for commercial production. The characteristics of commercial cultivars in northeast China include a broad, stringless pod with light-green and purple stripes, and uniform seed development. Hong Huapi, Zihuapi, Dahuapi are popular cultivars. In the east and center of China the cultivars are French types with round, short, light green pods. Fresh pods have a few strings. Seeds develop slowly, but fiber content increases as the pod ripens. Varieties widely used are Shanghai Baizichangqi, Shanghai Heizichangqi, Nanjing Baizijiadou and Nanjing Hezijiadou. Characteristics of some local cultivars are shown in Table 1.

Present Status of Snap Bean Improvement

Although farmers' local cultivars are most often used in commercial production in China, introduction and hybridization play an important role in bean breeding. At present the aim of snap bean breeding is to select varieties that ripen early, are high yielding and disease resistant, have good fresh eating quality and are suitable for open field production. Good quality means that in taste tests the pod flesh has little or no fiber and a good flavor.

Introduction of snap beans

Introduction of new varieties is an important means of increasing the number of cultivars for commercial bean production. Several early maturing, high yielding and good quality cultivars for commerical production have been selected. There is little bush bean germplasm in China. Especially lacking are early maturing, high yielding, dwarf accessions. Most of the beans introduced from abroad and channeled into commercial production are dwarf accessions. Some cultivars appear to have good adaptation.

For example, the bush bean Saxa introduced from Poland in the early 1980s is one of the main cultivars in commercial production in Jilin Province, where it occupies half the bean production area. Liaoning, Heilongjiang, Hebei and Shandong provinces have some land under bush bean production as well. In addition, during the 1960s the Institute of Vegetables and Flowers (IVF) of the Chinese Academy of Agricultural Sciences (CAAS) introduced the bean cultivars Contender from France and Fullcrop from the United Kingdom. These were extended to 20 provinces and municipalities.

In the 1970s CAAS introduced the bush bean Provider from the United States and extended it to more than 20 provinces and municipalities. It is now the main cultivar used for commercial production in Inner Mogolia, Shanxi, Jiangsu provinces and Wuxi, and Suzhou city, among others. It is produced on more than 7000 ha yielding 15-22.5 tons of fresh pods per hectare. Characteristics of important introduced cultivars are listed in Table 2.

These bush beans are not only useful in monoculture but can also be intercropped with cotton, watermelon and other crops, generating more income per unit area for the farmer.

Genetic Improvement

Hybridization is the principal of method used to develop new snap bean varieties. Varieties with high yielding characteristics and superior combining ability are selected as parental materials. Using the pedigree method of selection, stable lines exhibiting the desired characters of the parent varieties are selected from the progeny of successive segregating generations.

The Dalian Institute of Agriculture bred a new cultivar, Yunfeng, in 1982 (Song Haitan, 1986). The local elites Huapilian and Jiulibai were used as parents. Progeny progressed through 5-6 generations of pedigree selection before the new cultivar was released and extended to three northeast provinces and Shannxi, Henan province. Area of production has expanded to 3,300 ha. The new cultivar appears highly resistant to Bean Common Mosaic Virus (BCMV) and tolerant to anthracnose and rust. It ripens early, is highly productive, is daylength insensitive and suitable for open field production in spring and autumn. From 1982-1985, yields ranged from 12.8-30.0 tons fresh pods/ha, with an average of 23 tons/ha, 20.7% higher than the main local cultivar.

The Tianjin Institute of Vegetable Crops used Fenshon as a parent in crosses with local bean cultivars, developing several new varieties. Chunfeng 2 and 4 are suitable for spring sowing, while Kangqiu 6 and 19 are suitable for autumn sowing. These cultivars were released for the Tianjin district. Principal characteristics of introduced and developed cultivars released are shown in Table 2. In addition, other snap bean breeding programs have identified promising materials and evaluated them on a smaller scale.

Inheritance studies for various snap bean characters

In recent years studies on the heritability of certain bean characters have provided some guidance in selecting parental materials for use in crossing programs. The main results are summarized in Tables 3, 4 and 5.

The CAAS Institute of Vegetables and Flowers and the Institute of Plant Germplasm analyzed 14 bush bean cultivars with 10 quantitatively inherited characters. Results are presented in Table 3. In the same year, 1981, Tianjin Institute of Vegetable Crops analyzed 12 quantitative characters of 10 climbing snap bean cultivars and newly released lines (Yue Bin et al. 1983). (Table 4).

In a 13-year (1970-1983) investigation of the inheritance of qualitative characters, Tianjin Institute of Vegetable Crops used 20 bean cultivars for 15 different crosses, and analyzed the inheritance of flower color (Yue Bin, 1988). In 1985-1986 they studied the heritability of rust resistance and rust susceptibility (Yue Bin et al., 1987).

Prospects for Snap Bean Breeding in China

Bean production is seriously affected by the following diseases: bean wilt, Fusarium oxysporum f. sp. phaseoli); BCMV; bean anthracnose, Colletotrichum lindemuthianum (Sacc. et Magn.); bean rust, Uromyces appendiculatus (Pers.); and bean bacterial diseases, Xanthomonas phaseoli (E.W. Smith) Dowson etc. In some districts and in some years yields are substantially reduced by diseases. In the future the main objective of bean breeding will be disease resistance. For snap beans, selection criteria will also include lack of strings and high seed protein content. These are not only suitable for the fresh market, but also meet the needs of the developing processing industry that freezes and cans snap beans for export and off-season local demand.

Finally, an adequate supply of germplasm is the basis of any bean breeding program. In China, it is critical for the intensification of bean breeding efforts and identification of new cultivars with disease resistance, high yield potential and good quality. Since 1986 a national project titled "Study on Characteristics of Snap Bean Germplasm", under the auspices of IVF, CAAS, has been evaluating more than 2000 accessions collected in China for disease resistance and quality factors. The aim is to exploit local cultivars for commercial production and breeding purposes. However, this research is still in an early stage. The evaluation of disease resistance is limited to bean wilt and anthracnose, with plants inoculated at a seedling stage. Evaluation of quality is limited to crude protein in fresh pods and crude fiber content. Nonetheless, good progress is being made.

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Table 1. The agronomic characteristics of some local cultivars.

Cultivars	Plant type	Pod cross-section	Pod color	Pod weight (g)	Pod length (cm)	Pod suture (string)	Pod wall (fiber)	Pod maturily (date)	Region of cultivation
Zihuapi	Climbing	Very flat	Green & purple stripes	9.5	11.4	Stringless	No	Late	Northeast China
Honghuapi	Climbing	Very flat	Green & red stripes	7.8	13.9	Stringless	No	Late	Northeast China
Damazhang	Climbing	Very flat	Green & purple stripes	9.7	14.3	Stringless	No	Late	Northeast China
Jiang dongkuan	Climbing	Very flat	Green	7.7	13.7	Stringless	Few	Early	Northeast China
Shuang jidou	Climbing	Round-elliptic	Green	10.7	17.4	Few strings stringless	Few	Early	Northeast China North China
Shanghai Baizi-changqi	Climbing	Round-elliptic	Green	7.3	11.8	Very stringy	Few	Early	East, South China
Shanghai heizi-	Climbing	Round-elliptic	Green	8.8	12.9	Very stringy	Few	Early	East China
Gingdao-jiadou	Climbing	Pear shaped	Light green	13.4	18.4	Very stringy	Medium	Medium	North, East China
Shanyang gicunlian	Climbing	Round-elliptic	Green	17.4	20.1	Few strings stringless	No	Medium	North China
Jiaoxian liaolai-shao	Climbing	Approaching round-elliptic	Green	19.2	13.7	Very stringy	No	Early	North, East China

Table 2. The agronomic characteristics of important introduced and developed cultivars.

Cultivars	Plant Type	Pod cross-section	Pod color	Pod weight (g)	Pod length (cm)	Pod suture (string)	Pod wall (fiber)	Pod maturity (date)
Saxa	Bush	Round-ellipitic	Light green	5.6	11.8	Few strings	No	Early
Contender	Bush	Approaching round-ellipitic	Light green	11.9	18.4	Few strings	No	Early
Provider	Bush	Round-elliptic	Green	8-10	14.0	Few strings	No	Early
Yunfeng	Climbing	Round-ellipitic	Light green	13.9	22.8	Very stringy	No	Early
Chunfeng 4	Climbing	Round-ellipitic	Green	19.4	21.0	Very stringy	No	Early

Table 3. Heritability, genetic variability coefficient and genetic advance of 14 bush bean cultivars with 10 quantitative inheritance characters (Bejing 1981, 1982).

Characters	Plant height	Plant width	Days to flowering		Shoots per plant	Pod per plant		Pod weight		Pod length	Pod width	Pod thickness	Yield per * plot	
Year	1981	1981	1981	1982	1982	1981	1982	1981	1982	1982	1982	1982	1981	1982
Heritability %	77.6	82.4	63.6	81.9	57.6	53.8	55.3	86.1	85.0	76.7	56.6	80.1	79.2	75.3
Genetic variability coefficient %	15.0	10.0	3.8	4.8	11.0	25.2	14.6	16.8	17.2	7.0	4.3	8.0	39.4	39.7
Genetic advance (relative value) 5% (percentage selection)	27.0	18.4	6.2	8.9	17.1	38.0	22.4	32.0	32.6	12.5	6.6	14.7	72.3	71.0

* The area of plot = 6.44m^2

Table 4. Heritability, genetic variability coefficient and genetic advance of 10 climbing beans cultivars with 12 quantitative inheritance characters (Tianjin, 1981).

Characters	Mean internode length	Nodes on main stem	Shoots per plant	Days to flowering	Node number on main stem from base to first infl-orsens	Plant height	Pod per plant	Pod weight	Pod length	Seeds per pod	Seed yield per plant	Pod setting ratio
Heritability %	93.9	61.3	91.9	91.6	85.3	79.7	78.7	63.8	69.9	60.8	52.3	31.2
Genetic variability coefficient %	22.2	7.0	38.8	5.9	20.0	16.0	29.7	12.3	7.4	9.5	20.2	8.6
Genetic advance (relative value) 5% (percentage selection)	45.6	8.8	66.7	11.7	37.9	29.3	54.5	20.3	12.8	15.3	30.1	9.1

Table 5. Inheritance of flower, seed cost patterns, plant type and rust resistance in common bean (Tianjin, 1970-1983, 1985-1986).

Parent	F_1	F_2 Segregation ratio
white flower (wf) X wf	pf	pf:wf 9:7
wf X purple flower (pf)	pf	pf:wf 3:1
seed coat with patterns (scwp) X seed coat without patterns (scwop)	scwp	scwp:scwop 3:1
bush type (bt) X climbing type (ct)	ct	bt:ct 3:1
rust resistant (rr) X rust susceptible (rs)	rr	rr:rs 3:1

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SNAP BEAN BREEDING IN THE USA

Michael H. Dickson 1/

Abstract

Snap bean breeding in the USA is being reduced by public breeders and increased by seed companies. The major programs are by the USDA at Prosser, Washington State, and at Beltsville, Maryland. Oregon State University, the University of Wisconsin and Cornell University at Geneva, New York, have large snap bean breeding programs. Many other institutions with dry bean programs spin off related research that can be beneficial to the snap bean programs. The major areas of research are root rot, white and grey mold, brown spot and rust resistance, heat and cold tolerance, and improved architecture. The seed companies use the germplasm produced by the public breeders and are particularly interested in brown spot, root rot and white mold resistance, and heat tolerance. These problems are causing economic losses to both growers and seedsmen. The seed companies have research programs primarily in California and Idaho, and field plot trials in many states, especially Wisconsin, which has the largest acreage for processing. Many companies have winter nurseries in Florida, which also cater to the special fresh market potential there.

Introduction

Snap bean breeding in the United States is limited to relatively few programs at public institutions. The United States Department of Agriculture (USDA) program at Prosser, Washington State, managed by Dr. Silbernagel, tries to cater to nationwide needs. So does the rust

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resistance program of Dr. Stavely at Beltsville, Maryland. The other programs are state programs, but the benefits are usually nationwide. The major exception is that of Dr. Bagget at Oregon State University. His program benefits primarily Oregon growers because of their specific pod needs and the response of the Blue Lake beans he produces, which only do well in Oregon.

Other major programs are at the University of Wisconsin on disease resistance and nitrogen production. They are in a state of flux due to the retirement of Dr. Hagedorn and the relocation of Dr. Bliss to California. Dr. Bliss' program, however, will be continued as soon as a new breeder is hired.

In New York, at Cornell University, I have a fairly large snap bean program on heat and cold, white and grey mold, root rot and brown rot resistances. Dr. Bassett heads a program in Florida. Dr. Mullins in Tennessee heads up the Southern Cooperative Bean Trial, which tests snap beans for adaptability throughout the southern states. This trial tends to be a test for fresh market beans rather than for processing beans.

The commercial breeding programs are focused at Asgrow Seed Company, Rogers Seed Company, Ferry Morse Seed Company, Harris Moran Seed Company, Delmonte Corporation, and to a lesser extent Canners Seed Company and Pure Line Seed Company. These companies do their research either in Idaho or California, but have variety testing programs throughout the country. These companies are all trying to develop new varieties for sale. In most cases they are adding disease resistances as they become available from the public institutions. However, certain diseases take priority since they are causing greater economic losses. Bacterial brown spot is a major concern and most companies are trying to develop new cultivars with resistance. A number of sources of resistance are available, with BBL 94 having good resistance as well as some of the proprietary lines from Del Monte. Dr. Hagedorn, formerly with the University of Wisconsin, developed most of the sources of resistance. Resistance, though, is quantitative and the genetics are not fully understood.

Dry bean programs, which are often much larger than the snap bean programs, to provide both germplasm and practical screening systems which can be used by snap bean breeders. There is a lack of exchange between the research efforts, though, as in most cases the breeder specializes either in snap bean or dry bean breeding.

There are several types of snap beans. The old pole types are often also grown for green shelled or half-ripe seed as well as dry seed. The Blue Lake types are dark green and large sized with slow seed development. Another type of green bean is more slender and has lighter colored pods. Five percent (5%) of the crop are wax beans, and recently there has been an interest in the Italian type with its wide flat pods and strong bean flavor. The proportion of research on these types approximates their importance.

I will now try and discuss some of the major breeding programs.

USDA at Prosser, Washington State

Dr. Matt Silbernagel is interested in virus resistance, especially to Bean Common Mosaic Virus (BCMV) and its variants, and to curly top virus which is a problem in the western states.

He also has a program to develop root rot resistance to Pythium, Fusarium, and more recently to Aphanomyces, which has become a problem in Wisconsin, the major processing bean state. He is particularly interested in Blue Lake type beans and in heat tolerance.

USDA at Beltsville, Maryland

Dr. Rennie Staveley is primarily interested in rust resistance. He coordinates the national rust resistance nurseries, screens germplasm for new sources of rust resistance and analyzes the inheritance of resistance and the linkages for resistance to the many races of rust. He works with both dry beans and snap beans and releases advanced germplasm with rust resistance to other interested breeders.

Oregon State University

Dr. Jim Baggett is a breeder who is almost exclusively breeding Blue Lake type snap beans for use in Oregon. Under Oregon conditions these lines do very well, but they do not appear to be adapted to other parts of the country. However, they have some useful characters which can be of value to other breeders. He is trying to create Blue Lake lines with better upright habit, which has always been a major problem with bush Blue Lake beans. The Blue Lake beans tend to produce a lot of bits of broken stem and leaves when harvested mechanically. In Oregon they grow the beans in close rows. This results in increased yield, but also more disease problems, especially white and grey molds. Improved upright habit would help reduce these problems, although resistance is also needed. Dr. Baggett has also worked on root rot resistance and BV2 resistance, in particular using P. coccineus as his source of resistance.

Dr. David Mok works on interspecific crosses using embryo culture and is trying to develop somatic regeneration. He cooperates with other breeders around the country to produce germplasm with resistance to common blight and tolerance to heat based on some of these interspecific crosses. Some of this work relates to snap beans.

University of Wisconsin

Dr. Fred Bliss, before he moved to California, worked on root rot resistance (W36 and W46) and the development of beans which were good nitrogen producers. His work applied to both snap and dry beans. He was also interested in white mold resistance, using Perillo 70 as his source of tolerance. His position will be filled by another breeder with similar responsibilities.

