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Identifying appropriate technologies for farmers: the case of the bean + maize system in Ipiales, Colombia, 1982-1986

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IDENTIFYING APPROPRIATE TECHNOLOGIES FOR FARMERS: THE CASE OF THE BEAN + MAIZE SYSTEM IN IPIALES, COLOMBIA 1982-1986

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Summary

This document gives a complete account so far of an ongoing on-farm research (OFR) program. There is special emphasis on the evolution of activities from year to year and on the integration of agronomic and socio-economic information. The document is intended to be used for exercises and discussions in OFR training and to provide ideas and information to scientists working on bean + maize associations.

An ICA-CIAT project was carried out on the bean + maize sub-system in the Ipiales district of southern Colombia to test OFR methodology, demonstrate its effectiveness and generate technology suitable for small farmers. The target area has 10,000 ha of climbing beans + maize between 2450 and 2900m above sea level, 77% of farmers have under 6 ha and usually own their land. Ninety-four percent of the bean crop is marketed, but maize is a subsistence crop.

The methodology used based the design of different trial types on a rapid initial reconnaissance and formal survey which were backed up by additional brief studies as needs arose. Four seasons' work on stepwise changes in the climbing beans + maize sub-system led to the liberation of a stable variety of local seed type and the identification of a stable early

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line as a candidate for release. Both may be planted at farmers' density and spacing or at higher bean population. Other technological changes identified as adoptable by farmers were an improvement in foliar disease control and the control of *Fusarium* late wilt by use of the new varieties and chemicals. New themes which arose during the work and which are expected to lead to adoptable technologies are the change of maize varieties to allow more maize or bean yield, inoculation with *Rhizobium* with or without increased chemical fertilization so as to increase yields without upsetting the maize-bean balance, and foliar sprays with magnesium sulphate to cure foliar yellowing caused by cold weather. Short-season climbing-or bush-bean + maize crops which allow a rotation crop in the same season have also been identified.

The methodology used was thus highly effective in identifying technologies adoptable by farmers. Farmer participation has been important at all stages, but particularly in trial evaluation. Spontaneous testing and adoption by farmers of a line in the trials led to the decision for its formal release. Unusually severe frosts and low market prices have held back its diffusion.

The OFR has depended on a supply of bean lines and maize populations from the Obonuco experimental station, as well as close collaboration between researchers and extensionists. Partly as a result of the work reported here, ICA has embarked on an OFR project in six areas of Colombia, of which Ipiales is one.

1. Introduction

In many parts of the world there is interest in the efficiency of research in farmers' fields. There is however, relatively little information on the execution of the entire process. This document describes in detail a research program on small farms in Colombia and analyzes some of its successes and problems. Since the project is still in progress, conclusions may be modified in the future, and it is also expected that there will be more achievements to be reported.

Since 1978, the Bean Program of the Centro International de Agricultura Tropical (CIAT) and the Grain Legume Program of the Instituto Colombiano Agropecuario (ICA), have worked together on bean research. At the beginning, work concentrated on breeding programs in experimental stations, including Obonuco, in Nariño department. However, work was also conducted on the validation of technologies in farmers fields in the departments of Antioquia (Tobon et al, 1982) and Huila (Ruiz de Londoño et al, 1985).

Early in 1982, ICA-CIAT on-farm research focused on beans was initiated in Nariño department, following an approach to CIAT by the regional directors of ICA. Nariño was estimated in the period 1978-1982 to be third in national bean production with 9535t (15,000 ha) out of a total of 76,000t (113,600 ha) (URPA, 1985) (between 1983 and 1985 local extensionists have estimated 25000 ha annually of beans in Nariño). In 1982, Bean Program activities in farmers' fields were expanding from technology validation (Sanders and Lynam, 1982) to on-farm research using a model similar to that of other institutions, particularly CIMMYT. On-farm research activities in Nariño followed the methodological framework described by Woolley (1988) and included selection of the work area, diagnosis (revision of secondary information, reconnaissance, survey, and special studies), design (identification of problems, target groups of farmers and their practices, identification of appropriate solutions, and design of trials), and trials in farmers' fields (varietal, exploratory, economic levels, verification, and semi-commercial) each with their different methods of evaluation (Figure 1).

2. Selection of the Work Area

Three potential work areas were identified from municipal production data provided by ICA. Reconnaissance confirmed that beans were important in each and that their climate, farmers' situation, and bean cropping systems were sufficiently different to justify work in all. One area was

Ipiales district, the others (Funes and El Tambo) are described in other documents (Woolley et al 1988a, 1988b).

The suitability of Ipiales district for bean on-farm research was confirmed in May 1982 through interviews with ICA officials and by consulting meteorological data and a previous description of the area (ICA, 1980). Eight characteristics were important.

a. Ipiales district is important in the national agricultural development plan.

b. Land holdings are small, with 77% of the properties occupying less than 6 ha.

c. Beans are a main source of income for the small farmer (the survey later estimated that 94% of production is sold); they are always planted in association with maize, which is used for home consumption, and is one of the main food sources (potato, barley and wheat are the others).

d. Work in the zone is supported by the experimental station of Obonuco, 80 km from Ipiales.

e. ICA personnel, are assigned to Ipiales district, but they concentrate their work on potatoes, wheat, barley, and dairying due to the lack of resources for work on beans/maize.

f. Ipiales district had an estimated 10,000 ha in bean + maize associations.

g. The large seeded bean produced in the zone is easily sold at high prices (US$1/kg in the 1982 harvest).

h. The area has good communications thanks to the Panamerican highway.

Reconnaissance of the zone (see section 3), identified five other characteristics which confirmed its suitability for a research project in farmers' fields.

i. Farmers in the zone showed interest when questioned about beans and maize and asked if trials could be conducted in the zone.

j. Average bean yields were very low (400 kg/ha in nine months) despite the fact that maize yields were acceptable (2000 kg/ha).

k. Farmers were used to using inputs, especially for potatoes, but also for beans/maize. However all maize and beans planted were local cultivars.

l. Technologies used in the Obonuco station were apparently appropriate for the zone.

m. The association of beans with maize is attractive for producers because it offers more return than wheat and barley, but implies less risk and use of capital than potatoes.

3. Initial Diagnosis and Design

In three days, during May 1982, a group of 4 CIAT professionals (two economists and two agronomists) carried out a reconnaissance of the zone with ICA extensionists. All bean producing areas were covered in the municipalities of Ipiales, Pupiales, Contadero, Gualmatán, Potosí, Córdoba, Puerres, Túquerres, Ospina, and Sapuyes. The last three were eliminated from the initial work area since beans were observed to be less important due to the cool climate.

In June 1982 a survey was designed and executed, covering 45 farmers in the other seven municipalities. Planning for the first year of trials was based on the information gathered through the reconnaissance and the survey. Trials were planted in September and October 1982 in Ipiales, Contadero, Gualmatán, Potosí and Córdoba. Pupiales and Puerres were excluded so as to make the initial research area more compact. To verify the results of the survey and ask other questions, another survey was conducted in February 1983 with 27 farmers in the five municipalities where trials were concentrated. Based on secondary information, on the reconnaissance and on the two surveys which were mutually consistent (Pachico, 1984), a brief description of the zone is presented.

3.1 Description of the zone

The work zone covers altitudes between 2450m (the lowest part of the valley of the Guaitara river) and 2900m (the limit for beans because of the cold climate; maize is grown up to 3000m and potatoes up to 3200m). Slopes are often steep and soils are of volcanic origin. There is a drier period, from June to August, and the most rainy months are October to December with a smaller peak in March and April. Average rainfall is estimated to be 800 mm/year. Mean temperature varies from 11 to $14^{o}C$, depending on the altitude within the zone. Rainfall data taken at 2600 m on two farms in Contadero and Ipiales municipios estimated precipitation in 1986 as 723 and 779 mm. More data is available from meterological stations, but all are situated at the upper limit of the zone. Mean rainfall in Puerres town (2820 m), Gualmatan town (2830 m) and Ipiales airport (2960 m) was estimated as 898, 880 and 875 mm (mean 1980-1986).

Bean planting date varies slightly between the more humid municipalities towards the east (Potosí, Córdoba, Puerres, and Chaguaipe village in Ipiales) and the drier areas towards the west (Contadero, Gualmatán, Pupiales, and the rest of Ipiales). Plantings in the east are distributed from May to November with a maximum in August (30%). In the west, the planting period is more restricted, from August to November, with a maximum in September (32%) and October (41%).

Beans/maize are commonly planted after potatoes (38% of the bean plots), barley (27%), beans/maize (20%), wheat (7%) or peas (3%). In the east, a higher proportion is planted after a previous bean/maize crop and there are few plantings after potatoes; in the west, there are more plantings after potatoes and few after beans/maize. Most farmers cannot name the "principal crop" on their farms and face the variations in market prices by planting a little of all the crops.

Beans/maize are associated with other crops, including pumpkins (84% of the plots, but with few plants/ha), row intercropped broad beans (Vicia faba) (50%) or quinoa (Chenopodium quinoa) (8%). Lupinus sp is also found, but only on the borders of beans/maize plots.

Sixty-eight percent of the farmers prepare the land with oxen, 11% with a combination of tractor and oxen, 12% with tractor alone, and 9% with hoe. When oxen are used, the most common practice is to plow twice and rake once. Maize and beans are planted simultaneously. Almost all farmers plant 4 seeds of maize and 2 of beans. The most usual planting distance is about 1.0 m between furrows and 1.0 m between plants; the mean is 0.85 x 0.98m.

Seventy-seven percent of the bean plots are planted with the varieties Mortiño or Mortiñito, 10% with Sabanero, 13% with Cargamanto Rayado, and less than 1% with Conejo. Morocho Blanco or Capia maize is used. All are local cultivars; no improved bean or maize varieties were detected in the zone.

Very few farmers (5%) used credit for beans/maize in 1982 and 1983 but they used inputs, especially foliar fungicides (85%) and foliar insecticides (94%), in mixtures and with an average of 3 applications during the growth period. A large number of products was used, and farmers had little information on the characteristics of each. The most common fungicides were Manzate (maneb) or Dithane (mancozeb) (77% of farmers) and the insecticides Parathion (40%) and Roxion (22%). Only 18% of farmers treat their seeds before planting.

Farmers had applied chemical fertilizer to 58% of the bean plots surveyed and manure to 28%. On plots where fertilizer had not been used, 69% of farmers said that the reason was that they had planted in potato stubble or on "new land". Practices for chemical fertilizer application included side dressing at first weeding (43%); broadcasting at first weeding (14%); above the seed at planting time (21%); and broadcast during the second weeding (14%). The average fertilizer dose was 13.3N - 24.4 P_2O_5 - 9.6 K_2O. The most used product was 13-26-6, followed by 15-15-15, and 10-30-10.

3.2 Identification of problems

Unlike current CIAT and ICA surveys, the ones used in Ipiales in 1982 and 1983 did not ask farmers about their problems. Problem identification was based entirely on the problems identified by the farmers or observed by researchers during the reconnaissance, and was supplemented with inferences from the survey results. The following main problems were found:

a. High incidence of a microlepidopteron leaf miner known locally as "toston". Subsequently it was identified as *Phyllonoricter* sp. (Gracilariidae).

b. Leaf and pod diseases, their approximate order of economic importance being: anthracnose (*Colletotrichum lindemuthianum*), ascochyta (*Ascochyta phaseolorum*)*, rust (*Uromyces phaseoli*), powdery mildew (*Erysiphe polygoni*), and angular leaf spot (*Isariopsis griseola*).

c. Root rots, mainly those causing damage after flowering, identified as *Fusarium oxysporum*.

d. An inappropriate balance of elements in the formula 13-26-6 leading to unnecessary expenditure on potassium and lack of phosphorus (the soils have high phosphorus fixation).

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* Recent evidence indicates that this may be more correctly identified as phoma blight (*Phoma exigua* var. *diversispora*). (Pastor-Corrales, personal communication).

e. The low population densities for beans, used by farmers because the aggressive local bean varieties cause maize lodging.

f. Lack of time after beans/maize to plant another crop during the agricultural year, restricting the farm income.

Problems (a), (b), and (c) were identified both by farmers and researchers during the reconnaissance (although farmers did not always distinguish all the different leaf diseases). Problems (d), (e), and (f) were identified during observations by the researchers. The importance of problem (b) was supported by the observations from the survey that a high percentage of farmers used insecticides and fungicides and that they used many different products.

So far, one problem has been temporarily eliminated from the list and two have been added. Leaf miner was a major problem on a few farms in 1982/3, was slight in 1983/4, disappeared in 1984/5, and reappeared in 1985/6 on few farms, but not as an economic problem. It was thus eliminated from the list after one year, but will probably return in the future. One problem was implicit in the solutions tested, from the first year, although not expressed until later: "Low yield potential of the local bean cultivars". Another problem was added after four years, after better understanding of the effects of additional fertilization: "Maize needs more nitrogen, but its early application depresses bean yield due to competition".

The comments of the farmers during the reconnaissance and the survey show that the new technologies evaluated must be compared on the basis of profitability and risk in relation to other crops grown in the zone.

3.3 Identification of solutions and design of trials

Many of the solutions to be evaluated during the first year were apparent to researchers during the reconnaissance due to their knowledge of the technologies available from Obonuco station or because of their experiences in Antioquia, Colombia, with climbing bean systems in relay with maize. No explicit evaluation of solutions for ease of research, ease of adoption and potential benefit was carried out, in contrast to what is recommended today. However, during the preparation of the outlines of trials, there was discussion on the feasibility for farmers of the changes proposed and of their probability of success in the zone. Some 15 person-days were dedicated to internal debate during the preparation of trial outlines; these were discussed in a meeting among five CIAT and ICA Research and ICA Rural Development scientists. A further 10 person-days were invested in preparing the details of the trials.

In subsequent years, the time invested in design has been slightly less, but the planning meeting, held each August, now has 10 members.

