19.869

Nitrogen Fixation by *Rhizobium phaseoli*

Strain testing Testing of *Rhizobium phaseoli* strains continued in 1980 with both glasshouse and field evaluations of several new isolates

Final results were obtained during 1980 for the first International Bean Inoculation Trial (IBIT) involving 10 superior *R phaseoli* strains tested in seven countries (CIAT Bean Prog 1979 Ann Rept)

Bean yield increases following inoculation were obtained in five of the trials with strains CIAT 632 and 640 in particular showing consistency in N fixation (Table 1) In the first trial at Piracicaba Brazil strain 640 outyielded the N control to which the equivalent of 100 kg urea/ha was applied

Uninoculated control plants were well nodulated at Central American sites (Table 2) suggesting that competition between native soil rhizobia and inoculant strains could have been a major problem there

T bl 2 Nod le mbe /pla t f locat o the 1978 79 IBIT trial

L cat	Nodule /pla t		Ra g am g oc l t d tre tm t	
	N	N		
Chap g M l	102 5	102 7	68 0	223 7
Ch p g M 2	147 2	154 7	64 5	173 7
Ch l y P	15 4	7 1	12 2	32 4
Cochab mb B l	26 7	26 2	31 0	205 2
J l sc M	45 9	32 4	36 1	60 9
La S l C l mb	N T	N T	N T	N T
M U S A	0 1	0	0 1	26 2
P caba B l l	13 9	3 6	24 6	50 7
P cab B as l 2	50 0	42 2	50 5	88 1
S n A d El S l d l	36 1	0 8	28 8	54 3
Sa A d El S l ado 2	22 8	0	33 3	40 3
S ta de C l mb	N T	N T	N T	N T

N T d t k

Tabl 1 Y ld d ta (g/pla t) by locat o fo th 1978 79 IBIT series

Locati n of trial[1]	Y eld N	Y eld N	Y ld range inocul t d tr atm nts		Be t strai s	Y ld c ase with be t stra (%)
Ch p ng Me l	11 0	9 5	7 7	11 1	640	0 s
Chap ngo Me co 2	6 7	5 4	5 0	7 2	632	7 4 n
Ch lay Pe u	48 5	38 8	30 1	51 5	255	6 3
Cochab mba Boli ia	8 6	7 6	6 8	9 1	893 904	5 5
Jal sc M x	15 7	14 9	12 9	16 8	632 640	7 3
La Sel Col mb	11 5	19 3	13 18	17 95	632 640	56 3
Mau U S A	7 2	6 3	7 3	11 6	57 893	61 1
P ra caba B as l l	30 2	37 4	27 2	44 8	632 640 903	48 3
P b B l 2	1 3	3 6	1 0	1 9	903	46 1
S And es El Salv d	8 58	7 91	6 8	9 1	57	5 5
S And El Sal d	5 11	5 27	4 8	7 7	632 640 905	39 9
S ta d C l mbia	5 3	5 5	4 8	6 1	632 640	15 5 n s

1 h pe m t Chap g M re d m ged by h l

Nevertheless significant yield increases following inoculation were achieved in one of two trials at Ahuachapan El Salvador The high background nodulation in the Mexican and El Salvador trials emphasizes the need for more detailed studies on competition (see later section on Competition for nodule sites)

In the only location where nodules were typed (Piracicaba) the inoculant strains produced 60-100% of the nodules with strains 632 and 903 proving extremely competitive strains 45 and 904 induced a lower percentage of the nodules on inoculated plants

A second IBIT including additional new strains of *R phaseoli* was distributed this year Fourteen collaborators in 10 countries will be participating in this second test

Acid soil tolerance The ability of some isolates of *R phaseoli* to grow on synthetic media (with a pH of 4 6 and in the presence of excess Al and Mn) was reported (CIAT Bean Prog 1979 Ann Rept) Further studies to evaluate the relevance of these findings to field conditions were undertaken this year Figure 1 shows the survival of CIAT strains 640 (sensitive to low pH in media) and 899 (able to grow on modified Keyser s medium at pH 4 6) when inoculated into the unlimed soil at CIAT Quilichao (pH 4 15) or into the same soil limed to either pH 4 5 4 9 or 5 8 The greater ability of the acid tolerant strain to survive under unfavorable soil conditions is evident populations of CIAT 640 in the pH 4 5 soil declined to fewer than 10^2 cells/g of soil only five days after soil inoculation Studies to examine the nodulating ability of strain 899 in acid soil and how this could be affected by the bean cultivar are underway

