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Biological Nitrogen Fixation Technology for Tropical Agriculture

Based on papers presented at a
workshop held at the
Centro Internacional de Agricultura Tropical
March 9-13, 1981

Edited by

Peter H. Graham
Centro Internacional de Agricultura Tropical
Cali, Colombia

and

Susan C. Harris
University of Hawaii NifTAL Project
Maui, Hawaii, USA

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ADQUISICIONES - CANJE
15 NOV. 1982
53963

Centro Internacional de Agricultura Tropical
AA 67-13, Cali, Colombia

20.657

THE INTERNATIONAL BEAN INOCULATION TRIAL (IBIT): RESULTS FOR THE 1978-1979 TRIAL

P.H. Graham, C. Apolitano, R. Ferrera-Cerrato, J. Halliday, R. Lepiz, O. Menendez, R. Rios, S.M.T. Saito, and S. Viteri[1]

Summary

Response to the inoculation of dry beans (*Phaseolus vulgaris* L.) in Latin America has been extremely variable. Because of this a collaborative multi-location inoculation trial using ten highly efficient strains of *Rhizobium phaseoli* was initiated. This paper reports results obtained in 1978-1979.

Twelve IBIT trials were sown in seven countries. Significant yield responses (39-61% increase above control plants without nitrogen) were obtained at five sites, with the strains CIAT 632 and 640 generally among the most effective. CIAT 57 (syn. CC511) was disappointing. Extensive nodulation of uninoculated control plants occurred at several sites highlighting the problem likely to occur with native soil rhizobia in traditional bean-growing regions. At one site in Piracicaba, Brazil, one inoculant strain produced only 35% of nodules.

INTRODUCTION

Inoculation trials for dry beans (*Phaseolus vulgaris* L.) in Latin America have tended to use only a few strains of *Rhizobium phaseoli* and to include no strains of recognized efficiency. Inoculant quality has also been suspect at times. These and other factors have contributed to highly variable field inoculation results with this crop, a high proportion of investigators obtaining no response to inoculation (Pessanha *et al.*, 1970; Sistachs, 1970; Fontes, 1972; Nuñez & Valdes, 1976; Cuautle, 1979). To overcome these problems a collaborative multi-locational field trial was developed to evaluate the response of *P. vulgaris* to selected and highly efficient strains of *R. phaseoli*. This paper reports results from the first year of testing.

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[1] c/o CIAT, AA 67-13, Cali, Colombia.

FORMAT OF THE 1978-1979 IBIT TRIAL

No attempt was made in this first trial to impose standard conditions. Guidelines were provided, but the scientist implementing the trial was free to select the site, determine the need for liming and/or fertilizer application and select the variety and the cultural system to be used. Plot size could also be modified according to labor availability and expertise.

For each location the experiment contrasted ten selected strains of *R. phaseoli* with -N and +N controls in a randomized block design having four replications. The inoculant strains were selected from among 60 isolates provided by collaborators, and all had been retested for nodulation and nitrogen(N_2)fixation at the Centro Internacional de Agricultura Tropical (CIAT). The strains used, and their histories, are detailed in Table 1. Inoculants were normally provided to collaborating scientists as high-quality peat cultures, air mailed or hand carried to their destination less than six weeks before the intended planting date.

Again because of labor availability and expertise the data taken at each site could be varied. Yield data was required, but most collaborators also gave details of nodulation and some $N_2(C_2H_2)$ fixation data.

TABLE 1: Strains of *Rhizobium phaseoli* used in the 1978-1979 IBIT trial.