4. Experimentation, Evaluation, and Additional Diagnosis

Starting from the list of six problems, 10 solutions entered trials in 1982B (Table 1). Only two solutions (plant mulching for control of leaf diseases and the use of pyrethroid insecticides against the leaf miner) were abandoned after one planting cycle. Of the others, only one has been eliminated before reaching the verification or demonstration stage. However, the treatments evaluated for each solution have evolved, especially in the case of the genetic component. At present, 12 types of solution are being researched for the seven principal problems recognized. The wealth of research opportunities and the large work zone led to an aggressive search for promising technologies and to a great diversity of activities. The strategy in using different trial types is therefore described first, followed by a description of the progress achieved with each type of solution.

4.1 Strategy for trials and special studies

An aggressive strategy of OFR has been used in Ipiales. In 1982B, the stages of variety, exploratory, economic levels and verification trials were commenced simultaneously. The best three components from the 1982B exploratory trials went to verification trials in 1983B. The varietal component (Frijolica 0-3.2) was immediately acceptable to farmers and entered semi-commercial trials in 1984B. Lines with one year's clear superiority over Frijolica 0-3.2 in variety trials passed to economic levels trials the following year. Any component with one year's success in economic levels trials passed to verification trials the next year and, if successful, to semi-commercial trials the year after that.

Components with doubtful agronomic, economic or farmers' evaluation were either immediately discarded or retested the following year. For example, increased doses of fertilizer remained in economic levels trials for 3 years before being verified in 1985B; foliar applications of benomyl were verified for two years before being passed to semicommercial trials in 1985B.

As part of diagnosis, special studies were used to clarify the acceptability to farmers of technologies being tested when the information from the initial diagnosis was insufficient.

4.2 Evolution of recommendation domains

In the first year of trials, the area was divided into two tentative recommendation domains, eastern and western, which differed in farmers' planting date (see section 3.1). Earlier planting in the east reflects better moisture availability in the driest part of the year. For logistic reasons, it was necessary to plant in both tentative domains in the same months. It was decided to use fields destined for bean planting in the most popular months, September and October. According to the initial survey, this covered 73% of bean fields in the western zone but only 30% in the eastern zone, where planting dates were very variable. Equal numbers of each type of trial were assigned to the eastern and western zone for the first two years. No difference in results was detected for September-October planting dates, so the tentative domains were reunited as one only.

Bush beans suffered severely from foliar diseases above 2800 m in 1982B and were therefore not tested again above that altitude. Similarly, after two years' work, it was realized that, although farmers in the area plant maize + beans between 2800m and 2900m, they regard it as risky due to frost damage to beans and maize lodging due to high winds. Winds and frost indeed damaged all trials above 2800m in 1983B. Areas above 2800m were therefore separated into a separate domain after 1983B, but received little attention in trials.

Experimentation was commenced in a new area in 1985B, part of the municipality of Puerres. In this area farmers use a wider spacing within the maize row and place stakes alternately with maize plants as support for beans. Puerres was therefore treated as a separate recommendation domain. Variety and verification trials were planted. It was found that technologies could be successfully extrapolated from the rest of the research area, but their responses were different in magnitude.

Tentative domains which were more restricted were used for experimentation of three types. Firstly, it was feasible only below 2650m to shorten the maize + bean cycle sufficiently to include another crop. Experiments and recommendations on crop intensification therefore concentrated on the range 2450-2650m. Secondly, trials for the control of root rots were only assigned to fields with a previous history of root rot problems. Thirdly, after 1982B, trials on fertilizer dose were not placed on fields from which potatoes had just been harvested. The survey had shown that farmers do not fertilize maize + beans after potatoes.

4.3 Trial management

All trials were conducted with farmers who dedicated a majority of their time to the farm, by far the most typical category in the area. The lots requested were almost always destined by the farmer to bean production that year, so as to obtain typical rotation practices. Fields with a history of root rot problems were an exception to this rule.

Within the tentative recommendation domain, trials were distributed to sample adequately the range of variability in soil texture, soil fertility (usually soil analyses were available before planting), slope and altitude.

In all trials, farmers carried out routine operations when they were not experimental treatments: land preparation, weeding and ridging-up, foliar disease and insect control. Fertilizer was applied by the researchers in all except semi-commercial trials. In variety, exploratory and economic levels trials, the check included in the trial was the mode practice identified from the surveys and applied by the researchers. In verification trials, the host farmer first planted his own practice as one treatment. The researchers then, with his help, imitated those practices in other treatments changing only the components involved in the technology under test.

The bean seed used in trials was a mixture of the seed harvested from farmers' trials in the previous year. Seed produced on experimental stations was used only for new lines in their first year of testing. When maize variety was not an experimental treatment, each farmer's own maize (almost always Morocho Blanco) was used.

4.4 Change of climbing bean variety

The varietal component has been evaluated in a large number of trials, including all those planted since 1983.

A variety trial with Morocho Blanco maize has been designed each year since 1982. Half the lines included in 1982B had undergone preliminary testing in 1981B on two farms above 2900m. Then and each year since, new lines from Obonuco experimental station have been introduced (Table 2). Since 1985B, these lines are the best ones identified in two on-farm trials of advanced lines planted the previous year.

From the first year of testing, Frijolica 0-3.2 (released in June 1985; formerly known as Ecuador 605) showed promise. It was of good yield, 2 to 3 weeks earlier to harvest than Mortiño, more synchronized in its maturity and tolerant to anthracnose. It was later identified as tolerant to Fusarium late wilt (section 4.9).

TIB 30-42 entered trials in 1983B and is 5 to 8 weeks earlier than Mortiño, more resistant to anthracnose than Frijolica 0-3.2, and of similar resistance to Fusarium late wilt.

The line 32980-1-41 was highly promising in 1982B but has since been disappointing. Although often earlier than Frijolica 0-3.2, its earliness varies more with environment than other lines tested. It also showed anthracnose lesions on pods in some trials in 1984B, despite being classed as resistant at Obonuco. Reusing seed each year in farm trials may have allowed anthracnose susceptibility to show.

AND 53 is the newest promising line and is a rounded pure red type, early and resistant to anthracnose. The four lines mentioned all have seed types acceptable in the area. All had bean yields superior to Mortiño and Sabanero and depress maize yields little or nothing. The net benefit obtained from the new lines in the variety trials was usually superior to the lines of high commercial value, Mortiño and Sabanero (Table 3).

The results from all the trials in which the lines have been tested, not just variety trials, are summarized in Table 4. Frijolica 0-3.2 and TIB 30-42 both yield approximately 200 kg/ha more than Mortiño without depressing maize yield any more. Frijolica 0-3.2 was consistent in performance except in 1984B when its advantage over Mortiño was reduced by the "yellowing problem" on some farms (section 4.12). 32980-1-41, as in variety trials, declined in performance after 1982B.

Adaptability analysis of all lines tested in two or more years (Figure 2) confirms the superiority of Frijolica 0-3.2 over a wide range of environments. TIB 30-42, 32980-1-41 and 32980-1-44 outyielded it by up to 100 kg/ha on average in farms of below average yield. However, Frijolica 0-3.2 was the most stable overall, with an adaptability coefficient equal to Mortiño, but of higher yield. The performance of the less aggressive line TIB 30-42, was similar to Mortiño at high fertility when compared under similar agronomy. TIB 30-42 responds, however, to high density planting more than Mortiño does.

4.5 Change of climbing beans to bush beans

Researchers at Obonuco experimental station had proposed the use of bush beans in sole crop or row intercropping as an alternative to climbing beans.

Two or three sole-cropped bush bean lines were tested at the side of the climbing bean variety trial each year. From 1984B, row intercropping was also included. Despite an occasional good year for bush beans, like 1982B (1981B had also been good in ICA trials), their yields were generally poor (Table 5). Bush beans appeared more susceptible to poor soils and early-season drought than climbing beans. Surprisingly, bean yields were depressed little by maize, so row intercropping was economically superior to sole cropping and even gave similar benefits to association with climbing beans (Table 3). Frijolica 0-3.1 (originally TIB 33462) appeared slightly less stable in sole cropping from year to year than Antioquia 8 and TIB 33411 (results from other studies confirm this) and also appeared to depress maize yields more when intercropped (Table 5).

4.6 Exploratory trial: check for interactions

Variety, foliar disease control, fertilizer dose and density increase in beans (achieved by establishing 2 maize and 2 bean plants every 0.5m instead of 4 maize and 2 beans every 1.0m) were studied in 1982B in a 2^4 trial since all had been identified as promising solutions and all potentially had strong interactions with each other. Fertilizer dose had a slight negative effect on beans and maize (see section 4.10). The other factors had highly significant ($P \leq 0.001$) positive effects on beans, and the spacing change also had a positive effect on maize. These effects are discussed in the following sections. The only significant interactions were slight ($0.05 \leq P \leq 0.10$). Frijolica 0-3.2 responded more to density than Mortiño and improved disease control was more effective at higher bean densities (Table 6). The three new components had similar effects in a verification trial in 1983B, but their interactions were different (Table 7). There was a greater increase of net benefit for Frijolica 0-3.2 over Mortiño with farmers' practices than at high density.

4.7 Foliar disease and insect control

Three applications of benomyl plus mancozeb were more effective than three of mancozeb in 1982B, but the effect of benomyl was small in the 1983B and 1984B verification trials (Table 4). The apparent change between years was at least partly an artefact of trial design. In 1983B researchers applied benomyl + mancozeb 3 times as the "improved technology", but farmers were left to apply their control. They applied on average 3.8 times; of 13 farmers, 10 used insecticides and not just fungicides; 4 farmers used sulphur or oxycarboxin plus mancozeb as fungicide. A similar pattern was observed in 1984B. Thus 3 applications of mancozeb + benomyl is superior to farmers' present costly mixtures of products.

In 1984B, five of the 9 farmers used products which control rust in their applications but researchers did not. Mortiño and Frijolica 0-3.2 responded to researchers' disease control, but 32980-1-41 did not (Table 8). 32980-1-41 suffered more rust attack than the other lines and farmers' control of rust probably explains the difference.

Leaf-miner was a serious problem in 1982B. Researchers' attempts to control it with synthetic pyrethroids were unsuccessful in two trials and metamidofos had to be applied to avoid total loss for the collaborating farmers. Leaf-miner incidence fell off sharply in 1983B making impossible a further study of control which had been initiated. Leaf-miner symptoms reappeared in a few villages at the end of the 1985B season.

4.8 Density and spatial arrangement

There is a danger of maize lodging if the number of bean plants per hill is increased. The first attempts in increasing bean density therefore used a component which had been tested on station and farm in Antioquia department, Colombia. Two maize seeds and two bean seeds were planted every 0.5m instead of four maize and two beans every 1.0m within the row. Inter-row spacing was unchanged. In 1982B, this change in spatial arrangement increased maize yields, bean yields and net benefit for both Mortiño and Frijolica 0-3.2 (Table 6). When verified in 1983B, it increased bean yields but reduced maize yields, leading to a small gain in net benefit for Frijolica 0-3.2 and a larger one for Mortiño (Table 7). However, when evaluating the trials, farmers rejected the component owing to the change in cultivation practices needed (forming ridges instead of mounds), the difficulty of applying fungicide to dense bean growth and a fear of maize lodging and lower yield.

4.8.1 Frijolica 0-3.2

In 1984B, planting arrangements for Frijolica 0-3.2 with maize and bean densities close to 4 plants/m^2 but with maize spacing of 1.0, 0.8, 0.65 and 0.5m were tested and evaluated by farmers. 3 bean and 3 maize seeds (3B 3M) at 0.8m gave economic benefits for Frijolica 0-3.2 similar to 3B 2M at 0.5m (Table 9). In the same trial, 3 bean seeds/hill gave higher returns for Frijolica 0-3.2 given a fixed spacing of 1.0m and 4 maize seeds/hill. Four bean seeds/hill gave higher returns, but increased the risk of maize lodging.

In 1985B, 3B 3M at 0.8m was verified for Frijolica 0-3.2 and improved maize yields, bean yields and net benefit over 3B 4M at 1.0m under all conditions (Table 10). Meanwhile changes in the number of maize and bean seeds at 0.8m were tested in an economic levels trials. 4B 3M at 0.8m was the most favourable (Table 11). No maize lodging was observed.

4.8.2 TIB 30-42

As soon as this less aggressive, early line was shown to be promising, work was initiated to determine a suitable spatial arrangement.

TIB 30-42 responded well to high density (4B 2M at 0.5m) in 1984B (Table 9), but even for this variety farmers did not evaluate favourably the close spacing. When TIB 30-42 was verified in 1985B it was therefore tested with 4B 3M at 0.8m. TIB 30-42 performed well with the early maize Pool 7 in intensification trials (section 4.13). When planting densities were examined for this association, 6B 4M at 0.8m gave highest benefits, followed closely by 4B 4M at 0.8m and 4B 3M at 0.8m (Table 11). Different planting densities for the combination TIB 30-42/Morocho Blanco at 0.8m were evaluated for the first time in 1986B.

4.9 Control of root rots and other effects of seed and soil treatment

In 1982B the two trials planted suffered no attack and the control treatment yielded most. However, in an exploratory trial affected by patches of late wilt, the farmer observed that Frijolica 0-3.2 lost fewer plants than Mortiño. Thence began the study of integrated control by a combination of tolerant variety and chemical seed or soil treatment. In all three seasons 1983B to 1985B, the effects of variety and chemical treatment were found to be additive, not interacting, and are therefore reported separately.

In all infected trials, Frijolica 0-3.2 was superior in yield and plant stand at harvest, to Mortiño, whose plants died due to late wilt (Table 12). Potosi 1 was of similar tolerance to Frijolica 0-3.2 but outyielded it on one farm in 1984B when yellowing symptoms (see section 4.12) affected Frijolica 0-3.2. The testing of Potosi 1 was discontinued because of its lateness and anthracnose susceptibility and because it offered root rot tolerance no greater than Frijolica 0-3.2. Maize yields were not higher for Mortiño than the other lines, confirming that the elimination of competition (by death of plants) occurred late in its growth cycle. In 1985B, TIB 30-42 was observed to be at least as tolerant to late wilt as Frijolica 0-3.2, in two verification trials planted by chance on infected fields.

