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Bean technology for small farmers in Latin America

BY

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2 BEAN TECHNOLOGY FOR SMALL FARMERS IN LATIN AMERICA

Introduction

The impact of new agricultural production technologies on small farmers is a critical issue for those concerned with international agricultural research in part because some past advances in agricultural production technology have had serious adverse effects on the welfare of small farmers (Scobie and Posada Gotsch Sen) However there is also considerable evidence to show that in some circumstances small farmers can be more likely to adopt new technology and can thereby have access to the gains from technical change (Hayami and Herdt Sidhu Ashby and Pachico)

The poverty of small farmers demands interest in improving their welfare and new technology is perceived of as an important way of so doing In contrast small farmers are ill fit to absorb hardships that can ensue from new technology which improves the competitive position of larger farmers vis-a-vis small farmers Hence for better of worse new technology can have a major impact on the welfare of small farmers

This paper attempts to address some technical economic and policy considerations of orienting the technology development process towards the specific needs of small farmers (primarily in the tropical Americas) as a tool for planning a research strategy for the improvement of bean (Phaseolus vulgaris L)

Many examinations of economies in scale of new technology have focused on ensuring that new technology is scale neutral that is not biased in favor of large farmers but equally adaptable by large and small farmers In the case of beans though it will be considered here whether there exists the real possibility of directing research on new bean technology in a fashion that achieves a negative scale bias that is a technology that actively favors small farmers more than large

Such a technology biased in favor of small farmers would be especially important in the case of beans in the tropical Americas because beans are produced primarily by small farmers In most countries for which data are available 20% or more of the total bean production comes from farms of less than 5 ha and 50 or more of production comes from farms of less than 20 ha (Table 2 1) The major role of small farmers in bean production contrasts strongly with their share of cropland (Table 2 2) Small farmers account for a low proportion of total crop land (13-25%) and high proportion of bean production (39 -72%)

Given the importance of technical change for small farmers welfare and the importance of small farmers as bean producers this paper will now review the economics of what constitutes a technology for small farmers discuss some technical issues related to the feasibility of designing bean technology for small farmers consider the potential economic impact of new technology on small farmers and on bean production and finally explore some aspects of the policy environment in which the planning of bean research strategy takes place

An improved technology achieves more output with a given amount of inputs than previous technology Almost without exception new agricultural technology raises the productivity of some resources more than others (that is technological change in agriculture is usually non-neutral Heady p 805) Technical change is generally classified as being biased towards labor capital or land depending upon which factor has its marginal productivity raised the most When the productivity of a factor of production is increased more than that of others then the use of that factor will also increase (Ferguson p 386)

A new bean variety that has improved resistance to a yield limiting disease can illustrate the above points First this example portrays an improved technology in that more can now be produced with a given amount of inputs than before Since this improved variety is more resistant to disease the productivity of fertilizer is raised With a disease susceptible variety the returns to fertilizer may be much lower because the disease prevents the plant from responding to fertilizer However the productivity of fungicides will be reduced by the new resistant variety Because it is disease resistant it benefits less from the protection of fungicides than a susceptible variety Thus a disease resistant bean variety is a technology biased towards using one input fertilizer more than another fungicides Due to the introduction of this variety a decrease in the use of fungicides and an increase in the use of fertilizer should be expected

Because of new technology raises the productivity and utilization of some resources more than others it increases most the welfare of those who earn their incomes from those resources The relative share of an input in the value of total output and the total return earned by that input increase if technical change is biased towards the use of that input (Ferguson p 388) If for example a new technology raises most the productivity of land this will more favor landlords who earn their income primarily from land than it will tenants who own mostly labor and little land Given this framework examining the resource endowments and productivities of the typical small farm can provide a starting point for characterizing what kind of technologies are biased in favor of small farmers

By definition small farmers have little land and they typically have relatively ample labor Consequently small farmers produce with technologies that are intensive in their use of labor Because small farmers produce with high labor/land ratios the productivity of their labor is usually low and the productivity of their land is quite high Often yields on small farm are greater than yields on large farms (Table 2 3) Frequently small farmers have only modest amounts of capital This coupled with small land holdings and plentiful labor discourages investment in certain types of capital in particular labor saving machinery Thus a technology suitable for small farmers is one that provides substantial employment of labor earns high returns to land and is not dependent upon or even easily compatible with mechanization

Biases in Bean Technology

Cropping systems

Associated croppping systems provide an excellent example of such a small farmer technology Compared to monoculture they generally require more labor obtain higher returns to land and are more difficult to mechanize Venezuelan bean production data illustrate this relation between farm size and associated cropping (Table 2 4) Due to the importance of small farms in bean production it is hardly surprising that associated cropping systems accounts for a major share of total bean production (Table 2 5) Hence associated cropping systems with their particular factor bias are preeminently a small farm technology and are of great importance in bean production

Since associated cropping systems are a characteristic small farm technology new bean technologies for associated cropping systems clearly contain a bias in favor of small farmers The direction of varietal improvement towards particular cropping systems appears to be to some degree inherent in any selection progress for bean varieties Research at CIAT has shown that differences in (varietal) adaptation to cropping systems were almost as important as differences in adaptation to locations (CIAT Annual Report 1979 p 45)

Associated cropping systems impose different stresses on beans from those which prevail in monoculture Frequently disease and insect pressures are less in mixed cropping systems than in monoculture However competition for soil nutrients water and light tend to be greater in associated cropping systems A vigorous variety with moderate levels of pest and disease resistance may be well adapted to associated cropping while a less vigorous variety with greater disease and pest resistances could be better adapted in monoculture

Furthermore a study of the relationship between plant architecture and yield has shown that 'plant breeders choosing to exploit architectural variation must be cautious of selection under conditions of variable interplant competition (CIAT 1982 p 5) because both yields and the expression of architectural traits appear to be related to inter-plant competition

While the characteristics that adapt varieties to particular cropping systems are not known with exactitude current evidence does show that materials that perform best under monoculture do not necessarily exhibit clear superiority in associated cropping Research at CIAT has found that correlations between variety yields in the different cropping systems were low especially between relay cropping and monoculture It appears that the behavior of varieties in relay systems is quite different from that in monoculture (CIAT Annual Report 1979 p 44) This is illustrated by data which show correlations between bean yields in different cropping systems (Tables 2 6 and 2 7) Although among Type I Families the correlation between yields in monoculture and association are high and significant among Types II III and IV there are no significant correlations in yields between the two systems Selection of outstanding material in one system does not necessarily assure good performance in a different cropping system Consequently selection in association can develop materials that are particularly well adapted to small farm production systems