CIAT No.	Original No.	Source
45	F310	IPEACS, km 47, Campo Grande, Brazil
57	CC511	CSIRO, Canberra, Australia
255	Z272	Isolated from the Danli region, Honduras
632	21	Isolated by R. Aguilera, ICTA, Guatemala
640	Z632	Isolated by P. Graham, La Buitrera, Colombia
676	3620	Rothamsted Exp. Station, England
893	M20	Isolated by G. Ocampo, Carmen de Viboral, Colombia
903	TAL182	NifTAL, Maui, Hawaii, USA
904	487	UFRGS, Porto Alegre, Brazil
905	127K17	Nitragin Co., USA, Courtesy of J.C. Burton

RESULTS FROM THE 1978-1979 IBIT TRIAL

Sites used in the 1978-1979 IBIT series are characterized in Table 2. As is obvious from this table, sites varied appreciably in pH, soil organic matter, and available P and in climate. The varieties used and the planting systems adopted were also highly variable. Thus, while bush bean cultivars were used in most trials, four trials were planted to climbing beans; in three of these beans were grown associated with maize.

TABLE 2: Sites used in the 1978-1979 IBIT trial.

Location of trial	Soil type	Soil pH	Organic matter (%)	P (ppm)	Rainfall (mm)	Mgst[2] (°C)
Chapingo, Mexico[1]	sand	6.6	1.11	27.0		
Chiclayo, Peru	clay loam	7.8	1.43	6.8	irrigated	22.6
Cochabamba, Bolivia	clay loam	5.7		4	176	18.5
Jalisco, Mexico	clay loam	6.0	2.0	2.9	473	
La Selva, Colombia	sandy loam	5.0	22.5	2.0		
Maui, Hawaii, USA	silty clay	5.7		1.0		
Piracicaba, Brazil-Site 1	clay loam	5.8	1.5	1.0	210	18.6
Piracicaba, Brazil-Site 2	clay loam	6.1	2.4	5.0	211	18.6
San Andres, El Salvador[1]	clay	6.3		76.0	260	24.5
Santander de Quilichao, Colombia	clay loam	4.9	7.1	1.8	irrigated	22.0

[1]Two experiments on same site.
[2]Mean growth season temperature (°C)

Yield data for the 12 experiments of the 1978-1979 series is included in Table 3. As might be expected from the diversity of soils and cropping systems, yields are extremely variable. This notwithstanding, a significant response to inoculation was obtained in five trials including two with relatively high soil *Rhizobium* populations. Yields of the best of the inoculated treatments at the five sites were 39.9-61.1% greater than those of -N control treatments. The yield response to inoculation with the strains CIAT 632 and CIAT 640 was consistently superior to that of the other strains. In contrast, CIAT 57 (syn. CC511) fared poorly. This strain has been widely used in inoculants and was considered a standard, but it gave very poor yields at the higher-temperature Santander location. In early trials of the 1979-1980 IBIT, this strain has again performed poorly, raising the possibility that it has undergone some modification of symbiotic properties.

The yield data is also of interest for the number of sites with low soil organic matter at which the -N controls yielded at least as well as those receiving N fertilizer. In our experience, this is sometimes due to a higher incidence of foliar pathogens on the more luxuriant +N plants. Disease-resistant cultivars or heavy pesticide applications are needed.

As might be expected from the long history of bean cultivation in Latin America, there were a number of locations at which competition for nodule sites limited the opportunity for response to inoculation. This is evident in the nodulation data provided in Tables 4 and 5. Thus, uninoculated plants in the first Chapingo trial averaged more than 100 nodules/plant. For this location R. Ferrera-Cerrato (personal communication) has concluded that less than 2% of nodules are likely to come from the inoculant strain. High nodule numbers/plant were also evident at the San Andres, Piracicaba 2, Jalisco, and Cochabamba sites. For the noncompetitive site at Piracicaba S.M.T. Saito (personal communication) has shown that the inoculant strains produced 50-100% of nodules. In the second trial on a bean soil having approximately 10^4 rhizobia/gram, the percentage of nodules derived from the inoculant varied from 35%-90%, with CIAT 904 the least competitive strain. This finding parallels other results at CIAT.