The effects of chemical control have been more variable. Aldrin soil insecticide was the best control on an infected farm in 1983B, and channels of an unidentified insect were observed in roots. Fungicides offered no improvement (Table 13). However in 1984B, after Aldrin had been withdrawn from the market in Colombia, carbaryl was used and produced little effect, but benomyl and benomyl/carboxin fungicidal seed treatments were somewhat effective (Table 13). In 1985B captan seed treatment increased maize and bean yields on an infected farm (Table 14) but benomyl/carboxin was not effective.

Effects of seed and soil treatment, positive and negative, go beyond the control of Fusarium late wilt. From 1982B to 1984B, soaking seed in benomyl solution before planting, reduced yield slightly (Table 4). Carboxin seed treatment had a similar negative effect. In contrast, seed treatment with a mixture of benomyl and carboxin produced a yield increase in beans in 1984B and 1985B. It produced negative effects on beans (from 30 to 240 kg/ha) on 3 out of 12 farms. Possibly, when benomyl is absorbed by the young plant it slows the build up of anthracnose infection and increases yield for this reason and not by controlling late wilt. Yield losses in beans from seed or soil fungicide application may be the result of damage to Rhizobium or mycorrhizal populations, but as yet there is no evidence of this.

Soil fumigation at planting with captafol did not reduce late wilt (unlike seed treatment with captafol). However, it caused over 300 kg/ha increase in maize yields (Table 14). There was no interaction with benomyl/carboxin application to seeds. Thus, tentatively, seed treatment with captafol reduces loss to late wilt, but is best used in the presence of a tolerant variety. Benomyl + carboxin seed treatment protects against the build up of foliar disease, and captafol soil treatment increases maize yields.

4.10 Fertilizer application

From soil analyses (Table 15), no response of beans to any element would be predicted. There have however been some unexpected responses.

In 1982B, as mentioned in section 4.6, there was a negative effect of increasing fertilizer dose from 100 to 300 kg/ha of 13-26-6, due apparently to root burning of small plants. In fertilizer trials in the same year, plants were also lost due to nitrogen and boron application, but not to 13-26-6 application (Table 16). Beans responded to at least 40 kg/ha P and to magnesium, without maize yield being lost. Potassium increased bean and maize yields, but zinc and boron (which damaged plant stand when applied at planting) did not.

In 1983B, a trial with high fertilizer doses was specially designed to check application methods. Side dressing at ridging up was found to produce the highest bean yields, and also damaged bean population least (Table 17). This application method was shown in the 1983 survey to be the most used by farmers (section 3.1) and was used in all trials from 1983B onwards. Fertilizer responses were hard to interpret in 1983B and so the same treatments were repeated in 1984B and 1985B. No treatment by year interactions were found, except in beans for the factor nitrogen. The results are therefore presented as the mean of three years (Table 18).

Nitrogen x phosphorous interactions were absent. Nitrogen increased maize yields almost linearly, but depressed bean yields due to competition from maize. Bean yield declined in all years as N was increased from 13 to 39 kg/ha; it continued declining in 1983B as N was raised from 39 to 65 kg/ha, but recovered in 1984B and 1985B.

Levels around 65N appear economic for the association, but the investment is great and results vary from farm to farm. In contrast to 1982B with applications at planting time, the application of P at ridging up gave modest marginal returns since beans responded significantly only to high doses of P and maize did not respond. There was a response to potassium in beans, but not in maize. It is inferred from these results that the use of the formula 13-26-6 is appropriate since it is likely to be cheaper than separate N and K applications and may sometimes obtain response from P as well.

Response to magnesium was variable among farms and years. Although it was of no mean benefit, magnesium increased the yield of Frijolica 0-3.2 by 220 and 276 kg/ha on two farms which suffered yellowing (see section 4.12) in 1984B.

The application of 300 kg/ha 13-26-6 increased both bean and maize yields by approximately 100 kg/ha and was economic in comparison to farmers' present level of 100 kg/ha, which in turn gave a high marginal rate of return over leaving the crop unfertilized (Table 18). In 1985B only, levels of 200 and 400 kg/ha 13-26-6 were also tested. The latter gave the highest net benefit.

Despite these results, in the 1985B verification trials applying 300 kg/ha 13-26-6 only increased maize yield on fields with under 60 ppm P and did not increase bean yield in any of the tentative domains (Table 10).

4.11 Inoculation with Rhizobium

The benefits of *Rhizobium* inoculation were first studied in 1985B, with a view to the development on-farm of suitable technologies for the area. There was a strong effect on beans on two farms, but little response on a third (Table 19). On farms where there had been a response to inoculation, nodule counts were, surprisingly, lower in inoculated treatments. Nodule counts were also lower in Frijolica 0-3.2 than in

Mortiño, despite the superior yield of Frijolica 0-3.2. Rhizobium inoculation with or without nitrogen application may be a way of increasing nitrogen supply to maize and beans without the depression of bean yields which occurs when nitrogen is applied alone and maize responds strongly. This is being explored in trials during 1986B. In addition, the response to inoculation of Mortiño, Frijolica 0-3.2 and TIB 30-42 with three different cold adapted Rhizobium strains, and their mixture, is being explored.

4.12 Study of yellowing problem

Half way through the 1984B season, two months before the release date of Frijolica 0-3.2, a field problem was noticed which apparently affected Frijolica 0-3.2 more than Mortiño. Leaves turned yellow, beginning with the lower ones and gradually extending upwards. Sometimes purple spots were noticed on the leaves. Symptoms did not resemble Fusarium late wilt and there was no evidence of root rot in affected plants. Occasionally symptoms were observed in Mortiño and other lines. Even when symptoms were severe in Frijolica 0-3.2 and not in Mortiño, yield loss was only 280 kg/ha (eg. S.A. Mejia, Table 26). Eventually, over half of the farm trials were affected, but Frijolica 0-3.2 still outyielded Mortiño by 63 kg/ha in 1984B.

As soon as the problem appeared, a superimposed trial was designed for affected farmers' fields. The application of foliar magnesium increased yield by 128 kg/ha (applied at mid pod-fill in a field where yellowing was slight) and 324 kg/ha (applied at late flowering). A mixture of micronutrients (B, Zn, Mo and Mg) was not more effective than magnesium alone (Table 20). There was no response in Mortiño. In 1985B there was little yellowing. When the superimposed trial was repeated including a treatment with magnesium chloride, there were no significant treatment differences. It was therefore not possible to conclude definitely that magnesium and not the sulphur from magnesum sulphate was responsible for the benefit observed in 1984B although the lack of response to zinc sulphate provided some evidence for it being magnesium.

In the 1984B fertilizer trial, there was a significant response to application of 20 kg/ha magnesium at ridging up (220 and 276 kg/ha) in two fields with yellowing symptoms but not in another without yellowing. Yellowing was reduced in the magnesium treatments.

Seeds of Mortiño and Frijolica 0-3.2 from different years were analyzed for micronutrient deficiencies (Zn, Mn, Mo, B) which might build up when seed is produced year after year in the area, but no deficiencies were found.

In 1984B, the highest yields of Mortiño were obtained when it commenced flowering after 11 March, while Frijolica 0-3.2 only yielded less than Mortiño in trials where it commenced flowering between 20 February and 11 March (Table 21). Since the severest cold spells were in January and early February, this suggests that both varieties are sensitive to cold just before flowering. The seed weight of Mortiño was unusually low when it commenced flowering between 20 February and 6 March, suggesting that cold may affect seed weight too. However, the highest seed weights in Frijolica 0-3.2 were obtained when it commenced flowering on 21 February or 10 March.

The present diagnosis of the problem is that it is a magnesium deficiency aggravated by cold just before flowering. The problem can be corrected by foliar applications of magnesium sulphate as soon as it appears. Soil applications at ridging-up are also effective, but their high cost (and slight negative effect in fields without yellowing) make them an unattractive "insurance policy".

4.13 Intensification of the cropping cycle

Each year there has been an economic levels trial aimed at including another crop after an earlier maize + beans harvest.

In 1982B, Cundinamarca 431 was the most promising early maize to combine with the early bean ICA Llanogrande and offered an attractive marginal rate of return over the combination Morocho Blanco + Mortiño as well as enough time to plant another crop during the year (Table 22). Although Llanogrande yielded well at high density in this trial, its testing was discontinued because of very unstable performance in the variety trial and verification trial in 1982B.

In 1983B, Llanogrande was replaced by 32980-1-41 which dominated Cundinamarca 431 so much that farmers staked the trial (Table 23). 32980-1-41 was also later to maturity than in 1982B.

In the same season, a special study found that 15 farmers interviewed were generally interested in an earlier maize + bean association. Seven mentioned the possibility of planting another crop (usually potato or barley), four welcomed more time for land preparation, four an earlier harvest (to obtain food earlier or a higher market price). Four were however preoccupied with the quality of the early maize that might be used (Luna, 1984).

In 1984B, two early beans (L 32983 and TIB 30-42) were tested with Cundinamarca 431 and two other early maize populations obtained from the CIMMYT Andean Maize Program (via ICA Obonuco), Pool 7 and Pool 8. Some treatments from the trial were repeated in 1985B.

L 32983 was early enough to allow a second crop and not at all aggressive, but Cundinamarca 431 was incapable of supporting it. TIB 30-42 and Pool 7 (white grain) was a well-balanced combination which yielded as well as Frijolica 0-3.2 and Morocho Blanco, but was at least one month earlier to maturity. The combination Pool 7 + TIB 30-42 was thus too late to allow a second crop, but would suit a farmer who wanted more time for land preparation, or an earlier harvest. Sole-crop bush beans were early enough to allow a second crop (before or after). They yielded a little more than sole cropped when intercropped with Cundinamarca 431 (in contrast to intercropping with Morocho Blanco: Table 5), but the presence of Cundinamarca 431 would delay, by one month, the land preparation for the second crop (Table 24).

In 1983B and 1984B, Cundinamarca 431 proved unstable and weak in conditions of early season drought. A trial of early maize populations and varieties from Colombia, Peru and Ecuador, identified Pool 5 as the most suitable white "morocho" maize for association with L 32983 (Table 25). Harvest of both maize and beans could be obtained in 6.5 to 7 months at 2600 masl.

In 1986B, the intensification trial included Pool 5 either associated with L 32983 or row intercropped with bush beans and followed by barley as well as sole cropped bush beans planted before and after barley.

4.14 Full-season maize varieties

The maize populations MB 520 (yellow) and MB 521 (white) have been tested to see whether they increase the yield of associated maize or beans without affecting the other crop.

They appeared promising in observation rows and in the intensification trial in 1983B (Table 23) but no direct comparison with Morocho Blanco was possible.

In 1984B there was evidence of increasing suppression of Frijolica 0-3.2 bean yield by maize, moving from Morocho Blanco to MB 520 to MB 521 (Table 24). This was not confirmed by results from 1985B (Table 11), when MB 521 was the most favourable companion for Frijolica 0-3.2. Pool 7, which was a good partner for TIB 30-42 was an acceptable partner for Frijolica 0-3.2 although there may be more risk of lodging than when Morocho Blanco is used.

When verified with Frijolica 0-3.2 in 1985B, MB 521 lodged more than Morocho Blanco. Only in fields with more than 60 ppm P was there any advantage of using MB 521 (able 10).

4.15 Semi-commercial trials

Frijolica 0-3.2 was compared with Mortiño by farmers in 1984B in farmer-managed semi-commercial trials where each farmer's usual practices were applied to both varieties in plots of 1000-2000 m^2. Despite its yellowing problems in 1984B, Frijolica 0-3.2 outyelded Mortiño numerically on five out of seven farms (mean 95 kg/ha), permitted more maize yield on four farms (mean 67 kg/ha) and led to a greater net benefit on four farms (mean 1600 pesos, or 1%) (Table 26).

In 1985B, benomyl was supplied to farmers along with Frijolica 0-3.2 and instructions on how to add benomyl to their existing disease and insect control mixtures. It was also suggested that the number of applications be reduced to three. Frijolica 0-3.2 plus benomyl outyielded the local variety with traditional disease control on all 13 farms (mean advantage 265 kg/ha; range 42 to 659 kg/ha). Maize yield was higher (mean 195 kg/ha) on all except 2 farms (range -187 to 599 kg/ha). Net benefit was at least 16000 pesos/ha greater on 10 out of 13 farms (mean increase 35000 pesos/ha, or 40%) including three of the four farms included to extrapolate technology outside the original work area (Table 27). The new technology also performed well on all the four farms above 2850 m, despite earlier fears that Frijolica 0-3.2 might not be adapted to such high altitudes. Only on one farm was the net benefit slightly lower (3300 pesos) for the new technology than for the farmer´s own practices.

5. Movement of new technologies in trials

There has been a rapid flow of technological components through the stages of testing and a supply of new components, especially genetic material, from Obonuco experimental station.

Some lines have been discarded after variety trials, another, ICA Llanogrande was dropped after verification trials (Table 28). 32980-1-41 was dropped after verification trials in 1984B, but reincluded in verification in 1986B, after re-analysis of its potential across the years 1982-85. Potosi 1 was eliminated after two years in variety and economic levels trials showed more disadvantages then advantages compared to Frijolica 0-3.2. Frijolica 0-3.2 and TIB 30-42 were both tested for two years before verification, and then passed to semi-commercial trials in the fourth year. The information on Frijolica 0-3.2 in 1982B was so positive that it would probably have passed to verification trials in 1983B even without the information from regional trials in 1981B.

ICA is considering TIB 30-42 for release, depending on the progress of the 1986B semi-commercial trials.