Dr. Don Hagedorn, who recently retired, worked on many diseases of beans, especially root rot resistance, *Pythium* and *Aphanomyces* being his primary concerns. He also has been the prime developer of brown spot resistant snap beans. Dr. Hagedorn released a series of lines with good sources of resistance to be used as germplasm by other breeders.

Cornell University, Geneva, New York

I have a program working on root rot resistance, principally to *Pythium* and *Fusarium*, but also *Rhizoctonia* and *Thielaviopsis*. My lines have had good *Fusarium* resistance, but Dr. Hagedorn's lines have better *Pythium* resistance. I have also had a major program for the past few years in cooperation with Dr. Jim Hunter to develop white mold and more recently grey mold resistance in snap beans. This has been genetic resistance, rather than physiological escape. Under humid conditions the upright architecture does not help much to control these diseases. The grey mold resistance is partly associated with white mold resistance, but the breeder has to screen for each disease to be sure of double resistance.

I also have programs on developing cold tolerance at germination, growth, and bloom stages and recently on heat tolerance during the bloom stage. Cold tolerance is needed in snap beans in many parts of the country, because farmers and processors want to get early crops. Most beans are cold sensitive during imbibition and can be permanently stunted by cold at that stage. Rapid emergence also results in reduced seedling damage from maggot and *Pythium*. Cold during growth will result in small plants, and at bloom may result in poor set. The low temperature does not hurt the pollen, but pollen grows so slowly that fertilization is poor. We have recently found that resistance to heat and cold are associated. We have worked on seed quality, especially on white-seeded beans, in cooperation with Dr. Alan Taylor, who is interested in seed physiology problems. White-seeded beans are required for processed snap beans, but white seed are almost always inferior to colored seed in vigor and disease tolerance.

Research Problems

In 1987 Dr. Silbernagel reported on a survey of the breeding needs for beans as documented by both public and private breeders. That report highlighted the most important breeding needs, which tend to be similar in all areas for both snap and dry beans, although there are some local problems.

The problem areas were ranked as follows in order of importance: heat tolerance during bloom; lodging resistance, white mold; common blight; Fusarium; Pythium; cold tolerance during emergence; Rhizoctonia; Aphanomyces; and early maturity. Other important concerns were halo blight, brown blight, grey mold, seed quality, and viruses. Common mosaic resistance due to the I gene is universal now in all new varieties of snap beans, but there are needs for other virus resistances such as peanut stunt virus in the south and variants of BCMV. Recently brown blight has become a major problem in New York and Wisconsin.

Only a few pole snap beans are grown commercially in Florida for the fresh market. However, quite a number of old varieties are grown in home gardens. In some areas these can be sources of disease infection. All snap beans otherwise are type I bush beans, but there is still a need for improved uprightness. Because of the need for extreme concentration of flowering, other forms have not been successfully used. However, for hand picking, there is some interest in some type II bush beans. For home gardens or hand picking, extreme concentration of set is undesirable. This creates a dichotomy of needs in snap beans as most breeding is aimed at the commercial grower where concentrated set is needed. The Blue Lake beans tend to have excess numbers of flowers which are often on the top of the plant. There they may be damaged by excess exposure to the sun. Because there are more flowers than the plant can carry as pods, the extra pods abort. This is a waste of energy for the plant, and the excess flowers are an ideal nutrient source for the development of white and grey mold.

Heat tolerance is often needed in the summer. In the western states the temperatures may get to 40 °C during the day, but usually cool off to between 10 and 20 °C at night. In the northern and eastern states, on the other hand, the temperature does not usually exceed 35 °C, but the night temperatures may stay at 25-30 °C. This difference results in different responses by different varieties. Under New York conditions, some varieties are damaged by temperatures over 30 °C, while others will set at 34-35 °C. Recently we found that cold tolerant lines set well under high temperatures. This response is similar to that found in tomatoes.

Ozone damage can be a problem in some states, and large numbers of plant introductions and varieties have been screened by Dr. Benepal and others in West Virginia. Eagle has shown good resistance. It has also performed well in the Southern Cooperative trials where it was the best bean in their 1988 trials.

There is little work on common or halo blight resistance in snap beans because the seed is produced under dry conditions in Idaho and California. However, with the increase in exports, halo blight resistance is more important and being added by some seed companies. Dr. Silbernagel is doing some breeding for halo blight resistant snap beans and Dr. Coyne produced the resistant line HB 76-1 some years ago.

Pod quality is another concern, especially the roguing of the flat or stringy pod mutants. These mutants occur at a constant rate of 1:500 and 1:2000 depending on the variety, from round and stringless to flat and stringy pods. If the stock seed is not vigorously rogued the variety will rapidly deteriorate in quality. The processors also want small seed and slow seed development which is one of the attributes of Blue Lake type beans. Fiber has generally been bred to a low level and to some people the level is so low in some Blue Lake types that they become too soft when cooked.

Lastly, ease of pod detachment is important and there are some cultivars such as EZ Pick in which the pod detaches easily. This means the mechanical pickers can be operated more slowly, reducing the leaves and stems mixed with the harvested pods and causing less pod injury.

The Bean Improvement Cooperative serves as a valuable communication medium for snap bean breeders as it does for dry bean breeders. Likewise, the CAC (Crop Advisory Committee) serves the interest of both types of beans.

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SNAP BEAN RESEARCH IN COLOMBIA

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Abstract

In Colombia, about 3000 hectares are planted to snap beans each year. Varieties are almost exclusively climbing types. In the last 10 years, there has been a 398% increase in the area devoted to snap beans. Recently, research on snap beans has been receiving more attention from ICA, the Colombia national agricultural research organization. A program including germplasm characterization and documentation, varietal improvement, seed production and post-harvest studies is in progress, with activities based at the La Selva Regional Research Center.

Introduction

About 3000 hectares (ha) of snap beans (Phaseolus vulgaris L.) are planted annually in Colombia, with an average yield of 11.0 tons/ha, and approximately 50 tons of seed are imported per year (ICA, 1988). It is estimated that the value of snap bean production was about 2275 million Colombian pesos in 1987 (US$1 = 262 pesos in 1987) (Lobo and Jaramillo, 1989). Snap beans with a climbing growth habit are cultivated almost exclusively in Colombia, as part of small- and medium-sized farmers' production systems. The most important production areas are in Arbelaez

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and Fusagasuga (Cundinamarca), and Florida, Pradera and La Cumbre (Valle del Cauca). Snap beans are a potential crop for the mid-altitude regions and marginal coffee-growing areas of the country. An increase of 398% in area planted to snap bean occurred between 1980 and 1987, with an increase in productivity of 10% over the same period.

Research on snap beans by the Colombian agricultural institute (Instituto Colombiano Agropecuario, ICA) has received relatively little emphasis up to now. Only a single variety ("Icato"), a bush bean corresponding to US5, was selected at the beginning of the 1970s. Currently work on snap beans is carried out by the Legumes and Vegetables Program of ICA, where it has been included in the National Research Plan for 1989-1993. Research is conducted at the La Selva Regional Research Center, in Rionegro (Antioquia) and the results of these trials are extended to other areas of the country. Snap bean research is also conducted at the Regional Center for Education, Training, Extension, and Diffusion of Technology, Sumapaz (Fusagasuga).

Research Plan for Snap Beans 1989-1993

Snap bean was included in the the National Research Plan 1989-1993 (ICA, 1988) based on the following criteria: the area planted; the volume of seed imported; its utility both for fresh market and for processing; and its role in small-farmer and medium-sized farmer production systems.

Research on snap beans concentrates on four broad areas of activity:

Genetic resources: This involves the manipulation of germplasm used for the varietal improvement program, and includes the characterization, documentation and maintenance of introduced and local materials.

Varietal production: While breeding activities are based at the La Selva Regional Research Center, promising materials are sent to current and potential production areas for on-farm testing, an activity that is important to coordinate with CIAT. Varieties are tested for yield, quality, disease resistance and adaptability. The development of technological packages for various production zones is part of the varietal production program.

Seed production: A feasibility study of seed production in snap bean production areas, including alternatives for artesanal production or farmer-produced seed, will be undertaken.

Post-harvest studies: Snap beans, along with other vegetables, will be assessed for the economic losses that occur after harvest due to the crop's deterioration. The effect of pre- and post-harvest practices on storage life and losses will then be investigated.

La Selva Regional Research Center: Preliminary Results

Selection of varieties

Snap bean breeding work began with the evaluation of 162 segregating climbing materials and 52 bush types, mostly coming from CIAT. The climbing materials were handled in bulk from the F_2 up to the F_5 generation, with selection beginning in the F_5 generation based on vigor, uniformity, disease resistance and pod quality. Pod qualities sought are green color, length over 10 cm, round or oval cross-section, slow developing seed and the absence of fiber and curvatures. Given the small demand for bush type snap beans in Colombia it was decided to carry out trials with climbers only. Climbing varieties that tolerate low temperatures have been selected and seed produced.

As shown in Table 1, five promising lines were selected, four of which have registered yields significantly superior to the check Blue Lake. With these genotypes, regional trials could be carried out in the future. Tables 2 and 3 identify their geneology and pod qualities.

Evaluation of the Effect of Seed Color on Yield and Quality

Since snap bean selections show segregation for seed color, and because white seeds are usually preferred, an attempt was made to evaluate the effect of color on different production and quality aspects by using almost isogenous lines in selections LHVS 001 and LHVS 003. As presented in Table 4, significant differences in days to flowering were recorded for both genotypes, with the white-seeded materials being later.

Physiological Maturity of Snap Bean Seed

Research on the effects of physiological maturity of snap bean seed on pod quality included the cultivars Blue Lake (climbing) and Primel (bush). For both genotypes, it was found that significant regressions existed for the linear models that related the post-anthesis period and germination and accumulation of dry matter. Under experimental conditions, physiological maturity of the seed for the cultivar Blue Lake occurred between 35 and 50 days post-anthesis, and for Primel, it occurred at 50 days after anthesis. (Table 5).

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Table 1. Yields of selected snap bean genotypes at the La Selva Regional Research Center.

Genotype	Yield[a]			
	1988A	1988B	1989A (tons/ha)	Average
LHVS 001	5.4a	7.6b	18.1ab	10.4ab
LHVS 002	5.3a	13.5a	19.7a	10.2ab
LHVS 003	5.0a	7.8b	17.8ab	12.7a
LHVS 004	3.6a	8.8b	18.8ab	10.4ab
LHVS 005	4.1a	8.8b	16.4bc	9.8ab
Blue Lake (check)	5.8a	2.4c	14.2c	7.5b

a. Means followed by the same letter in each column do not show significant statistical differences at 95% confidence.

Table 2. Pod characteristics of selected lines, La Selva Regional Research Center.

Line	Pod length (cm)	Pod diameter (cm)	Pod color	Fiber
LHSV 001	14.7	1.0		
LHSV 002	15.2	1.1	All are	All
LHSV 003	14.8	1.1	bright	lack
LHSV 004	14.4	1.2	green	fiber
LHSV 005	14.3	1.1		
Blue Lake	12.8	1.0		

Table 3. Genealogy of selected lines.

Line	Genealogy
LHVS 001	Individual selection in F_{12}, Stringless Blue Lake x White Bohne.
LHVS 002	Individual selection in F_{12}, Alabama x White Bohne
LHVS 003	Individual selection in F_6, CIAT 19
LHVS 004	Individual selection in F_4, CIAT 22
LHVS 005	Individual selection in F_{12}, Alabama x White Bohne

Table 4. Effect of seed color on production and quality aspects in snap beans (La Selva Regional Research Center).

Variable	Genotype[a]					
	LVHS 001			LVHS 003		
	White	Black	Coffee	White	Black	Coffee
1989A						
Days to flowering	57.6a	52.3b	54.6ab	58.6a	54.0b	52.6b
Pod length (cm)	13.9c	14.0c	14.1c	14.5a	12.5b	14.2a
Pod diameter (cm)	0.9a	1.0a	0.9a	1.0a	1.0a	1.0a
Yield (tons/ha)	10.2a	10.9a	13.1a	12.3a	8.3a	10.9a
1989B						
Pod length (cm)	15.0a	15.5a	14.6a	14.6a	13.5a	13.8a
Pod diameter (cm)	1.2a	1.1a	1.2a	1.1a	1.1a	1.1a
Yield (tons/ha)	7.9a	8.1a	8.2a	9.9a	11.1a	10.6a

a. There are no significant differences among means followed by the same letter by row and genotype (95% confidence).

Table 5. Dry weight and germination obtained with snap bean seeds after different intervals between anthesis and harvest (La Selva Regional Research Center).

Variety	Days after anthesis			
	20	36	43	50
Blue Lake (climbing)				
Seed dry weight (g)	4.7	4.9	5.7	5.4
Germination (%)	63.0	61.0	98.5	98.5
Primel (bush)				
Seed dry weight (g)	1.5	7.2	9.4	10.8
Germination (%)	0.0	22.5	43.0	96.0

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INTERNATIONAL SNAP BEAN SEED PRODUCTION AND DISTRIBUTION

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Abstract

Commercial seed production in Europe and North America is a highly specialized industry. This paper discusses some of the aspects of seed production, with emphasis on the snap bean seed industry in the United States. Snap been seed production in Australia, Europe and East Africa is also highlighted, as is the state of international snap bean seed trade. Low quality seed inhibits improved snap bean production throughout the developing world. The snap bean seed market in Colombia is used as a case study to probe the dimensions of the problem. In the absence of effective public or private sector seed distribution systems, it is suggested that the development of small-scale artesanal seed production may be an alternative to improve Colombian snap bean production.

Introduction

The autonomous and complex character of commercial seed production within the agricultural sector is attested to by the numerous regional, national and international seed trade associations, seed companies, and publications that exist to support the seed industry (Seed World, 1989).

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Every country, and even province or state, has regulatory statutes affecting the production, transport, packaging, labelling and distribution of seed within its borders and between neighbors.

How Seed Companies Operate

In the developed countries of the West seed production and distribution have evolved in the private sector. In Europe vegetable seed companies began in the late 18th century and in America in the 19th century (Hawthorne and Pollard, 1954; Becker, 1984).

Seed companies, to stay competitive, have specialized functions, the two principal functions being seed production and seed marketing. In addition, quality control, inventory control, and research and development ensure the smooth flow of the appropriate quantity and quality of seed from production to marketing.

Most companies produce and sell many different kinds and varieties of seed. The marketing department forecasts potential sales two years in advance of actual sales so that the production department can set reasonable production goals for each new seed production cycle. Thus, the seed produced this year is not placed on the market until next year. After sales forecasts are completed, field representatives of the production department go to local farmers to contract the required seed production acreages for each variety.

Contract prices are negotiated each year. Contract terms include minimum acceptable germination, acceptable seed- moisture content at time of delivery, and freedom from certain weeds, seed mixtures and seed-borne diseases. Quality control personnel are responsible for maintaining seed stocks free of genetic offtypes, mixtures and seed-borne diseases, and for restraining each variety's stock from drifting away from the original description of the variety over multiple generations of seed production. They also conduct "grow-outs" of each new generation to control for identity and genetic purity.

Seed lots for marketing come under the jurisdiction of inventory control. They are first cleaned of foreign matter (soil particles, vegetative structures, other kinds of seed, etc.), then graded into more uniform-sized classes, tested for percent germination and indexed for freedom from seed-borne diseases. The seed lots are weighed in bulk and the contract farmer is then paid. Prior to packing, the seed is treated with fungicide, insecticide or other chemicals.

The marketing department has field representatives in the areas of the seed purchasers. Six months in advance of the next growing season seed purchasers "book" their seed requirements with the seed company's marketing representative. The order is confirmed before the customer's new planting season and can be refined as the crops are planted and growing. The seed customer maintains close contact with the marketing representative to focus his variety requirements and discuss disease problems as well as cultural and harvesting perplexities. At the time of actual purchase the buyer specifies the quantity, the seed size or count per unit weight, pesticide or hormone treatments, and the manner of packaging. The marketing representative conveys this information to inventory control, which supervises the preparation and delivery of the seed.