Available evidence indicates that if varietal selection is conducted under associated cropping sy tems then improved germplasm specific to such systems can be identified These selections will clearly have a bias in favor of small farmer production systems Conversely varietal selection in monoculture will tend to select different germplasm Varieties selected under monoculture achieve their superiority in monoculture They do not especially favor small farmers and will indeed tend to improve the competitive position of monoculture systems versus associated systems thereby favoring large farmers over small

Not all small farmers grow beans in associated cropping systems but improved varieties adapted to association benefit small farmers more than large since association is much more important among small farmers Germplasm selection and improvement by means of selecting improved varieties for intercropping can be a powerful tool to develop technology that is not merely neutral between small and large farmers but that specifically favors small farmers more than large

Plant type

Although the patterns of cultivation of different plant types by farms of different resource bases have yet to be exhaustively documented some patterns appear fairly clear Beans with indeterminate growth habits and moderate to good climbing ability (Types IV and IIIb) are especially well adapted to associated cropping systems that provide them with support In contrast determinent varieties (Type I and most Type II s) do not benefit from such support as can be offered by crop association and their erect growth habit makes them more suited for monoculture than are the climbers and semi-climbers

Besides compatibility with associated cropping, difficulty of mechanization also tends to make climbers and semi climbers less attractive to large farmers Of course production of these types could in principle be mechanized but these types are doubtelessly less convenient to mechanize than erect determinent varieties Moreover systems for mechanizing the production of these later types already exists for use by large farmers while machinery for large scale production of climbers and semi climbers are not currently commercially available

Recent studies have found that tolerance to drought stress is also related to plant type Since small farmers producing beans in Latin America only very rarely have irrigation and since they frequently face considerable drought stress drought tolerance is an important characteristic for many small farmers It is almost certainly a more important trait for small firmers than large due to differences in access to irrigation and also because small farmers typically cultivate poorer soils with less moisture holding capacity Plant type seems to be strongly related to drought tolerance with Type IV plants achieving the highest mean yields and Type III plants having the second highest mean yields (CIAT 1982 Annual Review - Beans) With drought stress being a constraint of particular importance to small farmers further work on drought tolerant Type III and IV plants may have great potential for small farmers

Yield potential may also be related to bean growth habit Indeterminate Type III plants yielded significantly more than Types I and II (CIAT Annual Review, 1982) Because small farmers must earn their living off of small areas of land high yields are of particular importance to them The greater apparent yield potential of the indeterminate types makes their improvement a technology of particular relevance to small farmers

Research to improve Types III and IV is likely to lead to technology that favor small farmers over large because these types are especially suited for associated cropping, they are rather more awkward for large scale mechanized production they are more likely to achieve drought resistance a particular problem for small farmers and they seem to have a greater yield potential thus contributing strongly to maximizing returns to the small farmer s scarce factor-land

However by no means do small farmers always and everywhere cultivate only Types IV and III Direction of technological development along lines that favor small farmers almost certainly implies a greater investment in improving climbers and semi-climbers than otherwise might occur but it would not entail abandonment of research on Types I and II if only because substantial numbers of small farmers may be cultivating beans of these growth habits Although improved varieties of Types IV and III would surely favor small farmers more than large not all small farmers would necessarily be beneficiaries of such varieties

Low input technology

Because small farmers in traditional subsistence agricultural systems generally have little available capital and a very weak cash flow use of purchased inputs--fungicides, insecticides chemical fertilizers--is typically very limited in such traditional systems However available data indicates that some groups of small farmers make intensive use of purchased inputs Farm survey data from Antioquia and southern Narino in Colombia show that in these areas a high proportion of small bean farmers are using chemical fertilizers fungicides and insecticides (Table 2 8)

The contrast between these data and the stereotype of the small farmer as being unable or unwilling to utilize modern inputs demands some consideration A principal reason why small farmers might not apply purchased inputs is that they simply can not afford them Where small farmers are producing primarily to meet their subsistence needs cash flow will be very problematic and use of purchased inputs will be low However the farms surveyed in Colombia are producing beans almost exclusively as a market crop so they can generate the cash flow to permit them to use purchased inputs These farms are not atypical of small farms in Latin America today as markets and the cash economy have penetrated throughout the region generally replacing subsistence production More and more small farmers in Latin America today are integrated into markets and are producing crops for sale Such sales generate a cash flow which permits use of purchased inputs