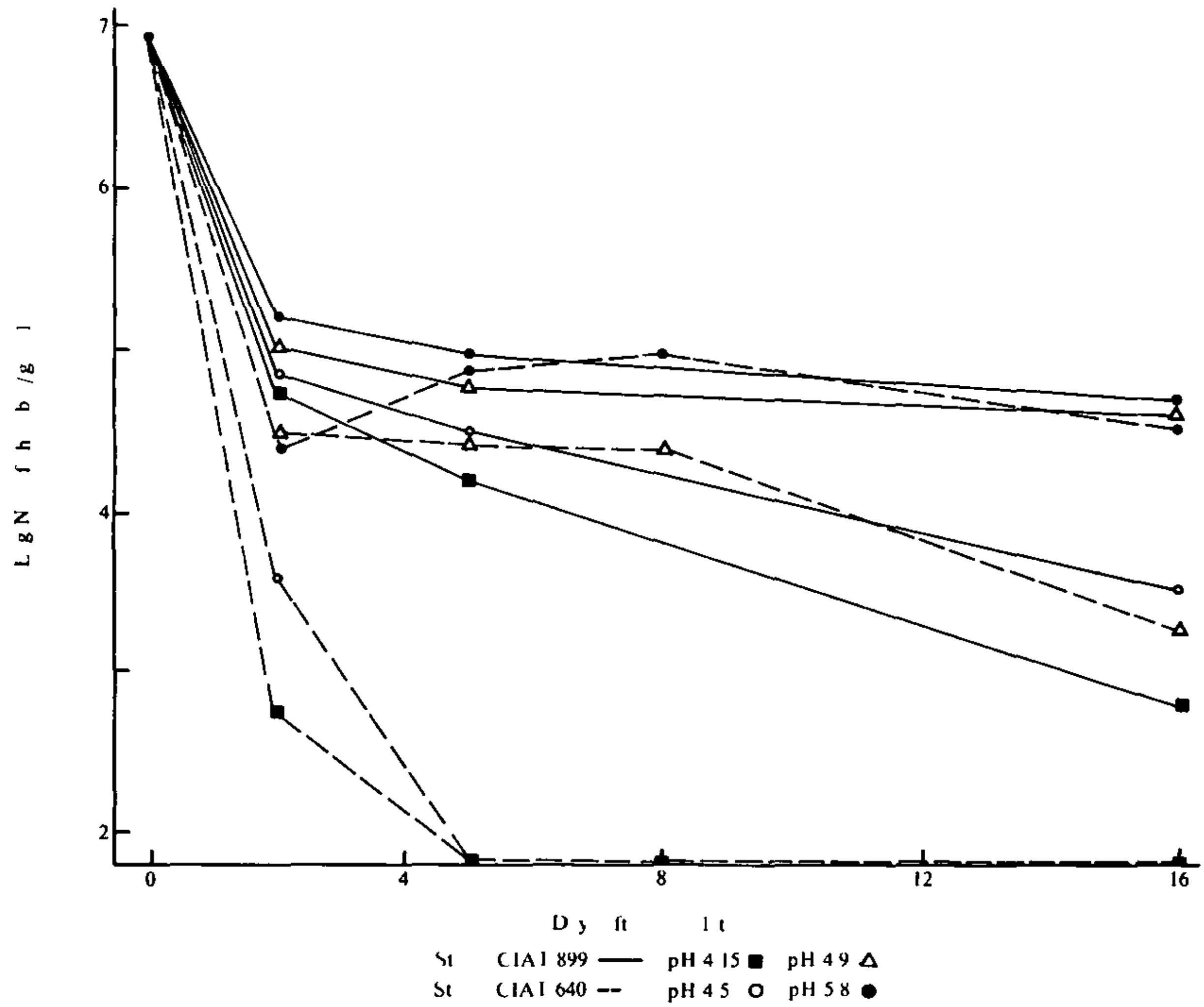


Fig 1 S l p t ns f t ns f Rhi b m phaseoli n l l ng l f l g j H l

Temperature tolerance Studies begun last year at CIAT Quilichao showed the inability of some strains especially CIAT 57 to function under high soil temperature conditions With new growth room facilities now available at CIAT experiments were initiated to evaluate the performance of currently important strains Results from one trial showed most strains to be relatively weak in N_2 fixation at the 34 / 28 day/night temperatures used Some host specificity was also evident Further studies are underway with the more effective strains CIAT 632 166 125 and 126