The primary responsibility of the research and development department is the breeding of new varieties to meet changing needs in the marketplace. Technical representatives of the seed companies work with buyers/cooperators to test the potential new varieties under commercial conditions.

The Importance of Geographical Location: The Case of the United States

In the United States in the 1800's most commercial vegetable seed production was limited to the northeastern United States. During the late 1800's vegetable seed production began to take root in California and by the turn of the century there was significant vegetable seed production in the western United States. Some snap bean seed production was also occurring in the Greeley, Colorado, area during this period. This production only lasted a few years, though. Most snap bean seed production moved into Idaho around 1920 (Parker, 1983a, 1983b). The Greeley, Colorado, production was adversely affected by severe thunderstorms. Either hail destroyed the crops or seed-borne bacterial disease was rapidly spread over the crops by the driving rains.

The reasonably long frost-free and rain-free periods, permitting full development and adequate drying of pods and seed, have enabled southern Idaho and areas of eastern Oregon and Washington to become the main production areas for dry and snap bush beans in the United States. Significant climbing type snap bean seed production occurs along the coast of south-central California where the growing season approaches 180 days, resulting in better seed yields of the climbing type snap bean varieties than in the Idaho areas. Due to the long rain-free growing seasons, the seed crops receive water by furrow irrigation alone. No water touches the foliage. Thus seed-borne disease organisms have little opportunity to infect the plants.

Seed Production Methods

Cultural practices

Seed quality, as measured by a high percentage of germination and rapid, vigorous emergence of strong, healthy plants, depends primarily on a healthy, vigorous "mother" plant and a long enough growing period to allow the seeds' full development on the mother plant. Seed quality will thus vary with geographical locations as well as with cultural practices.

Present cultural procedures are the result of experiences, both good and bad, gained by the seed industry over many years. Snap bean seed growers learned early that white-seeded cultivars require planting in moist, warm soil to assure good stands. *Pythium ultimum* seed and root rot is favored by soil temperatures of 10-15 °C (Dickson, 1971). Optimum temperature for germination and rapid emergence of snap bean seed is 18-25 °C. Planting snap bean seed in dry soil and then applying water lowers the soil temperature and very often causes heavy crusting of predominantly clay type soils, with damage and reduced stands resulting. Rhizoctonia root rot is often favored by deep seeding. More shallow planting appears to result in less Rhizoctonia root rot under warmer soil conditions. Application of zinc fertilizer has been found to correct certain chlorotic foliage conditions in beans and enhance productivity under heavier soil conditions (Viets et al., 1954). Timing of irrigation to enhance evapo-cooling of soil under the bean plants at the time of flowering, particularly when air temperatures are in excess of 27 °C, favors improved pod and seed set and more uniform seed development and maturation of the seed. This in turn yields a more uniform and smaller average seed size at harvest.

Harvesting Seed

Harvest begins when the pods just start to lose their color. Snap bean pods have been selected over time for lack of sidewall fiber and suture strings. Fiberless pods makes threshing snap beans difficult. In threshing with a conventional "cylinder-crossbar" type thresher, the pods will often break up into "peanuts" with a portion of the pod enclosing each seed, thus requiring each seed to be shelled out separately. In this case, to reduce injury to the seed, conventional threshing requires that only a portion of the seed be threshed free of the pod. The rest of the "peanuts" go out the back unshelled as part of the plant trash. Some reduction in frequency of peanuts has resulted from cutting and windrowing earlier and using pods with more sidewall fiber.

The threshing operation must be timed for when the pods are dry enough to release the seed, but the seed is not so dry that it will be injured in the threshing process. This is critical in Idaho, when during the threshing season relative humidity can fall to 10%-20% during the heat of the day under the dry desert conditions.

Seed processing procedures

Much experimentation has gone into the entire seed processing procedure (cleaning, grading, application of seed treatments, packaging and preparation for shipment) to reduce handling damage to seed.

Often in the milling process, the seed moves by falling from one operation to another. Efforts are made to keep the distances seed fall as short as possible and to cushion the seed with rubberized plates where it falls. Cold temperatures and dry conditions during milling make bean seed more brittle. Heating and humidifying the air during the processing warms the seed and raises the seed moisture content and reduces seed damage.

Research and Development

Studies and experiments on cultural methods, threshing procedures and seed processing are ongoing. Crop rotations to reduce root rot damage (Burke and Miller, 1983) and avoid similar crop-volunteer problems in seed fields are constantly reviewed. Farm implement manufacturers are constantly seeking to improve their tillage equipment, planters and other equipment to achieve better soil structure, less soil compaction and more precise placement of seed in terms of seed depth and distance between seeds. The mechanisms for threshing seed from the pods with maximum seed recovery and minimal damage aso require continual experimentation. Processing the seed with minimal seed movement and dropage is another area in need of improvement.

A lot of effort is being invested to identify safe but effective substances to apply to the seed to protect it against pathogens and insect damage after planting. Differential culture media, ELISA-methodology and monoclonal antibody development continue to provide time-saving and more precise means of indexing seed for various seed-borne pathogens. Electrophoretic methodology has greatly reduced the time and space requirements of variety grow-outs to verify variety identification and accurately determine the frequency of seed mixtures in seed lots. DNA-fragment analysis (RFLP) promises even more accurate and rapid variety identification and quantification of genetic purity in seed lots.

A wide spectrum of vegetable seeds are now exposed to various treatments to obtain better levels of germination and improved vigor of the emerging seedling. Better separation of living seed from dead seed on the basis of density by air separation and water separation is improving the levels of germination in particular kinds of seeds where the accepted levels were relatively low. Soaking and redrying seed in various salt solutions has given more rapid germination (Haigh and Barlow, 1987). In seed where dormancy occurs, treatments with plant hormones such as kinetin improve germination.

International Trade in Snap Bean Seed

The United States is the main exporter of bean seed. The five-year average is 14,725 metric tons. Nearly 80% goes to Western Europe and Canada and the remainder to Asia, Latin America, the Caribbean and Oceania, including Australia and New Zealand. Tanzania and Kenya rank a close second with nearly 10,000 tons, essentially all destined for Western Europe. Western European seedsmen export seed of their varieties in much lesser quantities to Canada, the U.S, the Far East, Oceania, the Caribbean and Latin America. They also export to African countries that have fresh-market snap bean production for shipment to Europe in the off-season.

Canada and Japan import nearly all of their snap bean seed from the U.S., and to a lesser extent from Western Europe. Japan also imports some snap bean seed from Australia. Countries in Latin America import some of their snap bean seed, particularly from the U.S. Colombia imports the climbing Blue Lake types from the U.S., and Argentina and Chile import Italian bush bean varieties. In many of the less developed countries of the world, much of the local requirements are met by small regional seed production and by growers saving seed from their previous season's crop.

Many seed trade agreements exist between developed nations. The United States, for example, produces certain kinds of vegetable seed for Japan, Taiwan and other areas of the Far East and imports seed useful in the United States from these countries. U.S. seedsmen have established vegetable seed-dealer relationships in most Latin American and Caribbean countries, as well as in the Middle East, Europe and some North African countries. Northern European countries export to Canada and the U.S., as well as to the same countries where the U.S. markets its seed. Japan is a formidable competitor, as is the Netherlands, in the international seed trade. Seed industries in Australia and New Zealand produce seed for export to Europe, the Far East, and South Pacific neighbors.

Generally speaking, the vegetable seed exported by a country is of varieties developed to meet the needs of that country. Another country will import seed of a particular variety if it is adapted to its environment and if there is a market demand. Seedsmen of the developed countries have only begun to consider developing varieties tailored to importing countrys' growing conditions and consumer requirements. This means the plant breeding, selection and evaluation must be done in the area where the variety will be used. Many developed-country seedsmen would welcome opportunities to develop and market such varieties, given a stable and friendly political environment and an economically practical market opportunity.

Snap Bean Seed Production and Marketing

Snap bean seed production as a complex industry exists in the United States in the state of Idaho, in Queensland in Australia, in France and

Hungary in Europe, and in Tanzania and Kenya in Africa. The snap bean varieties produced in Australia are similar to those in the United States, while the varieties produced in France, Hungary and Africa have been developed for Europe. The seed produced in these areas is marketed throughout the world, including the eastern European countries and the Soviet Union.

Snap bean seed production in the United States

Approximately 15 seed companies of varying capacities produce over 40 million pounds (18,000 metric tons) of snap bean seed annually, with nearly 80% of it planted in the U.S. for processing and fresh market usage and 20% exported to the rest of the world.

The United States' market can be divided into approximately 60% for processing and 40% for the fresh market. The specifications of varieties for processing in the U.S. are much more defined and critical than for the fresh-market trade. The processing types can be subdivided into: green pods with a round cross-section; green, flat-podded (Italian bean) types; and wax-colored varieties with round pods. All are bush beans. Green, round-podded varieties make up 85% of the processing market. Wax varieties have 10% of the market. The Italian green beans have 5% of the market. Approximately 70% of the processed beans are canned and 30% are frozen. Fresh-market beans can have round or flat pods among the green types, but only round pods for the wax beans.

Varietal development aims toward higher seed counts per unit weight with seed germination as close as possible to 100%. Particularly for the processing trade, the desired seed color is white to avoid anthocyanin bleeding into the color of the liquid in the canned product. For mechanical harvesting of the pods, the plants need to be bush types that stand erect with pods well off the ground. Leaves should be small. Pods need to detach easily from the plant for mechanical harvesting.

Maturities may vary, but yields need to be maximized. Green, round pods need to be: as perfectly round as possible and less than 11 mm in diameter; 15 cm long; dark green in color; and free of sidewall fiber (parchment) and suture strings. They also have to have straight spurs, firm internal solidity, no interlocular cavitation between seed cavities, small seed cavities, slow seed development and the flavor of the climbing variety Blue Lake. Wax beans need the same qualities as the green beans, except with a bright, buttery yellow color like the Earliwax cultivar. Beans for the "Italian bean pack" need to have flat pods, a medium-green color and the flavor of the climbing variety Romano. All varieties need to be resistant to Bean Common Mosaic Virus (BCMV) and contain the dominant I-allele for non-seed transmission of the virus.

To protect the yearly bean seed crop from serious infection with seed-borne bacterial disease, the Idaho Department of Agriculture, with seed industry representatives and growers, has developed a series of regulations and procedures to avoid, isolate and eradicate the problem as quickly as it occurs.

Australian snap bean seed production

Snap bean seed production is small in comparison to Idaho production, approximately 500 hectares (ha) (Smith, 1989). The production is centered in the state of Queensland (Jamieson, 1989), with less area in the state of Victoria (Smith, 1989). Victoria production has the potential for high yields and small seed with good vigor. However, the growing season from November to March faces severe problems from the "Summer Death" virus disease (Ballantyne, 1968) and bacterial blight infection due to rainy, wet conditions.

The Queensland bean seed production is in three main areas: 1) Bowen area, just south of Townville (Smith, 1989); 2) Callide/Dawson Valley, centered in Biloela; and 3) Burdekin Delta area, centered in Ayr (Jamieson, 1989). The Queensland government has established the

Burdekin Bean Seed Quarantine Area as a production area for "certified" and "approved" seed with a very reduced risk of seed-borne bacterial disease infection in the registered crops. The area gives generally higher yields than other locations and the government would like to see bean seed production concentrated in the area.

The Queensland scheme for registering bean seed for certification or as appproved seed has as its goal the production of seed free of bacterial brown spot (Pseudomonas syringae pv syringae), halo blight (Pseudomonas syringae pv phaseolicola), common blight (Xanthomonas campestris pv phaseoli), and anthracnose (Colletotrichum lindemuthianum).

The planting season in the Burdekin area is from late March to early April and in central Queensland from mid-February to mid-March (Jamieson, 1988). Planting in the late summer/fall period avoids a seed harvest during the high temperatures of the summer. Planting is in rows 80 cm apart and occasionally 1 km or longer in length. Furrow irrigation is preferred. Fertilization on the sandy, loamy river soils includes nitrogen, phosphorous and potassium as well as sulfur and occasionally zinc and boron. Bean rust, white mold and grey mold appear to be the most prevalent disease problems. Rainy weather often results in standing water in the fields which can be destructive.

Average snap bean seed yields are between 1.1 and 1.5 tons/ha. Early winter threshing is to avoid threshing during hot, dry periods like in Idaho, where care must be taken not to let seed moisture fall below 12% when seed is handled, otherwise injury to the seed and reduction in seed germination will occur.

European snap bean seed production

In Europe snap bean seed is produced mainly in France in the Loire valley from Tours to Angers and in Hungary, under the auspices of a state-controlled company. The actual production in these areas is not readily available. The Hungarian production serves both Eastern and Western Europe, whereas most of the French production is for the European Economic Community (EEC) market and for export. Snap bean seed production in Europe services both the processing industry as well as fresh market/home garden needs. The processing industry of the EEC (not including Spain's requirements) has a snap bean seed requirement of approximately 2,600 tons. The fresh market/home garden usage probably exceeds processing requirements. However, a good portion of European snap bean seed for the processing and fresh market industries is imported from East Africa (Tanzania and Kenya) with a lesser, but increasing amount imported from the U.S.-Idaho area of production. For this reason the French and Hungarian snap bean seed production is mainly of the fresh market/home garden type varieties.

Processing type varieties for Europe have similar characteristics as American varieties, but are distinct in their pod character. Processing varieties are white-seeded, but with seed-count requirements in excess of 5,500 seed/kg. Like American varieties, plants are upright, bush types with small leaves, concentrated pod maturity, and with pods high and dispersed in the plant for easy detachment by mechanical harvesters. The pods, however, are approximately 10 cm in length, ideally only 6 mm in diameter, have a very uniform medium-dark green color, solid flesh, small seed and are highly flavored. They are free of any string in the suture and parchment fiber in the sidewalls, have no interlocular cavitation and a tight, small seed cavity.

Wax-colored snap beans make up a small portion of the process pack. As in the U.S., the European processing industry either freezes or cans the snap beans. However, the yearly production now is increasingly frozen; each year less goes into cans. The fresh market/garden varieties of Europe include many types: climbing and bush types; green and wax-colored; round, oval, or flat pods; and with a range of maturities. Most distinct are the French "filet" beans that are bush varieties with a long flowering and pod-set period adapted to multiple hand-harvests. The filet pods are picked at a very young stage (small diameter) when they are free of sidewall fiber and suture strings (both of which are quite prominent in the pods at a more mature stage). The filet pods are generally dark green in color and very highly flavored.

Because seed production in Europe is under high humidity and natural rainfall conditions, the control of diseases has been more oriented towards the development of resistance to halo blight, common blight and anthracnose rather than the use of phytosanitary methods as practiced in the U.S. and Australia.

The growing season for seed production in Europe begins in the latter half of May and continues into early June, with the harvest occurring in late August to early September. Since the humidity in the growing areas remains relatively high (60% relative humidity or higher) at harvest time, the plants are left standing to dry completely; even then the seed moisture is no less than 18%. On the mornings of sunny days, the plants are cut and windrowed. By afternoon the pods are hardened enough to be threshed. Because of the high moisture content of the seed at harvest, seed is transported in grain wagons with forced air blown up through the bottom of the wagon to avoid heating, molding and seed spoilage on the way to the bean seed processing plant. At the plant the seed is further dried by forced hot air to 13%-14% moisture content for milling and storage. In comparison to U.S. quality standards, germination of European production seldom falls below 90%, whearas the average germination of the Idaho production is around 85%.

East African snap bean seed production

The Tanzanian snap bean seed production began in the early 1940's, when World War II shut off the West European continent as a source of snap bean seed for the British Isles. The British began producing snap bean seed in Arusha, Tanzania. After World War II the Dutch seedsman began to expand this snap bean seed production area because of the high germination of the seed produced as well as the low costs. However, with struggles for independence in Africa in the late 1950s and early 1960s, many settlers responsible for snap bean seed production left the area. Some went to Kenya and started new snap bean enterprises in the Kilimanjaro area of southern Kenya.

The culture of snap beans in Tanzania and Kenya is on deep, rich soils at elevations of approximately 1200 m (Michaelides, 1989). The planting season starts before the end of the main rainy season of April but is finished before the abrupt end of rain in June.

