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XN-ABA-906-B

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 9/22/88

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. 2. A- 03
PR - 9/1/82 - 9/1/83
trip report

Attachment

58084 2. A-03

AID Progress Report (September 1, 1982 to September 1, 1983)
Grant No. DAN-5542-G-SS-2126-00

Confirmation was received from the Agency for International Development that the project proposal entitled "Seed Vigor Influence of Nitrogen Fixation on Red Field Bean" was funded for $110,853 in a letter dated September 30, 1982.

Since the proposal identified a potential Ph.D. graduate student from the Dominican Republic (DR) to conduct this research, a trip to the DR from December 12-16, 1982 was established with four immediate objectives (Attachment 1). It was determined that Alberto Rodriguez, a faculty member in crop physiology at the Instituto Superior de Agricultura (ISA) in Santiago, retained an interest in obtaining a Ph.D. degree from Ohio State University (OSU) as part of this AID grant. Since the time of project proposal submission to receipt of the grant, Alberto had married and had a son. He wished to bring them with him and Ken Ellis, AID officer, suggested, in a letter of February 9 (Attachement 2), that the stipend be increased from the original proposal of $600/month to $900/month. Alberto was also concerned about health insurance which would cost $150/quarter for him and family. In order to comply with these requests, monies within the grant were shifted from part-time student help to increase the graduate student stipend to $9,600/year with no additional costs to AID as described in a letter dated February 15. It was also recommended that Alberto and family be ready to depart for Columbus, Ohio on March 24 in order to begin the Spring Quarter at OSU and initiate his graduate training as soon as possible.

A separate trip on March 21 to March 24 was planned to identify field sites for the conduct of research and to assist Alberto and family on their arrival in Columbus in adapting to their new environment. Of the two objectives established for this visit, only objective 1 was completed because of difficulties encountered in getting Alberto and family cleared for departure to the U.S. (Attachment 3) Following his arrival and enrollment for Spring Quarter, we requested seed lots from the DR to begin his research. These seed lots did not arrive until 2 months after the initial request. We still are not certain of the reason for delay. Importantly, we were able to start both greenhouse and field studies which are presently underway. Similar studies are also underway in the DR as part of this AID contract. A recent letter (Attachment 4) has specified the services for the field work expected from ISA. Finally, a trip by Alberto to the DR from September 1, 1983 to September 8, 1983 has been planned with the objectives of identifying field sites for the bean studies, procuring seed sources, and describing expected experimental approaches. These will coincide with studies at OSU. A second trip to the DR for myself and Alberto is under consideration for December. September is generally the planting time for field beans while late November is the tme for harvest. These two visits will enable us to direct the planting activities as well as follow-up on harvesting and data analyses.

Miller B. McDonald, Jr.
›al Investigator

Rec'd In

58-10

OSU

The Ohio State University

Department of Agronomy
Room 202
2021 Coffey Road
Columbus, Ohio 43210-1086
Phone 614-422-2002

JAN 17

January 8, 1985

2. A-03

Dr. LLoyd Frederick
AID
S & T/AGR, Room 240, SA-18
Washington, D.C. 20523

Dear Lloyd,

Enclosed is my trip report for my recent visit to the DR under the auspices of the AID project, "Seed Vigor Influence on Nitrogen Fixation of Red Field Bean". I believe the report accurately captures the progress of this project in the DR. Alberto Rodriguez will also forward you his trip report in the immediate future.

Having been involved in several overseas projects, I can state that this one is the most successful. I attribute this success to the integrity and diligence of the people we are working with. Although we may not always be successful in what we want accomplished, it is not for lack of trying. The people at ISA are dedicated to improving agriculture in the DR.

If you have any questions, do not hesitate to contact me.

Sincerely,

Miller

Miller B. McDonald, Jr.
Professor

MBM:mkj

cc: Marion Ford
Ellen Bieghler
Alberto Rodriguez
Federico Cuevas Perez

Rec'd In SCI: JUL 11 1988

TRIP REPORT

AID Project "Seed Vigor Influence on Nitrogen Fixation of Red Field Bean"

Miller B. McDonald, Jr.

The purpose of this travel from December 7-15, 1984, was to determine the quality of field, greenhouse, and laboratory research being conducted in the Dominican Republic under the AID project "Seed Vigor Influence on Nitrogen Fixation of Red Field Bean." Alberto Rodriguez, DR graduate student at OSU funded by this project, traveled to the DR to directly supervise this research from October 2 to January 4. My role was to visit with the ISA staff to evaluate the quality of the program, visit field research sites in Santiago and San Cristobal, and present a seminar on seed quality (see attached itenerary).

After arriving in Santo Domingo and traveling to Puerto Plata, I met with the ISA Board of Directors to discuss the progress of and the future for this research project. ISA is being provided approximately $3,000/year for supplies, travel costs, and personnel support. The first year of the field and greenhouse work was only moderately successful. This, in large part, was attributed to the lack of direct principal investigator supervision. Although we had provided specific guidelines on experimental technique and the acquisition of data, some misinterpretations of procedures occurred. Still, the committment of the ISA staff to the project was clearly apparent. A comprehensive research report directed to OSURF was prepared (enclosure). It demonstrates that ISA is fulfilling its obligation to the project.

In order to insure that the research was being properly conducted for 1984, Alberto Rodriguez departed for the DR in early October and will stay there until early January. He will directly supervise the field (Santiago and San Cristobal) and greenhouse (Santiago) studies. This departure time permitted him to direct all planting, 20 days after planting, and initial flowering studies. Unfortunately, he must return on January 4 to begin Winter Quarter at OSU so he will not be able to guide the mid-pod fill and harvest studies although we are confident that the methodology will be well defined at that point.

Discussions with ISA staff on Monday documented that they are extremely pleased with the progress of the project. They acknowledge that seed quality is a serious problem in the DR as well as optimum nodulation of field beans. In addition to evaluating this research problem in the DR, they also indicate that the project has been beneficial by providing additional research revenue as well as training of other faculty and students who have conducted the work in our absence. For example, two faculty members, Pedro Benoit and Raquel Fernandez, have supervised the work while two undergraduate students, who must as part

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of their graduation requirements complete a research project, have acquired the data. There is little doubt that this program has been well received.

Other discussions with ISA staff centered on the future of the project. At the present time, it is believed that the program will answer the immediate questions relating to the influence of seed quality on nodulation. For the future, following graduation of Alberto Rodriguez and his return to the DR, it was suggested that Alberto may establish and direct a seed testing laboratory established either at ISA or at a new research center which will be located in Santo Domingo in the next year. This would provide the country the only operating seed testing facility and will provide a focus on the importance of establishing seed quality prior to field planting. ISA staff also emphasized their desire to initiate training of an ISA faculty member in the U.S. in some aspect of tissue culture related to stress. They believe this training is essential to reforest many of their mountain slopes which are quickly becoming eroded.

Prior to departure for the DR, Alberto Rodriguez called and requested that I bring slides and give a seminar on seed quality. This seminar was given on Monday morning and was attended by 20-30 people. The session proved beneficial because it re-emphasized the importance, and created a greater awareness of, seeds in modern agriculture. Industry, faculty, and students were present at the seminar.