Competition for nodule sites Given the high populations of soil rhizobia found in the Mexican and Central American sites used for the first IBIT test studies were initiated to evaluate the competitive ability of the commonly used CIAT strains of *R phaseoli* Antibiotic resistant mutants which can be recovered from nodules and easily identified were prepared from all strains used in the 1979 and 1980 IBIT trials Extensive testing of these strains has been necessary as many of the mutants showed modified symbiotic properties evident from data in Table 3 Initial studies with selected mutants confirmed the poor competitive ability of strain CIAT 904 Studies to select highly competitive strains of *R phaseoli* are continuing

T ble 3 S m p met rs of odulation and n trog n f x t n f p e tal and m ta t t ain f *Rh b un ph ol*

St a		Symbiotic trait		
		Days t first n d l	Nodule f h weight (g/pla t)	Plant dry w ght (g)
640	P rental	6	1 38	3 55
	M ta t b	8	0 79	2 34
	M ta t-e	6	1 13	3 63
125	P tal	6	1 07	4 25
	Mutant b	6	1 61	4 35
	M ta t f	6	1 23	3 92
899	P tal	6	1 39	3 29
	M ta t-a	8	0 58	1 82
	M t t	6	1 66	3 86
632	Pa e tal	6	0 62	3 46
	M ta t	11	0 49	1 16
	Mut t b	14	0 26	1 08

S ra h k h se f d f mpe od l es

Nitrogen fixation in low-soil P tolerant bean cultivars Concern that low soil P tolerant cultivars (CIAT Bean Prog 1979 Ann Rept) might achieve P use efficiency at the expense of nodule P and thereby limit N_2 fixation prompted studies of N_2 fixation in the cultivars Iguacu (low P tolerant) and Puebla 152 (sensitive) Initial results indicated the sensitive cultivar did apportion a greater fraction of total plant P to nodules However the cultivars differed little in N_2 fixation at low soil P Up to the 35 day harvest the two cultivars also showed little difference in their ability to absorb P from the soil

Nitrogen fixation at Popayan and CIAT Quilichao With a much greater proportion of the N_2 fixation work in beans being done at the warmer CIAT Quilichao station experiments were conducted to determine if the assay methods used at Popayan were appropriate for this other site Two bean lines BAT 76 and BAT 332 previously shown to be active in N_2 fixation when inoculated with appropriate strains were grown in both locations and some parameters of N_2 fixation were measured weekly At flowering in each location N_2 fixation was followed over a 24-hour period to determine optimum times for measuring activity As was evident in earlier temperature studies nodules developed more slowly at Popayan although greater nodule fresh weight/plant was eventually obtained there Differences in N_2 fixation were not so marked although peak activity was observed 35 days after planting at CIAT Quilichao and 40 50 days after planting in Popayan

In the diurnal study maximum N_2 fixation/unit fresh weight of nodules (SNA) was obtained at the 10 a m sampling in both locations SNA declined steadily thereafter At CIAT Quilichao SNA was paralleled by a steady decline in the soluble carbohydrate content of nodules but at Popayan this was not observed

Biology and Control of Insect Pests

Cultural control of *Empoasca kraemeri* Last year it was reported that when beans were associated with sugarcane *Empoasca kraemeri* and other bean pests occurred in lower numbers than in beans grown alone The association had no effect on insect populations of the sugarcane or on biological control programs maintained in this crop Although beans initially affected sugarcane development final sugar yields were only affected when beans were planted 45 days after the sugarcane

This trial was repeated in 1980 with minor modifications Again bean insect pests were fewer in associated beans and no effect on sugarcane insects and control programs was detected Bean yields were satisfactory and highest in association when both crops were planted at the same time (Table 4) From these experiments it is concluded that the sugarcane bean association is both agronomically and entomologically feasible

Tabl 4 Y ld f be a ety D acol Cal m m o lt d lat w th g as fl d by d ffe e t pl t g d t

C pp g y t m	R lat pla t g d t f be (d y ft g a)	Y ld (kg/h)
Be	15	1543
Be	0	1433 b
Be a d ug a	0	1332 bc
Be d uga ca	15	1218 c
Be	30	865 d
Be a d ug ca	30	577