Table 29 shows the progress of other technological components. The use of benomyl for improved foliar disease control reached semi-commercial trials for the first time in 1985B after two years in verification due to doubts, now resolved, about the consistency of the benefit obtained. After the planting arrangement 2B 2M at 0.5m had been rejected by farmers during verification, it was modified to 3B 3M at 1.0m and verified two years later. An increase in bean population to 4B 3M at 0.8m followed one year behind and was being verified in 1986B while 3B 3M at 0.8m was in semi-commercial trials. Similarly benomyl + carboxin seed treatment passed to semi-commercial trials in 1986B, while the apparently more effective product captafol, identified one year later, was being verified. MB 521 maize was reverified in 1986B due to doubts about its consistency in 1985B while increased fertilizer doses were reevaluated in economic levels trials for the same reason. Pool 7 maize, in association with TIB 30-42 reached verification in 1986B.

6. Diffusion and follow-up of technologies

One of the most remarkable experiences in Ipiales has been the response of farmers to technological components which they liked.

Farmer initiative can be seen most clearly for the variety Frijolica 0-3.2. Farmers' attention was apparently attracted to Frijolica 0-3.2 during verification trials. Seven sold seed from trial borders (in six cases, mixed with Mortiño, without price discount according to their reports) and eighteen requested seed for the following year, which ICA supplied in 5 kg packets. In 1984B, an estimated 40 farmers planted semi-commercial quantities of Frijolica 0-3.2. This, together with favourable trial results on farm in 1981B, 1982B and 1983B, the favourable progress of semi-commercial trials and the positive evaluations by collaborating farmers (Table 30) led ICA to release Frijolica 0-3.2 in June 1985. This was a bold decision since the results of the first semi-commercial trials were not yet known, and allowed seed to be distributed in time for the 1985B season. 158 farmers received 1 kg packets of Frijolica 0-3.2 in two field days, one in Obonuco experimental station and one in the Ipiales area. During the field days, farmers who had collaborated in trials answered the questions of other farmers about practices, yields and marketing.

The acceptability of Frijolica 0-3.2 was evaluated with 38 farmers after the 1984B harvest (Guerrero and Pachico, 1985). Results were similar to those from one year earlier (Table 30), although more farmers now noted the small price discount (Table 31), estimated as 6.3% in June 1985. 61% of farmers sold Frijolica 0-3.2 alone, the rest mixed with Mortiño. Grain size of Frijolica 0-3.2 and Mortiño vary from year to year and farm to farm. In 1984B, Frijolica 0-3.2 was often inferior due apparently to the yellowing problem. Farmers noted the size difference, but did not consider Frijolica 0-3.2 more susceptible to yellowing than Mortiño (Table 31).

87% of farmers said they would plant Frijolica 0-3.2 in 1985B, and 85% kept seed for this purpose, on average 6.7 kg of Frijolica 0-3.2 compared to 18.2 kg of Mortiño. In the acceptability study, Frijolica 0-3.2 was estimated from farmers' reports and crop cuts, to be approximately 100 kg/ha superior in yield to Mortiño. The estimate from trials in 1984B was similar (63 kg/ha), but higher in the other three years with no yellowing problem (242 kg/ha) (Table 4).

If farmers with other access to seed are included, we estimate that 200-250 farmers planted Frijolica 0-3.2 in 1985B. Two events slowed its spread. A severe frost on three consecutive days early in November 1985, reportedly the worst for 20 years in that month, killed beans in many parts of Ipiales, including 60-70% of farmers' plots of Frijolica 0-3.2. For many farmers it was too late to replant. Then bean prices declined to a ten-year low at harvest, which increased the discount suffered by Frijolica 0-3.2 to at least 30%. At these prices it was still as profitable as Mortiño because of its superior, stable yield. However, farmers who depended on local intermediaries, rather than merchants in Ipiales, reported that the intermediaries were often unwilling to purchase Frijolica 0-3.2.

A study early in 1986B with a sample of farmers who had planted Frijolica 0-3.2 in 1985B found that 20% of them had lost all their seed due to frost. Fifty percent of the rest continued to plant Frijolica 0-3.2 and had increased the area planted to an average 35% of their area planted to beans which declined due to low prices. They were estimated to obtain on average 692 kg/ha from Frijolica 0-3.2, and 515 kg/ha from Mortiño. Maize yields were unaffected. The other 50% continued to evaluate the variety favourably for yield, resistance and earliness, but did not plant it in 1986B due to its low price (Pachico, personal communication). Current research is aimed at understanding the reasons for the difference in the strategies of the two groups of farmers. It is believed that Frijolica 0-3.2 is likely to be adopted by a high proportion of farmers if bean prices return to normal.

7. Analysis of resource use

Trials in Ipiales have been more numerous than is usual in on-farm research projects, principally because of our interest in the development and adaptation of methodology (Table 32). In order to give us more experience with different trial designs and technological components, more solutions have been studied than is usual or advisable in adaptive on-farm research. In order to obtain information on the minimum number of trials advisable in a recommendation domain, many copies have sometimes been planted.

The principal achievements reported in this document (that is, excluding information on fertilizer doses and cropping intensification) could have been achieved with an initial diagnosis and only 61 trials spread over four years. The liberation of Frijolica 0-3.2 could have been achieved with initial diagnosis and 25 on-farm trials spread over 3 years (Table 33). As part of methodology development, the initial survey was executed in 1982A and repeated with refinements in 1983A. With our present knowledge, a reconnaissance of one week (two to four professionals) and a survey of 50 farmers (15 person-days execution and 15 of analysis) would have been sufficient for initial diagnosis.

Thus, when farmer participation is included, on-farm research is neither a lengthy nor a costly process.

8. Analysis of lessons learnt

Here is a summary of the ways in which experiences in Ipiales have helped the evolution of the methodologies used, with particular emphasis on self-criticism.

8.1 Diagnosis and initial planning

The reconnaissance was useful in preparing the exploratory survey which followed, and in preparing the list of problems and possible solutions. More discussion of the results of the reconnaissance would have permitted questions to farmers about the reasons for certain practices to be included in the exploratory survey, as we now recommend. In retrospect, the trials planned in the first year generally took farmers' needs and reasons into account. However, in the case of fertilizer application, a better initial understanding would have improved the relevance of the first year's trials. In the reconnaissance, researchers found that some farmers applied fertilizer at planting time. However, in our eagerness we deduced from principles of plant nutrition and from application methods on Obonuco experimental station that this practice would be the most beneficial on farms. Root damage and low stand resulted (section 4.10). A survey during the first year showed that few farmers apply fertilizer at planting, and all of them apply it above the seed (which, incidentally, can also damage plant stand, see Table 17).

8.2 Farmer participation

Farmer participation can be divided into the management of trials, the choice of treatments to be included in trials and the evaluation of trials. In small-plot and verification trials, farmers have usually managed all non-experimental variables except fertilizer application, where unintentional variations in dose could severely affect results. In semi-commercial trials, all practices have been left in farmers' hands (Woolley, 1988). Farmers have not been explicitly consulted about the exact treatments to be included in trials, although their evaluations of previous trials influence researchers' choices. Farmers' reaction to components in future semi-commercial trials in this project will show whether this strategy has led to wasted effort by researchers.

From the start, farmers have participated in the evaluation of verification trials. In 1984B and 1985B, evaluation of all trials by farmers was introduced. We have found that, for effective evaluation, the farmer has to be introduced to the treatments from the time the trial is planted.

Farmer evaluation has sometimes been misleading, or possibly badly organized by us. For example, farmers who managed the 0.5m within row spacing in exploratory trials did not detect any problem in its management. Even those who worked with larger plots in verification trials, only expressed near harvest time their reservation about the new cultivation practices. Farmers were also over-optimistic about selling Frijolica 0-3.2 mixed with Mortiño, without a price discount. They may of course have been influenced by researchers' enthusiasm.

8.3 Communication between farm researchers and the experimental station

This has generally been excellent, and on-farm research can be said to have drawn together groups which were originally more separated. Both farm and station researchers have been involved in the planning of OFR and visit each others' work. Copies of farm trials have been planted at Obonuco to compare the results with those on farm.

Only on one occasion can communication be said to have failed due to omission. A decision to release the bush bean variety Frijolica 0-3.1 was taken based on limited OFR results from other areas. OFR research results already obtained in Ipiales and another OFR zone (Funes) from 1982B-1984B indicated that this variety is less stable than others like Antioquia 8 and TIB 33411. Discussions had centered on the prospects for climbing bean varieties. Since bush beans were apparently of little interest to farmers in Ipiales, these results had only been discussed superficially. Thus, researchers should be alert to apply their results to areas other than their own project area.

8.4 Use of an aggressive research strategy

In general, the rapid progress to verification and the simultaneous initiation of several avenues of research were successful.

Verification trials were not successful in the first year, mainly because the two fields chosen were unusually unproductive. ICA Llanogrande happened to be ill-adapted to the area, but farmers were not discouraged by this (both continued as collaborators). In general we can state that if verification is commenced in the first year, it should be done on sufficient farms (at least four per domain even if risky).

The variability of responses from year to year can interfere with an aggressive research strategy, but has not generally been a problem in Ipiales. The consistent response of Frijolica 0-3.2 was important in its rapid adoption by farmers and release. The response to changed spatial arrangements (section 4.8.1) and foliar disease control (section 4.7) was different in 1982B and 1983B. These components had passed directly from exploratory trials to verification trials, which reevaluated similar (more limited) treatment combinations. This strategy was more fruitful than simply repeating the exploratory trial in 1983B, since both components thus made more rapid progress to modification (spatial arrangement) or eventual recommendation (foliar disease control). The inconsistency of fertilizer results when verified in 1985B (section 4.10) is probably due to factors other than year to year variability.

The aggressive strategy has also evaluated certain technological components (fertilizer dose since 1982B and spatial arrangement/density since 1984B) only in the promising variety Frijolica 0-3.2, and not in Mortiño, the local variety. This has been indicated because farmers appear to adopt the new variety before the other practices.

8.5 Design of trials

8.5.1 Plot size and total number of replications

Groups of 3 or 4 trials of one design have usually had LSDs (10%) for bean yields of the order of 100-150 kg/ha before factorial effects are combined. This gives sufficient precision for most technological components, since smaller gains would not be of interest to farmers. However, seed treatments are not costly and farmers may be interested in smaller average gains, especially as insurance against occasionally severe disease attack. Trials have not generally been precise enough to determine whether seed treatments produce small positive or small negative effects. It is however difficult to justify investing more resources in increasing the number of replications in order to increase precision.

LSDs for maize are usually about three times greater than those for beans, since maize is an outpollinated crop and thus more variable from plant to plant than beans, which are self-pollinated. However since bean:maize price ratios have averaged 3:1 (range 2.4:1 to 4.5 to 1) over the four years, errors in bean yield have on average three times more effect on estimated net benefit than errors of the same size in maize yield.

It is not therefore necessary to increase precision in maize data, unless the bean:maize price ratio falls sharply.

8.5.2 Problems in defining disease control treatments

In section 4.7 the effectiveness of benomyl was underestimated by comparing variable farmer disease control practices, adjusted according to the occurrence of rain, with calendar treatments by researchers. Comparing new disease control practices with those of farmers is a complex problem, discussed further by Woolley (1987).

8.5.3 Number of replications/farm and number of farms

Data from four farms has usually been necessary for trials of climbing varieties, to detect the strong genotype x environment interaction of some less desirable lines. Four copies of the 1982B exploratory trial would be the minimum desirable (there were in fact five) and four copies seems to be the minimum desirable for trials dealing with changes in density and spatial arrangement. As many as nine trials (spread over three years) were necessary in order to understand the effect of fertilizer applications. Maize seems less variable, and the results from only 2 farms in the early maize trial are thought to be reliable. Two infected farms per year may be sufficient to understand root rot control, but more farms have to be planted since infection cannot be guaranteed.

In verification trials, two replications at the level of each farm are certainly necessary in our experience. Data from 1983B was hard to interpret since the end plots were often suspected to have been affected by a non-experimental source of variance. Eight harvested verification trials was the minimum necessary to stratify a variable zone like Ipiales, in 1985B.

8.6 New themes which emerged from unexpected results

Two lines of work which arose, show the adaptability of OFR to new situations. Trials on the benefits of inoculation began as a background study to determine the potential of inoculation and compare the nodulation of Mortiño and Frijolica 0-3.2. However, inoculation appeared to be a way to increase nitrogen supply to maize and beans without increasing competition from maize, prejudicial to beans, and in the second year is already being tested in treatments in a fertilizer trial.

In a different set of circumstances, studies of the yellowing problem began because of its sudden appearance, and led within 15 months to a preliminary recommendation of curative foliar applications of magnesium.

In a different way, seed treatment with benomyl + carboxin powder was tested as a control for root rots, but instead appears to give early protection against anthracnose. Captan soil fumigation did not protect against bean root rots, but provided an unexpected yield increase in maize. Neither of these results had been reported previously. Adaptive on-farm research may therefore lead to new themes for background or adaptive research.

8.7 Naming of varieties

It is unfortunate that the name used for the line Ecuador 605 as a new variety was chosen without consulting the local researchers and farmers and using a set of criteria apparently designed only for the convenience of research administrators. Our knowledge of farmer practices in naming materials would have permitted us to predict that farmers would shorten "Frijolica 0-3.2" to "Frijolica", the same name given to three other bean lines liberated in 1985 and 1986. We would recommend short, attractive names, which are already part of farmer's vocabulary. Names of local areas, from which the adaptation of varieties can also be inferred, have already been successfully used by ICA (eg. ICA Pijao).

9. The future in the Ipiales work zone

9.1 The future of OFR in the area

Influenced by the success of this project, and by the experiences in OFR of various national programs with CIMMYT and IDRC, ICA decided to set up six OFR pilot projects. One was initiated in Ipiales during 1986 and strengthens the contacts between scientists at Obonuco experimental station and those based in Ipiales. The maize-bean sub-system is included among various sub-systems being studied. The municipalities covered, Potosi, Cordoba and Puerres, cover part of the zone where this work was initiated, so results from the project reported here are being used extensively.