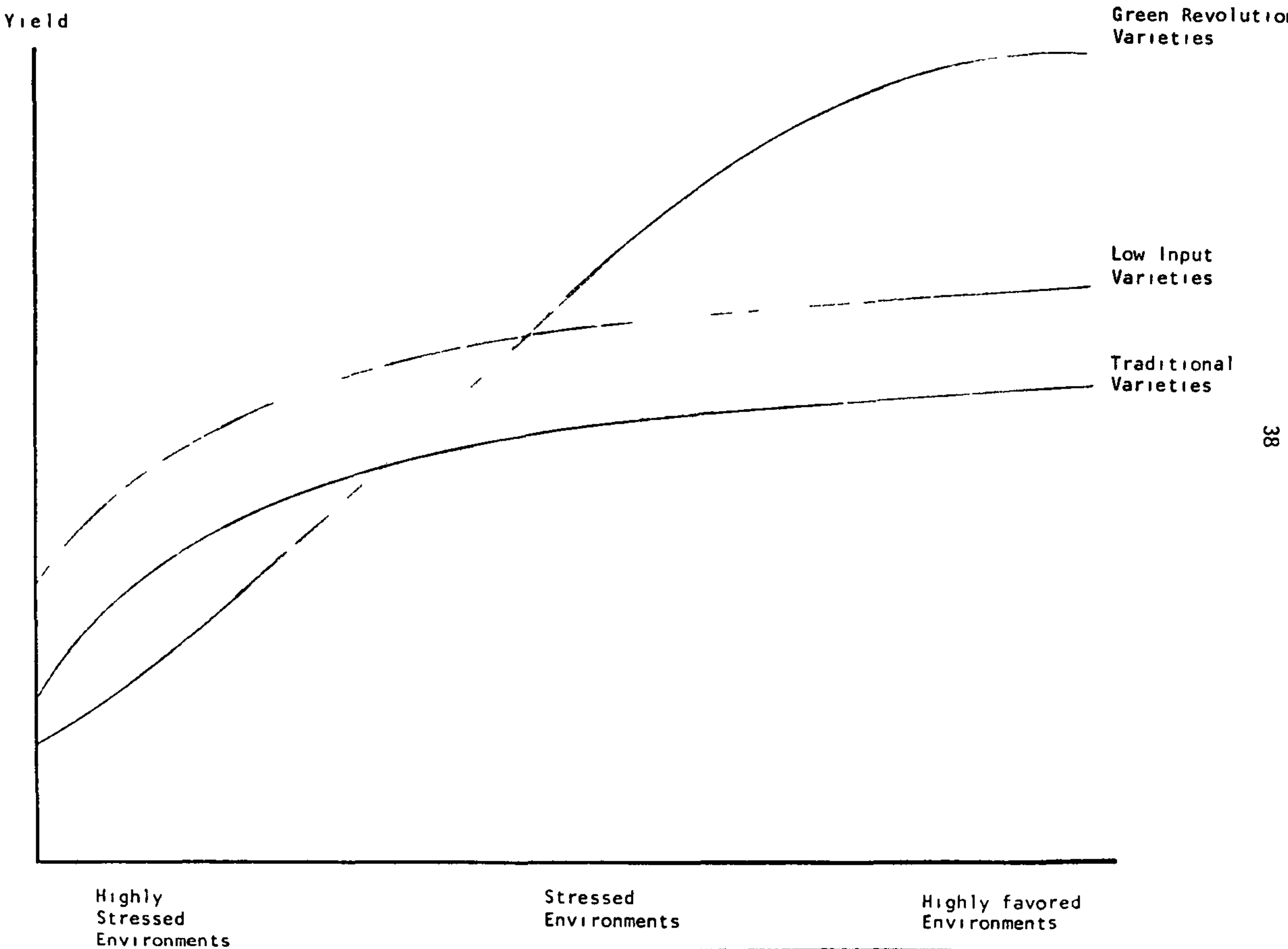
These inputs have also become more readily available for purchase by small farmers Although in the early stages of diffusion of the seed-fertilizer technologies in Asia during the 1960 s rationed access to new inputs may have been an important barrier to small farmer utilization of new technology today in Latin America the aggressive marketing strategies of the agro chemical firms are making chemical inputs reasonably well available to small farmers except in more remote area

Not only are small farmers in Latin America likely to be sufficiently well integrated into the cash economy as to be able to access and purchase new inputs but also small farmers face strong incentives to apply purchased inputs The defining characteristic of a small farm is the relative scarcity of land Because small farmers have so little land they face strong pressures to obtain high returns to land their scarce factor and yields and input use are frequently higher in small farms than on large If a farm is sufficiently large a reasonable income can be earned even if per hectare income is low Small farmers of necessity must obtain high returns on their very limited land holdings Use of purchased inputs especially fertilizer can be an important component of such a strategy for small farmers Chemical fertilizers are considered a land augmenting technology The association of small farms with low inputs is no longer automatic and is frequently misleading Despite these trends towards increasing input use by small bean farmers however intensive input use is probably still restricted to a minority of small farmers

Levels of input use can have a major effect on the design of new technology The Green Revolution improved varieties of rice and wheat achieve major yield gains over traditional varieties but the superiority of these varieties depended critically upon high fertility conditions and lack of moisture stress With irrigation and fertilizer they outperformed traditional varieties and displaced them Where farmers lacked irrigation and the capacity to purchase fertilizers traditional varieties have typically outyielded the new varieties (Figure 2 1)

In high stress-low input environments the farmers varieties have often been the better yielders while in low stress-high input environments the Green Revolution varieties have been the better performers Increasingly attention is being turned to the development of improved varieties for the high stress environments so characteristic of the small farm sector in Latin America Of special importance among small farmers are technologies for rainfed areas with marginal soils

FIGURE 1 ENVIRONMENTS AND VARIETAL RESPONSE



A crop improvement research shifts to selection of varieties that outperform traditional varieties in high stress-low input environments it does not seem improbable that new varieties that outyield traditional varieties across all environments can be developed However it is most unlikely that these materials will be the highest yielding under favored low stress-high input environments since the characters that confer optimal adaptation to these contrasting environments are almost certainly different Such for example is the case of cassava and it has been observed in cereals

While small farmers in Latin America cultivate beans across a wide range of environments a large proportion of these can certainly be classified as high stress especially with respect to drought and also due to low soil fertility and disease and pest pressures To some extent small farmers are using fertilizers and crop protection chemicals to compensate for the high levels of environmental stress

The variety of environments in which small farmers produce beans and the great differences in utilization of inputs to overcome production constraints leads to a very complex situation Often appropriate germplasm for small farmers should be high yielding under low input levels even if this sacrifices high yield potential associated with greater input use In other instance a technology that responds to high levels of inputs may be more appropriate for small farmers

Unfortunately no single alternative can serve as a rule as to what type of technology always favors small farmers In some regions today small farmers are observed using very high input levels while in others small farmer input use is nil In southern Narino as noted above input use is almost universal among small farmers In central and north Narino only a few miles distant input use among small farmers is very low (Table 2 8) Both populations of small farmers are marketing their bean production they have equal access to input markets they are both aware of the existence of inputs There are differences in response to inputs between these two groups of small farmers that are determining differences in input use Whether the key factors are capital availability land tenancy system drought soils varietal response or differences in the disease--pest complex is not clear What is certain though is that factors other than simply being small farmers' are restricting input use in central and north Narino

Consequently the design of technology for small farmers can not be guaranteed success by simply opting for low input or high input technologies in general Ráther a characterization of they limiting factors for small bean farmers in a given country or region of a country is needed to first serve as guideline as to what level of input use and environmental stress should be associated with new bean technology developed for that specific population of farmers

Risk and small farmers

Yet another consideration that may impede the use of inputs by small farmers is that of risk and uncertainty both in production and in the price of output If as is commonly believed small farmers were strongly risk averse then they would utilize low levels of inputs to avoid potential loses due to risk While this view of small farmers behavior is widely accepted as a major impediment to their use of high levels of inputs and modern technology there are reasons for caution in accepting such a view