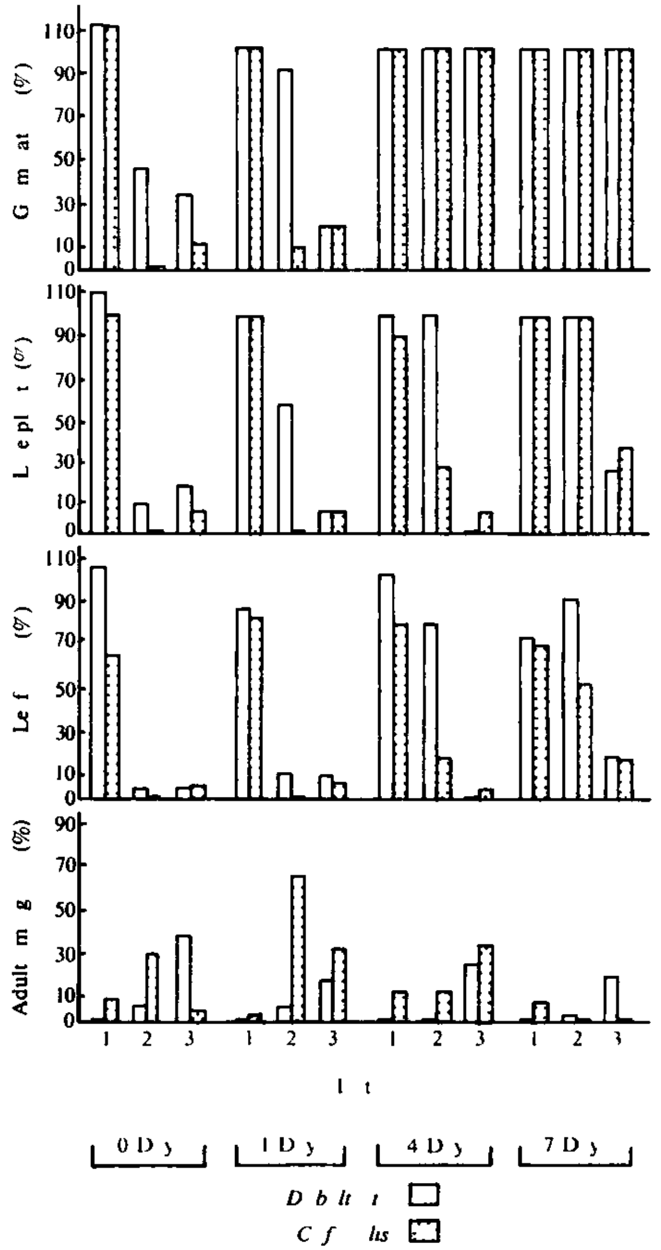
V l m f f pl ca (C V 8 9%)
M f ll d by h sam l t ig if ca tly d fl re t h 5% l l f l d ce (D)

Chrysomelids Final studies on populations of *Cerotoma facialis* indicated that four adults per plant is a critical level during early bean growth stages (8 15 days) and to a lesser extent during the flowering period When an attack lasts for two weeks *Cerotoma* is more damaging than *Diabrotica balteata* Both species consume flowers and pods but when attacks occur between 36 and 50 days after planting damage does not affect final bean yields

Larvae of *Cerotoma* and *Diabrotica* caused significant damage to plants less than 14 days old (Fig 2) Second and third instar larvae affected plant germination and reduced leaf area especially during the initial growth period (0-7 days after planting) These results confirm previous reports and are conclusive

Validation of storage technology One of the principal problems in bean production is the price collapse at harvest Low-cost on farm storage might help farmers overcome this problem Bruchids are responsible for most storage losses but it has been shown they can be easily controlled by using a low dosage of vegetable cooking oil applied to the seed before storage (CIAT Bean Prog 1979 Ann Rept)