9.2 The future of beans in Ipiales

The price of beans will undoubtedly influence farmers' enthusiasm for the technologies studied with them in this project. Given prices similar to the 1982B and 1983B harvests, most technologies which have reached verification or farmer-managed trials in 1986B are already being adopted (Frijolica 0-3.2 and maybe use of foliar benomyl) or stand a good chance of adoption. Farmers would apparently welcome the availability of a range of varieties of different maturity and different commercial seed-types and there are promising lines and a released variety (Frijolica 0-3.2, TIB 30-42, maybe AND 53 and, in bush beans Antioquia 8-II) which meet these needs. Fusarium late wilt is a problem apparently on the increase, fortunately the first two lines are known to be tolerant. Leaf miner is expected to be a problem in 1986B and this will at least provide the opportunity to study its control.

Marginal rates of return for the components tested were calculated from the effects in Table 4 and are presented in Table 34. The bean: maize price ratio is the parameter that most affects which treatments are economic. The variable costs and net benefits presented were therefore calculated using mean costs and prices of products (corrected for inflation) for three seasons when the bean:maize price ratio was around 2.5 (1982B, 1983B and 1985B) and one when it was near 4.5 (1984B). These approximate the bean:maize price ratios over a longer period, for which data are available. Of course, bean:fertilizer and maize:fertilizer price ratios also affect the interpretation of some trial results and these are not constant either. Variability of economic returns on particular technologies from farm to farm are outside the scope of this document but are discussed elsewhere (Luna and Valderrama 1986) using some of the data from Ipiales.

9.3 Summary of present recommendations

For full-season associations of maize and beans (occupying 8-9 months at 2600 masl), the following components can be adopted independently by farmers:

- The variety Frijolica 0-3.2, planted at farmers' normal spacing and with farmers' maize, or, if closer spacing is desired, with 3 maize and 3 bean seeds every 0.8m within the row (the advantage of using 3 maize and 4 bean seeds is expected to be confirmed shortly). Alternatively, the earlier line TIB 30-42 may be used with farmers' practices, or with 3 maize and 4 beans at 0.8m in the row. It is expected that Pool 7 maize will be confirmed as a suitable partner for TIB 30-42.

- The addition of benomyl (0.5 kg/ha) to the disease and insect control fumigation used at present, with a reduction of maneb to 1.0 kg/ha.

- Bean seed treatment with 0.75 g/kg benomyl + 0.25 kg/ha carboxin 300 powder (provisional recommendation, captafol powder expected to be included instead of, or as well as, benomyl + carboxin).

For a short season crop of 6-6.5 months at 2600 masl, the cropping system can be provisionally described as Pool 5 maize (early white "morocho" type) associated with L 32983 (M4) early climbing beans (medium sized red seed) or row intercropped with Antioquia 8 (II) bush beans.

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This document is dedicated to the memory of our colleague Oscar Herrera Duran who contributed enthusiastically to the first two years of the work until his untimely death.

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Table 1. Search for solutions and present situation of research in Ipiales District (December 1986)

PROBLEM	SOLUTION	PRESENT SITUATION
Low yield of local bean cultivars	-Search for higher yielding varieties with similar characteristics	-Frijolica 0-3.2 released
	-Use less competitive maize	-MB 521 in verification
	-More chemical fertilizer	-300 kg/ha 13-26-6 in verification
	-Add B, Mg or Zn	-Mg necessary only when yellowing occurs due to low temperature
Foliar diseases, root rots	-Tolerant variety	-Frijolica 0-3.2 released -TIB 30-42 in semi-commercial trials and being considered for release
Low bean density	-Less aggresive variety at increased density	-0-3.2; 3 seeds at 0.8m x 1m in semi-commercial trials; 4 seeds at 0.8 m x 1 m in verification -TIB 30-42; 3 seeds at 0.8m x1m in semi-commercial trials; 4 seeds at 0.8m x 1m already verified
Foliar diseases	-Mulch soil using cut weeds	-Insufficient weeds. Abandoned after first year
Root rots	-Chemical control + tolerant variety	-Benomyl + carboxin in semi-commercial trials. Captafol in verification. Frijolica 0.3-2 and TIB 30-42 tolerant; searching for increased resistance
Long cycle of maize + beans	-Maize + early beans	-Pool 5 maize + L 32983 (climbing beans) or Antioquia 8-II (bush beans) under evaluation
Foliar diseases (mainly anthracnose)	-Add benomyl to farmers' fumigations with maneb	-Under demostration managed by farmers. It is suspected that benomyl-treated seed also helps in control
Lack of P for beans and unnecessary expenditure on K	-Change N:P:K ratio	-13-26-6 was found appropriate for applications at first weeding. P + K applications at planting are being investigated
Leaf miner	-Use of pyrethroid insecticides	-Only metamidophos worked. Problem disappeared after 1982/83
Maize requires more N, but its early application decreases bean yields due to competition	-Apply N to maize later	-Under evaluation for the first time in 1986/87
	-Combine inoculation and N applications	-Under evaluation for the first time in 1986/87

Table 2. Summary. Variety Trials. Ipiales district. 1982B-1985B.

Identification	Weeks to Harvest at 2600m (estimate)	100 Seed Weight (g)	Grain Color	Yield (kg/ha) 1982B		1983B		1984B		1985B		Weighted Mean	
				B	M	B	M	B	M	B	M	B	M
Frijolica 0-3.2*	33	72	Purple/cream	707	1920	545	903	570	1404	615	1860	609	1522
TIB 30-42	30	60	Red/cream	-	-	461	1235	584	1724	515	1786	601	1582
32980-1-44	32	43	Purple	754	2071	485	1305	479	1366	-	-	566	1646
32980-1-41	32	56	Cream/purple	956	1745	505	1060	311	1701	440	1767	553	1568
Potosí 1	36	65	Black/Purple	-	-	355	1193	311	1323	-	-	412	1526
ICA M-8*	31	47	Red	629	2178	231	1111	-	-	-	-	366	1737
Mortiño (check)*1	35	85	Purple/cream	466	2062	370	1107	139	1484	416	1922	348	1644
Sabanero (check)*	36	97	Pink/red	485	2149	380	1377	173	1555	-	-	343	1763
TIB 33-41	34	43	Red	-	-	228	1259	220	1704	-	-	277	1797
5799	31	45	Red	480	2276	-	-	-	-	-	-	-	-
Cargamanto rayado (check)	36	93	Beige/black	436	1855	-	-	-	-	-	-	-	-
Llanogrande*	29	49	Cream/purple	293	1747	-	-	-	-	-	-	-	-
Sañudo 36	36	57	Purple/cream	606	1969	-	-	-	-	-	-	-	-
32980-1-43	32	56	Purple	572	2327	-	-	-	-	-	-	-	-
32976-1-41	32	46	Red	561	2269	-	-	-	-	-	-	-	-
V 33003*	31	52	White	545	2367	-	-	-	-	-	-	-	-
Ecuador 521*	34	51	Red	537	2291	-	-	-	-	-	-	-	-
Selección Mat local V2	35	66	Purple/cream	-	-	283	1097	-	-	-	-	-	-
Selección Mat local V1	35	59	Purple/cream	-	-	276	1129	-	-	-	-	-	-
ICA M-4 (L 32983)*	28	50	Red	-	-	201	1550	-	-	-	-	-	-
TIB 19-42	30	51	Purple	-	-	-	-	212	1818	-	-	-	-
TIB 19-41	30	56	Purple	-	-	-	-	123	1670	-	-	-	-
AND 53	31	55	Red	-	-	-	-	-	-	615	1709	-	-
AND 27	30	65	Red	-	-	-	-	-	-	436	1713	-	-
AND 37	31	64	Red	-	-	-	-	-	-	418	1897	-	-
AND 39	31	46	Red	-	-	-	-	-	-	355	2262	-	-
Mortiño x Llanogrande-413	34	71	Cream/red	-	-	-	-	-	-	342	1891	-	-
AND 58	30	62	Red	-	-	-	-	-	-	302	1858	-	-
LSD (10%)				202	572	131	290	131	422	97	345	-	-

* Lines tested on 2 farms in 1981B.

Table 3. Variable cost and net benefit of various systems tested in the variety trials, Ipiales district 1982B-1985B. Calculated using mean costs and prices of the four years and expressed in December 1986 pesos.

Bean variety	Price Relative to Mortiño	Variable Cost thous. pesos/ha	Net Benefit (thousand pesos/ha) 1982B	1983B	1984B	1985B
Climbing beans associated with maize						
Frijolica 0-3.2	0.91	10.3	75.3	123.9	153.2	82.8
32980-1-41	0.61	6.7	66.0	96.8	92.9	49.5
32980-1-44	0.67	6.0	72.1	128.0	106.8	-
TIB 30-42	0.72	7.3	-	119.3	153.1	61.3
AND 53	-	-	-	-	-	67.4
Mortiño (check)	1	12.6	59.9	109.0	61.9	67.1
Sabanero (check)	1.18	16.1	70.5	150.0	78.5	-
Bush beans row intercropped with maize						
Antioquia 8	0.62	21.7	-	-	107.5	59.1
TIB 33411	0.59	22.4	-	-	114.4	48.5
Frijolica 0-3.1	0.55	18.9	-	-	112.0	50.7
Sole cropped bush beans						
Antioquia 8	0.62	16.9	-	8.8	42.2	-11.0
TIB 33411	0.59	17.9	23.5	20.0	25.7	-10.8
Frijolica 0-3.1	0.55	16.5	-	-	11.9	-10.8

Table 4. Summary of effects. Ipiales 1982B-1985B. kg/ha of beans and maize

Effect	1982B		1983B		1984B		1985B		Mean	
	B	M	B	M	B	M	B	M	B	M
Change of Bean variety										
Mortiño to Frijolica 0-3.2	243	-131	238	-79	63	58	233	142	194	-3
Mortiño to TIB 30-42			91	69	296	197	228	-136	205	43
Mortiño to 32980-1-41	490	-317	135	-93	30	243	24	-155	170	80
Change of Maize variety										
Morocho blanco to MB 520 (0-3.2 & Mort)[b]					-144	324	56	-12	-44	156
Morocho blanco to MB 521 (0-3.2 & Mort)[b]					-187	549	133	307	-27	428
Change of fertilization (at ridging-up)										
13N to 39N			-126	496	-34	427	-81	235	-80	386
39N to 65N			-44	513	105	392	111	119	57	341
11.3P to 34P			40	176	38	27	77	-218	52	-5
34P to 56.7P			35	-113	153	-29	22	439	70	100
0 to 100 kg/ha 13-26-6			156	822	122	19	157	674	145	505
100 to 300 kg/ha 13-26-6			149	152	67	397	-54	-108	54	147
0 to 20 Mg (in presence of 300 kg/ha 13-26-6)			-52	221	160	-357	-53	-552	18	-229
0 to 15K (in presence of 39N + 34P)			107	-577	108	297	64	356	93	25
Change in density										
4M 2B, 1m to 2M 2B, 0.5m (0-3.2 & Mort)	209	355	194	-175	205	2			203	60
4M 3B, 1m to 3M 3B, 0.8m (Frij 0-3.2)					92	-24	159	208	125	92
Control of foliar diseases										
Farmers'control to mancozeb + benomyl(3)	313	-116	16	35	52	-30			127	-37
Seed and soil treatment										
Soaking in benomyl	-75	-	24	-138	-109	12			-53	-60
Carboxin	-59	-	-106	200	11	60			-53	130
Benomyl + carboxin 3:1					56	-186	57	239	56	26
Captafol applied to seed							118	323	118[a]	323[a]
Aldrin alone	-23	-	112	11					44	11
Carbaryl alone					41	-209			41	-209
Farmers' mean yield	401	1997	636	1838	557	2137	515	1632	527	1901

a Result from only 1 farm with *Fusarium* infection

b 1984B: effect measured only in Frijolica 0.3-2

Table 5. Summary of maize and bush bean yields (kg/ha) in variety trials. Ipiales 1982B-1985B

Sole crop beans

Bean Variety	1982B 4 farms	1983B 3 farms	1984B 3 farms	1985B 4 farms	Mean 1984B & 1985B	Weighted Mean 1983B to 1985B
Antioquia 8	-	506	639	702[a]	670	616
Frijolica 0-3.1	-	-	476	788	632	600
TIB 33411	1445	625	575	755	665	652
TIB 33341	1231	283	-	-	-	-
LSD (10%)	202	131	131	124	-	-

Beans row intercropped with maize

Bean Variety	1984B Bean	1984B Maize	1985B Bean	1985B Maize	Mean 1984B & 1985B Bean	Mean 1984B & 1985B Maize
Antioquia 8	434	1928	503[a]	1993	468	1960
Frijolica 0-3.1	429	1752	510	1820	469	1786
TIB 33411	368	2058	528	1768	448	1913
LSD (10%)	131	422	124	514	-	-

a In 1985B Antioquia 8-II (selection of habit 2 plants) was used: in the previous years a mixture of growth habits 1 y 2 was used.

Table 6. Yield, costs and benefits of new technologies with Mortiño and Frijolica 0.3-2 (from an exploratory experiment on disease control x variety x fertilizer x density) Mean of five farms, Ipiales 1982B

	Farmer Technology		Increased Bean Density		Improved Foliar Disease Control		Increased Bean Density + Improved Foliar Disease Ctrl	
	Bean	Maíze	Bean	Maíze	Bean	Maíze	Bean	Maíze
Yield (kg/ha)								
Mortiño	435	1832	550	2094	658	1462	890	2049
Frijolica 0-3.2	592	1617	818	1874	847	1509	1253	1736
Variable cost (thousands of pesos/ha)[a]								
With Mortiño	12.8		16.6		16.4		20.2	
With Frijolica 0-3.2	11.9		16.3		15.5		19.8	
Net return (thousands of pesos/ha)[a]								
With Mortiño	127.8		158.6		140.7		210.0	
With Frijolica 0-3.2	133.9		179.1		163.4		234.7	
LSD (10%) for yield (kg/ha), same disease control			159		441			
LSD (10%) for yield (kg/ha), different disease control			168		513			

a Estimated using mean costs and prices 1982B to 1985B and expressed in December 1986 pesos.

