# RESULTS AND METHODOLOGY OF DIAGNOSTIC TRIALS ON COMMON BEANS (PHASEOLUS VULGARIS) IN RWANDA: A CRITICAL APPRAISAL

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## 1. Introduction

Diagnostic trials play an important role in the diagnostic process of crop improvement programs when informal and formal surveys don't provide enough information to quantify the identified problems nor their relatif importance (CYMMIT, 1980; CIAT, 1985). In Rwanda surveys indicated that Diseases, Insect pests and low soil fertility may be the most limiting factors for bean yield. However it was not clear, which factor should get first priority for technology development nor whether or not there are interactions between these factors should be considered.
For this reasons the national bean program of ISAR (Institut des sciences agronomiques du Rwanda) in collaboration with the regional bean program of CIAT (Centro International de Agricultura Tropical) decided to start a serie of diagnostic trials in several major bean producing areas of Rwanda.

## 2. Material and Methods

Trials were carried out between second season 1984 and second season 1986 in 6 natural agricultural zones of Rwanda with the primary objectif to quantify the contribution of the three major agronomic limiting factors described above on reduction of bean yield. Other important factors such as drought and acidity were not included because it was judged that it would be difficult to generate appropriate technologies to control them. Table 1 gives a summary of factors included in the trials and the treatments to control them.
The trials had to be carried out on farmers fields because no representatif experimental stations were available in some areas and it was judged that direct interaction with farmers would help furthermore to guide research.
Due to small farm size a complete factorial design including 8 treatments was not appropriate since at least 2 repetition per farm are required for this type of trial. Subsequently three designs, "Plus one", "Extended plus one" and "Minus one", were used. They are described in Table 2."Extended plus one" designs add to a traditional method alternatives, in this case fertilization, fungicide sprayings/soil treatments and insecticide sprayings/soil treatments. The effect of each treatment is simply measured as increase over farmers parctice which is included as a treatment. In the plus one design extended

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a treatment was added to the basic set combining the two factors most likely to interact with each other, in our case fungicides and fertilization. The third design was a minus one design, which is the opposite of a "plus one" trial. To a treatment "farmers practice" a treatment controling all factors at one time and three treatments were the control of two factors is combined are added. The contribution of one factor is calculated by deducting the yield of the treatment were the factor to examine is not controled from the yield of the treatment were all factors are at optimum level. The difference between "farmers control" and the optimum treatment may be called potential yield increase (De Datta, 1980; CIAT, 1985).
In general the trials were conducted at 3-4 farms per region with 2 reps per farm.
Observations were made regularily on plant vigor, density and especially disease incidence. Differences between plots were discussed with farmers in order to get an idea on their knowledge of effects of fertilization and disease/pest control.

## 3. Results

Table 3 gives a summary of the results obtained from 1984 to 1986 (cropping seasons 85A to 86B) using "Plus one" and "Minus one" trials. Fig.1. shows the differencies between the data obtained from the two series of trials. "Plus one" - Trials suggest diseases to be the most limiting factor, whereas results from "Minus one"-Trials suggest that low fertility and diseases are of almost equal importance.Yield increase due to control of pests is estimated by both designs to be in the magnitude of 150 to 250kg/ha. In 86B a comparison of "Minus one"-Trials with "Plus one extended" was carried out in one area to further confirm this finding. Table 4 shows yield data of this trials. Again "Plus one"- Trials underestimated the effect of fertilization but the treatment with combined fungicide/fertilizer application makes a tremendous positive interaction beween those two treatments apparent. However the interaction can also be estimated from the minus one design. If the addition of all the calculated contribution exceeds or is less then the difference between the optimal treatment and farmers control a interaction between at least two of the tested factors must be present. In the case of the trials in Nyabisindu the additon of the calculated yield increases due to the control of the three factors adds up to 3071kg/ha which is more then the difference between Potential yield and farmers yield which is 2497kg/ha (3497 - 1000kg/ha). This is rather suggestive of a negativ interaction between factors and not a positiv one as we found in the "Plus one"-design.

In the "Minus one"-Trial series in the zone of Mahaga the combined analysis over two seasons again shows another facet of possible relations between the factors tested (Table 5).
The calculated effects of the three factors adds up to 1039kg/ha, meanwhile the difference between optimum treatment and farmers control is of 1084kg/ha.
In this case no interaction seems to intervene. Similar

calculations could be done for all the other areas and one could develop various hypothesis on types and magnitudes of interactions.