Beans are a risky crop subject both to great variations in yields and prices yet they are a crop produced principally by small farmers Similarly potatoes tomatoes and cassava are crops that involve substantial risks in production or marketing and they are also crops that are produced largely by small farmers These small farm crops entail risks that are greater than those encountered in crops produced in the large farm sector such as rice sorghum or sugarcane These latter crops often enjoy price stabilization policies that greatly reduce market risk and they are grown on prime lands frequently with irrigation and thereby are less likely to experience substantial variation in production than most of the above mentioned small farm crops Hence review of the crops characteristic of large and small farmers offers little evidence that small farmers are less prepared to confront risk than large and indeed it seems that small farmers are less averse to risk than large at least in terms of crop selection

Although small farmers appear to be more prone to confront risks than large and indeed that one way small farmers may stay in business is by their willingness to accept risks that large farmers will not accept risk is real concern to small farmers because they do face it so directly Application of inputs in particular pesticides and fungicides can be an important part of small farmer strategy to cope with some risks The existence of risk does not therefore always discourage the use of high input levels but sometimes makes it the more essential

Similarly fertilizer application is an inherently risky investment because the farmer does not know whether the crop will later experience drought stress or intensive disease or pest attack Because small farmers are driven to seek high returns to their scarce factor land they more frequently utilize higher doses of fertilizer than large farmers Here again it can be seen that the small farmer often assumes more risk than large

In this context therefore it is clear that the relation between risk input use and technologies for small farmers merits careful rethinking It is simply untrue that small farmer production systems necessarily utilize low levels of inputs Likewise it is untrue that high risk crops are less favorable to small farmers than to large farmers It seems likely that willingness to venture into the production of risky crops gives small farmers a competitive edge over large Moreover small farmers are able to more intensively manage and protect their crops than large if only because it is easier to be meticulous in the care of one hectare than one hundred and this gives them a further competitive advantage over large farmers

All this implies that low risk low input technology may not be a boon to all or even most small farmers Although decreasing risk in bean production appears an attractive goal and although certainly it is obvious that small farmers suffer from having to contend with yield and price variability the unpleasant truth may be that it is this very riskiness of beans that protects small farmers from the competition of large farmers Stable but moderate yields with low inputs may sometimes be a technology more attractive to large farmers than small

Market acceptability

Consumer preferences with respect to grain color size and other characteristics frequently lead to substantial differences in price among grain types Because these price differences have a major effect on the profitability of growing beans of different grain types preservation of preferred grain characteristics has been given strong emphasis in bean breeding at CIAT in order to assure that farmers will find it profitable to adopt new varieties The imposition of these additional selection criteria, however greatly complicates the breeding task and in some cases it has been a highly challenging task to incorporate for example a needed disease resistance into a grain with good market acceptability

While some improved varieties may not be able to compete in the market it is possible that they may be quite acceptable to farmers producing for their own consumption Although farm families certainly have preferences with respect to beans they may well be far more relaxed than those required in the market Thus among subsistence producers of beans there may be scope for promotion of improved varieties that would not be readily acceptable on the market Such subsistence production continues to be important in total bean consumption in Latin America accounting for about a quarter of consumption of in the region (Table 2 9) Since subsistence production of beans is more important among small farmers than large (Table 2 10) improved varieties for subsistence purposes are a technology biased towards small farmers

Moreover beans generally play a greater role in nutrition in rural areas principally because they are widely produced for own consumption Since incomes are low and nutrition is frequently suboptimal among the rural poor who constitute a major part of the rural consumption of beans produced for subsistence new bean varieties for subsistence could have a positive impact on a deprived group

Nonetheless the relative role of subsistence production of beans is likely to continue to decline due to urbanization while the absolute quantity of beans produced for subsistence may also be falling Even among farm families whose bean consumption depends upon their own production the sale of any surplus above subsistence needs may be an important activity Such farmers may be reluctant to adopt a new variety of poor market acceptability which denies them the opportunity to sell surplus output in years of bumper production

Furthermore the greater part of beans produced by many small farmers are destined for the market Among small farmers producing beans for market highly preferred bean grain types are likely to be very attractive because high priced beans permit small farmers to earn a high return in a small piece of land In contrast large farmers may find it profitable to cultivate low price beans which they can produce in volume over a large area The future growth in demand for preferred quality (i e high price) beans is also likely to be greater than that for less preferred (i e low price) beans A study of the bean market in Cali Colombia showed that bean price is strongly related to size with larger beans obtaining a higher price Consumption of large beans rose as incomes increased while consumption of small beans dropped with higher incomes The income elasticity of demand for small (less preferred) beans was negative suggesting a probable decline in this consumption over time In contrast the income elasticity of demand for large (preferred) beans was positive suggesting continued growth in demand for preferred beans

These relationships between grain type market growth potential and suitability for large and small farms are summarized in Table 2 11

Unacceptable beans on the market are suitable for small farm subsistence production but future growth in the demand for this type of beans is likely to be negative Among less preferred beans suitable for production on large farms where volume can counteract low per hectare returns future demand growth is also likely to be weak as with rising incomes consumption shifts to more preferred beans Among highly preferred high price beans the type most appropriate for small farmers future demand growth is likely to be positive However simply from the point of view of grain quality high quality beans are also attractive to large farmers

Ecosystem Identification

Agroclimatological studies have classified bean cultivation environments into relatively homogenous ecosystems or micro-regions that are characterized by similar production constraints Given the constraints characterizing an ecosystem new bean technologies that overcome those particular constraints can be developed Such an approach may be useful in establishing what types of new technologies are most likely to favor small farmers

As a first approximation available farm size distribution data could in principle be mapped over the existing micro-regions defined by past studies of beans The ecosystems with greatest overlay with small farm bean production could then be given high priority in technology development As further data became available on plant type production system and input use in major small farm bean producing areas this information could be utilized to establish more clearly what types of technology are in fact characteristic of small farmers and research priorities could be set accordingly

Current impressions for example suggest that for small farmers associated cropping systems are important plant types vary but climbers and prostrate types are of significant importance input u e is variable and cultivation of steep slopes in moderate to low fertility soils with drought stress appear to be relatively frequent

Agroclimatological studies can aid in clarifying further the main environments and systems of small farmers but such findings need to be treated with care Just as improved bean technology does not necessarily help small farmers simply because today most beans are produced by small farmers in Latin America so also an improved bean variety adapted for example to regions with average temperature and possible late season water stress will not necessarily benefit small farmers simply because they are currently the main bean producers in such regions An improved variety can make it attractive for large farmers in the same region to enter bean production and can potentially lead to the displacement of small farmers as bean producers