Tuesday was spent visiting the field sites in Santiago. Excessive rains had delayed planting three weeks and the seedlings were only beginning to emerge. Further, it was obvious that the field had been plowed when the soil was wet because of excessive clodding. What impact this may have on field data remains to be determined.

On Wednesday, we returned to Santo Domingo and visited San Cristobal on Thursday. San Cristobal is the location of CESDA which is a government research station where most of the field bean research is conducted. Alberto Rodriguez, Emilio Martinez (an AID mission employee), and myself, visited the plots which were in excellent condition. Most of the bean plants were in the third trifoliate and obvious differences in seed quality treatments were apparent. The plots were also clean of any weeds, irrigated, and were well attended. The data from this site should prove meaningful. We also visited a laboratory at CESDA which has three new gas chromatographs. Alberto has received permission to use these in our acetylene assay of nitrogen fixation.

On Friday, Alberto and I met with AID Director, Marion Ford, in an exit visit. We provided him a copy of the ISA Progress Report and updated him on the status of the program.

The research program and the academic progress of Alberto Rodriguez in Ohio is moving smoothly and a similar trend is now apparent in the DR. We anticipate having useful research data from the DR for this year. For the final year of the project, we hope to extend the program to March of 1986. This would enable Alberto to again return to the DR from October through January. He could then return to the U.S. to write and defend his thesis. Sufficient monies for this extension and for these activities are available in the present grant and no new monies are anticipated.

In general, I am pleased with the progress and reactions of people to this project. It is accomplishing the major objectives of solving an important research problem while simultaneously improving the agricultural capability of one of our important Latin American neighbors. In addition, we have established academic linkages with DR faculty which will remain and be beneficial for many years in the future.

INSTITUTO SUPERIOR DE AGRICULTURA

M SI No. 2-85

MEMO

To: Ohio Research Foundation
Columbus, Ohio, USA

From: Federico Cuevas Pérez
Assistant Director for Research

Subject: First Report on Project No. 714931 Seed Vigor Influence on Nitrogen Fixation of Field Beans (Phaseolus vulgaris, L.)

Date: January 3, 1985

We are enclosing the first report on the project Seed Vigor Influence on Nitrogen Fixation of Field Beans (Phaseolus vulgaris, L.) in which we collaborate with the Department of Agronomy, Ohio State University (OSU).

The report includes research results and expenditures for the period September 1983 - December 1984. Research data is partly analyzed and should be discussed with scientists of the Department of Agronomy, OSU.

The research project continues and this year's plans have already been discussed with Dr. Miller McDonald and Mr. Alberto Rodríguez of OSU.

Project Title	:	Seed Vigor Influence on Nitrogen Fixation of Field Beans (*Phaseolus vulgaris*, L.)
Project Number	:	714931
Institutions	:	The Ohio State University (Department of Agronomy) Instituto Superior de Agricultura Agency for International Development
Reporting Period	:	September 21, 1983-December 31, 1984
Date	:	December 31, 1984

This report includes research progress and expenditures for the period September 21, 1983-July 31, 1984 for field and greenhouse experiments conducted in the Dominican Republic. Research results are presented in the following order: seed aging and germination tests; and field and greenhouse experiments.

1. Seed Aging

The central objective of this research project is to determine the influence of seed vigor on nodule initiation, nodule number and distribution, and nitrogen fixation of field beans. To obtain different levels of seed vigor, three different seed sources with different germinating capacities were used. The source with the highest germination percentage was subjected to an accelerating aging procedure (42°C and 100 percent relative humidity) for one, two and three days in order to obtain three levels of artificially aged seeds.

Two cultivars of field beans, "Pompadour Checa" and "Venezuela 44", were used. The seeds of Pompadour Checa are red motted and the ones of Venezuela 44 are black. Germination percentages of the different seed quality groups planted in two locations (San Juan and Santiago) are shown in Table 1.

2. Field Experiments

Field experiments included six seed quality of each of two field bean cultivars. Both treated and untreated seeds were included in order to determine the effect of this agronomic practice on nodulation. The fungicide "Captan" at rate of 4 to 6 ounce per 100kg of seed was used for seed treatment. The seeds of all treatment combinations were inoculated with a strain of Rhizobium Phaseoli at the recommended rate of 4-6 ounce/bushel. Non-inoculated checks of both cultivars, treated and untreated, were also included. The highest quality was used for the non-inoculated checks. A list of the treatments is shown in Table 2.

Variables measured included number and dry weight of nodules of primary root, number and dry weight of nodules of the secundary roots; and dry weigh of primary root, secondary roots and plant tops, fresh and dry weight. Three sampling date were used: 20 days after planting, at a initial flowering (about 35 days after planting) and at mid-pod filling. Five plants were used for each observation.

Comparisons of interest were: Treated vs untreated seeds, Pompadour Checa vs Venezuela 44, inoculated vs non-inoculated seeds, artificially aged vs naturally aged seeds, and comparisons among different seed aged levels.

Field experiments were conducted at two locations. San Juan de la Maguana and Santiago. A split plot design with three replication, seed treatments as main plots and cultivar-seed aged treatment combinations.

Table 2. List of the treatments used in the field and greenhouse experiment at Santiago

Treatment	Cultivar	Seed quality	Inoculate with Rhizobium	Treated with Capta
1	Pompadour Checa	High	Inoculated	Treated
2	Pompadour Checa	Medium	Inoculated	Treated
3	Pompadour Checa	Low	Inoculated	Treated
4	Pompadour Checa	1 Day Aging	Inoculated	Treated
5	Pompadour Checa	2 Days Aging	Inoculated	Treated
6	Pompadour Checa	3 Days Aging	Inoculated	Treated
7	Venezuela 44	High	Inoculated	Treated
8	Venezuela 44	Medium	Inoculated	Treated
9	Venezuela 44	Low	Inoculated	Treated
10	Venezuela 44	1 Day Aging	Inoculated	Treated
11	Venezuela 44	2 Days Aging	Inoculated	Treated
12	Venezuela 44	3 Days Aging	Inoculated	Treated
13	Pompadour Checa	High	Non Inoculated	Treated
14	Venezuela 44	High	Non Inoculated	Treated
15	Pompadour Checa	High	Inoculated	Non-Treated
16	Pompadour Checa	Medium	Inoculated	Non-Treated
17	Pompadour Checa	Low	Inoculated	Non-Treated
18	Pompadour Checa	1 Day Aging	Inoculated	Non-Treated
19	Pompadour Checa	2 Days Aging	Inoculated	Non-Treated
20	Pompadour Checa	3 Days Aging	Inoculated	Non-Treated
21	Venezuela 44	High	Inoculated	Non-Treated
22	Venezuela 44	Medium	Inoculated	Non-Treated
23	Venezuela 44	Low	Inoculated	Non-Treated
24	Venezuela 44	1 Day Aging	Inoculated	Non-Treated
25	Venezuela 44	2 Days Aging	Inoculated	Non-Treated
26	Venezuela 44	3 Days Aging	Inoculated	Non-Treated
27	Pompadour Checa	High	Non Inoculated	Non-Treated
28	Venezuela 44	High	Non Inoculated	Non-Treated

as subplots, was used in both locations. Sub-plot sizes were adjusted according to germination percentages to ensure minimum population sizes of 45 plants.