Most of the growers plant fields of 10-20 ha with mechanical seed planters in rows about 50 cm apart and 15 cm between plants. Soil fertility is very good, but limited rainfall and decreasing soil moisture during the growing period are the prime limiting factors to high yields on a regular basis. Snap bean seed yields average .5 tons/ha (Idaho production averages about 1.5 tons/ha). Most unique to the production is the means of threshing the seed. As the pods and plants reach a dry condition, they are pulled and loaded on wagons and moved to the drying area where the plants with pods are placed on a canvas to finish drying. The dried plants on the tarpaulins are then run over repeatedly with a rubber-tired tractor to thresh out the seed. Hand-powered or engine-powered fans are used to winnow the seed. The cleaned seed is then transported in sacks to Europe for processing and distribution.

In the mid-1970s seed production for European seedsmen in Tanzania and Kenya had peaked at nearly 50,000 ha. As a result of pressure from the European snap bean processors for disease-free seed, the area under seed production contracted by European seedsmen has decreased to less than 20,000 ha, with much of the seed production being moved to the U.S.-Idaho area.

The Colombian Snap Bean Seed Market: A Case Study

A case study on the snap bean seed market in Colombia (Belt, 1989) was undertaken to determine why seed is one of the major constraints to snap bean production in developing countries. (CIAT, 1988). In addition, the snap bean seed marketing channel was investigated.

As documented in an earlier study (van Dijken, 1988), Colombian snap bean farmers share a major concern about disease susceptibility of poorly adapted seed, which has led to frequent (10-14 times per crop) pesticide applications. The current and only variety used, Blue Lake (Lago Azul), is a climbing type garden variety introduced from the U.S. some 25 years ago. Since that time no major seed quality improvements have been made to this variety. Moreover, commercial incentives or resources for the Colombian national program (ICA) to alleviate this problem are lacking. Colombian snap bean farmers have thus adapted and selected this variety to make it more suitable to local climatic and market conditions. However, over time, pesticides applications have become an important management feature to insure good yields and quality. Fungicide and insecticide expenses constitute at least 20% of total production cost. If labor is included, this may well be more than 30%. Apart from the high direct costs, the small farmer faces a personal health hazard from frequent spraying with inadequate protection.

Government data show that, on the average, some 20%-25% of Colombian snap bean seed is imported, mainly from the U.S. (ICA, 1988). As demonstrated by the flowchart (Figure 1), the remainder of domestic seed demand is met by small commercial seed-producing farmers (35%) and by farmers producing for their own purposes or to exchange with neighbors (40%). Only one third of all seed is purchased from agro-inputs shops. In these shops twice as much imported as regional seed is sold. Farmers hesitate to buy regional seed from a store because of the uncertain history of the seed.

The distinction between imported and regional seed is apparent to the farmers. Imported seed is more expensive (50%-100%), is somewhat cleaner and its quality is more constant. However, it produces pods that are shorter and subsequently are discounted in the market. Regional seed, on the other hand, has been somewhat adapted (from imported U.S. seed) to local conditions and selected to satisfy consumer preferences. It is cheaper than imported seed but its quality level is unpredictable. This is because farmers usually produce seed when prices of snap beans have fallen below a profitable level. In addition, the technology level is low and the climatic conditions for seed production are not favorable. Currently in Colombia, two types of regional seed are produced, "semi-larga" and "extra-larga". As the names suggest they differ in size. In the Sumapaz area, 75% of the regional-seed users plant the former and 25% plant the latter type. Another interesting observation is that more farmers use a mixture of regional/imported seed than imported seed alone. In this way, they take advantage of the positive traits of imported seed, while hedging against too low a discount in the market.

Farmers' decisionmaking with respect to purchasing seed is complex. What influences this process most are: 1) the farmers' perception of market preferences; 2) the farmers' experience with different seed types and the origin of the seed; 3) the availability and the price of the seed; and 4) if the farmer selects and saves seed from his own crop, which can depend on the price of fresh snap beans. Data from surveys in the Sumapaz area (Belt, 1989) show that two thirds of the farmers always use the same type (regional, imported or a mixture) of seed. When analyzed by farm size, it was found that smaller farmers (<1ha) are significantly less consistent, percentage-wise, in producing own seed than larger farms (>3ha).

Supply and retail prices of regional seed show major fluctuations, which occur far less for imported seed. As mentioned, when snap bean prices at the producer level fall significantly, especially small farmers retain their crop for seed. This in turn may cause surpluses and subsequently depress seed prices. The seed quality that these incidental seed producers supply is questionable at most.

In Colombia the marketing channel for regional seed shows a maximum of two pricing points (when seed is purchased from the retail shop). The marketing channel for imported seed generally contains three pricing points. Besides some monopolistic price-setting, the higher marketing margin, due to the longer channel and higher transportation costs (U.S.-Colombia), accounts for the price difference between imported and regional seed.

There is little doubt that a demand for improved seed exists among snap bean farmers in Colombia. This was evidenced on two different occasions. In 1986, in the Colombian Cauca Valley, small farmers spontaneously started to adopt an improved CIAT variety that was being tested in the area (CIAT, 1988). The variety showed a significant tolerance to BCMV, anthracnose and rust, which are among the major snap bean diseases in Colombia. A similar process has recently been taking place in the Sumapaz area, where farmers selected the same improved CIAT variety as part of "Farmers Participatory Diagnostic Variety Trials" initiated by CIAT and the Colombian national program, ICA. Preliminary results show that varieties with improved disease resistance make it possible to decrease pesticide applications by at least 50% and increase average yields by 30%-40%. This translates into an income (from snap beans) improvement of 25%-30% (CIAT, 1989). As such, improved varieties show a significant potential for improving incomes of small farmers, while at the same time diminishing the threat to human health and the environment.

Discussion

Evidence has been presented that developing countries, like Colombia, are severely constrained by the lack of well adapted, disease resistant, high quality snap bean seed. No economic incentives currently exist for foreign or domestic (mostly, non-existing) seed producers to introduce and market improved varieties. It has also been shown that a demand for improved seed exists and new CIAT varieties demonstrate a significant economic potential.

The crucial link in the successful transfer of new varieties is seed production. Who is going to produce and market the seed? CIAT's task, under different circumstances, would be carried out by foreign or domestic seed companies acting on profit-maximizing motives. A lack of economic incentives and the small size of the market have prevented this. ICA's function is to screen, select and release promising varieties to the seed industry. But with the absence of the latter this process leads nowhere.

In order to break this stalemate, two alternatives might be considered. First, ICA could diversify its activities by assisting, directing and monitoring small-scale local artesanal production of improved seed under an ICA "approved" or "certified" label. Second, if local vegetable seed producers could be made aware of the high economic potential of a new variety, expected profits may be enough of an incentive to produce and market it. Hence, in the case of snap beans, the success of technology transfer may be depending, to a great extent, on the superiority of the new technology itself in relation to the traditional product.

Unless national programs allocate resources for development of and collaboration with farmers' small-scale artesanal seed production, the absence of economic incentives will leave the snap bean seed market open to foreign seed producers' residual supplies of poorly adapted seed and to the quality and price fluctuations of locally produced seed.

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SNAP BEAN RESEARCH IN PUBLIC AND PRIVATE INSTITUTIONS IN BRAZIL

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Abstract

In Brazil, publically funded snap bean research is seeking to raise yields, control diseases, weeds and pests, improve crop management and improve quality aspects. Efforts to obtain new bush type varieties with good plant architecture that facilitate mechanical harvesting are also in progress. In the last few years, three new bush varieties, Alessa, Andra and Cota, were released to producers. Work is also underway to achieve root rot resistance and better tolerance to stress through interspecific crosses with Phaseolus coccineus. Private institutions concentrate on breeding. Their major objectives for both climbing and bush type snap beans are high yield, disease and pest resistance, high pod yield, low fiber content, seed color and post-harvest keepability.

Public Institutions

Brazilian public institutions, under the leadership of the Brazilian Enterprise for Agricultural Research (EMBRAPA), are working on snap bean research with the objective of improving yields, disease resistance and quality, and evaluating new and introduced varieties. Agronomic aspects, such as intercropping and the use of herbicides are also being investigated.

In Brazil the major public institutions involved in snap bean studies are:

1/ Plant Breeder, EMPRAPA and PESAGRO-RIO/EEI, Rio de Janeiro, Brazil; and Plant Breeder, Sementes Agroceres S.A., Betim, MG., Brazil.

1. Centro Nacional de Pesquisas de Hortalicas (CNPH)
2. Centro Nacional de Pesquisas de Tecnologia Agroindustrial de Alimentos (CTAA)
3. Centro de Pesquisa Agropecuaria das Terras Baixas (CPTAB/EMBRAPA)
4. Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA)
5. Empresa de Pesquisa Agropecuaria do Estado de Minas Gerais (EPAMIG)
6. Empresa de Pesquisa Agropecuaria do Estado do Rio de Janeiro (PESAGRO-RIO)
7. Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ)
8. Instituto Agronomico de Campinas (IAC)
9. Instituto Biologico de Sao Paulo (IB)
10. Universidade Federal Rural do Rio de Janeiro (UFRRJ)
11. Universidade Federal de Santa Maria (UFSM)
12. Universidade Federal de Vicosa (UFV)

Only PESAGRO-RIO, CPTAB and UFV have ongoing programs in research and germplasm evaluation. The following are some examples of snap bean research presently being pursued.

Snap Bean Breeding

The national breeding program has been developing slowly but surely for several years now. In 1988, the National Agricultural Research Program, coordinated by EMBRAPA, had only three snap bean breeding projects (PRONAPA, 1988). However, examples of success already exist, such as the Teresopolis pole type or climbing snap bean variety. This variety, now widely cultivated, has strong rust resistance. For several years it has served as a good source of germplasm for new breeding programs.

Lately, Itaguai Experiment Station of PESAGRO-RIO has developed three new determinate bush type varieties with high yield and rust resistance. The varieties are named Alessa, Andra and Cota. Alessa has flat, fiberless pods, and an average yield of about 11.5 metric tons/hectare (t/ha). Andra yields over 13.5 t/ha and has round pods. Cota has a semi-cylindrical pod form, rustic plants, and yields about 12.5 t/ha.

These varieties are appreciated not only for their food value but also for their ecological value. Due to their disease resistance, pesticide use can be reduced. These varieties also have a shorter growing cycle, 52-60 days, and require only 1-5 hand harvests. The shorter growth period puts less demands on the soil.

The new varieties were obtained by using the diallel crossing method. Although the parental lines showed low genetic variability, superior progeny were obtained through transgressive segregation. Other breeding work involves genetic recombinations through interspecific crosses, mainly between P. vulgaris and P. coccineus. Research on disease and root rot resistance is also being pursued. Another line of research involves the search for a new dual purpose variety that can be harvested for either pods or dry grain (Leal et al., 1982; Leal, 1985 and 1987).

In a study of genetic diversity among 10 varieties, the results showed little diversity between BBL47/Eagle and BBL92/Cape, and substantial diversity between Checkmate/Provider, Astro/Strike, Provider/Strike and Astro/BBL47. For breeding purposes the following crosses were recommended: BBL92 x Strike; Cape x Strike; and Cape x XPB3069 (Maluf et al., 1983).

Characterization of snap bean varieties was through horizontal polyacrylamide gel electrophoresis, mainly for esterase, acid phosphates, leucine aminopeptidase, isozymes and soluble proteins (Gomes et al., 1982).

Variety Testing

In recent years snap bean varieties from different Brazilian institutions and from other countries have been tested in various regions of Brazil. At Santa Maria Federal University in Rio Grande do Sul State, the climbing varieties Campineiro and Americano yielded 29.1 t/ha and 21.5 t/ha, respectively (Behnk et al., 1974). In Campinas region, Sao Paulo State, the highest yielding varieties were: Manteiga

(30.1 t/ha); and Direita (IAC-2132) and Suico (IAC-3882), both at 20.0 t/ha (Bernardi et al., 1975). In Ribeira Valle, another part of Sao Paulo State, Suico yielded only 9.8 t/ha while Teresopolis yielded 27.9 t/ha (Ishimura et al., 1985). With normal cultural practices it should be possible to harvest around 25.0 t/ha of green pods from climbing type snap beans. Production costs are as low as 40%.

Determinate bush type snap bean varieties were studied in Rio de Janeiro State. Yields were low for Contender (7.2 t/ha) and Bush Blue Lake (3.1 t/ha). The other varieties tested were Tendercrop, Top Crop, Regal, Blue Lake and Harvester (Coelho et al., 1974). Bush type snap bean varieties evaluated in Rio de Janeiro State yielded on average about 12.5 t/ha, including among others, Alessa, Andra and Cota.

In another test the following results were obtained: Americano (11.6 t/ha); Campineiro (10.8 t/ha); Macarrao (10.0 t/ha); Namorada de Atibaia (9.7 t/ha); Teresopolis (9.1 t/ha); and Kentucky Wonder (8.5 t/ha) (Coelho et al., 1974). In the Itaguai region the varieties Macarrao Itatiba and Campineiro yielded 8.5 t/ha and 12.5 t/ha, respectively (Ika et al., 1988). Table 1 characterizes the main snap bean varieties grown in Brazil according to growth habit, pod shape and seed color.

Cultural Practices

Different cultural practices have been adopted by vegetable growers to increase their yields. Different arrangements of poles and varying lengths of poles have been studied. The best yield was obtained with a spacing of .70 m x .50 m using 2 m long poles. With this system the average yield was 25.1 t/ha.

Research comparing climbing beans with bush types shows the determinate bush types having many advantages. These include good yield and trade value, lower production costs and less land, labor and pesticide requirements. Based on these results, the gradual substitution of pole snap bean varieties with new determinate bush type varieties is recommended. The new genetic materials also facilitate mechanization of farming activities (Leal et al., 1974).

Fertilization

Results of soil fertilization studies show notable increases in yield. In Ribeira Valle, Sao Paulo State, combinations of fertilizers at the rate of 354 kg N/ha, 576 kg P_2O_5/ha and 558 kgK_2O/ha, increased the yield of the Teresopolis variety by 21% to 23 t/ha.

When seed of the variety Campineiro was inoculated with Rhizobium and PK (phosphorus and potassium) was applied, yields were better than when NPK plus nitrogen (ammonium sulphate) was applied. This result was obtained in a snap bean field with good soil and furrow irrigation (Leal et al., 1974a). Inoculation practices are useful for climbing snap beans, as they are in the soil longer than bush types.

Herbicide

Research on the application of herbicides indicates no relation to yield increases. Use of herbicides does, however, reduce operational costs. Results obtained in the Campinas region of Sao Paulo State, using the climbing variety Maripora I-7234 show the efficacy of herbicides to control weeds (Alves et al., 1968). In some cases, though, this had toxic effects on the snap beans. In the last few years, nonetheless, there have been increases in herbicide applications on snap bean fields, mainly to reduce labor costs.

Disease

In addition to the efforts to breed for better disease resistance, a large number of other control measures are being tested to control leaf diseases. Most of the work has concentrated on the control of anthrachnose, Oidium (powdery mildew) and rust. In Paulinia region, Sao

Paulo State, fungicides were used to control Oidium and rust. Results indicate that fungicides help increase yields up to 22.1 t/ha. In the control plots, the highest yields were around 15.1 t/ha, good yields nonetheless. In the Atibaia region, good results were obtained using fungicides to control anthrachnose, Oidium, Sclerotinia and rust. Against rust, for example, a combination of different fungicides gave the best results (Campacci et al., 1975).

Pests

In Brazil, snap bean pests are controlled mainly by pesticide application. The results, though, are sometimes not convincing and yields can decrease considerably. In snap bean seeds a natural predator, Eulophides, can be found in bruchid populations (Acanthoscelides sp.). Probably, biological control of this important insect pest will soon be possible (Cruz et al., 1987). Breeding work is also in progress to incorporate resistance to important pests causing yield reductions in snap beans.

Intercropping

Bush snap beans are useful for intercropping, particularly with cabbage, corn, tomato, cucumber and eggplant, among others (Fonseca et al., 1988; Perez et al., 1988). If snap beans are planted following the harvest of tomatoes grown on stakes, the snap beans benefit from the residual fertilizer applied to the tomato crop.