## 4. Discussion

The various designs tested all have advantages and disadvantages. "Plus one"-designs permit to estimate the potential effect of technologies developed to control one single factor, e.g. diseases. They are easier to understand by farmers and therefore facilitate the interaction between farmer and researcher. On the other hand they are of limited help to direct a research program when they neglect a potentiually important factor because of interactions with an other factor as demonstrated at the exemple of soil fertility in Rwanda.
"Minus one"-designs give an interesting information on the potential yield increase through control of the major limiting factors. This may be important for policy making. In Rwanda e.g. the "Plan alimentaire" is assuming a 100% increase in bean yields to the year 2000. The optimum parcels in the "Minus one"-Trials just reached this 100% increase with all inputs at optimum level. This makes the assumption look rather unrealistic. "Minus one"-designs also give more probability that an important limiting factor is shows up as demonstrated at the exemple of soil fertility in Rwanda. Important disadvantages are the complex design, especially when trails are conducted on farmers fields and the fact that the number of factors should not exceed 3 or maximum 4 because of numerous hidden interactions one may have in the combined treatments. Sometimes you may even have the problem to underestimate the potential benefit of the control of a factor because you mesure the contribution of the factor to yield loss at high levels of other inputs. Beanfly attack as an exemple is known to have less effect on yield at high levels of fertility then under low fertility conditions (Autrique, pers. comm.). It is also difficult to estimate the potential benefits of future technologies if they are not applied as a packages. This disadvantages on the other hand is mildered by the fact that one can target technologies towards a situation were other factors are controled. In Rwanda e.g. fertilization of climbing beans may be more promising then of bush beans because of the fact that climbers may escape the microclimat favoring disease development. Disease resistant varieties may be first recommended for more fertile plots since they are more likely to express their potential at higer fertility levels.

"Minus one"-designs extended by one combined treatment are a good solution when there is a strong hypothesis on what factors would most likely interact, otherwise the number of treatments is getting very close to the number of treatments in a complete factorial trial,because one has to combine the control of various factors, a case in which the powerfull complet factorial design should be choosen.

## 5. Summary/Conclusions

On-Farm-Diagnostic-Trials were carried out in 6 natural zones of Rwanda between 1984 and 1986. Three designs were used, "Plus one","Minus one" and "Plus one extended". "Plus one"- trials tended to underestimate the importance of soil fertility as a yield limiting factor but the showed clearly the importance of diseases. "Minus one"-designs made the importance of both factors visible and "Plus one"-trials showed a strong positiv interaction when disease control was combined with fertilization. However none of the described designs is able to completely explain the interactions between tested factors.

Given the various advantages and disadvantages described above the researchers who carried out this trials in Rwanda would recommend that if diagnostic trials are choosen to be necessary in an area, a considerable effort should be done to find representative sites Off-Farm (schools etc.) to permit the installation of complete factorial trials. In addition several "Plus one"-trials could be established On-Farm which would result in a combination off a powerfull design and trials which make the interaction with farmers easy and permit direct conclusions on the potential effect of new technologies and the interactions to consider. "Plus one"- designs alone may be appropriate when no interactions are expected, but in this case one should seriously think of testing different levels of a treatment and consider the trial as the a step in technology testing rather then a diagnostic trial. The methodology to use depends obviously also from available ressources to the research program.

For Rwanda it is to recommend that the research program is focussed on technologies which control both diseases and fertility at the same time or to target technologies to situations where one factor is controled through existing practices such as disease control through the use of climbing beans. Technologies to control pests should have lower priority but can play an important role in some areas from season to season. Therefore it may still be justified to carry out research on technologies which seem to be easy to generate and to diffuse such as seed treatments against beanfly with endosulfan (Trutmann et al.,1987).