Table 7. Comparison between Mortiño and Frijolica 0.3-2 at different technology levels. Verification trial, Ipiales 1983B. Mean of 12 farms.

	Farmer Technology		Improved Disease Control		Improved Disease Control and Increased Bean Density	
Bean variety	Mort.	Frij. 0-3.2	Mort.	Frij. 0-3.2	Mort.	Frij. 0-3.2
Bean yield (kg/ha)	622	965	648	971	879	1128
Maize yield (kg/ha)	1609	1578	1693	1563	1488	1418
Variable costs (thousands of pesos/ha)[a]	12.8	11.9	16.4	15.5	20.2	18.4
Net return (thousands of pesos/ha)[a]	146.6	184.6	152.3	185.6	175.8	198.5

LSD (10%) for yield: beans 267 kg/ha; maize 302 kg/ha. Fixed costs: 38.8 thousand pesos/ha.

a Estimated using mean costs and prices, 1982B to 1985B, and expressed in December 1986 pesos.

Table 8. Comparison between Mortiño and Frijolica 0.3-2 and 32980-1-41 at different technology levels. Verification trial, Ipiales 1983B. Mean of 9 farms.

	Farmer Technology			Improved Disease Control		
Bean Variety	Mort	Frij 0-3.2	32980-1-41	Mort	Frij 0-3.2	32980-1-41
Bean yield kg/ha	327	374	433	450	445	395
Maize yield kg/ha	1987	2177	2265	1949	2199	2191
Variable costs (thousands of pesos/ha)[a]	8.4	7.5	6.1	16.5	15.6	14.2
Net return (thousands of pesos/ha)	122.9	137.0	130.6	133.4	141.1	114.2

LSD (10%) for yield : beans 68 kg/ha; maize 304 kg/ha. Fixed costs: 38.8 thousand pesos/ha.

a Estimated using mean costs and prices 1982B to 1985B, and expressed in December 1986 pesos

Table 9. Bean varieties x planting arrangement trials. Ipiales, 1984B.

Bean Variety	Spacing between planting sites (m)[a]	Seed/Sites Bean	Seed/Sites Maize	Yield (kg/ha) Bean[c] (2 farms)	Yield (kg/ha) Maize (3 farms)	Variable Costs (thousands of pesos/ha)[b]	Net Return (thousands of pesos/ha)[b]
TIB 30-42	0.5	4	2	1057	1285	16.4	176.6
TIB 30-42	1.0	4	4	762	1116	9.4	128.2
TIB 30-42	1.0	2	4	623	1500	6.9	133.7
32980-1-41	0.5	4	2	577	1359	14.5	98.0
32980-1-41	1.0	4	4	515	1387	8.5	97.7
32980-1-41	1.0	2	4	382	1540	6.5	92.0
Frijolica 0-3.2	0.5	3	2	821	1327	17.7	175.0
Frijolica 0-3.2	0.65	3	3	666	1189	15.4	138.9
Frijolica 0-3.2	0.8	3	3	654	1437	11.6	156.0
Frijolica 0-3.2	1.0	4	4	653	1401	11.9	153.1
Frijolica 0-3.2	1.0	3	4	562	1461	10.1	141.3
Frijolica 0-3.2	1.0	2	4	357	1355	8.2	97.2
Mortiño (check)	1.0	2	4	476	1346	9.3	127.4
LSD (10%)				115	305		

Fixed costs: 48.3 thousand pesos/ha

[a] Interrow spacing was always 1.0 m.
[b] Estimated using mean costs and prices 1982B to 1985B and expressed in December 1986 pesos.
[c] Variety, arrangement and variety x arrangement effects were significant in beans but not in maize.

Table 10. Verification trial. Ipiales 1985B. Yields of beans and maize (kg/ha.), and net benefits.

Bean Variety	Maize Variety	Distance between hills	Seeds/Hill B	Seeds/Hill M	13-26-6 (kg/ha)	Mean of 2 fertile fields(1) Yield B (kg/ha)	Yield M (kg/ha)	Variable costs[a] (thous. pesos/ha)	Net benefit[a] (thous. pesos/ha)	Mean of 4 infertile fields (2) Yield B (kg/ha)	Yield M (kg/ha)	Variable costs[a] (thous. pesos/ha)	Net benefit[a] (thous. pesos/ha)	Mean of 2 fields in Puerres (3) (4) Yield B (kg/ha)	Yield M (kg/ha)	Variable Costs[a] (thous.pesos/ha)	Net Benefit[a] (thous.pesos/ha)
Frijolica 0-3.2	MB 521	0.8	3	3	300	936	1147	27.9	181.0	547	2267	27.9	176.8	1437	1506	79.3	248.3
TIB 30-42	Morocho Bco	0.8	4	3	100	823	1292	16.0	147.4	644	2158	16.0	174.7	1290	1520	55.4	193.3
Frijolica 0-3.2	Morocho Bco	0.8	3	3	100	962	1229	16.8	202.2	533	2104	16.8	175.0	1228	1439	80.8	202.5
Frijolica 0-3.2	Morocho Bco + T	0.8	3	3	300	763	845	28.1	125.6	556	2254	28.1	177.5	1268	3103	90.4	305.2
Frijolica 0-3.2	Morocho Bco	0.8	3	3	300	872	938	28.0	155.5	527	2081	28.0	161.2	991	1682	100.5	152.6
Frijolica 0-3.2	Morocho Bco	1.0	3	4	100	782	1000	15.2	155.0	453	1741	15.2	138.5	847	1227	79.1	117.8
Mortiño	Morocho Bco	1.0	2	4	100	338*	1062	14.4	80.9	217	2087	14.4	119.8	850	2365	81.8	203.4
Mortiño	Morocho Bco	1.0	2	4	100	564	1375	14.4	148.2	214	2793	14.4	163.6	555	3063	77.3	189.6
Mean						755	1111			461	2186			1058	1988		
LSD (10%)						151	306			117	643			465	1157		
% Lodging in Morocho Blanco Maize							0				10				0		
% Lodging in MB 521 maize							0				34				30		
Effects																	
Frijolica 0-3.2 (3M 3B) to TIB 30-42 (3M 4B)						-169	63			111	54			62	81		
100 to 300 kg/ha 13-26-6						-90	-291			-6	-23			-237	243		
Benomyl + carboxin (1g/kg)						-109	-93			29	173			277	1421		
Morocho Blanco to MB-521						64	209			20	186			446	-176		
Frijolica 0-3.2 (4M 3B) 1.0 m to (3M 3B) 0.8 m						180	229			80	363			381	212		
Mortiño (4M 2B) 1.0 m to Frijolica 0-3.2 (4M 3B) 1.0 m						218	-375			239	-1052			292	-1836		
Fixed costs: 42.7 thousand pesos/ha																	

(1) Fields with high P content (60 ppm) and previously cropped with potato

(2) Fields with intermediate P content (21 to 45 ppm) and not previously cropped with potato.

(3) Maize data from only one farm in Puerres

(4) Costs that vary include the value of stakes used in each plot.

a. Calculated using mean prices for 1982B to 1985B and expressed in December 1986 pesos.

T. Seed treatment , benomyl + carboxin.

*. One farmer used Cargamanto rayado, not Mortiño

Table 11. Maize varieties x bean varieties x planting arrangements trial. Ipiales, 1985B. Mean of 2 farms.

Bean Var.	Maize Var.	Distance between hills(m)	Seeds/ hill F	Seeds/ hill M	Yield (kg/ha) Bean	Yield (kg/ha) Maize	Variable Costs (thousands of pesos/ha)[a]	Net Return (thousands of pesos/ha)[a]
TIB 30-42	Pool 7	0.8	6	4	541	2491	15.0	175.6
TIB 30-42	Pool 7	0.8	4	4	488	2517	11.9	172.2
TIB 30-42	Pool 7	0.8	4	3	670	2122	11.2	175.7
TIB 30-42	Pool 7	1.0	4	4	375	2140	9.8	133.5
Frijolica 0-3.2	M. blanco	0.8	4	4	368	2359	14.6	156.1
Frijolica 0-3.2	M. blanco	0.8	4	3	531	2342	14.1	186.8
Frijolica 0-3.2	M. blanco	0.8	3	4	286	2306	12.3	139.3
Frijolica 0-3.2	M. blanco	0.8	3	3	308	2191	11.7	136.8
Frijolica 0-3.2	Pool 7	0.8	3	3	321	2059	12.1	130.7
Frijolica 0-3.2	MB 520	1.0	3	4	290	2353	9.9	145.4
Frijolica 0-3.2	MB 521	1.0	3	4	350	3254	9.9	213.6
Frijolica 0-3.2	M. blanco	1.0	3	4	234	2365	10.1	135.3
Mortiño	M. blanco	0.8	2	3	128	2913	10.8	151.1
Mortiño	MB 520	1.0	2	4	214	3233	9.2	191.0
Mortiño	MB 521	1.0	2	4	85	3130	9.2	157.3
Mortiño (check)	M. blanco	1.0	2	4	199	2479	9.3	140.3
Mean					337	2516		
LSD (10%)					194	748		

Fixed costs: 48.3 thousand pesos/ha

[a] Estimated using mean 1982B to 1985 B costs and prices, and expressed in December 1986 pesos.

Table 12. Varietal response to *Fusarium* late wilt

Bean yield (kg/ha)	Mortiño	Frijolica 0-3.2	Potosí 1	LSD (10%)
1983B farm with infection	222	980	921	138
1983B farms without infection (2)	697	641	615	128
1984B farm with infection	148	479	488	124
1984B farm with infection and yellowing	323	510	916	88
1985B farm with infection	149	204	-	35
Bean plants harvested (%)[1]				
1983B farm with infection	57	82	75	11
1983B farms without infection (2)	60	55	50	8
1984B farm with infection	50	50	57	-
1984B farm with infection and yellowing	75	68	72	-
1985B farm with infection	50	55	-	4
Maize yield (kg/ha)				
1983B	2070	1933	2078	191
1984B	2171	2124	2034	265
1985B	954	1046	-	166

1 As percentage of number of seeds planted.

Table 13: Effect of seed and soil chemical treatments.
Ipiales, 1983B and 1984B.

Seed Treatment (g/kg)	Soil Treatment (kg/ha)	Bean Yield: Farms with root rots 1983B-1	Bean Yield: Farms without root rots 1983B-2	Bean Yield: 1984B	% bean plants harvested[b]: 1983B -1	% bean plants harvested[b]: 1983B -2	% bean plants harvested[b]: 1984B	Maize Yield: 1983B	Maize Yield: 1984B
PCNB (1)	Insecticide[a]	675	651	537	73	59	62	1970	2228
Benomyl (0.75) + carboxin (0.25)	Insecticide	–	–	529	–	–	63	–	1944
Benomyl (1)	Insecticide	–	–	522	–	–	63	–	1798
Carboxin (1)	Insecticide	768	590	484	76	53	64	2263	2190
Benomyl (soaking 5 g/1)	Insecticide	719	811	364	60	56	61	1925	2142
Without	Insecticide	846	710	473	78	56	59	2063	2130
Without	Without	712	607	432	74	54	64	2052	2339
Without	Carbofuran (20)	591	619	–	66	56	–	1979	–
Without	PCNB (6) + insecticide	645	572	–	68	49	–	1939	–
LSD (10%)		210	195	115	16	11	10	254	405

a Aldrín (50 kg/ha) in 1983B; carbaryl 80% spray with 2 kg/ha in 1984B
b As % of number of seeds planted

Table 14. Seed treatment trial. Ipiales, 1985B
(mean data for Mortiño and Frijolica 0-3.2)

Seed treatment (g/kg)	Soil treatment with captafol[a]	Yield kg/ha: Farm with Fusarium		Farm without Symptoms		Established population (%)[b]: Farm with Fusarium		Farm without Symptoms	
		Bean	Maize	Bean	Maize	Bean	Maize	Bean	Maize
Benomyl (0.75) + Carboxin (0.25)	No	150	904	474	1609	45	68	50	74
Benomyl (0.75) + Carboxin (0.25)	Planting	200	1109	417	2065	57	69	59	68
Orthocide (2)	Planting	170	868	446	1934	53	63	64	74
Captafol (1)	No	255	1087	331	1383	53	63	51	63
No	No	137	764	420	1538	54	58	53	66
PCNB (1)	Planting	162	1010	374	1446	48	61	50	67
No	Planting	169	1122	293	1876	48	70	40	75
No	Planting and 3 months	171	1138	266	1743	57	60	47	63
Mean		177	1000	378	1699	52	64	52	69
LSD (10%)		70	333	202	436	9	12	12	8
Mean effect benomyl + carboxin[c]		22	63	89	130	0	4	8	0
Mean effect captafol (to soil)[c]		41	281	-92	397	3	6	-2	1
LSD (10%)		49	235	143	308	6	8	8	6

a 3 kg/ha in 150 l water
b As % of number of seeds planted
c Estimated from the 2 x 2 factorial set (the components showed no interaction).

Table 15. Soil analysis summary (0-20 cm). Ipiales District, 1982-1985. Total 129 samples

	Minimum	First quartile	Median	Third quartile	Maximum
O.M. %	1.4	2.8	3.2	4.0	7.7
P ppm Bray II	15.1	39.4	69.0	109.5	560.0
pH	4.9	5.6	5.8	6.1	6.7
Ca meq/100g	1.7	5.0	6.2	7.7	14.9
Mg meq/100g	0.43	1.09	1.4	2.1	4.8
Ca/Mg	1.40	3.2	4.2	5.6	14.0
K meq/100g	0.1	0.6	0.8	1.1	3.4
Na "	0.04	0.06	0.08	0.1	0.66
CEC "	6.4	11.8	13.8	17.6	34.0
B ppm	0.4	0.64	0.87	1.11	1.9
Zn ppm	1.2	2.7	3.5	5.1	14.7
Mn ppm	6.0	20.5	28.0	39.3	84.0
Cu ppm	0	0.47	0.81	1.28	4.5
Fe ppm	3.9	20.8	29.8	38.4	112.0

Table 16. Fertilization trial. Ipiales, 1982B (fertilizers applied under seed and covered at planting). Mean of 4 farms for beans and 3 for maize.