2.1 San Juan de la Maguana

Planting dates were October 21 and 28, 1983. Replanting was necessary due to poor germination, specially in seeds artificially aged for two and three days. The first observation of nodule number and dry weight, and root and plant tops dry weight was done on November 19, 1983. Second measurement, at the onset of flowering, was done on December 9, 1983.

At flowering, 100 percent of the plants were infected with Golden Mosaic Virus, and the experiment was dropped.

2.2 Santiago

Planting was done on December 1, and 5, 1983. The first observation was done on December 29. Second and third observations were done depending on flowering time, the second from January 11-17, 1984 and the third from January 28 to February 1, 1984. Insecticide and fungicide applications were done to prevent insects and fungal diseases.

2.2.1 Results

Germination was erratic on some treatments, which did not permit the evaluation of several combinations (Table 3), only those treatments with more than 15 plants were evaluated.

Table 3. Number of germinating plants per sub-plot. Field, ISA 1983-84.

Treatment	Replication I	Replication II	Replication III
1	+ 15	+ 15	+ 15
2	+ 15	+ 15	+ 15
3	- 15	+ 15	- 15
4	+ 15	+ 15	+ 15
5*	- 10	- 10	0
6*	0	0	0
7	+ 15	+ 15	+ 15
8	+ 15	+ 15	+ 15
9	+ 15	+ 15	+ 15
10*	0	0	0
11*	0	0	0
12*	- 10	+ 15	0
13	+ 15	+ 15	+ 15
14	+ 15	+ 15	+ 15
15	+ 15	+ 15	+ 15
16	+ 15	+ 15	+ 15
17	- 5	+ 15	+ 15
18	+ 15	- 15	- 15
19*	- 10	- 10	- 10
20*	0	0	0
21	+ 15	+ 15	+ 15
22	+ 15	+ 15	+ 15
23	+ 15	+ 15	+ 15
24*	0	0	0
25*	0	0	0
26*	0	0	0
27	+ 15	+ 15	+ 15
28	+ 15	+ 15	+ 15

* Treatments eliminated

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2.2.1.1 Number of Nodules on the primary root

Table 4 shows the Analysis of Variance for the number of nodules on the primary root for the three observations. There was an interaction between seed treatment and cultivar-seed age combination at 20 days after planting. No significant differences were detected at flowering time, and at mid-pod filling there significant differences among the cultivar-seed age combinations.

Both cultivars used had similar number of nodules on the primary root regardless of seed treatment (Table 5). Pompadour Checa had 6.8 and 10.3 nodules per plant for treated and untreated seeds respectively, while the respective number of nodules for Venezuela 44 were 5.8 and 9.7.

Untreated seeds of Pompadour Checa resulted with a larger number of nodules when non-inoculated (27.3) than when inoculated (16.3) (Table 6). Venezuela 44 had similar pattern when the seeds where treated (15.7 nodules per plant when non-inoculated, 2.0 when inoculated). Although inoculum was not effective in increasing the number of nodules, its relationship with seed treatment seem to depend on the cultivar used.

The number of nodules for the different seed ages is shown in Table 7. In Pompadour Checa the medium germinating seeds showed a larger number of nodules (15.3) than the high (4.3) germinating seeds, when treated with Captan. The non-treated showed that high germination yielded more nodules. No significant differences were observed among seed ages in Venezuela 44.

Table 4. Analysis of variance for the number of nodules of the primary root in the first, second and third observations1/. Field, ISA 1983-84

	Observation					
	First		Second		Third	
Source:	DF	MS	DF	MS	DF	MS
Treated with captan	1	207.186	1	184.79	1	1048.82
Replication	2	53.709	2	106.29	2	472.12
Error(a)	2	71.243	2	956.79	2	813.90
Cultivar - aging	8	126.15*	8	339.80	8	567.22*
Interaction	8	233.33*	8	251.20	8	220.21
Error (b)	31	36.27	29	405.37	29	162.12

* Significative at 0.05 level

1/ First observation: 20 day after planting
Second observation: at initial flowering
Third observation: at mid-pod filling.

Table 5. Interactions in the number of nodules of the primary root for cultivar x treatment with Captan in the first observation. Field, ISA 1983-84

	Pompadour Checa	Venezuela 44	LSD 0.05
Treated	6.8	5.8	4.76
Non-treated	10.8	9.4	4.84

Table 6. Interactions in the number of nodules of the Primary root for inoculated seed with Rhizobium x treatment with Captan in Pompadour Checa (A) and Venezuela 44 (B) in the first observation. Field, ISA 1983-84

	Inoculated	Non-Inoculated	LSD 0.05
	A. Pompadour Checa		
Treated	4.3	5.0	10.04
Non-treated	16.3	27.3	10.04
	B. Venezuela 44		
Treated	2.0	15.7	10.04
Non-treated	7.3	2.0	10.04

Table 7. Interactions in the number of nodules of the primary root for treatment with Captan x germination percentage in Pompadour Checa (A) and Venezuela 44 (B) in the first observation. Field, ISA 1983-84.

A. Pompadour Checa

	High	Medium	Lowm	LSD 0.05
Treated	4.3	15.3	8.0	10.04
Non-treated	16.3	3.0	3.7	10.04

B. Venezuela 44

	High	Medium	Lowm	LSD 0.05
Treated	2.0	1.3	4.0	10.04
Non-treated	7.3	7.7	10.8	19.04

Table 8. Number of nodules of the primary root in the third observation for Cultivars (A) and inoculated seeds with Rhizobium (B). Fiel, ISA 1983-84.

A. Cultivar

Pompadour Checa	10.2
Venezuela 44	22.1
$DMS_{0.05}$	7.38

B. Inoculation with Rhizobiom

Inoculated	15.5
Non-Inoculated	25.8
$DM_{0.05}$	8.63

At mid-pot filling the number of nodules in the primary root (Table 8) for Venezuela 44 was higher (22.1) than the nodules produced in Pompadour Checa (10.2). No effect to inoculation with Rhizobium Phaseoli was observed as non-inoculated seeds produced more nodules (25.8) than the inoculated ones (15.5).

2.2.1.2 Nodules dry weight of the primary root

The Analysis of Variance for the dry weight of the primary root is shown in Table 9. The first observation shows no significant differences. Significant differences were detected at flowering time and at mid-pod filling for interactions between seed treatment and cultivar-seed aged combinations.

Table 10 shows the comparisons of interest for the second observation. The medium germinating seeds showed a larger dry weight (0.1198g) than the high and lowm (0.0261g and 0.005 g respectively) in Venezuela 44.

At mid-pod filling, nodules dry weigh were higher in treated seeds of Venezuela 44 (0.045 g) than those of Pompadour Checa (0.0107 g) (Table 11) In non-treated seeds, nodules dry weight of both Pompadour Checa and Venezuela 44 was similar (0.0274 g and 0.044g respectively).

2.2.1.3 Number of nodules on secondary roots

The Analysis of variance for the number of nodules on secondary roots for the three observations (Table 14) shows interactions between seed treatment and cultivar-seed age combination 20 days after planting, however, no differences were detected at flowering time.

At mid-pod filling there were significant differences among the cultivar seed age combinations.