Nevertheless inclusion of sufficient detail in both the characterization of agroclimatological zones and in the design parameters for new technology can be vitally useful in tailoring research to meet small farmer needs This can be achieved by incorporating into region definition more detailed data on production systems growth habit and input use permitting for example a sounder basis for determining the relative role for small farmers of the cultivation of Type III beans in direct association with maize without use of inputs versus Type IV in relay with maize and moderate to high use of inputs

Such extensions in data and methodology which expand the agroclimatological approach to include more detailed information on farm systems would be of great utility in refining concepts about what type of technologies are most responsive to small farmer needs Although the time and costs involved in developing such an analytical capacity are not to be dismissed even moderate advances along these lines could substantially improve the ability to define the needs of small farmers for technology and orient technology development accordingly Obviously the length of time involved in developing new technologies makes it important that progress be made along these lines earlier rather than later

Summary Biases in Bean Technology

Available evidence clearly suggests that there exists a real potential of directing the research and development of new bean technology so that biases are built into the technology that favors small farm production systems over larger

- Selection under the stresses of associated cropping systems
- Emphasis on plant types most suited for small farmer use
- Selection under the stresses of the environments faced by small farmers and with appropriate input levels
- Attention to grain quality and market characteristics that favor small farmers

All these can combine to increase the probability that technology is developed that favors small farmers The efficiency of this approach is substantially dependent upon the development of a data base to define more accurately the specific characteristics of new technologies that are most important for small farm systems Finally there seems to be little doubt that in the case of beans it is technically feasible to orient research and development along lines that are biased towards the needs of small farmers The wisdom of making a policy decision to commit research resources to such a course remains to be considered

Economics Policy and Technology

There is little doubt that in the case of beans in Latin America that it is possible to design improved technology that is biased toward the small farmer The critical question of policy therefore becomes whether such a research strategy is optimal In order to address this issue the economic consequences of new bean technology will be considered First the role of the small farm sector in the context of overall societal development and economic strategy will be presented Second some basic economic principles on the impact of technical change will be reviewed Third the costs of developing technology biased toward small farmers will be discussed Finally some conclusions will be drawn

Small farms and development strategies

Latin America has been undergoing a social and economic transformation characterized by urbanization growth in total economic output as well as output per capita and the increasing relative importance of non-agricultural activities for income and employment At the same time the agricultural sector has experienced some substantial changes in technology as significant increases in production have been achieved in large scale farms for example producing wheat and sorghum in Mexico rice and sorghum in Colombia soybeans and rice in Brazil In the face of such rapid social and economic changes questions inevitably arise about the current importance and the future potential of the small farm sector in Latin America

Without question the small farm sector is still an important social and economic fact in the region From available agricultural census data it is conservatively estimated that at least 40 million people one seventh of the population of the entire region and a number equal to the combined population of all the Central American nations as well as Peru live on farms smaller than 10 hectares Moreover beans play an important role in this small farm sector with roughly 4 million people living in small farms where beans are a major crop and food staple even if not the single leading enterprise Thus the small farm sector retains considerable importance in the region and bean farms constitute a significant proportion of small farms

The future of this small farm sector in Latin America is a rather more controversial issue One view the high growth model argues that long run growth in per capita productivity and income is inevitably associated with increased industrialization and mechanization and a secular decline in the importance of the small farm sector A small farm necessarily imposes a relatively low ceiling on maximum labor productivity and per capita income Long run growth in labor productivity wages and per capita income implies a substantial hift of labor out of the small farm sector Moreover in Latin America labor is more a scarce factor than land The small farm sector with its high labor/land ratio is inconsistent with the region s resource endowments and is therefore inefficient

The contrasting view of the future role of the small farm sector in Latin America the high employment model accepts that long term economic growth in the region would indeed lead to a decline in the small farm sector However it is pointed out that even the fairly rapid growth of the non-agricultural sector during the 1960 s and early 1970's was unable to create sufficient employment to productively absorb the flow of population out of the rural sector This led to increasing unemployment malnutrition and immiseration in the cities that has overtaxed the urban sector s capacity to provide basic needs and is potentially associated with severe forms of social and political alienation

With the world economy having entered a phase of slower growth through the late 1970 s into the 1980 s prospects of even more rapid growth in production and urban employment are less likely as net capital inflows to Latin America fall off sharply due to increasing difficulty of managing the debt that was incurred to finance the previous period of relatively buoyant growth In short strong growth in the recent past has not created enough employment to provide livelihoods for many of those seeking to leave the rural sector and employment growth in the urban sector is likely to be even slower through much of the 1980 s

Investment in the small farm sector for example through improved agricultural technology can in the view of the high employment strategy raise productivity employment and incomes on small farms thereby creating a large rural market whose demand for goods stimulates the urban economy Moreover it is argued that the small farm sector remains important because it supplies a substantial part of food production in all Latin American countries

Both these factors and the limits to the employment generating capacity of the non-agricultural sector have led some to argue that public policy including agricultural research policy should be utilized to promote the small farm sector in order to maintain employment there Although continued migration out of agriculture in response to the pull factors of high wages and available jobs in the urban sector simply represents opportunities for many low income rural families the push factors of decreasing competitiveness of small farms versus large farms may result in shifting people out of agriculture where they had been self-supporting and productively active to wasteful unemployment in the cities Since the flow of technological innovations suitable for either large or alternatively to small farmers is an important determinant of the ability of these two sectors to compete agricultural research can either have the effect of promoting productivity on large farms thereby exacerbating the push factors , or research can be directed to favor small farmers in order to mitigate the push factors and reduce the pressures of employment creation and service provision in the urban sector