Food Technology

In the last few years snap bean has been studied in food processing institutions. Normally it is processed for baby food, mixed with other vegetables or cut into small pieces or in slices for canning. Tests at UFRRJ and CTAA/EMBRAPA in 1984, showed that Cascade was the best variety for processing; however, Brazilian varieties such as Amarelo Baixo and Verde Baixo also performed well in processing tests (Correia, 1984).

Germplasm Resources

Several public institutions in Brazil keep germplasm collections to meet researcher's needs. Snap bean collections can be found in Itaguai Experiment Station (PESAGRO-RIO), Federal University of Vicosa (UFV), National Research Center of Rice and Bean (CNPAF), and the National Germplasm Resources Center (CENARGEN). Better access to information about the snap bean collections is necessary, however, to stimulate researchers, professors and students to get involved in a snap bean germplasm protection program.

Seeds

Seed production in Brazil can not meet farmers' demand. A special program should be set up to increase seed availability. Seed production is carried out by public institutions on a small scale. The maintenance of seed quality is a major job. Work done to evaluate the performance of "old seeds" of Blue Lake 3265 shows that age alone reduces emergence and yield by 78.7% and 85.3%, respectively (Andreoli, 1980).

Private Institutions

In Brazil only a few private institutions working on vegetable seeds have a systematic snap bean breeding program: Agroflora S.A. Reflorestamento e Agropecuaria; Bioplanta Tecnologia de Plantas S.A.; Topseed Sementes Ltda.; and Sementes Agroceres S.A. The latter was a pioneer, having initiated research in 1975. (See Table 2.)

In general the aims of the plant breeding programs are similar. The more important traits sought are: high yield; disease and pest resistance; good commercial value; pod appearance (size, shape and color); good post-harvest storability, low fiber content; determinate and indeterminate growth habit; seed color; and suitability for consumption as dry bean as well as snap bean. As there are many characteristics warranting improvement, priorities need to be refined. Nonetheless, a description of the most important traits follows:

Disease and pest resistance. Incorporating improved resistance is very important in Brazil. Snap bean varieties should be resistant to rust, anthrachnose, halo blight, Oidium, Fusarium, nematodes, Common Bacterial Blight and Bean Common Mosaic Virus. Among the pests requiring special attention are leafminer and leafhopper.

Pod shape. There are essentially two types of pod shape based on the pod's cross-section: flat and round. The round cross-section types form the group called "macaroni" or cylindrical pods. Their quality is usually better than those of the group named "butter", with a flat cross-section. In a breeding program it is possible to produce plants of intermediate shapes, incorporating advantages of both pod types.

Pod color. Varieties can have yellow or green pods. Green pods may vary from light green to dark green. Both are accepted in the market. Brazilian markets normally prefer pods of light green color, due to the influence of commercial buyers. This is hard to understand, as consumers usually prefer the appearance of the dark green pods in prepared dishes. For this reason chemical products are added to turn the pods dark green. Undoubtedly, this procedure damages the food's nutritional value. Not much importance has been give to varieties with yellow pods up to this moment, but an expansion of this market is expected.

Post-harvest storability. Special attention should be given to selecting for varieties that retain their quality for a long time after harvest.

Fiber content. Fiber content varies according to the variety, the pod's and plant's age, crop development, fertilization, climate and storage. Pods with low fiber content provide better quality. The pod's fiber quantity can be easily estimated in a laboratory. Pods are graded, cleansed, dried and then weighed. The result of this process yields the fiber content. Care should be taken that samples are collected at the optimal pod-harvest stage. In practice it is also possible to get an idea of the fiber content by breaking the pod's terminal part.

Growth habit. There are basically two types of snap bean growth habits: determinate bush and indeterminate climbers. Until now, climbing types have been predominantly produced. However, these require stakes to support the plants and staking materials are becoming increasingly expensive. Thus, there is a good possibility of increasing the planted area of bush varieties, which have lower production costs. The bush types are particularly recommendable in dry areas and dry seasons, in order to avoid losing pods that come in contact with the soil.

Seed color. The most popular snap beans varieties grown in Brazil have colored seeds. It would be more practical to develop varieties with brown, whitish-yellow, black, striped or spotted-colored seeds. This would allow them to be exploited as dry beans when there is an overproduction of snap beans or when it is impossible to produce green pods good enough for fresh consumption.

Conclusions

In summary, public institutions are working on a wide diversity of research projects while private institutions concentrate on breeding. The financial support for snap bean research in public institutions has been maintained at about the same level, but private companies have considerably increased their resource commitment to snap bean. On a positive note, the relationship among public and private organizations has increased in the last few years. Seed production, in order to meet farmers' demands, should be promoted in both the public and private sectors. And finally, snap bean research priorities, in particular for public institutions, should be better focused.

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Table 1. Main snap bean varieties grown in Brazil, 1989.

Main varieties	Growth Habit	Pod Shape	Seed Color
Macarrao Trepador	Climbing	Round	White
Macarrao Favorito	Climbing	Round	White
AG-480			
Macarral Atibaia	Climbing	Round	White
Macarrao Rasteiro	Bush	Round	White
Brasilia	Climbing	Round	Black
Campineiro	Climbing	Flat	Brown
Manteiga Maravilha	Climbing	Flat	White
AG-481			
Namorada de Atibaia	Climbing	Flat	Brown
Senhorita	Climbing	Flat	Brown
Teresopolis	Climbing	Flat	Brown

Table 2. Snap bean varieties developed by private institutions in Brazil, 1989.

Varieties	Growth habit (1)	Pod shape (2)	Seed color (3)	Disease resistance (4)	Year
Macarrao Favorito	C	C	B	F	1980
AG-480 (5)					
Manteiga Maravilha	C	Ch	B	FA	1984
AG-481 (5)					
Mimoso Rasteiro	B	C	B	FA	1989
AG-461 (5)					
Preferido Rasteiro	B	C	M	FA	1989
AG-462 (5)					
Campeao (6)	C	C	B	-	1988

(1) C = Climbing; B= Bush

(2) C = Cylindrical Cross section; Ch = Flat Cross-section

(3) B = White; M= Brown

(4) F = Rust; A = Anthrachnose

(5) Sementes Agroceres S.A.

(6) Topseed Sementes Ltda.

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EXPECTED BENEFITS OF SNAP BEAN RESEARCH FOR THE DEVELOPING WORLD

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Abstract

In an assessment of the possible benefits to consumers and producers from snap bean research, four different technologies are proposed and their impact analyzed. Benefits are measured by using a welfare analysis and calculating the internal rate of return under different assumptions. The range of total benefits from the four technologies is between US$12 million and US$99 million a year. The most benefits would be generated by Integrated Pest Management technologies and adoption of insect and disease resistant snap bean varieties. Even when costs are doubled and impact halved, the IRR on these technologies is higher than 40%.

Introduction

What is the economic potential of snap bean research in the developing world? To answer this question requires an assessment of where, how and what quantities of snap beans are currently produced, and where they are marketed and consumed. With this information the constraining factors in the snap bean production and marketing can be identified and analyzed. This involves analyses of primary and secondary data, at both the country and farm levels. Then, to evaluate the potential of a research program, the expected returns from the research must be calculated *ex-ante*, using a range of assumptions.

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This approach is used in this paper to analyze the anticipated benefits from snap bean research. Four likely or prototypical technologies are assumed, based on a cross-country evaluation of the major snap bean production and marketing constraints. Three different methods, including a welfare assessment, are then used to estimate the potential future gains from these technologies. In addition, this paper suggests priorities for research strategies, impact areas, and institutional changes necessary to improve the transfer of technologies.

Snap Bean Production and Marketing Constraints: Alternative Technological Solutions

In their discussion of the snap bean country surveys, Henry and Janssen (1989) concluded that disease and insect problems were the most important limiting factor in snap bean production. However, this may be a symptom rather than the problem itself. The country surveys also revealed that most of the snap bean seed available in LDCs has been bred and selected by European, Japanese or American seed companies for temperate climates and tailored to developed-country demands. Consequently, LDCs experience major problems with the adaptability of imported snap bean seed to their tropical conditions. This suggests that the heavy disease and insect pressure so frequently mentioned is largely attributable to a lack of seed with good genetic and agronomic qualities.

To alleviate the symptoms, then, research efforts might include a three-pronged approach. First, snap bean breeding programs need to emphasize the development of resistant varieties. Secondly, more rational disease and insect management should be developed by means of IPM (Integrated Pest Management) strategies. Thirdly, a research investment needs to be made in the development of efficient domestic seed production programs.

Within the marketing channel several major constraints have been identified (Henry and Janssen, 1989). Foremost is the problem of widely fluctuating farmgate prices. Colombian data show prices varying by 200% during one week. In other LDCs price fluctuations of 50%-150% are not uncommon (Henry and Janssen, 1989). However, retail prices on average show much less variation. The extensive marketing channel, with an average of 3-5 intermediaries, absorbs most of the oscillations. The farmgate price for snap beans is, for the most part, dependent on snap bean supplies, which are largely a function of farmers' price expectations and climatic conditions. Besides some improved management practices, such as staggered planting and irrigation, there are few research opportunities to alleviate the price fluctuations. However, the complexity of the marketing channel and the size of the marketing margin may offer possibilities for improvement.

An average marketing margin of 50%-100% on snap beans is evident throughout the developing world (Henry, 1989). The major reason for this is the perishability of snap beans. Although not much higher than comparable green vegetables, approximately 25%-30% of production is lost from the time snap beans are harvested until they are consumed. The most important factors influencing perishability include the variety, the product's maturity at harvesting, climatic conditions, packaging, distances between markets, mode of transportation and the number of intermediaries. In Colombia, snap beans are marketed in 62.5-kg polyethylene sacks. In these sacks snap beans are very vulnerable to damage in loading and unloading, and from the excessive weight applied on the bottom sacks during transport. These sacks account for a large portion of total losses. As such, research into the development of alternative snap bean packaging would appear to be a fourth appropriate strategy.

In addition to the constraints mentioned, there are several other limitations less obvioulsy amenable to agricultural research: the availability of credit, irrigation, the labor intensive nature of snap bean cultivation, high input requirements, and market acceptance.

The design parameters for these technologies will be determined on the basis of the experience in the case studies, especially for seed and packaging. However, in the case of the Integrated Pest Management (IPM) strategy, the improved technology is partly validated by preliminary experimental evidence, while resistant varieties have been submitted to on-farm experiments and have already undergone some unexpected diffusion. In the following section, the four technologies will be referred to as Seed, IPM, Resistance, and Post-harvest.

Seed technology

Small scale commercial seed production could be developed among snap bean farmers. This approach would require the identification of several snap bean producing farmers with experience in the production of seed, albeit occasional. In the Sumapaz region of Colombia 40% of snap bean farmers produce a portion of their own seed requirements (Belt, 1989). However, they do not have the expertise to produce reliable, clean, high quality seed. Selected farmers would need to receive relevant training from a country's National Agricultural Research Institute (NARI) on seed production techniques. The NARI would coordinate and supervise the seed production enterprises to ensure seed was of a satisfactory quality. In addition, the NARI could provide the seed producers with special packaging material, bearing a numbered NARI label certifying that the seed adhered to a standard level of quality, cleanliness and vigor.

Figure 1 compares price columns of the proposed solution with the present situation. The "certified regional seed" demonstrates a higher marketing cost than "current regional seed" since it includes a fee to the NARIs for technical control and support to guarantee a "certified" product. It is assumed that snap bean farmers would be willing to pay the relatively higher price in exchange for a better, higher quality product. This proposal appears to be an appropriate and feasible alternative, given existing on-farm seed production in LDCs.

Resistance technology

In 1986-87 in the Cauca region of Colombia, CIAT tested several improved snap bean lines. "Lago Azul" (Blue Lake), the traditional variety, was used as the control. Participating farmers were impressed by the superior characteristics of the improved lines, particularly line HAB-229, and saved seed to multiply on their own farms. Subsequently, farmers started to plant HAB-229 on a commercial basis and a rapid, spontaneous diffusion of the new variety took place. The driving force behind the adoption was HAB-229's resistance to rust. Survey results indicated that HAB-229 generated significantly higher (30%) yields than Lago Azul (CIAT, 1987). Pesticide costs were reduced 30%-40%., and the quality of the new variety was comparable to that of the traditional snap bean.

This technology adoption took place in a limited area, and has not spread to other snap bean producing areas. Presently, similar trials are being conducted in other regions of Colombia. Although preliminary, evidence suggests that this package, based on improved snap bean varieties, has the potential to relieve some of the current snap bean production constraints.

IPM technology

Early on, field surveys in Sumapaz, the major snap bean producing region of Colombia, drew attention to the high frequency of pesticide applications in snap bean cultivation. On-farm trials have been conducted to test different levels of pesticide use and various packages of IPM practices. Although the study is not completed, preliminary results are promising. One specific trial tested three management systems for the local snap bean variety Lago Azul (Henry, 1989). As Table 1 shows, there was a significant difference between the IPM system and the Traditional system. With the IPM system the number of pesticide treatments was halved. Expenditures for chemicals and labor were reduced thus by 20%. Moreover, this system demonstrated a 22% increase in yield. These changes can be translated into an increase of the benefit/cost (B/C) ratio from 1.14 to 1.37. In this particular trial, only levels of insecticides were variable, fungicide treatments remained constant for all systems. This technology needs further research,testing and evaluation. However, to a limited extent, farmers in the region have started to adopt the IPM technology.

Post-harvest technology

In Colombia, the traditional method for packaging snap beans is to use polyethylene bags of 62.5-kg capacity. The same type of bags are also used for peas, onions and potatoes. On the other hand, tomatoes, peppers, cucumbers, and other vegetables are packaged in small, disposable wooden boxes with a capacity of 8-12 kg. The considerable post-harvest losses noted earlier, point to a need for alternative packaging of snap beans.

Some farmers who deliver snap beans to supermarket chains in the city (Bogota), use plastic crates accomodating 15 kg of snap beans. These crates are used for all fresh produce. By using these crates post-harvest losses are reduced and the quality offered to consumers is better.

The proposed technology involves the use of such plastic crates for snap bean marketing. The central vegetable wholesale market would invest in the initial purchase of the crates. Vegetable farmers, intermediaries, wholesalers and retailers would be the principal users. A crate deposit would be paid by each user. Table 3 shows a partial budget comparing traditional versus alternative packaging costs. In addition, several assumptions are made on the use of each system. In general, actual costs of using the crates are lower or equal than to the traditionally used sacks (including transportation). This does not, however, include the difference in post-harvest losses.

Technology Impact Measurement

In the following analysis, the assumption is made that the new technologies translate into production increases and subsequently into aggregate snap bean supply shifts. Moreover, it is assumed that no overlap among the different technologies will occur, so that the impact of each technology can be calculated separately.

Innovative snap bean farmers will be the first to adopt the new technologies. They will increase yields and/or decrease production costs. In the short run, the relatively small number of farmers using the new technologies will not affect the market price with their increased supplies. Consequently, these innovative farmers will reap maximum benefits from the adoption of the technologies. In the long run it is assumed more farmers will recognize the value of the technologies and also adopt them. As a result, the new technology will increase aggregate snap bean supply. This can be translated as a shift from S to S', as depicted in Figure 2. Since there is no clear evidence of increased scale economies resulting from the new technology, a parallel shift of the supply curve is assumed. As conflicting arguments exist on this point (Lindner and Jarret, 1984), a pivotal supply shift is assumed in a second case.

In the short term the aggregate snap bean supply faces a relatively inelastic demand (assumed to have an elasticity of -0.5). However, in the intermediate to long run, this demand will become increasingly elastic because of demand substitution with other vegetables. Thus, in a second scenario, potential benefits are calculated with an elastic demand (Figure 3).

To measure expected benefits, a welfare analysis was conducted following Just et al. (1989). Table 4 summarizes the benefits as estimated with different assumptions for supply shift and elasticity of demand. With a parallel suply shift, net gains are twice as much as in the case of a pivotal supply shift, both in the short and long run. More important, however, in the short run, benefits to consumers are more than double benefits to producers.