Table 9. Analysis of Variance for nodules dry weight of the primary root in the first, second and third observations 1/. Field, ISA 1983-84

Source:	Observation					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated with Captan	1	0.00436	1	0.00276	1	0.00006
Replication	2	0.00645	2	0.00165	2	0.00669
Error a	2	0.00978	2	0.00459	2	0.01075
Cultivar x vigor	8	0.00486	8	0.00287	8	0.00271
Interaction	8	0.00415	8	0.00436*	8	0.00552*
Error b	29	0.00538	29	0.00197	28	0.00163

* Significative at 0.05 level

1/ First observation : 20 days after planting
Second observation: at initial flowering
Third observation: at mid-pod filling

Table 10. Interactions for nodules dry weight (g) of the primary root at flowering Field. ISA 1983-84.

A. Variety x treated with Captan

	Pompadour Checa	Venezuela 44	$LSD_{0.05}$
Treated	0.0173	0.0485	0.0370
Non-treated	0.0116	0.0218	0.0360

B. Treated with captan x Inoculation with Rhizobium in Pompadour Checa

	Inoculated	Non-inoculated	
Treated	0.0018	0.0214	0.074
Non-treated	0.0140	0.0195	0.074

C. Treated with Captan x Inoculation with Rhizobium in Venezuela 44

	Inoculated	Non-inoculated	
Treated	0.0261	0.0287	0.074
Nom-treated	0.0256	0.0419	0.074

D. Treated with x germination % in Pompadour Checa

	High	Medium	Low		
Treated	0.0181	0.0296	0.0115	0.074	NS
Non-treated	0.0139	0.0085	0.0085	0.074	NS

E. Treated with Captan x germination % in Venezuela 44

	High	Medium	Low	$LSD_{0.05}$
Treated	0.0261	0.1198	0.0050	0.074
Non-treated	0.0256	0.0130	0.0064	0.074

Table 11. Interaction in nodules dry weight of the primary root for cultivar x treatment with captan, at mid-pod filling Field. ISA 1983-84.

	Pompadour Checa	Venezuela 44	$LSD_{0.05}$
Treated	0.0107	0.0450	0.0325
Non-treated	0.0274	0.0440	0.0330

Table 12. Interaction in nodules dry weight of the primary root for treatment with captan x inoculation with Rhizobium in Pompadour Checa (A) and Venezuela 44 (B) at mid-pod filling. Field. ISA 1983-84.

A. Pompadour Checa

	Inoculated	Non-inoculated	LSD 0.05
Treated	0.0030	0.0074	0.0673
Non-treated	0.0347	0.0566	0.0673

B. Venezuela 44

	Inoculated	Non-inoculated	$LSD_{0.05}$
Treated	0.0328	0.1276	0.0673
Treated	0.0631	0.0309	0.0673

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Table 13. Interaction in nodules fry weight of the primary root for treatment with Captan x germination percentage in Pompadour Checa (A) and Venezuela 44 (B) in the third observation. Field, ISA 1983-84

A. Pompadour Checa

	High %	Medium %	Low %	$LSD_{0.05}$
Treated	0.0299	0.0260	0.0000	0.0673
Non-treated	0.0347	0.0193	0.0023	0.0673

B. Venezuela 44

	High %	Medium %	Low %	$LSD_{0.05}$
Treated	0.0328	0.0362	0.0136	0.0673
Non-treated	0.0631	0.0238	0.0584	0.0673

Table 14. Analysis of Variance for the number of nodules of the Secundary root in the first, second and third observation[1/] Field, ISA 1983-84.

	Observation					
	First		Second		Third	
Source:	DF	MS	DF	MS	DF	MS
Treated with captan	1	165.84	1	137.37	1	524.88
Replication	2	193.92	2	3663.20	2	6110.46
Error a	2	371.56	2	2889.62	2	2329.39
Cultivar x vigor	8	233.45	8	1010.68	8	3200.80*
Interaction	8	722.02*	8	1012.64	8	935.30
Error b	31	224.76	29	1147.63	28	1619.00

* Significative at 0.05 level

1/ First observation : 20 days aftes planting

Second observation: at initial flowering

Third observation : at mid-pod filling

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Table 15. Interactions in the number of nodules of the secondary roots for cultivar x treatment with Captan in the first observation. Field· ISA, 1983-84.

	Pompadour Checa	Venezuela 44	LSD 0.05
Treated	14.1	11.7	12.4
Non-treated	15.4	17.8	12.26

Table 16. Interactions in the number of nodules of the secondary roots for inoculation with Rhizobium x treatment with Captan in Pompadour Checa (A) and Venezuela 44 (B) in the first observation. Field, ISA, 1983-84.

A. Pompadour Checa

	Treated	Non-Treated	LSD 0.05
Inoculated	5.0	24.7	24.9 NS
Non-inoculated	4.7	31.3	24.9 *

B. Venezuela 44

	Treated	Non-Treated	LSD 0.05
Inoculated	5.3	19.7	24.9
Non-inoculated	29.7	7.3	24.9

B

Both cultivars used had similar number of nodules on the secondary root regardless of seed treatment (Table 15). Pompadour Checa had 14.1 and 15.4 nodules per plant for treated and non-treated seeds, respectively, while the respective number of nodules for Venezuela 44 were 11.7 and 17.8.

For Pompadour Checa, the larger number of nodules (31.3 was obtained when untreated seeds were not inoculated. The cultivar Venezuela 44 did not show significant differences between inoculated and treated seeds .

The Table 17 shows the number of nodules for the different seed ages, 20 days after planting. For Pompadour Checa the larger number of nodules (44.7) was observed in seeds with medium germination percentage and treated with Captan. Seeds with high and low germination percentages had 5.0 and 14.7 nodules respectively. Nodule production on secondary roots for the different seed ages were similar.

At mid-pod filling (Table 18), differences between cultivars were observed. Venezuela 44 showed larger number of nodules (49.3) than Pompadour Checa (21.9). No significant difference was detected between inoculated and non-inoculated.

Table 17. Interactions in the number of nodules of the secondary roots for treatment with Captan x germination percentage in Pompadour Checa (A) and Venezuela 44 (B) in the first observation. Field, ISA, 1983-84.

A. Pompadour Checa

	High	Medium	Low	LSD 0.05
Treated	5.0	44.7	14.7	24.9
Non-Treated	24.7	5.7	7.7	24.9

B. Venezuela 44

	High	Medium	Low	LSD 0.05
Treated	5.3	4.3	7.3	24.9
Non-Treated	19.7	15.7	28.7	24.9

Table 18. Number of nodules of the secondary roots at mid-pod filling Field, ISA, 1983-84.

A. Cultivar

Pompadour Checa	21.9
Venezuela 44	49.3
LSD 0.05	23.32

B. Inoculation with Rhizobium

Inoculated	35.1
Non-Inoculated	35.2
LSD 0.05	27.28

2.2.1.4 Dry Weight of Nodules on the Secondary Roots

Table 19 shows the Analysis of Variance for nodules dry weight in the first, second and third observations. Interactions were detected in seed treated and cultivar-seed ages combinations in the first observation only.

The treated seeds of Pompadour Checa and Venezuela 44 showed very similar nodule weights (0.0243 g and 0.0260 g respectively). The same pattern was observed for non-treated seeds, 9.0266 g for Pompadour Checa and 0.0168 g for Venezuela 44 (Table 20).