## Bibliographie


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Table 1: Factors Included in Diagnostic Trials on Beans in Rwanda

| Factor | Treatments | Code |
|---|---|---|
| Fungal Diseases | Soil treatment:<br>Benlate 25kg/ha<br>Ridomil 5kg/ha<br>Foliar treatment:<br>(weekly)<br>Benlate 1.1kg/ha<br>Cupper oxycloride<br>4.4kg/ha (-86A)<br>Copper hydrocloride<br>4.4kg/ha (86B) | A |
| Pests | Soil treatment:<br>Carbaryl 1.5kg/ha<br>Foliar treatment:<br>Dimethoat 1l/ha | B |
| Soil fertility | Cow manure 40t/ha<br>Diammoniumphosphate<br>(at stage V3) 110kg/ha | C |
| Diseases + Fertility | A + C | A + C |
| Diseases + Fertility + Pests | A + B + C | D |
| Farmers practice | - | E |

Table 2: Comparison of trial designs used for Diagnostic Trials on beans (Phaseolus vulgaris) in Rwanda (1984 -1986)

| | Designs | | |
|---|---|---|---|
| | "Plus one" | "Minus one" | "Plus one extended" |
| Treatments (control of) | | | |
| Diseases | + | | + |
| Pests | + | | + |
| Fertility | + | | + |
| Fertility + Diseases | | + | + |
| Fertility + Pests | | + | |
| Diseases + Pests | | + | |
| Diseases + Pests + Fertility | | + | |
| Farmers practice | + | + | + |

Table 3. Yield advantage obtained through control of diseases and pests and optimization of fertility using both minus and plus one designs in on farm exploratory trials in Rwanda.

| | | | | YIELD ADVANTAGE RELATIVE TO FARMER CONTROL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NATURAL REGION | Altitude (meters) | Season | Trial Design | Control of Diseases (kg/ha) | Control of Pests (kg/ha) | Augmentation of Soil fertility (kg/ha) | Reduction of Acidity (kg/ha) | Farmer Control kg/ha | Combined treatment | % Over Farmer Control |
| Zaire-Nil Crest | 2100 | 85 b<br>86 a,b | Plus[1]<br>Minus[2] | 556<br>381*a | 623<br>150 | 489<br>605*;a,b | 334<br>– | 444<br>1008 | –<br>1508* a b | 150 |
| Buberuka Highlands | | 85 b<br>86 a,b | Plus[1]<br>Minus[2] | 556*b<br>401*a | –200<br>18 | –156<br>588*,a | –67<br>– | 1500<br>825 | –<br>1884*,a,b | 228 |
| Central Plateau and Granitic Spur | 1700 | 85 a,b<br>86 b<br>86 b | Plus[1]<br>Plus[1]<br>Minus[2] | 640*a,b,b<br><br>719*,b | 190*,b<br><br>95 | 250<br><br>906*,b | 98<br><br>– | 981<br><br>987 | –<br><br>2935*,b | –<br><br>297 |
| Central Plateau | 1900<br>1800 | 86 b<br>86 b | Minus[2]<br>Minus[1] | 46<br>550 | 9<br>150 | 242*,b<br>567*,b | –<br>– | 375<br>833 | 675*,b<br>1867*,b | 180<br>224 |
| Mayaga | 1400 | 85 b<br>86 a,b | Plus[1]<br>Minus[2] | 493<br>299*,b | 166<br>104 | 240<br>399*,b | 193<br>– | 267<br>1051 | –<br>2056*,a,b | 196 |
| Lake Kivu Shore | 1450 | 86 b | Minus[2] | 967*,b | 434 | 667 | – | 1133 | 2900*,b | 256 |
| Bugesera | 1200 | 85 a | Plus[1] | –9 | 297 | 8 | –84 | 628 | – | |
| Mean | | 85<br>86 | Plus[1]<br>Minus[2] | 447 (59%)<br>497 (52%) | 233 (31%)<br>158 (17%) | 166 (22%)<br>566 (60%) | 112 (15%)<br>– | 764<br>– | –<br>949 1995 | (210%) |

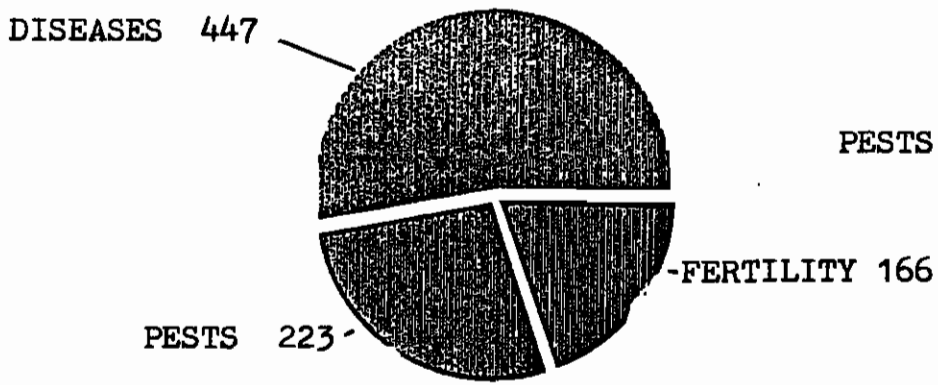
* a = Significantly different (P = .05) from farmer control in season A