The present analysis was conducted in a partial equilibrium framework. In a general equilibrium framework, when other commodities (including vegetables) enter the picture, consumers will obtain long-term benefits, resulting from a generally lower priced basket of vegetables. Snap bean producers will improve their incomes to some extent at the cost of other vegetable producers. Due to the substitution of snap beans for other vegetables in consumption patterns, in the long run benefits are transferred from snap bean consumers to snap bean producers.

Seed technology impact

Improved seed production systems will generate a more stable supply of high quality snap bean seed at a higher price than regional seed, but at a lower price than imported seed. This will lower production costs, resulting in an aggregate supply shift. Assuming supplies increase by 10% and that 25% of snap bean farmers purchase the "certified" seed, in the short run this will generate per annum benefits of US$21.2 million to consumers and US$8.8 million to producers. In the long run, though, the total benefits of US$31.2 million per year will flow to snap bean producers (Table 3).

Resistance technology impact

Introduction of a new resistant variety will have a direct two-fold impact. First, production costs will decrease since less chemicals are needed. Secondly, snap bean yields should increase, by approximately 30%. These two effects are conservatively translated into a supply shift of 30%. Because a relatively rapid diffusion of this new technology is expected, it is assumed that 25% of LDCs snap bean producers will adopt the improved variety. This means that in the short run yearly benefits to prodoucers will be US$17 million, and to consumers US$66 million. In the long run the benefits shift to producers in the amount of US$93.7 million a year (Table 3).

IPM technology impact

IPM practices in snap bean cultivation decrease total production cost and might improve yields. It is assumed that this translates into a supply increase of 20%. Due to the relative complexity of the IPM package, it is expected that only 20% of LDC-snap bean producers will adopt this technology. In the short run, then, annual benefits to producer and consumers would be about US$11.7 million and US$26.0 million, respectively. In the long run, producers gain all the benefits, an estimated US$50.0 million per year (Table 4).

Post-harvest technology impact

This technology could reduce post-harvest losses 20%-30%. It would reduce the snap bean marketing margin and increase the efficiency of the marketing channel. This can be translated into a snap bean supply increase of 10%. However, this improved technology is not easily applicable in LDCs. Its success depends on many factors: volume of snap beans produced; size of the vegetable market and its level of integration; complexity of the marketing channel; seasonality of supplies; and the distance between production areas and centers of consumption. In addition, an industry needs to exist that manufactures the plastic crates. For these reasons, it is anticipated that only 10% of LDC-snap bean producers would adopt the technology.

In the short run producers and consumers gain US$3.5 and US$8.5 million a year, respectively. In the longer run the ultimate beneficiaries are the snap bean producers with annual benefits of US$12.5 million.

In reviewing the ex-ante estimations of benefits to producers and consumers from the four proposed technologies, it is apparent that benefits are considerable. Recognizing that the impact varies according to the particular assumptions used, the range of total benefits would be between US$12 million and US$99 million per year. According to the calculations in this paper, most benefits could be generated by implementing IPM and Resistance technologies.

Calculation of IRR

Besides this welfare analysis, another measure of the potential benefits from improved technology is the Internal Rate of Return (IRR) on the research projects needed to develop these technologies. According to Gittinger (1974), the IRR is defined as "the discount rate which just makes the net present worth of cash flow equal to zero" (p.71). In other words, it measures the average earning power (or interest) of capital invested in a project (technology), over the project life.

To calculate the IRR, several assumptions need to be made. First, the long-term benefits shown in Table 3 are used as the benefits that can be generated from improved technologies. Secondly, snap bean research needs a lead time of five years before any benefits will be generated. Thirdly, benefits will increase in another five-year period to their long-term anticipated value, and will maintain this value only for another 10 years. Finally, it is estimated that minimum annual research costs will be about US$ 0.5 million.

Table 4 shows the results on the basis of these assumptions as well as the outcome of a sensitivity analysis. In the first scenario, the benefits and costs as specified in the preceding paragraph were used. The second scenario indicates the IRRs if annual snap bean research costs are doubled. In the third scenario, it was assumed that the technologies would generate only 50% of the expected impact, but with double the costs. Again, no overlap between the technologies is assumed.

It is evident that the IPM and Resistance technologies can generate a higher pay-off than the Seed and Post-harvest technologies. In addition, the IRR does not seem to be very sensitive to doubling of the annual research costs, nor to the halving of impact. Even when costs are doubled and impact is reduced by 50%, Resistance and IPM packages still generate healthy returns of higher than 40%. The World Bank's standard project selection criterion requires projects to have an IRR greater than the opportunity cost of capital (Gittinger, 1974). In practice, this means the IRR needs to be more than 20% to be feasible. From a project point of view, thus, the IPM and Resistance technologies represent feasible alternatives.

In addition to the tangible, monetary benefits, the improved technologies would generate intangible benefits. These are related to such issues as sutainability, human health and the quality of life. These aspects are treated more extensively by Henry and Janssen (1989). The major obstacle is that intangible benefits are often difficult to quantify. Nonetheless, an attempt was made to measure such benefits that would accrue from the four technologies (Table 5).

While this is clearly a subjective exercise, an examination of the results show IPM and Resistance technologies scoring highest for most of the issues. Of special interest is their high score for "probability of success", which reflects the feasibility of the technologies realizing their potential impact.

Conclusions

In their paper providing an overview of snap bean in the developing world, Henry and Janssen (1989) concluded that China represented the most important developing country in terms of snap bean production, even though per capita consumption is intermediate compared to other countries. The Far East, the Middle East and several Latin American countries are snap bean producers that traditionally also include snap beans in their consumption patterns. Based on LDC snap bean production statistics, at the current rate of growth, supplies will reach 5.5 million metric tons by the year 2000. Demand is projected to be about at 6.5 million by the end of the century. Hence, in 10 years time the developing world will be faced with a snap bean deficit of 1.0 million tons.

Major snap bean production constraints are poor seed quality and availability, pest and disease pressure, high labor demand, and lack of credit. The most important constraints in the marketing channel are highly fluctuating producer prices and a relatively large marketing margin (including post-harvest losses). In international snap bean trade, government policies of industrialized countries have a detrimental effect on LDCs' export of fresh snap beans.

Estimations of potential future benefits from four improved technologies indicate that significant benefits can be generated and that the smallholder farmer will be the ultimate beneficiary. Improved snap bean technology will also enhance equity and improve sustainability in the developing world. Of the four different technologies elaborated in this paper, the IPM and Resistance packages generate more benefits than the other two technologies.

While the matter of priorities among research topics, strategies and impact regions is still debatable, it is clear that the potential benefits from snap bean research in developing countries would be substantial. Based on the evidence assembled thus far, further research on snap beans appears justified.

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FIGURE 1.

SIMPLIFIED COMPARISON BETWEEN SNAP BEAN SEED PRICE COLUMNS IN COLOMBIA

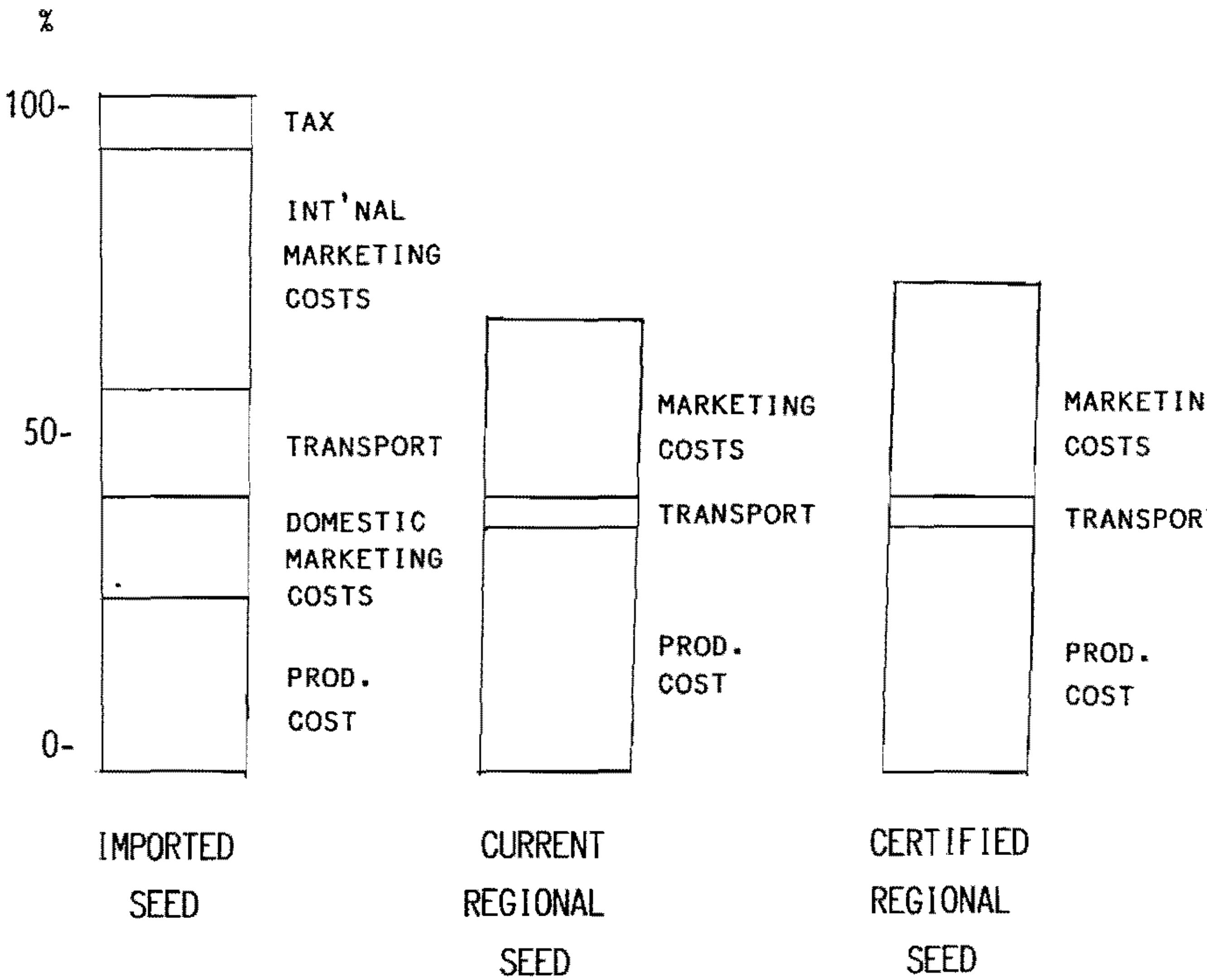
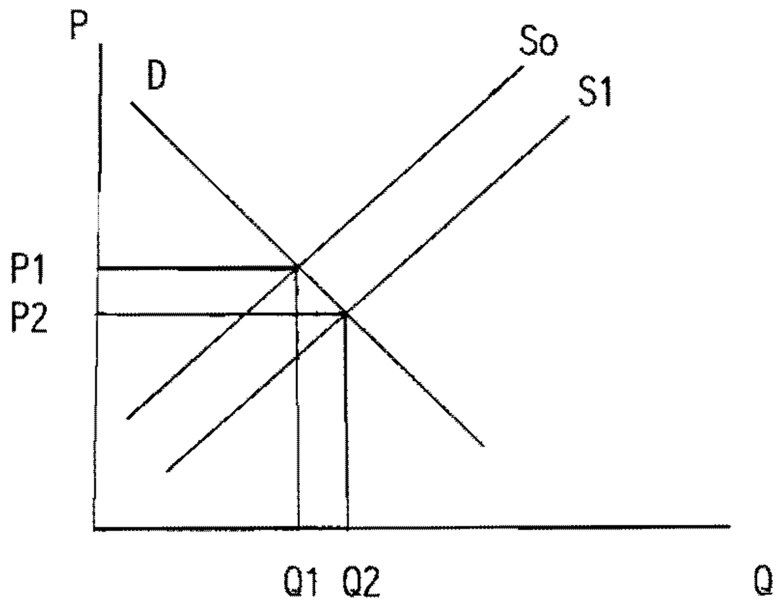
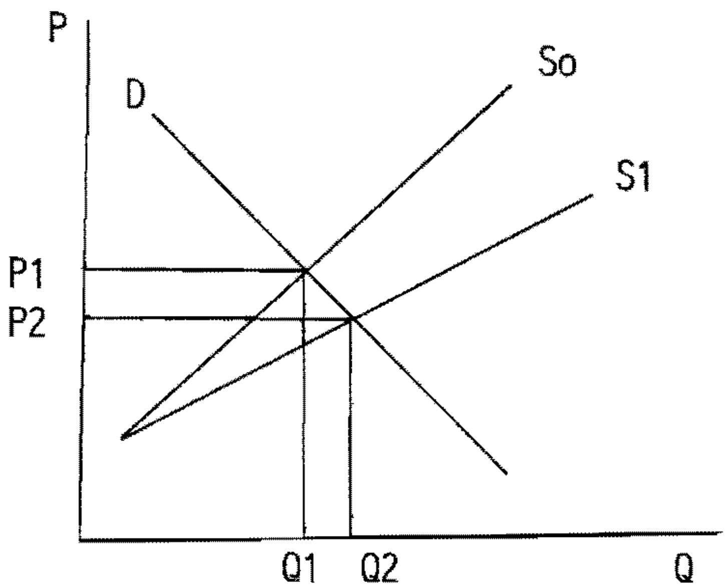


FIGURE 2.

SIMPLIFIED REPRESENTATION OF THE SNAP BEAN INDUSTRY
REACTING TO IMPROVED TECHNOLOGY
IN THE SHORT RUN



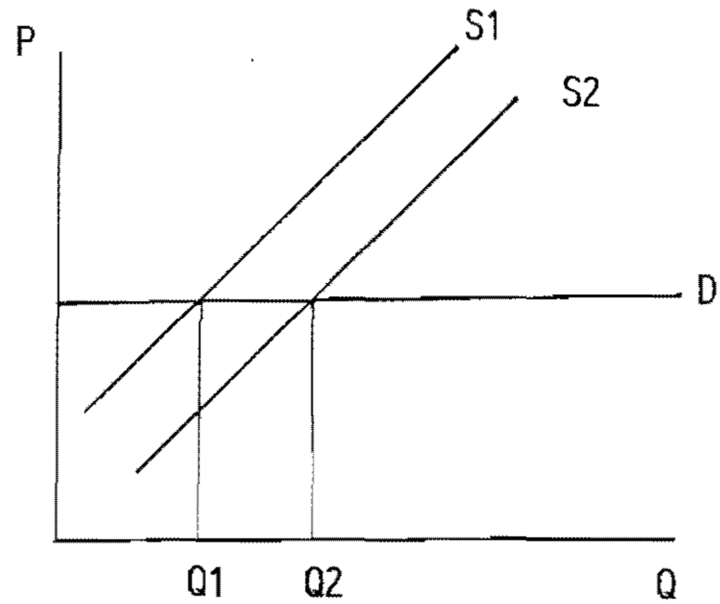
(A) PARALLEL SUPPLY SHIFT



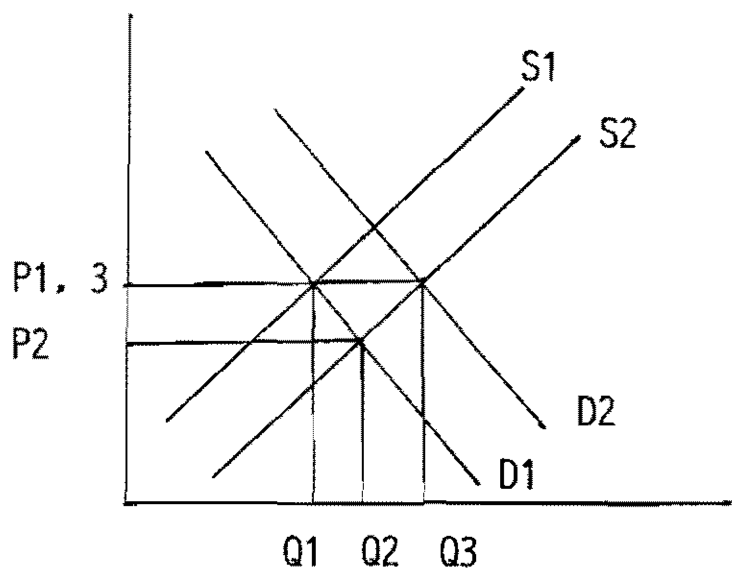
(B) PIVOTAL SUPPLY SHIFT

FIGURE 3.