For Pompadour Checa it was observed that untreated seeds showed the heaviest nodules on secondary roots when inoculated (0.0574g) (Table 21). However, for Venezuela 44 the largest nodules were observed in seeds treated and inoculated (0.0748 g).

Table 19. Analysis of variance for nodules dry weight of the secondary root in the first, second and third observation.[1/] Field, ISA, 1983-84.

	Observation					
	First		Second		Third	
Source:	DF	MS	DF	MS	DF	MS
Treated with C	1	0.00001	1	0.1580	1	0.0450
Replication	2	0.00170	2	0.0611	2	1.2850
Error a	2	0.00154	2	0.0123	2	2.3450
Cultivar-Seed ages	8	0.00135	8	0.0114	8	0.3225
Interaction	8	0.00346*	8	0.2432	8	0.3308
Error b	29	0.00121	29	0.0047	28	0.4105

* Signigicant at 0.05 level

[1/] First observation : 20 days after planting
Second " : at initial flowering
Third " : at mid-pod filling

Table 20. Interaction in nodules dry weight of the secondary roots for cultivar x treated seed with Captan in the first observation. Field, ISA, 1983-84.

	Pompadour Checa	Venezuela 44	LSD 0.05
Treated	0.0243	0.0260	0.0280
Non-Treated	0.0266	0.0168	0.0284

Table 21. Interactions in nodules dry weight of the secondary roots for treatment with Captan x inoculation with Rhizobium in Pompadour Checha (A) and Venezuela 44 (B) in the first observation. Field, ISA, 1983-84.

A. Pompadour Checha

	Inoculated	Non-Inoculated	LSD 0.05
Treated	0.0061	0.0064	0.0184
Non-Treated	0.0574	0.0226	0.0184

B. Venezuela 44

	Inoculated	Non-Inoculated	LSD 0.05
Treated	0.0748	0.0128	0.0184
Non-Treated	0.0094	0.0153	0.0184

Table 22 shows the relalionship between germination percentage and treatment with fungicide. In Pompadour Checa, treated seeds with medium germination percentage had higher dry weight. (0.0773 g) than seeds with high and low germination percentages (0.0087 g and 0.0189 g respectively).

Table 22. Interaction in nodules dry weight of secondary roots for treatment with Captan x germination percentage in Pompadour Checha (A) and Venezuela 44 (B) in the first observation. Field, ISA, 1983-84.

A. Pompadour Checha

	High	Medium	Low	LSD 0.05
Treated	0.0087	0.0773	0.0189	0.0184 *
Non-Treated	0.0367	0.0163	0.0055	0.0649 NS

B. Venezuela 44

	High	Medium	Low	LSD 0.05
Treated	0.0128	0.0053	0.0112	0.0184
Non-Treated	0.0153	0.0115	0.0308	0.0184

3. Greenhouse Experiment

The greenhouse experiment was established in Santiago. A split-plot design was also used. Seeds were planted in polyethylene bags containing sand. Six to ten seeds were planted per bag depending upon the vigor of the seeds, in order to ensure a minimal number of plants.

The same variables as in the field were evaluated for the three observations (twenty day after planting, at the onset of flowering and a mid pod filling). Three plants were evaluated per observation.

3.1 Results

At the greenhouse experiment all the treatments reached the necessary germination to be evaluated.

3.1.1 Number of Nodules of the Primary Root

The analysis of variance of the number of nodules on the primary root (Table 31) shows that the three observations were significative differents for the combinations cultivar-aged seeds. Also at the second observation significance was found for treated and no-treated seeds.

Table 31. Analysis of Variance for the number of nodules of the primary root in the first, second and third observations.[1] Greenhouse, ISA, 1983-1984

SOURCE	OBSERVATIONS					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated with Captan	1	1855.51	1	2856.75*	1	2815.43
Replication	2	2766.97	2	470.875	2	135.25
Error (a)	2	264.93	2	58.25	2	450.09
Cultivar x aging	13	3298.89*	13	1537.2*	13	990.72*
Interaction	13	997.49	13	407.72	13	302.05
Error (b)	52	674.68	50	311.834	50	191.4796

* Significative at 0.05 level.

1/ First observation : 20 days after planting.
Second observation : At initial flowering.
Third observation : At mid-pod filling.

In Table 32 (part A) is shown that the cultivar Pompadour Checa produces more nodules on the primary root than the Venezuela 44 for the three observations. In the same table (part B) is observed the effect of inoculation with Rhizobium on the nodulation. It was observed a difference for the first observation, where plants from inoculated seeds produced a greater amount of nodules (124.2) than in the case of non-inoculated seeds (65.2). The second and third observations showed a lesser number of nodules in both inoculated and non-inoculated seeds.

In Table 33 comparisons among the different type of aging are shown. When natural and artificial aging were compared, natural aging produced greater number of nodules than artificially aged seeds for the three observations.

For the artificial aging, significant difference was found for the 2 days aged seeds in the first observation with 86.8 nodules. No significative differences were found in the second and third observations for the number of nodules for the different aging days.

Table 32. Number of nodules on the primary root for cultivar (A) and nodulation with Rhizobium (B) in the three observations. Greenhouse, ISA, 1983-84.

A. Cultivar

	Pompadour Checa	Venezuela 44	LSD 0.05
First observation	64.0	35.1	11.48*
Second observation	32.5	16.3	7.80*
Third observation	20.7	10.3	6.11*

B. Inoculation with Rhizobium

	Inoculated	Non-inoculated	LSD 0.05
First observation	124.2	65.2	32.62*
Second observation	33.1	31.5	14.42 NS
Third observation	30.2	33.8	11.29 NS

Table 33. Number of nodules in the primary root for agings (A) and artificial aging (B) in the three observations. Greenhouse, ISA, 1983-84.

A. Agings

	Natural Aging	Artificial Aging	LSD 0.05
First observation	46.6	28.7	11.56*
Second observation	31.9	15.2	7.85*
Third observation	23.8	9.0	6.16*

B. Artificial Aging

	1 day aging	2 days aging	3 days aging	LSD 0.05
First observation	51.5	86.8	30.6	29.99*
Second observation	17.1	18.5	10.1	14.41 NS
Third observation	9.1	16.4	1.6	11.29 NS

Table 34. Analysis of variance for nodules dry weight of the primary root in the first, second and third observations.[1] Greenhouse, ISA, 1983-84.

SOURCE	OBSERVATION					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated	1	0.0004	1	0.00031	1	0.00016
	2	0.00130*	2	0.00006	2	0.00130
Error (a)	2	0.00005	2	0.00018	2	0.00145
Cultivar x aging	13	0.00120*	13	0.0004*	13	0.00240*
Interaction	13	0.00030	13	0.00018	13	0.00050
Error (B)	52	0.00026	34	0.00011	49	0.00035

3.1.2. Nodules Dry Weight of the Primary Root

Table 34 shows the analysis of variance for nodules dry weight of the primary root. It shows significative differences for the combinations cultivar x aging in the three observations.

Table 35 (part A) shows that the dry weight of the nodules on the primary root was higher in Pompadour Checa than in Venezuela 44, in the first and third observation. However, at the onset of flowering it was similar.

In part B of the Table 35, it is observed that the nodules dry weight was higher for non-inoculated seeds (0.042) than in inoculated seeds (0.025), for the first observation. In the other hand, in the second and third observation was similar for inoculated and non-inoculated seeds.