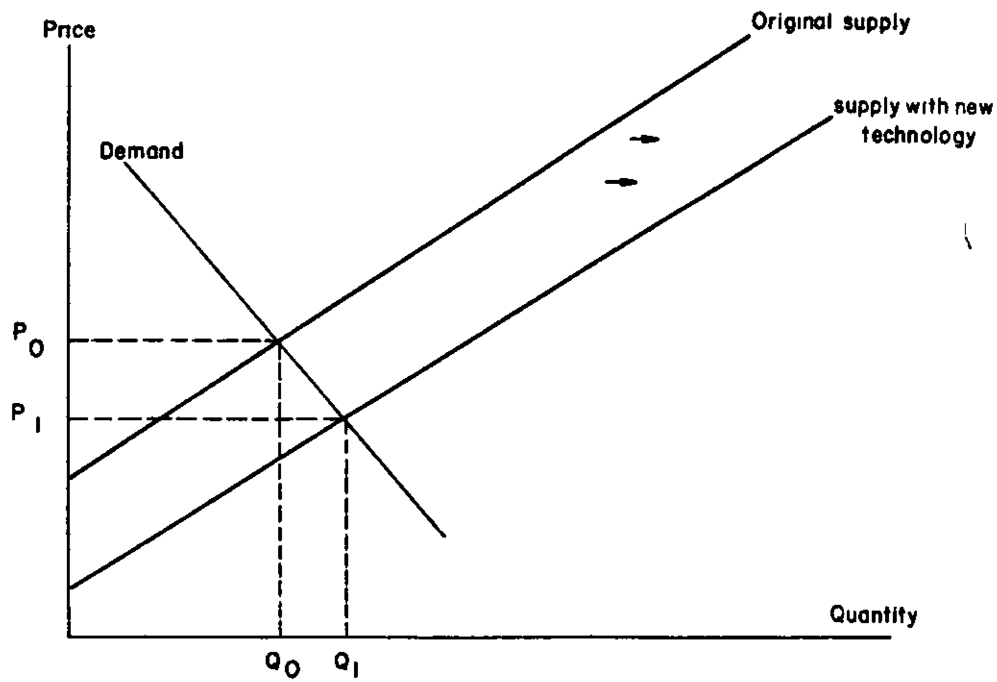
Impact of technical change

While a cogent argument justifying consideration of using new agricultural technology to preserve gainful employment in the small farm sector can be made both the likely benefits and expected costs of developing small farm biased technology need to be considered Technical change generally has several effects First it typically reduces the cost of production per unit of output even though total costs per hectare may rise Since new technology reduces the unit costs of production for the farmer at any given price the farmer can now produce more output than was previously profitable as that price In the aggregate this cause the supply function to shift to the right (Figure 2 2)

As the supply function shifts rightwards the equilibrium price between supply and demand drops Consequently the widespread adoption of a new technology confronts farmers with two changes Cost of

FIGURE 2

IMPACT OF NEW TECHNOLOGY



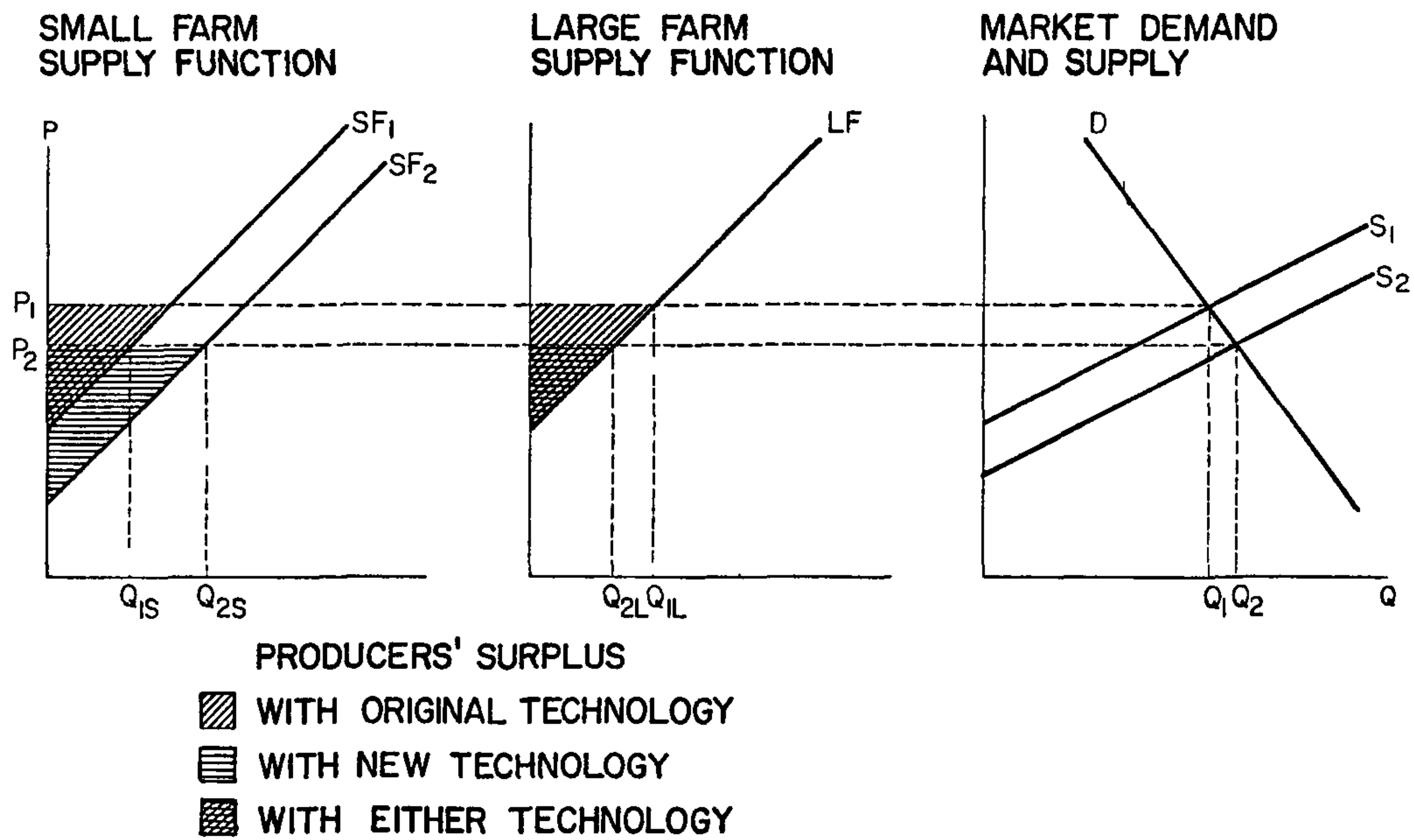
production per unit output declines but the price the farm sector receives for output also falls If the effect of the decrease in costs is greater than that of the price then net income for farmers as a group rises and the farm sector has benefited from new technology If on the other hand the fall in costs is less than that of the price then net farm income is less than before the change and the farm sector is worse off because of the new technology It is worth noting that given a market system and a good not entering significantly into international trade consumers should always gain from new technology because the price they pay for farm products has decreased