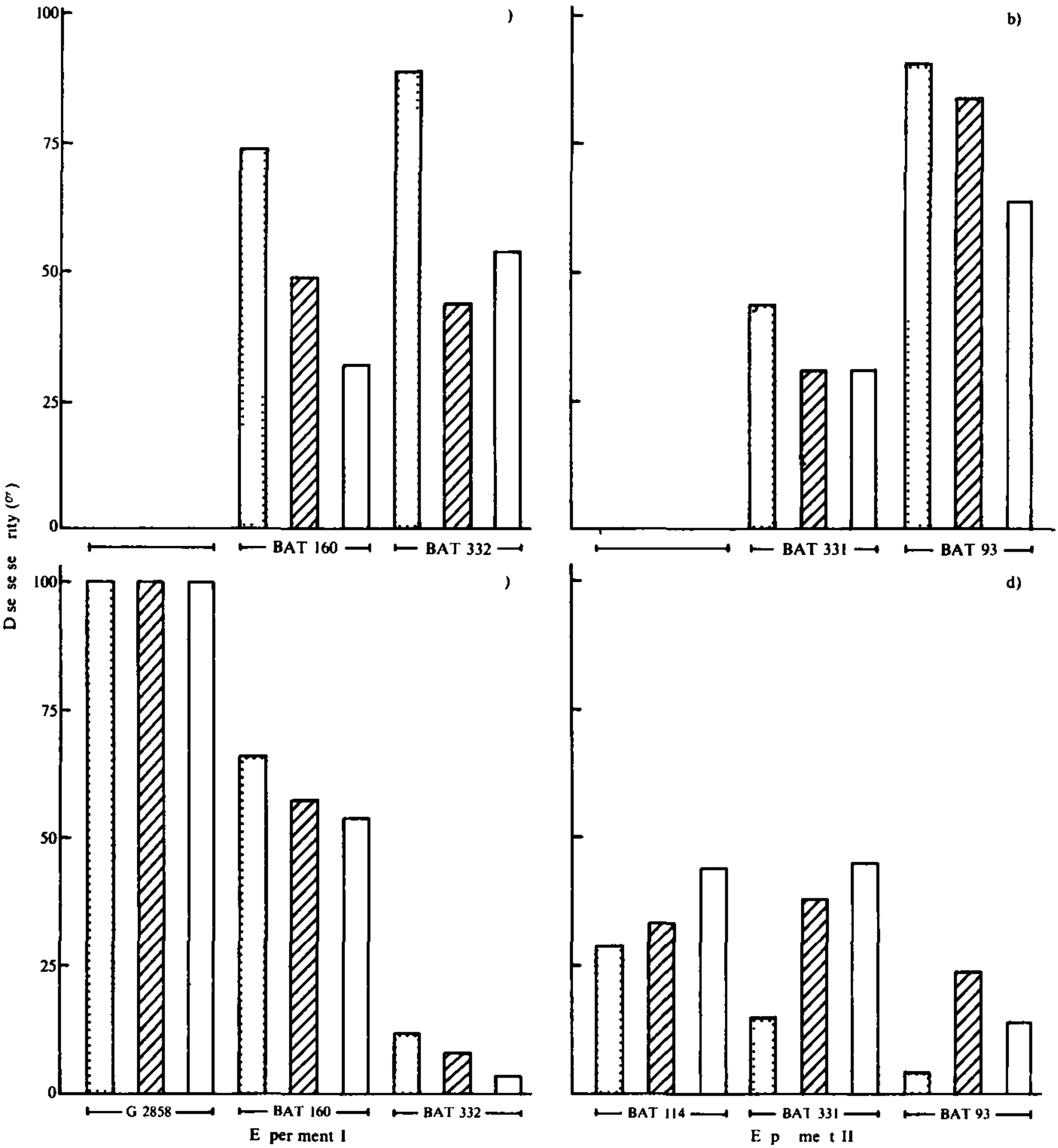
To introduce this technology a series of seven on farm demonstration trials was established in the Huila region of Colombia After four months of storage no damage has



Fgu 2 D g l h f d d th d nst l r j D b ot balt t d Cer tom f ciali t d ff t g th t g f th b n pl t

been observed and farmers are satisfied The system may allow them to sell their product at a better price and/or utilize some of the seed for planting next season

Oil treated beans have been seen in popular markets in the Cauca Valley To test their acceptance 200 kilograms of soil treated Diacol Calima variety were offered for sale in the same area All were sold easily at normal prices



F gu 3 *Eff t of th pl t d ns tie pon dis d l pm nt n b ns (Expe m nt I was no ul t d w th l l is l t of th gul l f p t path g n nd natu lly nfe t d w th nth acno Exp m t II ll) f t d by po de y m lde nd wh t leaf pot p thogens)) Anth o b) P d y m ld) Angul l f p t d) Whit l f pot*

A series of experiments was planted in 1980 to study effects of different plant population densities upon disease development after inoculation with or under natural infection by various bean pathogens Three population densities (67 133 and 267 x 10^3 plants/ha) of three to 10 entries were planted in a split plot design (6 m^2 per entry density combination) which was separated by border rows and replicated four times in each experiment Disease evaluations were made periodically to estimate the percentage leaf area infected by each pathogen

Figure 3 illustrates selected data obtained from two of the experiments conducted at Popayan Experiment 1 was inoculated with a mixture of local isolates of the angular leaf spot pathogen and was naturally infected by anthrac nose Experiment 2 was naturally infected by powdery mildew and white leaf spot pathogens