When naturally aged and artificially aged seeds were compared for the three observations, the nodules dry weight of the naturally aged seeds were higher than the artificially aged seeds (Table 36). For the seeds of the three different aging days no difference was found for the nodules dry weight of the primary root.

3.1.3. Number of Nodules on the Secondary Roots

Combinations cultivar - aging were significantives across the three observations, according to the analysis of variance (Table 37).

The Table 38 shows that the number of nodules on the secondary roots was higher for Pompadour Checa than in Venezuela 44 for the three observations. The effect of inoculation with *Rhizobium* was not important, because the number of nodules for the inoculated and non-inoculated seeds was almost the same in the three observations.

The Table 39 shows the effect of aging on the nodules dry weight on the secondary roots. It shows significative differences for naturally and artificially aged seeds respectively. The nodule dry weight of the naturally aged seeds were higher than the artificially aged seeds for the first and third observation (Table 39-A) Not significative difference was found for the seeds of the three different aging days in term of nodule dry weight (Table 39-B).

Table 35. Nodules dry weight for the primary root for cultivar (A) and inoculation with *Rhizobium* (B) in the three observations. Greenhouse, ISA, 1983-84

A. Cultivar

	Pompadour Checa	Venezuela 44	LSD 0.05
First observation	0.026	0.017	0.007*
Second observation	0.017	0.014	0.005 NS
Third observation	0.058	0.029	0.008*

B. Inoculation with Rhizobium

	Inoculated	Non-inoculated	LSD 0.05
First observation	0.025	0.042	0.013*
Second observation	0.016	0.024	0.009 NS
Third observation	0.053	0.049	0.015 NS

Table 36. Nodules dry weight for the primary root for natural aging (A) and artificial aging (B) in the three observations. Greenhouse, ISA, 1983-84.

A. Aging

	Natural Aging	Artificial Aging	LSD 0.05
First obsrvation	0.026	0.015	0.007*
Second observation	0.019	0.011	0.005*
Third observation	0.053	0.030	0.008*

B. Artificial Aging

	1 day aging	2 days aging	3 days aging	LSD 0.05
First observation	0.013	0.024	0.10	0.018 NS
Second observation	0.015	0.009	0.008	0.009 NS
Third observation	0.029	0.034	0.031	0.015 NS

Table 37. Analysis of variance for the number of nodules of the secondary root in the first, second and third observations.[1] Greenhouse, ISA, 1983-84.

	OBSERVATION					
	First		Second		Third	
SOURCE	DF	SM	DF	SM	DF	SM
Treated with Captan	1	5802.98*	1	86.10	1	1180.68
Repetition	2	2914.96	2	1628.38	2	2269.70
Error (a)	2	241.54	2	1538.58	2	1368.98
Cultivar x aging	13	6945.20*	13	4116.80*	13	1817.77*
Interaction	13	1541.38	13	956.85	13	698.15
Error (b)	52	1903.42	50	1257.95	49	585.86

* Significantive at 0.05 level.

1/ First observation : 20 days after planting.
Second observation : At initial flowering.
Third observation : At mid pod filling.

3.1.4. Nodules Dry Weight of the Secondary Roots

Table 40 shows the analysis of variance for nodules dry weight of the secondary roots. No significative difference was observed for any of variables evaluated.

3.1.5 Dry Weight of the Primary Root

The analysis of variance of the dry weight of the primary root is shown in Table 41. Significative differences were detected for the combination cultivar x aging in the first and third observation.

In Table 42 (part A) the dry weight of the primary root of the cultivars is compared for each observation. The cultivar Venezuela 44 shows a higher weight in the first (0.28) and second observation (0.33). However, for the third observation both cultivars had a similar weight (Pompadour (0.28) and Venezuela 44 (0.33).

Part B shows that the non-inoculated seeds produced roots with higher weight than the inoculated ones (0.42 and 0.26 respectively). In the third and second observation no differences were found between inoculated and non-inoculated seeds.

38. of ies on the
for cultivar (A) and inoculation with Rhizobium in the three observations. Greenhouse, ISA, 1983-84.

A. Cultivar

	Pompadour Checa	Venezuela 44	LSD 0.05
First observation	133.8	82.6	19.27*
Second observation	88.8	57.5	15.67*
Third observation	64.2	48.3	10.76*

B. Inoculation with Rizobium

	Inoculated	Non-inoculated	LSD 0.05
First observation	124.2	120.4	35.62 NS
Second observation	88.9	89.2	28.96 NS
Third observation	60.3	62.3	19.76 NS

Table 39. Nodules dry weight for the secondary roots for aging (A) and artificial aging (B) in the three observations. Greenhouse, ISA, 1983-84.

A. Aging

	Natural Aging	Artificial Aging	LSD 0.05
First observation	0.067	0.045	0.010*
Second observation	0.075	0.041	0.07 *
Third observation	0.053	0.031	0.007*

B. Artificial Aging

	1 day aging	2 days aging	3 days aging	LSD 0.05
First observation	0.043	0.052	0.034	0.019 NS
Second observation	0.049	0.046	0.029	0.218 NS
Third observation	0.043	0.38	0.031	0.019 NS

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weight of the secondary root in the first, second and third observation.[1] Greenhouse, ISA, 1983-84.

SOURCE	OBSERVATION					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated	1	0.0100	1	1.400	1	0.139
Repetition	2	0.0086	2	1.218	2	0.080
Error (a)	2	0.3000	2	0.258	2	0.280
Cultivar x aging	13	0.1219	13	0.186	13	0.280
Interaction	13	0.0536	13	0.228	13	0.0975
Error (b)	52	0.0795	50	0.143	49	0.187

Table 41. Analysis of variance for dry weight of the primary root in the first, second and third observations.[1] Greenhouse, ISA, 1983-84.

SOURCE	OBSERVATION					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated	1	0.00062	1	0.0042	1	0.0002
Replication	2	0.000235	2	0.00339	2	0.0016
Error (a)	2	0.000115	2	0.0029	2	0.0014
Cultivar x aging	13	0.00290*	13	0.0026	13	0.0025*
Interaction	13	0.00048	13	0.00196	13	0.0005
Error (b)	52	0.00058	30	0.0229	49	0.00035

1/ First observation :
Second observation :
Third observation :

In Table 43 (part A) agings are compared. Natural aged seeds had a higher dry weight of the primary root than the artificially aged seeds. When artifically aged seeds were compared significative difference was found between one day aged seeds and three days aged seeds for the first and third observation.

3.1.6. Dry Weight of the Secondary Roots

Table 44 shows the analysis of variance for dry weight of the secondary roots for the three observations. No difference was found for any of the variables.

3.1.7. Plant Top Dry Weight

The analysis of variance (Table 45) shows differences for the combinations cultivar x aging in the three observations.

Table 46 shows the comparisons between cultivars. Plant top dry weight was higher for Pompadour Checa than in Venezuela 44 in the three observations.

Table 42. Dry weight of the primary root for cultivar (A) and inoculation with Rhizobium for the three observations. Greenhouse, ISA, 1983-84.