* b = Significantly different (P = .05) from farmer control in season B

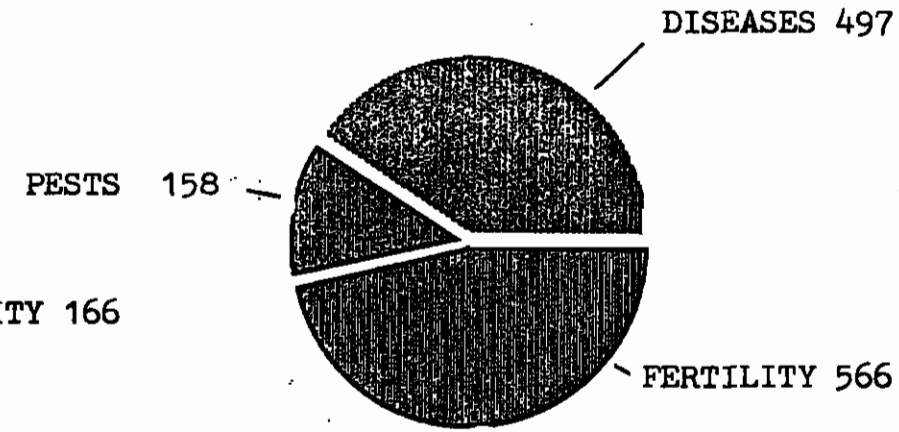
1 = Y factor – farmer control = Yield advantage

2 = Combined treatment – Y factor = Yield advantage

FIG 1: DIAGNOSIC TRIALS IN RWANDA ON COMMON BEANS: YIELD INCREASES RELTIVE TO FARMERS PRACTICE THROUGH CONTROL OF PESTS, DISEASES,AND LOW FERTILITY MESURED WITH "PLUS ONE" AND "MINUS ONE" - TRIALS (KG/HA)




"PLUS ONE" - TRIALS




"MINUS ONE" - TRIALS

Table 4: Diagnostic trials on Beans (Phaseolus vulgaris) in Rwanda: Comparison of yield data from "Minus one" and "Plus one extended" - Trials; Nyabisindu 1986B

| Factors controled | Yield advantage (kg/ha) over control as measured by "Minus one" | "Plus one ext." |
|---|---|---|
| Diseases | 1399* | 677* |
| Pests | 169 | 151 |
| Fertility | 1591* | 308 |
| Fertility + Diseases | 2327* | 1765* |
| Fertility + Diseases + Pests | 2497* | - |
| Farmers practice | 1000 | 633 |
| LSD (0,05) | 505 | 355 |

Interaction Fungicides x Fertilization:

Calculated additiv effect: 308 + 677kg/ha = 985 kg/ha
Yield advantage in trial: 1765 kg/ha

effect of positiv interaction: 780 kg/ha

* effect significant over farmers practice at p=0.05

Table 5: Diagnostic Trials on Beans (Phaseolus vulgaris) in Rwanda: Yield data from "Minus one"-Trials over two seasons and calculated contributions of limiting factors to total difference between potential and actual yield; Mugusa, 1985/86 (kg/ha)

| Treatment | Yield (kg/ha) | Difference to optimal treatment (kg/ha) |
|---|---|---|
| Fungicide + Insecticide + Fertilization | 1959a | ---- |
| Fungicide + Fertilization (A + C) | 1834ab | 125 |
| Insecticide + Fertilization (B + C) | 1616bc | 343 |
| Fungicide + Insecticide (A + B) | 1388c | 571 |
| Farmers practice (E) | 873d | 1086 |

Contributions of factors to total difference D - E (kg/ha)

| | |
|---|---|
| Fertility (D - [A + B]: | 571 |
| Diseases (D - [B + C]: | 343 |
| Pests (D - [A + C]: | 125 |
| Total calculated: | 1039 |
| Difference in trial (D - E): | 1086 |

LSD (0.05) = 310.5 , CV = 17.86%