SIMPLIFIED REPRESENTATION OF THE SNAP BEAN INDUSTRY
REACTING TO IMPROVED TECHNOLOGY
IN THE LONG RUN



(C) PARALLEL SUPPLY SHIFT WITH INELASTIC DEMAND



(D) PARALLEL SUPPLY SHIFT WITH EXOGENOUS DEMAND SHIFT

Table 1. On-farm insect management trial for snap beans in Sumapaz, Colombia, 1989.

Management system	No. of insecticide applications	Total insect management costs (US$/ha)	%[d]	Yield (kg/ha)	%d	B/C ratio
1. Traditional [a]	10	416	0	13,408	0	1.14
2. Chemical [b]	5	388	- 7	14,194	+ 6	1.20
3. IPM [c]	5	330	-21	16,337	+22	1.37

a) Traditional insect management based on weekly insecticide applications.

b) "Rational" management based on insecticide applications as warranted by infestation levels.

c) Integrated Pest Management based on biological and chemical control and improved agronomic practices.

d) Percentage difference with respect to traditional system.

Table 2. Partial cost budget for traditional vs. alternative snap bean packaging in Sumapaz, Colombia, 1989.

Costs	US$/t Traditional (sack = 62.5 kg)	US$/t Alternative (case = 12 kg)[a]
Packing	12.00	2.90
Transport (50 km)	6.25	14.00
Total [b]	18.25	16.90
Total [c]	18.25	18.35

a) Assumes a case is used once a week for 4 years.

b) Assumes cost of overcapacity of cases is spread over all vegetables.

c) Assumes cost of overcapacity (50%) is carried by snap beans only.

Table 3. Total expected annual producer and consumer benefits from improved snap bean technologies.

Technology	Benefits (million US$)		
	Producer	Consumer	Total
	Short Run		
1. Seed [a]	8.8	21.2	30.0
2. Resistance [b]	17.0	66.0	83.0
3. IPM [c]	11.7	26.0	37.7
4. Post-harvest [d]	3.5	8.5	12.0
	Long Run		
1. Seed [a]	31.2	0	31.2
2. Resistance [b]	93.7	0	93.7
3. IPM [c]	50.0	0	50.0
4. Post-harvest [d]	12.5	0	12.5

a) Assuming a 10% supply shift with an impact of 25% of snap bean producers.

b) Assuming a 30% supply shift with an impact of 25% of snap bean producers.

c) Assuming a 20% supply shift with an impact of 20% of snap bean producers.

d) Assuming a 10% supply shift with an impact of 10% of snap bean producers.

Table 4. Internal rate of return* (IRR) of snap bean technologies for different scenarios.

	Scenarios		
	Base impact	Base impact + double costs	Half impact double costs
	%		
1. Seed	48	44	31
2. Resistance	68	64	51
3. IPM	56	52	40
4. Post-harvest	34	28	15
All technology	81	78	65

* It is assumed that research costs are US$200,00 for CIAT and US$300,000 for NARIs (total is US$.5 million). It is also assumed that impact starts only after nine years and reaches a ceiling after 15 years.

Table 5. Snap bean technology as it relates to different issues.

	IPM	Resistance	Seed	Post-harvest
Potential for economic benefits	**	***	**	*
Equity				
urban consumers	*	*	*	**
rural incomes	**	**	**	**
Sustainability	***	**	*	*
Human well being	***	**	*	**
Possibility of success	**	***	*	*
Complementarity with dry bean research	***	**	*	*
Unique role of CIAT	*	**	*	*

*** Relatively high importance

** Relatively intermediate importance

* Relatively low importance

Table 6. Current snap bean research activities in the developing world.

Issue	L-Am.	Asia	Africa	M-East
Resistance	***	***	*	*
Yield	***	***	*	**
Seed	*	*	*	*
Climatic	*	**	*	*
Post-harvest	*	**	*	*

*** = Relatively high involvement

** = Relatively moderate involvement

* = Relatively low involvement

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CIAT'S ROLE IN INTERNATIONAL SNAP BEAN RESEARCH

Julia Kornegay 1/

Abstract

Snap bean research at CIAT is relatively new. It began in 1982 as a student thesis project to evaluate snap bean germplasm. Later, new introductions were received and sources of resistance to rust were identified. A modest crossing program was initiated and the first advanced lines entered the VEF nursery in 1985. At CIAT all snap bean research is carried out within the Bean Program. Much of the research conducted on common bean is directly applicable to snap beans. The demand for new snap bean technology is high. The majority of the varieties being planted in the tropics come from Europe and North America and are susceptible to many tropical bean diseases and insect pests. Pesticide abuse is becoming a major problem. To provide some solutions to these problems, CIAT will continue and even expand research on the genetic improvement of snap beans during the next five years. Improved breeding lines will be a critical component in the on-farm testing of IPM technologies. National agricultural research institutions and private industries will be expected to be the leaders in developing snap bean technologies for the tropics, working in a network together with CIAT.

Introduction

Most of the characteristics that distinguish snap beans from common beans have evolved as mutations. Over the past 150 years these mutations have been selected, refined and recombined through

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hybridization primarily in Europe, and later in the United States and China.

In the tropics, an estimated 600,000 hectares (ha) are planted in snap bean each year; the majority of the area is planted with snap bean varieties originally developed for European or North American production systems. Consequently, poorly adapted, highly susceptible snap bean varieties are being grown throughout many areas of the tropics. As a result, there is an increasing abuse of pesticides on these varieties.

Genetic improvement is the critical component to the development of more efficient and safer snap bean production systems. Snap bean varieties, as well as other vegetables and fruits, which are purposely developed for tropical conditions are urgently needed. However, because the lead time for genetic improvement is relatively long, it is necessary that pest management practices be developed to provide temporary solutions to adaptability and resistance problems. Integrated Pest Management (IPM) technologies will also be valuable in enhancing the potential of the improved varieties as they come into production.

History of Snap Bean Research at CIAT

Snap bean research at CIAT is relatively new. It began as a student thesis project in 1982 with the evaluation of 250 snap bean accessions that were available in the germplasm collection. Of these, 16 accessions showed good adaptation and acceptable pod characteristics (Montes de Oca, 1987). In 1984, CIAT received additional germplasm, breeding lines and F4 populations from Dr. Silbernagel of the United States Department of Agriculture for evaluation and selection. From these introductions and the initial germplasm screening, several materials were identified that were resistant to rust and had excellent pod quality under tropical conditions. Crossing was begun to recombine the best traits of these materials and to incorporate resistance to other diseases. The first advanced lines from CIAT's snap bean breeding program entered the VEF (CIAT's Bean Program nursery) in 1985. In May 1987, the first international workshop on snap beans was held at CIAT. During 1988, CIAT and ICA began an integrated pest management pilot project in the snap bean production regions of Sumapaz, Colombia. At present CIAT has produced 369 bush and 32 climbing snap bean lines foı the tropics.

Snap Bean Breeding at CIAT

Germplasm evaluation

Approximately 1000 snap bean accessions are available in the Phaseolus vulgaris L. germplasm collection at CIAT. Most of these lines have been evaluated at CIAT's main research station at Palmira (1000 meters above sea level) and at the Popayan substation (1750 meters above sea level) for adaptation and disease resistance.

In 1988, as part of the IPM pilot project in Sumapaz, a subset of the collection was also evaluated. Out of the 154 climbing (or pole type) accessions tested, only 11 were superior to Pole Blue Lake (the local variety) for pod load and disease resistance under natural disease pressure (Table 1). Of the 15 improved CIAT breeding lines evaluated, 5 climbing lines, HAB 229, HAB 236, HAB 221, HAB 214 and HAB 208 showed high levels of disease resistance and were equal to or better than Blue Lake for adaptation and yield (Table 2).

CIAT is also actively trying to update and expand its germplasm collection. Recent acquisition and evaluation of the Southern Cooperative Snap Bean Trials from the U.S. identified several materials with resistance to rust and with good yielding ability under CIAT - Palmira conditions. Nevertheless, only two lines from the U.S. had higher yields (although not significantly different) than CIAT's checks, HAB 30 and HAB 53.

Snap bean germplasm and bred lines have also been evaluated for photoperiod response under 18 hours daylength as compared to 12.5 hours daylength (Table 5) (White et al., 1990). Almost all accessions with bush growth habit were day neutral (no delay in flowering) which is consistent with the expectations that day neutrality would be favored in a crop typically grown over a wide range of planting dates, where varieties are often grown over a wide range of latitudes, and where there is strong interest in early, uniform pod development. The climbing types included both day-neutral and short-day responses. The presence of intermediate levels of sensitivity in the pole beans may reflect selection for prolonged pod production for home gardens and fresh market growers (White et al., 1990).

Breeding objectives

As our awareness of snap bean varieties and their production problems increase the breeding objectives at CIAT are being adapted to address some of these needs. Better balance is needed in the breeding of bush and climbing bean growth habits. Although bush snap beans are more preferred on a worldwide scale, several countries like China, Colombia, Turkey, Argentina and Brazil, grow significant amounts of pole snap beans for fresh market consumption. The pole snap beans are, in general, the least improved types.

As for pod type, breeding at CIAT has concentrated on selecting round-podded types that are widely accepted in many countries. Some future work, however, will be done on the flat-podded types which are highly preferred in China and Turkey. Very little will be done on wax or other colored types. Within pod types, selection is only made for the fresh market type, although shipper types, which maintain their pod quality over a week or more, will also be important for selection as a means of reducing post-harvest losses.

During the next five years, there will be an overall increase in snap bean breeding activities. While the snap bean breeding project is modest in scope, up to 250 crosses can be made each year. In the future, more crosses between dry beans and snap beans will be conducted, with dry beans being used as sources of disease and insect resistance. The improved lines are distributed in international nurseries to interested collaborators. During 1987-1989 over 50 international nurseries were dispatched.

The Role of the NARIs in Snap Bean Research

In the future, the reliance on European and North American snap bean technologies must be minimized for the tropics, unless the public and private sectors in the temperate regions become active participants in adapting and developing their snap bean technologies to tropical production systems. For many reasons, however, we do not foresee these groups becoming leaders in conducting the research that will be needed. To get the job done, the majority of the research will have to come from the national agricultural research institutes (NARIs), CIAT and other international centers. As resources are limited for snap bean research, a division of responsibilities is needed. Since the NARIs are most closely involved with the snap bean production systems in their countries, most of the research should be directed by them.

Responsibilities of the National Agricultural Research Institutes:

* The NARIs must obtain information on snap bean production systems within their areas of responsibilities to understand the needs of the farmers, the problems in the production systems and the requirements of the markets.

* The snap bean varieties currently grown by farmers should be evaluated for the positive and negative traits they may have, and the breeders must decide on the best strategy for improving these materials. The

breeders are also responsible for the introduction and evaluation of new germplasm as potential new varieties or sources of resistance for crossing.

* Breeders and agronomists should test their breeding lines at an early stage in the evaluation process for farmer acceptability. Potential new varieties should also be market and consumer-tested for acceptability of pod type and culinary qualities.

* Agronomists, entomologists, pathologists and extension scientists must implement research on IPM practices and make recommendations to farmers on how to manage the crop to reduce pesticide applications and to recommend appropriate pesticides and dosages. Governments should be pressured to regulate better the use of pesticides on crops and periodically check snap beans in the market for pesticide residue.

* Research on reducing post-harvest losses is also needed. An estimated one third of the harvest is lost as damaged product in the packing and transportation of the pods.

* Local or regional seed industries are essential to supply high quality seed to the farmers of varieties that have been released or approved by the NARIs for their production regions. The packaging and distribution of the seed is critical to the success or failure of a new variety.

The Challenge of Forming Snap Bean Networks

The Consultative Group for International Agricultural Research (CGIAR) in its recent Highlights newsletter (August, 1989), recommitted itself to establishing a global vegetables research network. The bean program at CIAT commonly uses networks to solve dry bean production problems within targeted regions. In these networks new technologies are exchanged among participants, with particular research groups given the responsibility of working on an important constraint for the benefit of the whole region. Conferences and workshops are held so that the research results are made available to all persons interested. For snap beans, CIAT envisions using a similar strategy that would include national agricultural research institutes, private industry and CIAT as the key contributors to the network. The responsibilities of these three groups for snap bean research is presented in Figure 1. The NARIs will be the leaders in developing appropriate snap bean technologies for the future. However, no research group working alone will be able to solve snap bean production problems.

If the CGIAR decides to fund tropical vegetable research, additional resources may be made available to CIAT to coordinate the snap bean network. In this case CIAT would foresee its activities to be the following:

*1. Breeding activities would continue and increase. The bean team, in general, would become more involved in disease and insect resistance screening and evaluation.

*2. Segregating populations of crosses specifically tailored to a country would be sent to the NARIs for resistance screening and local adaptation selection.

*3. CIAT would utilize existing dry bean networks in Latin America and Africa and include snap bean in their network activities.

4. Special research projects (i.e. heat tolerance) would be given to strong NARIs to take the leadership role in developing technologies to solve specific problems.

5. An IPM specialist would be hired to work on both snap and dry bean in pilot projects such as Sumapaz.

6. One scientist would be placed in Asia to coordinate germplasm flow, research activities and training.

*7. CIAT would act as a coordinator for the various activities among research groups and sponsor international workshops and conferences where the information could be exchanged.

If the CGIAR decides not to fund a snap bean network, CIAT will still continue some areas of snap bean research and networking. The points above which are starred will continue at CIAT with or without additional resources. The bean program is committed to developing appropriate technologies for small farmers (Pachico, 1987). Snap beans offer a very attractive alternative for small farmers who have good market access. They yield very high returns per unit of land and provide abundant employment opportunities.

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	NARIs	CIAT	PRIVATE
Breeding	***	***	**
Agronomy	***	**	*
Economics and Marketing	**	*	***
Post harvest technology	***	**	*
Seed	***	*	***

Figure 1. Snap bean research responsibilities over the next five-year period. Number of stars indicates level of responsibility, where *** = high responsibility and * = low responsibility.

Table 1. Best snap bean accessions for disease resistance and adaptation to the Sumapaz region, Colombia. ICA-CIAT, 1988.

Materials[1]	Growth habit	Vigor at flowering	Efficiency at harvest	Disease evaluation[2] Rust	Powdery mildew	Ascochyta blight	Pod characteristics[3]
G 1253	4A	3	5	6	2	3	1 Round
Alabama 1	4A	3	6	6	5	3	1 Flat
Kentucky Wonder 814	4A	6	5	7	6	5	1 Round
G 9604	4A	5	5	2	5	3	2 Flat
G 10134	4A	3	5	2	5	3	1 Flat, purple
G 10835	3B	5	5	2	5	3	2 Flat
Phenomenon	4A	6	6	Var	6	6	1 Semiflat, large
OSU 4852	4A	7	5	3	5	7	1 Round
G 18044	4A	7	5	3	5	7	1 Round
G 18806	3B	7	8	4	7	7	1 Round, fine
G 19070	3B	7	5	1	3	3	2 Semiflat
Pole Blue Lake	4A	6	8	8	8	8	1 Round

[1] Best 11 accessions out of 154 evaluated.

[2] Scale 1-9, where 1 = immune and 9 = severely diseased

[3] Scale 1-3, where 1 = excellent pod quality and 3 = non acceptable quality

Table 2. Yield and disease response of best advanced lines, Sumapaz, 1989.

Bred line	Growth habit	Seed color	Disease[1]						Yield (tons/ha)[2]
			Rust	CBB	ANT	ALS	ASCO	BCMV	
HAB 236	4A	4	R	S	R	S	I	R	3.9
HAB 229	4A	9	R	S	R	S	I	R	5.5
HAB 221	4A	1	R	S	R	S	I	R	3.7
HAB 214	4A	3	R	S	R	S	I	R	4.4
HAB 208	4A	1	R	S	R	S	I	R	4.2
BLUE LAKE (Check)	4A	1	S	S	S	S	S	R	3.8

Total of 16 lines evaluated, including check.