A. Cultivar

	Pompadour Checa	Venezuela 44	LSD 0.05
First observation	0.24	0.32	0.06*
Second observation	0.40	0.62	0.09*
Third observation	0.30	0.33	0.08 NS

B. Inoculation with Rhizobium

	Inoculated	Non-inoculated	LSD 0.05
First observation	0.26	0.42	0.10*
Second observation	0.64	0.066	0.17 NS
Third observation	0.43	0.48	0.15 NS

Table 43. Dry weight of the primary root for aging (A) and artificial aging (B) for the observations. Greenhouse, ISA, 1983-84.

A. Aging

	Natural Aging	Artificial Aging	LSD 0.05
First observation	0.32	0.23	0.05*
Second observation	0.57	0.40	0.09*
Third observation	0.37	0.28	0.05*

B. Artificial Aging

	1 day aging	2 days aging	3 days aging	LSD 0.05
First observation	0.26	0.28	0.15	0.10*
Second observation	0.53	0.40	0.28	0.17 NS
Third observation	0.23	0.36	0.08	0.15*

Table 44. Analysis of variance for dry weight of the secondary root for first, second and third observation.[1] Greenhouse, ISA, 1983-84.

SOURCE	OBSERVATION					
	First		Second		Third	
	DF	MS	DF	MS	DF	MS
Treated	1	0.0100	1	1.400	1	0.139
Repetition	2	0.0086	2	1.218	2	0.080
Error (a)	2	0.3000	2	0.258	2	0.280
Cultivar x aging	13	0.1219	13	0.186	13	0.280
Interaction	13	0.0536	13	0.228	13	0.0975
Error (b)	52	0.0795	50	0.143	49	0.187

Table 45. Analysis of variance for plant top dry weight for the first, second and thir observation.[1] Greenhouse, ISA, 1983-84.

	OBSERVATION					
	First		Second		Third	
SOURCE	DF	MS	DF	MS	DF	MS
Treated with Captan	1	0.079	1	1.02	1	0.027
Replication	2	0.130	2	1.62*	2	2.864
Error (a)	2	0.236	2	0.084	2	1.958
Cultivar x aging	13	0.800*	13	0.58*	13	1.987*
Interaction	13	0.0039	13	0.19	13	0.329
Error (b)	52	0.1732	50	0.213	49	0.2745

* Significative at 0.05 level.

1/ First observation : 20 days after planting.
Second observation : At initial flowering.
Third observation : At mid-pod filling.

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In part B of Table 46 shows that the inoculated seeds had a higher plant top dry weight than in the case of non-inoculated seeds (1.01 and 0.55 respectively) for the first observation. However, in the second observation the plants from non-inoculated seeds had a higher weight (2.78) than in the case of inoculated seeds (1.53). At the third observation both inoculated and non-inoculated seeds gave similar values.

Table 47, agings are compared. In part A no difference was detected between natural and artificial aging for plant top dry weight. No difference was observed for the different aging days in any of the observations (Table 47-B).

Table 46. Plant top dry weight for cultivar (A) and inoculation with Rhizobium (B) for the three observations. Greenhouse, ISA, 1983-84.

A. Cultivar

	Pompadour Checa	Venezuela 44	LSD 0.05
First observation	1.89	1.20	0.19*
Second observation	2.33	1.90	0.20*
Third observation	3.10	2.15	0.23*

B. Inoculation with Rhizobium

	Inoculated	Non-inoculated	LSD 0.05
First observation	1.53	1.65	0.34*
Second observation	1.53	2.30	0.38*
Third observation	2.70	2.7	0.43 NS

Table 47. Plant top dry weight for aging (A) and artificial aging (B) for the three observations. Greenhouse, ISA, 1983-84.

A. Aging

	Natural Aging	Artificial Aging	LSD 0.05
First observation	1.59	1.46	0.20 NS
Second observation	2.2	2.01	0.21 NS
Third observation	2.64	2.6	0.24 NS

B. Artificial Aging

	1 day aging	2 days aging	3 days aging	LSD 0.05
First observation	1.51	1.43	0.43	0.34*
Second observation	2.1	2.06	1.90	0.38 NS
Third observation	2.67	2.43	2.40	0.44 NS

INSTITUTO SUPERIOR DE AGRICULTURA

Seed Vigor Influence on Nitrogen Fixation of Field Beans (*Phaseolus vulgaris*, L.)

Expenditures October 1, 1983-December 31, 1984

Item	Account No.	Quantity ($)
Personal Services		
Salaries	83-33-10-01	1,916.96
Insurance	83-33-10-08	14.40
Non Personal Services		
Per Diem	83-33-20-26	900.50
Transport	83-33-20-27	53.50
Miscelaneous	83-33-20-38	97.50
Inputs		
Fuel	83-33-30-73	92.93
TOTAL		3,075.29

2. A-03

SEED QUALITY INFLUENCE ON NITROGEN FIXATION OF RED FIELD BEAN (*Phaseolus vulgaris* L.)

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

ALBERTO A. RODRIGUEZ R., B.S., M.S.

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The Ohio State University

1987

Reading Committe:

Dr. Miller B. McDonald, Jr.
Dr. John G. Streeter
Dr. Trevor Arscott
Dr. Robert D. Lineberger

Approved By

Miller B. McDonald Jr.
Adviser
Department of Agronomy

Rec'd In SCI. JUL 11 1988

General Discussion

The preservation of seed quality in tropical countries is an immense problem and one of the principal factors limiting crop production (FAO, 1975). It is now well recognized that seeds must possess high vigor to produce rapid and uniform seedling emergence under a wide range of field conditions (McDonald, 1980). Thus, one of the primary targets in field bean production as well as any other crop is to produce uniform stands with excellent seedling emergence to maximize N_2-fixation and consequent yield production. However, the success of establishing a crop stand and maximizing N_2-fixation and yield potential is dependent on the quality of seed planted. Since the initial stages of Rhizobium infection can be detected in soybean seedlings after only seven days following planting (Vest et al., 1973), the quality of the seed may play an important role in the initial success of nodule infection and formation.

Satisfactory seed germination and field emergence of seeds varying considerably in seed vigor can be obtained if

moderate planting conditions such as warm soils with sufficient moisture levels are used. Under these conditions, uniform stands can be achieved even with poor quality seed lots. Results of experiments in this study, however, indicate that the establishment of uniform stands does not assure maximum yield of the crop. The seed quality tests (SG, SVC, and Conductivity) confirmed that differences in seed quality existed in the different seed lots used in the study (Tables 6 and 7). Seed industries and Federal seed control agencies have used the SG test as the official test of seed quality. However, the SG test lacks sensitivity to detect changes in seed quality (Egli et al., 1979). The SG test has been recognized to consistently overestimate field emergence in soybeans (Tekrony and Egli, 1977; Johnson and Wax, 1978). In this study, however, field performance results were highly correlated with SG, SVC, and conductivity tests.