	Kg/ha	Yield (kg/ha) Beans Frijolica 0-3.2	Maize Morocho blanco	Established plants[1] Beans	Maize
Mean	23N	909	1852	80	84
of P	46N	844	1784	72	77
levels	92N	820	1979	59	69
Mean	10P	677	1774	65	71
of N	40P	901	1881	72	82
levels	80P	995	1960	75	77
LSD (10%)		133	277	11	8
Additional treatments					
23N 10P		893	1559	79	82
46N 40P		898	1891	69	84
46N 40P 20Mg		1210	1836	78	85
46N 40P 1B		780	1730	49	75
46N 40P 5Zn		889	1973	71	75
46N 40P 50K		1032	2130	65	84
300 kg/ha "13-26-6"		896	1618	91	91
LSD (10%)		251	478	23	13

1 Expressed as a percentage of total seeds planted

Table 17. Fertilization methods in Frijolica 0-3.2, 1983B. Mean of 2 farms.

			Beans			Maize		
Kg/ha 13-26-6	Position	Application Time	Yield kg/ha	% plants established[1]	% plants harvested[3]	Yield kg/ha	% plants established[1]	% plants harvested
DAP/RP[2]	Under seed	Planting	192	20	30	778	36	28
500	Band	Ridging-up	484	60	58	1216	61	40
500	Under seed	Planting	440	32	58	1586	64	49
500	Above seed	Planting	336	43	47	1247	46	38
500	Hole at side	Planting	445	62	51	1812	65	48
500	Side-dressed	Ridging-up	752	66	74	1199	67	42
100	Side-dressed	Ridging-up	461	64	54	1263	62	42
LSD (10%)			247	9	19	508	16	15

1 As percentage of number of seeds planted

2 446 Huila RP + 79 DAP + 110 Urea + 50 KCl (kg/ha) (nutrient rates equivalent to 500 kg 13-26-6/ha)

3 Established and harvested plant counts were made in different rows of the plot, thus estimations of plants harvested may be greater than plants established.

Table 18. Fertilization trial. Ipiales, 1983B-1985B (fertilizers applied side-dressed at ridging-up). Mean of 9 farms (3 per year)

	kg/ha	Yield kg/ha Beans cv Frijolica 0-3.2	Yield kg/ha Maize M. Blanco	Variable Costs (thousands of pesos/ha)[a]	Net returns (thousands of pesos/ha)[a]
Mean of P levels	13N[b]	735	1326	17.0	136.2
	39N	627	2074	20.4	159.3
	65N	679	2392	23.8	182.3
Mean of N levels	11.3P[b]	571	2050	13.2	156.6
	34.0P	657	2018	20.4	160.8
	56.7P	731	2086	27.7	168.8
LSD (10%)		59	161	-	-
Additional treatments					
39N 34P		632	2080	20.4	160.5
39N + 34P + 15K		739	2119	21.7	177.9
300 kg/ha 13-26-6		688	2096	19.7	170.7
300 kg/ha 13-26-6 + 20 Mg		706	1869	33.3	146.8
100 kg/ha 13-26-6		599	1981	9.5	160.6
0 (unfertilized)		454	1563	4.4	119.2
LSD (10%)		106	288	-	-

a Estimated using mean 1982B to 1985B costs and prices, and expressed in December 1986 pesos. Costs and returns for the N x P factorial set are calculated by adjusting the other element to its lowest level.

b Equivalent to mean farmer application according to 1982 and 1983 surveys.

Table 19. Rhizobium inoculation trial. Ipiales, 1985B

Mean of 2 varieties	Two farms with response[1] to inoculation		One farm with no response		
	Bean yield (kg/ha)	Nodules/plant	Bean yield (kg/ha)	Nodules/ plant	Maize yield (kg/ha)
Inoculated with a mixture of 3 strains	378	17.3	156	14.8	3898
With 50 kg N/ha	221	19.5	215	15.3	4575
Without nitrogen	229	25.3	240	12.3	3824
LSD (10%)	91	7.4	76	6.5	714
Mean of 3 practices					
Frijolica 0-3.2	380	15.3	268	12.4	4123
Mortiño	172	26.1	126	15.9	4012
LSD (10%)	75	6.0	62	5.3	583

There was no variety x practice interaction. All treatments received 20.3 P + 9 K at ridging-up.

1 Farmers harvested maize in both trials. Maize showed improved growth in N-fertilized treatments.

Table 20. Superimposed trial on foliar fertilization. Ipiales 1984B and 1985B. Bean yield in kg/ha

Fertilizer	Concentration (g/l)	G. Rosero[2] (0-3.2) Chaguaipe	G. Rosero[2] (Mortiño) Chaguaipe	S. Romero[3] (0-3.2) Suraz	Mean (0-3.2)	Mean 2 Farms 1985 B
Magnesium sulphate	10	859	733	945	902	152
Mixture[1]		833	766	945	889	207
Borax	2	862	728	735	798	202
Ammonium molybdate	10	828	665	719	773	154
Urea	20	882	758	649	765	-
Check	-	731	886	621	676	203
Zinc sulphate	5	647	699	578	612	144
Magnesium chloride					-	188
LSD (10%)		144	133	407	198	53

1 Mixture of magnesium sulphate, borax, ammonium molybdate, and zinc sulphate at the same rates as individual treatments.

2. Applications at pod filling. Farm with some yellowing visible in Frijolica 0-3.2.

3. Applications during late flowering. Visible yellowing in Frijolica 0-3.2.

Table 21. Yield and 100 seed weight of Mortiño and Frijolica 0-3.2 in relation to flowering date. Ipiales, 1984B

Estimated flowering date[1]		No. of trials	Yield (kg/ha)			100 Seed Weight(g)		
Frijolica 0-3.2	Mortiño		Mortiño	Frijolica 0-3.2	Difference	Mortiño	Frijolica 0-3.2	Difference
26 January	15 February	1	276	465	+189	70	63	-7
31 January	20 February	3	244	501	+257	66	58	-8
1 February	21 February	1	366	483	+117	67	52	-15
3 February	23 February	1	578	630	+52	nt[2]	nt	nt
14 February	6 March	1	108	412	+304	64	60	-4
15 February	7 March	3	319	332	+13	71	58	-13
16 February	8 March	2	306	389	+83	71	63	-8
17 February	9 March	1	323	510	+187	72	59	-13
19 February	11 March	1	339	722	+383	84	61	-23
21 February	13 March	3	542	449	-93	75[3]	70[3]	-5
22 February	14 March	1	757	319	-438	77	56	-19
10 March	30 March	1	573	415	-158	77	67	-10
11 March	31 March	1	531	441	-90	nt	nt	nt
Linear regression coefficient on days to flowering			7.3	-2.2	-9.5	0.32	0.23	-0.10
Standard error of coefficient			3.22	3.08	3.93	0.11	0.11	0.12

1 Based on planting date and height above sea level

2 No data taken

3 Data from one trial only

Table 22. Results of the intensification trial. Ipiales, 1982B. Mean of 3 farms. The most outstanding treatment for each varietal combination is included.

Maize variety (4 plants/m^2)	Bean variety and population (/m^2)	Yield (kg/ha) Beans	Yield (kg/ha) Maize	Variable Costs (thousands of pesos/ha)[a]	Net Returns (thousands of pesos/ha)[a]
Local	Llanogrande** (8)	582	2706	4.5	160.6
Cacahuacintle**	Llanogrande** (8)	637	2597	4.5	158.7
Cundinamarca 431**	Llanogrande** (8)	861	2847	4.5	192.4
H 556*	Llanogrande** (8)	477	3371	4.5	189.7
Local	Mortiño (check) (2)	545	2147	3.9	125.6

** 2 months earlier than local variety

[a] Fixed costs = 41.3 thousand pesos/ha

* 1 month earlier than local variety

a Estimated using mean 1982B to 1985B costs and prices, and expressed in December 1986 pesos.

Other populations evaluated: 4M 2B, 4M 4B, 8M 8B

Table 23. Bean and maize yields in the intensification trial. Ipiales 1983B. Mean of 3 farms.

Bean Variety	Maize Variety	Planted population plants/m[2]		Spacing between hills(m)[1]	Mean Yield (kg/ha)	
		Beans	Maize		Beans	Maize
32980-1-41	Cundinamarca 431	4	4	1.0	989	153
32980-1-41	Cundinamarca 431	4	4	0.5	1100	104
32980-1-41	Cundinamarca 431	6	4	0.5	1323	128
32980-1-41	Cundinamarca 431	8	4	0.5	1226	99
32980-1-41	Cundinamarca 431	8	6	0.5	1260	189
32980-1-41	Cundinamarca 431	8	8	0.5	1277	203
32980-1-41	MB 520	8	4	0.5	1230	1597
32980-1-41	MB 521	8	4	0.5	1086	1015
Ecuador 605	Morocho blanco	4	4	0.5	1124	1074
Mortiño	Morocho blanco	2	4	1.0	1242	779
LSD (10%)[2]					274[3]	170

1 Distance within rows. Rows always at 1.0 m.

2 For treatments with Cundinamarca 431; multiply by 1.414 for LSD between other treatments and by 1.225 for treatments with and without Cundinamarca 431.

3 There was a farm x treatment interaction; evaluations with this LSD are valid for the whole zone.

Table 24. Intensification trial. Ipiales 1984B (mean of 2 farms) and 1985B (data from 1 farm)

Bean Variety	Maize Variety	1984B Yield (kg/ha) Beans	1984B Yield (kg/ha) Maize	Time for second crop	1985B Yield (kg/ha) Beans	1985B Yield (kg/ha) Maize
TIB 30-42	Cund. 431	693	1187	No	147	986
L 32983-M4	Cund. 431	656	1503	Yes	101	806
TIB 30-42	Pool 7	619	2021	No	461	1779
L 32983-M4	Pool 7	499	2773	No	-	-
TIB 30-42	Pool 8	628	1974	No	-	-
L 32983-M4	Pool 8	513	2931	No	-	-
TIB 33411 (arb.)	Cund. 431	826	1008	Yes	540	830
TIB 33411 (arb.)	-	706	-	Yes	498	-
Frijolica 0-3.2	MB 520	527	2390	No	-	-
Frijolica 0-3.2	MB 521	484	2615	No	-	-
Frijolica 0-3.2	Morocho blanco	671	2066	No	440	1327
Mortiño	Morocho blanco	422	1750	No	416	1466
LSD (10%)		209	602		323	749

A trial was lost due to root rots in 1984B and one was eliminated in 1985B due to its very variable experimental field.

Table 25. Early maize variety trial. Ipiales, 1985B. Bean and Maize yields in kg/ha. Mean of 2 farms at 2600-2630 m.

Maize variety	Color/ texture[b]	Weeks to harvest	Associated Maize	Associated Beans[a]	Sole Cropped Maize
Batan 8104	Y-F	37	2636	356	3024
Oriental Catalina 8204	Y-F	37	2437	273	3119
Pool Andino 5	W-M	30	2071	194	2568
Choclero 101	W-F	34	1551	311	1739
Pool Andino 3	Y-M	30	1468	293	2004
Morocho 501	Y-M	37	1347	236	2213
Pool Andino 1	W-M	30	1345	237	1692
Pool Andino 6	Y-M	34	1147	282	1833
Canchero 301	Y-F	34	1095	372	1395
MB 524	Y-M	33	809	371	1129
Mean			1591	292	2071
LSD (10%)			102	162	102

a Beans L 32983 (M4), red-colored, weight 50.3g/100 seeds.

b Y: yellow; W: white; F: floury; M: morocho (semi-floury).

Table 26. Semi-commercial trials. Ipiales, 1984B.

Farmer	Village	Height masl	Planting date	Yield (kg/ha) With Frijolica 0-3.2 Beans	Yield (kg/ha) With Frijolica 0-3.2 Maize	Yield (kg/ha) With Mortiño Beans	Yield (kg/ha) With Mortiño Maize	Net returns (thousands of pesos/ha) With Frijolica 0-3.2	Net returns (thousands of pesos/ha) With Mortiño
D. Pinchao	Chaguaipe	2600	16 Oct	940	1740	853[1]	1624[1]	282.1	273.2
G. Rosero	Chaguaipe	2600	29 Oct	433	1540	367	1236	120.8	93.4
S. Romero	Suraz	2680	15 Nov	610	1520	460	1170	200.3	151.8
M. Rodríguez	Sta. Lucia	2710	16 Oct	815	2050	590	2328	271.9	247.9
V. Hernández	Sta. marta	2800	22 Oct	380[2]	1120	412	998	106.8	115.7
S. A. Mejía	San Antonio	2650	19 Oct	533[3]	1340	813	1346	139.3	226.3
A. Murillo	San Francisco	2600	18 Oct	333[4]	1340	280	1480	80.7	82.5
Mean				578	1521	483	1454	171.7	170.1

1 Local check was Cargamanto Rayado and not Mortiño
2 Frijolica 0-3.2 planted in an infertile slopy field. Mortiño in a flat fertile field
3 Severe yellowing symptoms in Frijolica 0-3.2
4 The farmer applied more fertilizer to Mortiño than to Frijolica 0-3.2
a Estimated for each farm using 1984B costs and prices and expressed in December 1986 pesos.

Table 27. Semi-commercial trials. Ipiales 1985B.