Although this analysis clearly demonstrates that farmers in the aggregate do not all automatically and necessarily gain from new technology it is quite likely that in most cases at least some farmer will benefit Of course, those who adopt new technology early before aggregate supply has increased and the price has dropped benefit from lower costs due to the new technology, without at least for a while suffering a decline in output price Since large farmers typically are earlier adopters of new technology then small farmers even a scale neutral technology would likely benefit large farmers more than small

Not all farmers have the same type of soil or use the same techniques or the same proportions of capital and labor Any new technology as discussed above will raise the productivity of some inputs more than others for example performing better in a particular soil or environmental condition This again is the bias inherent in any new technology Those farmers with the resource endowments most compatible with the new technology gain most from new technology because the productivity of their inputs is raised disproportionately This emphasizes the importance to the small farm sector of ensuring that new technology is specifically designed for small farms

This is illustrated in Figure 2 3 where the impact of technical change on small and large farms is portrayed Here small farmers and large farmers are shown to produce with different technologies and the market supply curve is the sum of the supply curves of the large and

Figure 3 Impact of technical change biased towards small farmers



small farms Consider a technical change that is biased towards small farms Here the limiting case of a technology that can only be used on small farms is presented As always the market equilibrium price drops with supply shifting technical change At this lower price large farmers supply less to the market so gross income to the large farm sector falls both because prices decrease and because the amount that they produce declines

Small farmers confront the same drop in price but their costs have also fallen due to the technical change Since their costs have decreased they are able to produce and sell a greater quantity than they did before the technical change Consequently small farmers may have a greater gross income after the technical change than before Similarly in this example large farmers necessarily experience a decrease in their profits on fixed factors (technically producers' surplus or economic rent) while small farmers may enjoy an increase in these profits depending on the relative magnitude of the price drop and the fall in their costs

Naturally this analysis can be reversed A new technology for large farmers would necessarily lead to losses for the small farmers while the large farmers might gain This emphasizes the importance of considering the bias of new technology Even though all farmers as a group may usually lose from new technology (Figure 2 2) if there is a dual structure between large and small farmers a technology biased towards one of these groups may well lead to gains on their part while the other group will certainly be worse off (Figure 2 3) If technology is biased towards small farmers they may benefit even while producers as a whole suffer In contrast if technology is neutral between large and small farmers small farmers will probably lose If technology i biased towards large farmers then small farmers will certainly be worse off

Consequently small farmers can be made better off through new technology though this outcome is not certain To achieve this it is practically necessary that new technology be biased in favor of small farmers Scale neutral technology is likely to leave small farmers relatively worse off both because of their slower adoption rate than large farmers and also because of the general producer losses that typically accompany technical change in agriculture

However it must be noted that direct improvements in small farmer welfare may often be fairly modest Technical change cannot be expected to make rich a farmer who cultivates two hectares of beans but small farm biased technology may permit such a farmer to remain in business educate the family s children and avoid joining the swelling ranks of the urban unemployed The alternative of not directing the development of new technology is very likely to depress dramatically the incomes of small farms increase the social adjustments and costs associated with migration while putting increasing pressure on already saturated urban job markets

Cost of biased technology

Achievement of the goal utilizing technology to help sustain for some time yet the viability of the small farm sector does not come without costs The research costs of developing technology biased towards small farmers are likely to be greater than those for developing technology without this bias for two reasons First technology for small farmers will in general have to overcome more intense stresses--stresses of competing with associated crops stresses of steep slopes and poor soils stresses of sub-optional rainfall distribution There seems little doubt that developing new bean technology for prime land and monoculture presents a far less challenging and thereby less expensive research task

Second the very diversity of environments production systems and patterns of resource use among small farmers substantially increases the cost of developing improved technology for small farmers It is improbable that widely adaptable solutions can be found to he highly varied problems and circumstances of small farmers Although improved germplasm developed for prime land and a monocultural production system may well be widely adaptable throughout the region new varieties of the particular growth habit and compatible with the varied cropping systems and input levels of specific populations of small farmers are extremely likely to have a narrow range for diffusion Consequently a research program aimed at developing technology appropriate the needs of small farmers entails very high costs because a variety of different technologies tailored to specific conditions is required

Moreover the returns to successful technologies for small farmers are going to be individually modest A technology for small farmers is likely to be suitable only for a subset of bean farmers in a given country nor for all Because a smaller number of farmers benefit than would generally be the case for a widely adaptable technology that was not designed specifically for small farmers total returns are less Since small farm technologies are frequently suitable only for a given region in a country the impact of even very successful new technology may not be easily apparent in national production statistics especially with the great year to year variability in bean production

Likewise the diffusion of new technology among small farmers is typically slower and involves more extension effort than to promote a new technology among larger farmers Not only is the number of decision makers who must be contacted greater but also small farmers are usually less well integrated into information systems As a result extension costs will tend to be greater with technologies for small farmers and the slower rate of diffusion postpones the onset of the flow of benefits from new technology and depresses yet more the benefit/cost ratio

In summary then development of new technology for small farmers is more costly because the stresses to be overcome are more intense wide adaptability cannot be anticipated so a number of new technologies is needed diffusion is generally more gradual and more expensive to achieve With higher costs and typically modest returns to any single small farm technology as a pure investment decision research aimed at small farms can be expected to have benefit cost ratios that are lower than those for research on bean technologies not specifically oriented to small farmers

Summary and Conclusions

Policy makers have the opportunity for choice in investment in bean research It is feasible to bias new technology towards small farmers by for example selecting for adaptation to associated cropping systems high stress tolerance and plant types difficult to mechanize Investment in this type of technology can have a favorable impact on small farmers income and welfare but it is a more expensive and time consuming process than developing new bean technology without a small farmer bias Returns to investment and rate of economic growth are both likely to be greater by not opting for a small farm bias in new technology Where equity and employment are major policy concerns small farm biased technology is attractive but where emphasis is on achieving maximum growth in output it is less attractive