In 1980, Smith and Ellis provided the first report that seed quality influenced the rate of field emergence and the average number of tap root nodules per plant in soybeans. However, beyond these general observations, no assessment of the cause of enhanced root nodulation in high vigor seeds was made nor was the degree of N_2-fixation determined. Results of experiments presented in this study confirmed those reported earlier by Smith and Ellis (1980) for

soybeans. Regardless of whether the seeds were naturally or artificially aged, as seed quality decreased, the rate of emergence, plant growth, nodulation and N_2-fixation rate concurrently decreased. Furthermore, high vigor seeds continued these trends throughout the various growth stages sampled and this association ultimately culminated in yield increases of up to 30% compared to low vigor seeds. Also, increases up to 25 and 35% for nodulation and N_2-fixation rate, respectively, were observed in high vigor seeds relative to low vigor seeds. These general trends were consistent throughout the two year study and were observed both in the DR and Ohio. These findings suggest that similar associations between seed quality and N_2-fixation may be occurring in field beans as well as soybeans. Other studies also have shown that seed vigor has a profound impact on field bean yield (Wijandi and Copeland, 1974), snap bean yield (Toole et al., 1957; Viera, 1966), and soybean yield (Torrie, 1958; Wu, 1977; Tekrony and Egli, 1977; Johnson and Wax, 1978; Yaklich and Kulik, 1979).

The results obtained in this study fail to support the theory postulated by many investigators that "...because of the ability of the soybean plant to compensate for low plant density, differences in seed yield cannot be detected in seeds varying in vigor levels and that the principal benefit from using high quality seeds is to enhance stands" (Mason

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et al., 1982; Byrd, 1970; Johnson and Wax, 1978; Egli and Tekrony, 1979). The data presented here indicate that this theory does not apply for field beans under either tropical (DR) or temperate (Ohio) conditions. Thus, based on these findings and those who have reported reductions in yield as a consequence of either naturally or artificially aged seeds (Torrie, 1958; Wu, 1977), it is logical to conclude that low vigor seeds, whether they are a result of poor production pratices, severe weather conditions during seed development and maturation, or poor storage conditions can present a potential form of biological stress which culminates in reduced crop yields.

Significant seed yield increases due to the direct effects of inoculation with R. phaseoli seldom have been observed in field beans grown in the field (Graham, 1981). However, this report documents consistent yield increases in excess of 600 kg. ha^{-1} followin inoculation with R. phaseoli of high quality seeds relative to the uninoculated control in the DR and Ohio during two years. These findings clearly justify the continuation of studies to adapt inoculant technology for use by farmers in developing countries such as the DR.

It is well known that seeds are treated with fungicides to promote excellent seedling establishment, to reduce yield

loss, to maintain and improve quality and to avoid the spread of dangerous organisms. In this time course study of plant growth, field emergence was increased by fungicide application relative to the non-treated control for naturally aged seeds in Columbus and Santiago. However, no promotive effect on artificially aged seeds was observed. Even though seed treatment at San Cristobal showed no effect for naturally aged seeds, it increased field emergence for artificially aged seeds. This finding suggests that seed treatment is more effective for seeds that have been more deteriorated as a consequence of aging in which the incidence of pathogen invasion is increased. Although nutrient leakage does occur in seeds as a result of accelerated aging (Abdul-Baki and Anderson, 1972), the beneficial effect of fungicide seed treatment was not observed at Columbus and Santiago probably because these two locations were free from field bean diseases and fungi. These fields, at least in Columbus, have never been planted to field beans. These data contrast with those from San Cristobal where the incidence of pathogens was very high and the seed treatment effect was observed.

Seed treatment also influenced nodulation and/or N_2-fixation during early plant growth because the plant root system had not extended beyond the immediate toxic zone surrounding the seed. In general, seed treatment increased

nodulation and N_2-fixation in this study. A possible explanation for this enhancement is that the rhizobial inoculant used was a granular rather than a powder inoculant, avoiding the close contact between the fungicide and the inoculant. Graham (1980) and Rennie et al. (1985) were able to overcome the inhibitory effect of captan on nodulation by using granular inoculant.

No significant effect of seed treatment on seed yield was observed; however, a trend for increasing seed yield was found on treated seeds relative to nontreated seeds for both naturally and artificially aged treatments which could be economically important for field bean production.

Conclusions and Recommendations

The following conclusions are made:

o Both the SG and SVC tests were good predictors of field performance for field beans varying in seed quality level.

o Yields for field beans produced either under tropical (DR) or temperate (Ohio) climates were dependent on initial seed quality levels. These findings failed to support the theory that the field bean plant compensates for low plant density resulting in similar yields. The principal benefit, therefore, from using high quality seeds extends beyond enhancing stands to include increased yield. These findings confirm those reported earlier by Smith and Ellis (1980) for soybeans who showed that increased seed quality resulted in improved rates of field emergence, plant growth, nodulation and N_2-fixation. Moreover, high vigor seeds continued to display these trends throughout the growth of the crop.

o Since many Latin American countries possess high ambient temperatures and relative humidities, seed deterioration is often rapid. Such reductions in seed

quality have been shown in this study to decrease the incidence of subsequent rhizobial seedling nodulation (25%), N_2-fixation (35%), and yields (30%).

An improved understanding of the relationship between seed quality and rhizobium root colonization of field beans could potentially result in an increase of 8,850 metric tons of beans at a value of 6.6 million U.S. dollars in the DR alone. Considering the Latin American Region, this 30% increase in potential yield would provide an additional estimated value of 588 million U.S. dollars as well as an increase of 0.72 million metric tons of food.

o Early nodulation provided sufficient nitrogen necessary to support higher yields.

o Consistent yield increases of up to 600 kg. ha^{-1} following inoculation relative to uninoculated seeds were observed at both the DR and Ohio sites indicating that the field bean cultivar Pompadour Checa has the ability to respond to inoculation with R. phaseoli strain "DG-2". This finding clearly justifies the continuation of studies to adapt inoculant technology for use by farmers in developing countries such as the DR.

o Fungicide seed treatment increased field emergence in both naturally and artificially aged seeds but the effect was more consistent for artificially aged seeds suggesting

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that fungicide seed treatment is more important for seeds that have been deteriorated as a consequence of aging stress.

o Fungicide seed treatment also produced enhanced nodulation and N_2-fixation. This was possible because of the use of a granular inoculant which avoided the intimate contact with the seed as would have been the case with a powdar inoculant.

o A trend of increasing seed yield due to fungicide application was also observed. This suggests that the use of fungicide seed treatment not only enhances field emergence but also results in greater economic benefit for the farmer.

Based on these findings, it is concluded that low vigor seeds, whether they are a result of poor production practices, severe weather conditions during seed development and maturation or poor storage conditions present a potential form of biological stress which can result in substantial crop yield losses. This study, therefore, serves as a framework from which other studies could be based. The following investigations are suggested:

1. Determine how reduced field bean seed vigor leads to reduced nodule formation and subsequent reduction in N_2-fixation.

2. The identification of inoculant strains which are efficient, compatible, and competitive should be examined because seed inoculants represent a convenient method of insuring root infection.

3. Quantification of the population of R. phaseoli in the soils of the principal bean producing regions is necessary in order to avoid inoculation failure due to competition with indiginous rhizobium populations in the soil.

4. Since most of the field beans planted in the DR are treated with captan and if the inoculant technology is going to be adopted, the general use of granular inoculant applied to the soil surface should be further evaluated.

5. Since the genetic constitution of the host determines whether or not nodulation occurs, the number of root-hair invasions, the number of nodules that form, and the speed with which infection takes place, breeding programs with high N_2-yielding cultivars of field bean should be established in order to insure higher N_2-fixation rates which would lead to increased seed yields.