FUTURE OF THE IBIT SERIES

The 1979-1980 IBIT series with new strains of *R. phaseoli* included has already been distributed. For the 1981 trial we are proposing to use again the better strains from the previous two years of testing, but a number of them will be distributed as antibiotic-resistant mutants, the competitive abilities of which can be followed in soil. Simultaneously, we propose more intensive collection of additional isolates, with particular attention to those from acid soils or regions of high temperature. We do not propose to reissue already tested strains repeatedly, but will only continue the IBIT trials if additional select isolates can be identified.

TABLE 3: Yield (g/plant) by location for the 1978-1979 IBIT trial.

Location of trial	Yield -N	Yield +N	Yield range in inoculated treatments	Best strains	% yield increase with best strains	
Chapingo, Mexico 1	11.0	9.5	7.7 - 11.1	640	0	n.s.
Chapingo, Mexico 2	6.7	5.4	5.0 - 7.2	632	7.4	n.s.
Chiclayo, Perú	48.5	38.8	30.1 - 51.6	255	6.3	n.s.
Cochabamba, Bolivia	8.6	7.6	6.8 - 9.1	893, 904	5.5	n.s.
Jalisco, Mexico	15.7	14.9	12.9 - 16.8	632, 640	7.3	n.s.
La Selva, Colombia	11.5	19.3	13.2 - 17.9	632, 640	56.3	*
Maui, Hawaii, USA	7.2	6.3	7.3 - 11.6	57, 893	61.1	*
Piracicaba, Brazil 1	30.2	37.4	27.2 - 44.8	632, 640, 903	48.3	*
Piracicaba, Brazil 2	1.3	3.6	1.0 - 1.9	903	46.1	*
San Andres, El Salvador	8.6	7.9	6.8 - 9.1	57	5.5	n.s.
San Andres, El Salvador	5.1	5.3	4.8 - 7.7	632, 640, 905	39.9	*
Santander, Colombia	5.3	5.5	4.8 - 6.1	632, 640	15.5	n.s.

TABLE 4: Nodule number per plant for locations in the 1978-1979 IBIT trial.

Location of trial	-N	+N	Range among inoculated treatments
Chapingo, Mexico 1	102.5	102.7	68.0 - 223.7
Chapingo, Mexico 2	147.2	154.7	64.5 - 173.7
Chiclayo, Peru	15.4	7.1	12.2 - 32.4
Cochabamba, Bolivia	26.7	26.2	31.0 - 205.2
Jalisco, Mexico	45.9	32.4	36.1 - 60.9
La Selva, Colombia		data not taken	
Maui, Hawaii, USA	0.1	0	0.1 - 26.2
Piracicaba, Brazil 1	13.9	3.6	24.6 - 50.7
Piracicaba, Brazil 2	50.2	42.2	50.5 - 88.1
San Andres, El Salvador 1	36.1	0.8	28.8 - 54.3
San Andres, El Salvador 2	22.8	0	33.3 - 40.3
Santander, Colombia		data not taken	

TABLE 5: Nodule fresh weight for locations in the 1978-1979 IBIT trial.

Location of trial	-N	+N	Range among inoculated treatments
Chapingo, Mexico 1	42.5	69.5	27.5 - 143.0
Chapingo, Mexico 2	131.0	95.5	57.0 - 176.5
Chiclayo, Peru	72.0	12.0	33.0 - 171.0
Cochabamba, Bolivia	7.5	11.0	15.4 - 79.5
Jalisco, Mexico	190.0	82.0	80.0 - 247.0
La Selva, Colombia		data not taken	
Maui, Hawaii, USA	0	0	0 - 18.6
Piracicaba, Brazil 1	11.8	2.4	20.6 - 73.4
Piracicaba, Brazil 2	104.8	10.6	93.4 - 183.8
San Andres, El Salvador	15.5	7.4	11.0 - 30.0
San Andres, El Salvador	15.0	0	14.0 - 26.0
Santander, Colombia	38.4	2.6	14.8 - 34.4

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