National research institutions may be heavily influenced in their choice of technology decision by three considerations First research institutions are under severe pressure to produce visible results rapidly In many countries agricultural research institutions are relatively young and therefore have not had a chance to develop a strong historic record of achievement Inter-institutional competition for scarce public sector resources is fierce especially when many states in the region are facing grave fiscal crises and key national policy makers may be unconvinced of the value of expenditures on agricultural research Consequently there are strong incentives for research directors to opt for a research strategy that is most likely to yield quick results This will not include investment in technology biased towards small farmers

A second consideration is that research institutions struggling to secure funding are likely to find it advisable to select research programs that favor politically influential groups A research project that promises to benefit a producers group that has substantial political leverage is more likely to receive adequate financing Since small farmers typically are poorly organized to lobby on their own behalf and generally lack resources and influence needed to get political support for research that meets their particular needs there are strong political pressures encouraging the allocation of agricultural research funds to crops that are large farm crops and to technologies that are biased towards large farmers

Third economic analysis may contribute to selection of a research strategy One economic criterion is that new technology should be so biased as to maximize returns to the scarce factor in the economy This has had to the development of land-saving technology in Japan and labor-saving agricultural technology in the United States (Hayami and Ruttan Binswanger and Ruttan) Such a policy prescription does not carry clear recommendation in Latin America because of the dual structure of the agricultural sector larae farms for whom labor is the scarce factor and small farms for whom land is the scarce factor (Lynam) It is difficult though to argue that overall factor endowments in most of Latin America would suggest the need for land augmenting small farmer biased technology

The argument for small farm biased technology in Latin American rises more out of the institutional framework of a highly unequal distribution of land coupled with a large population of small farmers than it rises out of economy wide relative factor endowments In this context there naturally emerges some question as to the efficacy of using new technology to redress poverty and inequality that is largely due to the distribution of the ownership of resources One solution argues that investment in research be concentrated where returns are highest thereby achieving maximum growth which creates sufficient wealth that income could be transferred to the poor though it is not obvious how this transfer can be effected

An alternative solution argues that poverty be eliminated by altering the existing distribution of resources The historic experience with agrarian reform in Latin America provides ample evidence that political consensus in favor of resource distribution does not exist within the current institutional framework Given the difficulties associated with these two prescriptions for poverty it becomes clearer why many advocate using biased technical change as a tool to deal with this problem even though technology may not be especially well adapted to the task

Despite the complexity of the issues involved it should be clear that neither political nor economic considerations are likely to encourage national research institutions to make an unequivocal or major committment to research on small farm technology This may offer the international research institutions the opportunity to make a valuable contribution towards small farm biased technology because national researchers may be hindered from fully under taking this task alone While this role for the international centers may have its advantiges it requires that some acceptance that the task of developing small farm biased technology is comparatively expensive Moreover care must be taken to insure some broad consistency of objectives and programs with respect to small farm and large farm technology research conducted by national and international institutions

Table 2 1 Bean production by farm size groups (%)

Country	Small (0-20 ha)	Medium (20-100 ha)	Large (100 ha)
Brazil	51	31	17
Costa Rica	39	49	12
Ecuador	72	18	10
Honduras	72	19	10
Venezuela	65	21	14

SOURCE Agricultural Census Brazil 1975 Costa Rica 1963, Ecuador 1974 Honduras 1974 Venezuela 1975

Table 2 2 Shares of farm size groups in cropland and bean production (%)

Farm size	Brazil		Costa Rica		Ecuador	
	Beans	Cropland	Beans	Cropland	Beans	Cropland
Small farms	51	13	39	19	72	25
Medium farms	31	27	49	39	18	27
Large farms	17	60	12	42	10	48

SOURCE Agricultural Census Brazil 1975 Ecuador 1974 Costa Rica 1963

Table 2 3 Bean yields by farm size Brazil 1975

Farm size	Yield (kg/ha)
0 - 20 ha	429
20 - 100 ha	411
100 + ha	363

SOURCE Agricultural Census Brazil 1975

Table 2 4 Cropping system by farm size Venezuela

Farm size	Association %	Monoculture %
0 - 5 ha	55 7	33 3
5 - 10 ha	56 4	43 6
10- 20 ha	48 2	51 8
20 - 50 ha	46 5	53 5
50 - 100 ha	40 3	59 7
100 + ha	30 4	69 6

SOURCE Agricultural Census 1975

Table 2 5 Percent of bean production in associated cropping systems

Country	Beans in association	Monoculture
Brazil	70 2	29 8
Mexico	33 0	67 0
Honduras	53 4	46 6
Venezuela	51 6	48 4

SOURCE Agricultural Census Brazil 1975 Mexico 1970 Honduras 1974 Venezuela 1975

Table 2 6 Correlations between yields in monoculture and associated cropping for F_3 families of different growth habits

Maize variety	Bean Type I	Bean Type II & III	Bean Type IV
La Posta	83[a]	01	44
Suwan 1	83[a]	08	24
Población 30	78[a]	- 26	26

[a] p 0 01

SOURCE Perez 1982

Table 2 7 Correlations between yields of 25 climbing bean varieties in different cropping systems

	Association	Monoculture
Relay	35	- 01
Association		37

SOURCE CIAT Bean Annual Report 1979

Table 2 8 Input use in four bean cropping systems Colombia

Input use	Eastern Antioquia	Southern Narino	Central Narino	Northern Narino
Farms				
Fumigating (%)	100	93	65	3
Average number of fumigations	6 8	4 3	2 2	-
Using chemical fertilizer (%)	94	62	40	20
Fertilizer dosages (kg/ha)				
Nitrogen	45	17	12	9
Phosphorus (P_2O_5)	75	26	19	28
Potassium (K_2O)	44	14	9	9
Farms treating seed (%)	32	24	0	3
Farms surveyed 1982 (no)	53	45	35	20

Table 2 9 Subsistence production of beans Per cent of production consumed on-farm

Country	%
Brazil	23
Costa Rica	29
Ecuador	28

SOURCE Agricultural Census Brazil 1975, Costa Rica 1963, Ecuador 1974

Table 10 Subsistence bean production by farm size, Costa Rica

Farm Size	% Production consumed on-Farm
0 - 10	52
10 - 20	45
20 - 100	24
100 +	13

SOURCE Agricultural Census 1973

Table 11 Grain quality characteristics Scale Bias and future demand

Grain quality	Probable Bias	Market potential
Unacceptable in market	Small farm	Negative
Less preferred	Large farm	Some Future negative
Highly preferred	None	Strong

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