Municipio	Village	Altitude masl	Yield (kg/ha) With Frijolica 0-3.2 and benomyl Beans	Maize	With Mortiño Beans	Maize	Net Benefit[a] (thousands of pesos/ha) With Frijolica 0-3.2 and benomyl	With Mortiño
Ipiales	Suraz	2850	1010	2786	678	2238	208.4	140.5
Ipiales	Soledad	2650	724	1538	612	1725	96.0	99.3
Contadero	San Francisco	2670	480	1124	438	1025	51.1	48.0
Contadero	San Francisco	2620	1200	2733	894[1]	2134	235.1	187.3
Contadero	Población	2600	834	1896	684	1732	140.4	123.7
Contadero	Población	2600	714	1154	538	1064	79.1	62.8
Gualmatán	Guatis	2900	812	1518	420	1125	90.6	16.4
Pupiales	Santa Lucía	2850	992	1538	650	1490	124.7	88.0
Pupiales	Santa Lucía	2850	1110	1694	720	1542	147.9	99.9
Túquerres	Arrayán*	2800	534	1542	385	1462	103.1	85.0
Túquerres	Chalitalá*	2800	1200	1730	541[2]	1532	162.7	89.8
Ospina	San Miguel*	2830	480	780	366	878	31.0	25.4
Guaitarilla	San Germán*	2400	870	1840	584	1432	135.2	83.8
Mean			843	1686	578	1491	123.5	88.5

1 Local check was Bolón Rojo, not Mortiño.

2 Local check was Cargamanto Rayado, not Mortiño.

a Calculated for each farm, using prices of the 1985B season and expressed in December 1986 pesos.

* Trials outside original work area.

Table 28. Movement of promising lines in on-farm trials in Ipiales. Data refer to total number of trials planted that included the line.

	1981B	1982B	1983B	1984B	1985B	1986B
ICA Llanogrande	2R	10V				
Frijolica 0-3.2	2R	14	33V	40VS	44VS	42VS
32980-I-41		4	8	20V	5	15V
Potosí 1		*	8	6		
TIB 30-42			4	10	28V	38VS
AND 53				*	5	4
L 32983 (For intensification studies)	2R	0	4	3	4	4

R Included in regional trials before the project began

V Included in verification trials and others

S Included in semi-commercial trials and others

* Evaluated only in nurseries or observations rows

Table 29. Movement of non-genetic technologies in on-farm trials. Ipiales District. Data refer to the total number of trials planted that evaluated the component.

Technology	Before 1982	1982B	1983B	1984B	1985B	1986B
Addition of benomyl to control foliar diseases	Successful in another region	6	14V	13V	11S	10S
2 maize, 2 bean at 0.5m	Successful in another region	6	14V	3		
3 maize seeds and 3 bean seeds at 0.8m for Frijolica 0-3.2				3	15V	10S
3 maize seeds and 4 bean seeds at 0.8m for Frijolica 0-3.2					4	11V
Increase in use of 13-26-6 for Frijolica 0-3.2		10	6	3	14V	3
Maize MB 521 with Frijolica 0-3.2				3	15V	11V
Maize Pool 7 with TIB 30-42				4	6	15V
Benomyl + Carboxin seed treatment				2	14V	10S
Captafol seed treatment					3	11V

V Included in verification trials.
S Included in semi-commercial trials.

Table 32. Type and number of trials planted in Ipiales, 1982-1985

	1982B		1983B		1984B		1985B	
	Number planted	Number lost	Number planted	Number lost	Number planted	Number lost	Number planted	Number lost
Technology development								
Benefits of inoculation							3	0
Advanced lines			1	1	1	0	3	2
Stage: varieties								
Bean varieties	4	0	4	1	4	2	5	1
Early maize varieties							2	0
Stage: exploratory	6	1						
Stage: determination of economic levels								
Intensification	4	1	4	1	3	0	2	1
Var. x root rot control	2	(2p)	4	(2p)	2	0	3	1
Fertilization (rates)	4	0	4	1	3	0	3	0
Insect control (leaf miner)	2	0						
Fertilization (methods)			2	0				
Variety x planting arrangement					3	1	4	2
Stage: verification	2	0	14	1	13	4	11	3
Stage: Semi-commercial					11	3	8	0
TOTAL	24	2	33	5	40	10	44	10

p Number of trials with no infection

Table 33. Use of resources in on-farm research in Ipiales, 1982-1985.

Achievements desired	Number of trials necessary 1982B	1983B	1984B	1985B
Actually executed (including methodological information)	24	33	40	47
Main achievements[1]	10	20	31	38
Main achievements (reducing trials to the minimum recommended)[2]	6	11	22	22
Frijolica 0-3.2 released as a stable line (minimum recommended)	6	11	8	0
Possibility of intensifying production (additional)	4	4	3	4
Recommendations on Fertilization of Frijolica 0-3.2 (additional)	4	4	3	3

1 Frijolica 0-3.2 released; TIB 30-42 candidate for release; AND 53 in progress to release; benomyl use in demonstration; use of increased density, use of benomyl + carboxin and maize MB 521 in verification.

2 i.e. 3 farms for small plot trials, 8 for verification trials and semi-commercial trials.

Table 34. Marginal rates of return (using mean 1982B to 1985B prices and costs) for main effects.

Effect	1982B	1983B	1984B	1985B	Mean
Fertilización					
13N to 39N		3.4	7.1	0.4	3.6
39N to 65N		8.4	14.3	8.8	10.5
11.3P to 34P		14.7	6.7	-0.6	6.9
34P to 56.7P		-1.0	19.8	26.0	14.9
0 to 100 kg/ha 13-26-6		11.2	3.1	9.9	8.0
100 to 300 kg/ha 13-26-6		2.5	2.6	-1.2	1.3
0 to 20 Mg (300 kg/ha 13-26-6)		0.3	0.3	-3.0	-0.8
0 to 15 K (39N + 34P)		-20.0	40.0	36.0	18.8
Change in density					
4M 2B, 1m to 2M 2B, 0.5m	14.6	5.9	9.1		9.8
4M 3B, 1m to 3M 3B, 0.8m (Frij. 0-3.2)			13.4	34.9	23.5
Foliar disease control					
Farmer control to mancozeb + benomyl (3)	5.7	0.6	0.9		2.4
Seed and soil treatment					
Soaking in benomyl	-34.0	-3.7	-47.8		-28.3
Carboxin	-153.0	-276.0	81.9		-137.8
Benomyl + carboxin 3:1			-56.7	210.0	98.4
Captafol				1384.0	1384.0
Aldrín alone	-2.1	10.2			4.0
Carbaryl alone			-2.6		-2.6

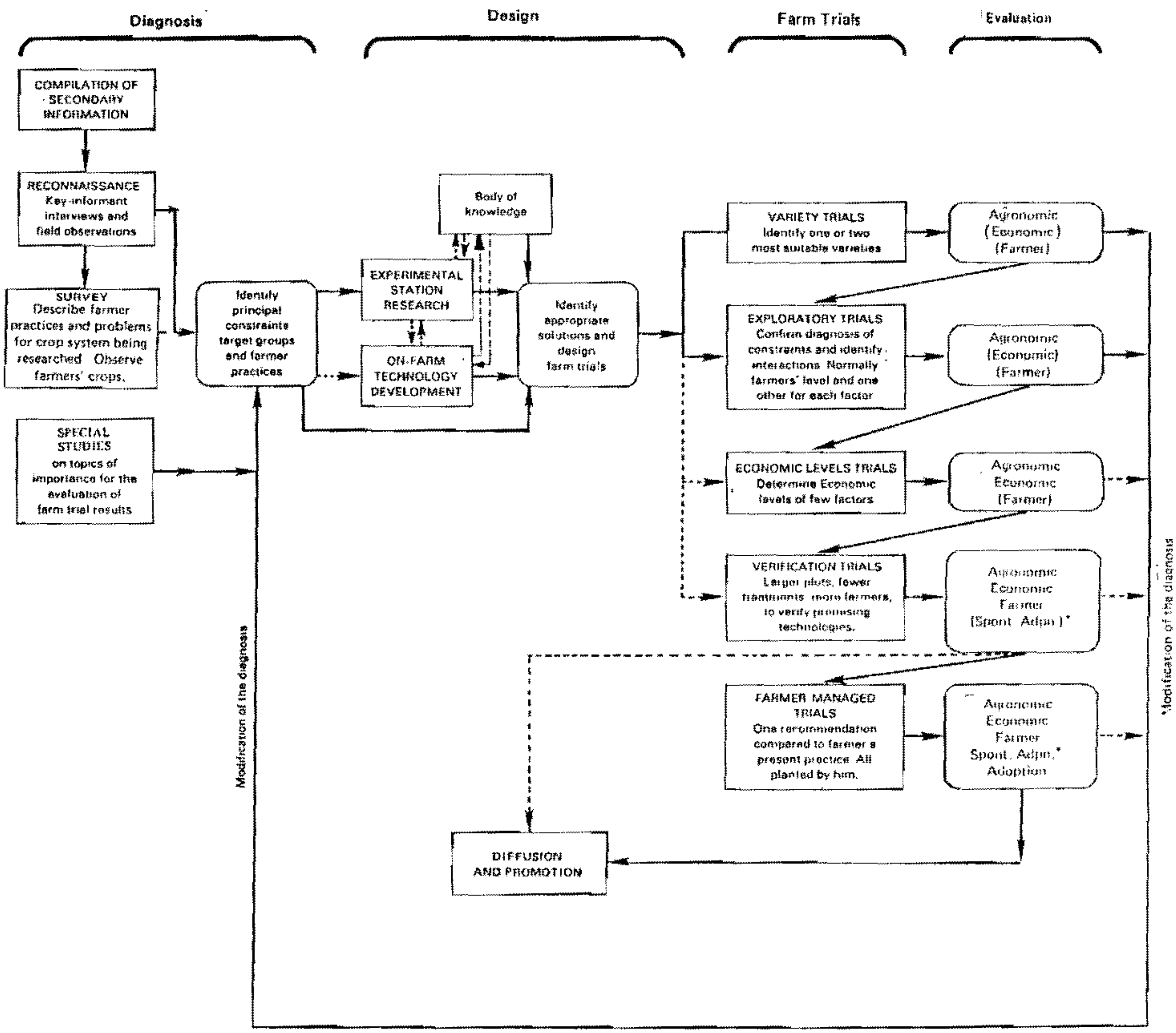

Figure 1. A conceptual framework for on-farm research being tested by CIAT and collaborators. (Continuous lines show usual steps, broken lines show possibilities.)

* Spontaneous adoption by trial collaborators and adoption by farmers in general are measured at least one cycle after these trials.

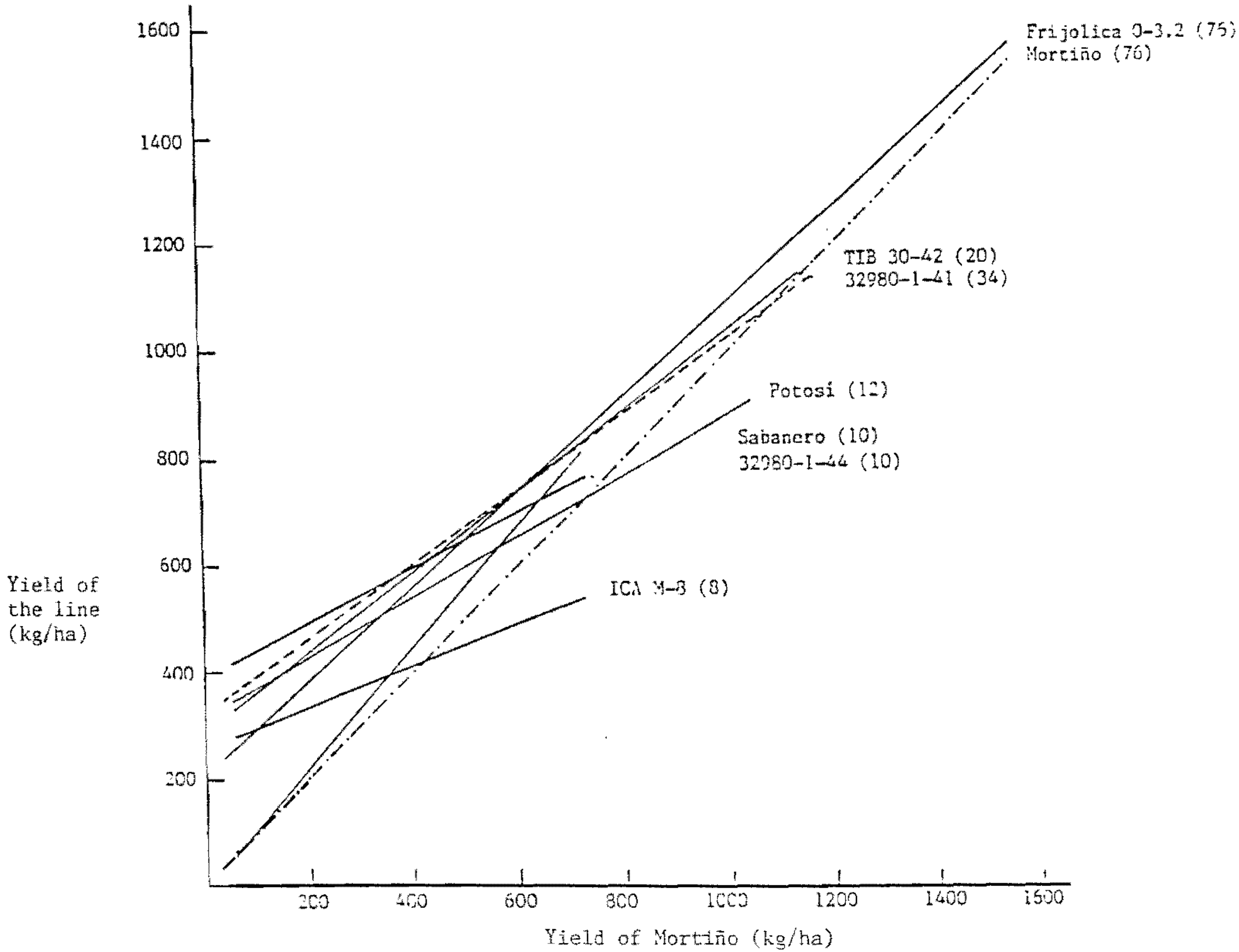

Fig. 2: Adaptability analysis of lines on farms of Ipiales district. Number of trials in parenthesis. The regression lines are drawn only within the range in which they are valid.