1 Disease data taken from VEF 1985 evaluations.

2 Yield of lines taken at ITUC, Colombia under natural disease and insect pressure.

Table 3. 1989 Southern cooperative elite snap bean trial evaluated at Palmira, 1989 A.

Variety	Days to harvest	Pod characteristics: shape	length (in)	curvature	color	Rust rating	Pod yield (kg/ha)	
86 EP-5196	55	R	5.4	2	1	3	8208	a
HAB 30 (Check 1)	50	R	5.4	2	1	5	7097	ab
HAB 53 (Check 2)	50	R	5.3	2	1	3	7011	ab
Shore	55	R	6.2	3	1	6	6914	ab
Sentry	55	R	4.7	1	1	7	6389	ab
FM 175	55	R	6.0	3	1	7	6306	b
Hystyle	55	R	5.5	3	1	7	5950	b
PLS 53	55	R	4.5	2	1	4	5794	bc
FM 216	50	R	6.0	2	1	5	5734	bc
Applause	55	O	5.7	2	2	8	4428	cd
XP B202	55	O	5.0	2	1	8	3600	de
Eagle	55	R	5.5	2	2	7	2472	e

Pod yield means followed by the same letter are not significantly different at P=0.05 level

Pod characteristics: Shape R = round, O = ovoid.

Curvature 1 to 5 rating; where 1= no curvature and 5= severe curvature

Color 1 = uniform dark green, 2 = pale green

Rust rating: Scale of 1-9; where 1 = immune and 9 = severely diseased

Table 4. 1989 Southern cooperative snap bean observation nursery evaluated at Palmira, 1989 A.

Variety	Plant type	Pod type	Rust rating	Pod yield (kg/ha)
XP B203	2	3	5	7333
HAB 30 (Check 1)	1	2	5	7097
HAB 53 (Check 2)	1	2	3	7011
PLS 713	2	3	2	6590
OPUS	2	2	4	6014
MSX I-484	3	2	5	5861
PLS 74	2	2	7	5812
Brio	3	2	8	5557
Trueblue	2	1	6	5215
Sunex 9030	3	3	8	5125
MSX 65	2	3	4	4722
FM 343	3	2	7	4646
FM 456	2	1	5	4292
Sunex 9048	4	3	7	4236
FM 259	2	2	7	3618
FM 136	4	3	4	3319
Slenderella	3	2	7	3257
MSX 578	4	2	5	3021
Sunex 9035	3	1	7	2989
Acclaim	4	3	7	2792
XP B230	5	3	7	2556
Legion	4	1	8	2271
PLS 71	3	2	7	2076
Crest	3	2	7	1296
LSD 5%				3221

Plant and pod type: rating of 1-5; where 1 = excellent and 5 = poor

Rust rating: 1-9 scale; where 1 = immune and 9 = highly susceptible.

Table 5. Photoperiod response of snap bean germplasm accessions and breeding lines as compared to dry beans (adapted from White et al., 1990).

	Response at 18 h photoperiod[1]		
Growth habit	Day Neutral	Intermediate	Sensitive
Germplasm accessions			
I	70	8	0
II	0	3	0
III	0	3	0
IV	16	20	1
Bred lines			
I	104	0	0
IV	6	6	0
Total snap beans	196	40	1
Dry bean accessions (as percentages)			
I	7	8	7
II	20	7	3
III	10	10	11
IV	1	2	15
Total of dry beans	38	27	36

[1] Day Neutral is 0 to 10 days delay in flowering, Intermediate 11 to 39 days, and Sensitive ≥ 40 days.

CONCLUSIONS

The papers presented at the International Snap Bean Conference provide a wealth of information on snap beans. They cover not only snap bean production, marketing and trade, but also consider nutrition and consumption issues. From export production in Rwanda and processing activities in Turkey, they proceed to analyze snap bean in relation to competing crops in Asia and Latin America. Disease and insect control, genetic improvement, post-harvest problems and seed improvement strategies are discussed as well. Finally, the future impact of snap bean research on economic development, human health and the environment is assessed.

What then to conclude? The material presented during the conference allows for many conclusions, depending on the scope of the analyst. One major contribution of the conference proceedings to the literature on vegetable crops in the developing world is precisely that it illustrates the numerous dimensions of these crops. As such it provides a framework in which to evaluate their present role and potential. It also demonstrates how, through the concerted effort of national and international scientists, a vast body of information can be collected and analyzed in a relatively short time.

In reviewing the economic importance of snap beans and their potential for research, many issues come up that are not specific to snap beans, but true for most vegetable crops. In this way, the exercise of rigorously querying the value of further snap bean research is useful in considering the merits of vegetable research in general. This theme will be explored in these conclusions.

Evaluation of the Study Approach

Before proceeding to a discussion of the feasibility and desirability of international snap bean research, it is worth drawing attention to the underlying principle of the studies commissioned for this conference.

This was that the relevance of research should be evaluated in rigorous, consistent and well coordinated way before research is undertaken. In this study the relevance of research was measured by the socio-economic importance of the crop, such as its present production value and production costs, its contribution to small farm income and to balanced diets, and the expected supply and demand growth. Still, these dimensions alone do not provide a final answer to whether or not research is justified. Socio-economic importance is a "conditio sine qua non" for justifying research, but should be substantiated by the identification of potentially successful research projects. Whereas Cock (1978) sees biological and social scientists primarily getting involved after the decision to fund research has occurred, the premise of the snap bean study was that they should take the lead, in an integrated approach, in analyzing and discussing whether and what research would be useful.

The study, then, provided an opportunity to evaluate objectively the desirability of snap bean research before interested researchers had dug their trenches and fixed their positions. Consequently, the cost of a negative decision on snap bean research would be very low, namely the price of the present study. Yet the potential benefits, in the form of research orientation, are significant. Any international snap bean research will now, from the start, incorporate consumer preferences and more rational pesticide management in its objectives. The trial and error process that occurs in many research programs has been substantially reduced by means of the study.

This approach would be useful for research decisions on many commodities. While the economic importance of some staple crops makes the value of research on them apparent, it would still be useful for orienting priorities, organization and scope. For commodities of less outstanding value, this type of study becomes even more critical, because the number of alternative commodities is larger. Ideally, in addition to the focus adopted here, such studies should have a more comparative framework. Besides elucidating the details of a specific commodity, the commodity should be compared with other crops on a number of key parameters. In the case of snap bean research at CIAT, that comparison was not very relevant, as CIAT did not foresee doing research on any vegetable other than snap bean.

Snap Bean Research: Yes or No?

The studies published in this conference proceedings show snap bean to be a vegetable of intermediate value. Henry and Janssen (1989) estimate its value in developing countries at US$1.2 billion at the producer level and about US$1.8 billion at the consumer level. These are considerable values, but not outstanding. For example, TAC (1989) estimates the value of production for tomatoes at US$4.5 billion; for onions at US$2.7 billion; and for cabbage, pineapple and lemons, each at US$1.7 billion. For most other vegetables information on the value of production is lacking and does not allow a consistent comparison. Snap bean also compares favorably with a number of staple food crops. The value of snap beans is 22% of the value of its staple relative, the common dry bean. Snap beans have a higher production value than peas or taro and approach the value of such crops as sunflower and barley.

The potential pay-off of snap bean research, as calculated by Henry (1989), is considerable. The yearly impact of certain snap bean research could be over US$90 million. The internal rates of return on a small-scale snap bean program could be between 30% and 50%, even with the least favorable assumptions. While the value of production alone would justify snap bean research, the expected benefits endorse it.

Several other factors further strengthen the case for snap bean research. The first is the way in which economic development influences snap bean demand. Growth in incomes and urbanization, especially in Asia, will escalate the demand for snap beans and may even precipitate shortfalls between supply and demand. A second factor relates to the type of benefits flowing from snap bean research. Snap beans are grown by small farmers. Their incomes would increase with higher snap bean yields. Improved snap bean technologies might also reduce pesticide misuse, thereby diminishing risks to human health (Cojocaru, 1989). A third argument favoring snap bean research is the efficiency factor. Snap bean research, piggybacked to CIAT's dry bean program, would not only have a headstart by virtue of the advances already made in dry bean research, but would benefit from future spinoffs. CIAT's bean program has already made important strides in applied bean research (Kornegay, 1989).

The principal argument against snap bean research is a simple yet persuasive one. That is that a similarly convincing case could be made for many other vegetables. So why single out snap beans for research? Or, why not argue for research on many more vegetables. This question shifts the attention away from snap beans to the desirability of vegetable research in general.

While the justifications for vegetable research in general and snap bean research in particular are similar, there are two important differences that argue for snap beans. As reasoned by Janssen (1989), the fluid substitution in consumption among vegetables means that the expected benefit-cost ratios of research for a limited group of vegetables would be larger than for the total group. Second, the synergy between dry bean and snap bean research is unique.

It is evident, though, that vegetable research receives less funding compared to staple food crops. This is because vegetables have a more luxurious image than staple crops. Thus, governments usually allocate research resources first to those commodities essential for their food security. Vegetables, not belonging to this group, receive the leftovers after the major staples have been dished out their part of the pie. Moreover, in the developed world vegetable technology and diffusion is largely in the hands of private companies. This raises the additional question of whether there is any advantage in allocating public funds to vegetable research.

These arguments need to be considered seriously before deciding on more vegetable research, or in this case, snap bean research. As the present studies make clear, the relative importance of vegetables is growing. And with respect to the food security argument, this is less critical for many countries than it was 20 years ago. Newer concerns more in favor vegetables, such as sustainability and income generation, now crowd the international agricultural research agenda. While the ability of the private sector to take the lead in snap bean research can be debated, it appears as if the basic genetic improvement will remain a public sector responsibility (Emery et al., 1989; Kornegay, 1989).

Most research managers and research policy advisers are aware of these changes in the agricultural sector of the Third World, but are hesitant to make major decisions. The Technical Advisory Committee (TAC) of the CGIAR advised the funding of a modest vegetable research initiative by the end of 1989, after considering this issue on and off since the early 1970s (CGIAR, 1989). But the funding for this initiative was undefined. CIAT research management expresses a similar reluctance with respect to a commitment to snap beans, partly because of the difficulty in withdrawing resources from ongoing activities and partly because of lingering doubts as to the urgency of snap bean research versus staple food research.

The papers collected in this volume provide considerable ex-ante evidence on the attractiveness of a snap bean research program. It is doubtful that the remaining doubts can be removed by further theoretical exploration of the crop's research potential. Perhaps the most feasible way of removing or confirming these doubts would be to start up a snap bean research effort and evaluate its progress frequently. In this way, a snap bean research program would have to accommodate the views of its proponents as well as of those who are still skeptical of its social urgency.

The final discussions in the conference reflected this understanding. It was agreed that a snap bean program would be of a more temporary nature than programs for staple commodities. For example, there might be a five-year commitment, with an evaluation to continue or halt research at the end of this period. An organizational model that guarantees the efficient use of research resources would be essential. The conference discussions favored a network, with a coordinator in Southeast Asia, supported by a small research effort at CIAT (one or maximum two international scientists) that would also handle coordination within Latin America. AVRDC would be requested to take a leading role in steering the Asian network. Commitments to Africa would be minimal given the minor role of snap beans in African diets.

Snap beans could thus serve as a pilot crop in the ongoing evaluation of various approaches to international vegetable research. At the same time it could also be a pilot crop in the transfer of research concepts and methods to vegetable researchers in the developing world. This function appears more relevant for Latin America than for Asia, where many researchers have already passed through AVRDC courses.

Snap Bean Research Directions

A pilot research program for snap beans should be designed with care. In reviewing the major issues related to the planning of a snap bean research program, two principal dimensions should be distinguished: consumption issues; and production conditions.

Consumption

First, snap bean research must be geared to the domestic markets of the developing countries. There are possibilities for substantial profits in international snap bean trade, but these are confined to very reduced volumes (Peterson and Henry, 1989). The bulk of snap bean production in the developing countries is for domestic consumption. Generally, too, the importance of processing is low (Erkal, 1989). At existing income levels the price increase due to processing outweighs the additional convenience. The significance of processing as a means of storage is also limited because the crop can be grown and harvested for a longer period of the year than in the temperate zones.

Thus, the principal focus of snap bean research should be for fresh market consumption. Cajiao (1989) shows that quality characteristics for snap beans can vary markedly. It is important to have country-specific data on what consumers want and to incorporate these preferences in the research objectives. Post-harvest losses of snap beans are considerable, even though the marketing process occurs relatively rapidly. Since prospects for significant improvements in the marketing methods are slight (van Tilburg et al., 1989), it might be useful to include shelf life as a breeding objective. Silbernagel (1986) describes how this has been done in the United States.

As observed by Kelly and Scott (1989), the nutritional value of snap beans does not warrant improvement efforts. However, it should be implicit in snap bean research that the value is maintained. A final consideration with respect to consumption is year-round availability. Even in many tropical countries, availability is irregular. According to the conference participants, improving year-round availability should have high priority, higher even than consumer price reductions.

Production

Phaseolus vulgaris L. has its center of origin in the Latin American Andes and Mesoamerica. One would expect then that most snap bean lines are well adapted to tropical conditions. In fact, many snap bean varieties currently used in the tropics were bred in European and North American countries (Dickson, 1989; Noguera, 1989), and do not offer adequate resistance to the most important production problems of the tropics. The development of more adapted varieties must be a principal objective of international snap bean research. Here the germplasm resources at CIAT and the knowledge of parental materials will be useful.

As noted in the paper of Li Peihua (1989), China is a secondary center of genetic diversity for snap bean. The genetic resources available there could play a major role in obtaining improved disease and insect resistance. China's genetic pool might also provide many useful pod and plant characteristics.

In turn, these more adapted varieties will have to be made available to vegetable growers. This will require developing more effective seed production and distribution systems or improving contacts with existing seed distributors. While the development of new seed distribution systems will be highly beneficial to vegetable production, it is debatable whether improved snap bean varieties alone represent a broad enough product range to ensure the success of such enterprises. It might be more efficient to leave these efforts to development-oriented organizations outside a snap bean research network.

Poor insect and disease resistance and the high quality demanded by the urban markets have forced many farmers to resort to frequent use of chemicals, often of high toxicity. Chemical control is so intense that in certain cases secondary pest problems have replaced the original ones. The development of rational plant protection strategies with significantly lower reliance on chemicals (Cardona and Pastor-Corrales, 1989), deserves major attention, not only to reduce production costs, but also to diminish the chemical contamination risks to snap bean producers and consumers. This appear a field of research with a potentially high and rapid pay-off (Velasquez et al., 1989).

Some issues cannot be defined a priori. Like, for example, the relative emphasis on bush snap beans versus climbing snap beans. Kornegay (1989) notes that climbing snap beans have received little research attention and sees a need for more work on climbing than on bush snap beans. Climbing beans are more popular in many countries, such as China and Turkey (Turkes, 1989; Henry and Li Peihua, 1989). In Brazil, however, bush beans are more popular than climbing beans (Leal and Carrijo, 1989). Henry and Li Peihua (1989) also see potential for bush beans in the temperate zones of China. There is an apparent need for improved germplasm of both growth types; which should have priority remains open to discussion.

Heat tolerance is another frequently mentioned objective, to extend the availability of snap beans in countries with limited temperate-climate areas. Evidence presented in the papers by Francisco (1989) and Soejono (1989) suggests that more immediate solutions are possible. In the case of the Philippines, off-season production is possible in the lowlands and its profitability is acceptable. In the case of Indonesia, the potential of substituting products such as yardlong beans was explored, even though their profits at the time of the study were lower than for snap beans.

The limited resources that might be available for international snap bean research highlights the need for a clear and sharp focus. Improved plant protection strategies and resistant, commercially acceptable germplasm should be the principal objectives of any research undertaken. Effective collaboration between national and international researchers will be essential in achieving these objectives. In this way, snap bean research can be expected to contribute to more balanced diets and to a healthier and more profitable agriculture for the developing countries.

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