White leaf spot development was significantly less in higher plant densities which agrees with other reports Anthracnose and powdery mildew infections (71 days after plant germination) were significantly increased in the high plant density of BAT 160 or BAT 332 and BAT 93 or BAT 331 respectively Angular leaf spot development (65 days after germination) was likewise favored by increased plant density Similar trends were observed in other experiments for rust Ascochyta leaf spot halo blight and common bacterial blight Therefore high plant population densities generally favored disease development in susceptible materials This interaction may be counter productive to the yield gains commonly expected from standard agronomic recommendations to maximize yields and must be considered when developing bean production policies

Cropping systems also influenced bean disease develop ment in determinate and indeterminate materials grown in monoculture or associated with maize at CIAT Palmira and Popayan Natural infection by rust was initially greater in monoculture than in association but the relative difference between the two systems lessened as the season progressed at CIAT Palmira Natural infection by anthracnose was initially greater in association than in monoculture and the relative difference between the two systems lessened as a mild rainy season progressed at Popayan More recent results indicate that a heavy rainy season may completely overcome the cropping system effect and incite severe anthracnose infection in either system

Appendix A

Description of *Phaseolus vulgaris* L Growth Habits

Type I Determinate growth habit reproductive terminals on the main stem with no further node production on the main stem after flowering commences

Type II Indeterminate growth habit vegetative terminals on the main stem with node production on the main stem after flowering commences erect branches borne on the lower nodes of the main stem erect with relatively compact canopy variable guide development depending on environmental conditions and genotype

Type IIIa Indeterminate growth habit vegetative terminals on the main stem with node production on the main stem after flowering, relatively heavily branched with variable number of facultatively climbing branches borne on the lower nodes variable main stem guide development but generally showing climbing ability

Type IIIb Indeterminate growth habit vegetative terminals on the main stem with node production on the main stem after flowering, relatively heavily branched with variable number of facultatively climbing branches borne on the lower nodes variable main stem guide development but generally showing climbing ability

Type IVa Indeterminate growth habit vegetative terminals on the main stem with heavy node production after flowering commences branches not well-developed compared to main stem development moderate climbing ability on supports and pod load carried evenly along the lenght of the plant

Type IVb Indeterminate growth habit, vegetative terminals on the main stem with heavy node production after flowering commences branches not well-developed compared to main stem development strong climbing tendency with pod load mostly borne on the upper nodes of the plant

Notes The growth habit classification has been expanded for the climbing types since the 1977 Annual Report Type III materials with some tendency to climb are now recognized as Type IIIb,and Type IV has been divided on the basis of vigor and pod distribution

The most important distinguishing features of the growth habits are as follows terminal raceme on main stem for Type I indeterminate with erect branches for Type II indeterminate with prostrate branches for Type IIIa indeterminate with semi-climbing main stem and branches for Type IIIb indeterminate with moderate climbing ability and pods distributed evenly up the plant for Type IVa indeterminate with aggressive climbing ability and pods carried mainly on the upper nodes of the plant for Type IVb

Growth habit is not necessarily a stable characteristc since changes in growth habit may occur from one location to another The classification of growth habit for a particular genotype is only useful in a defined environment particularly with regard to climbing ability

Appendix B

CIAT Accessions of *Phaseolus* Referred to in this Report

CIAT No	Identification	Local register	Source[2]
G00057	Swedish Brown	PI 136735	USA
G00076	R d Kloud		USA
G00118	Forty Days	PI 162566	USA
G00124		PI 163372	USA
G00159	Cali Fasulya	PI 165078	USA
G00489	Raytal	PI 175269	USA
G00687	Windsor Long Pod	PI 182026	USA
G01507	Ojo de Cabra	PI 281988	USA
G01820	Negro Jamapa	PI 309804	USA
G01854	Nima	PI 310512	USA
G02005		PI 310739	USA
G02006		PI 310740	USA
G02047		PI 310805	USA
G02758	Morada del Agua	PI 311904	USA
G0 333	Colorado de Teopisca	PI 311998	USA
G02525	Magdalena 3	PI 313624	USA
G02618	Col No 168	PI 313755	USA
G02858	Zacaticano	PI 319665	USA
G02959	Pecl o Amarillo	GTA-014	GTA
G03353	*Puebla 152*		MEX
G03607	C C G B-44	I-462	VNZ
G03645	Jamapa	I-810	VNZ
G03652	Puebla 152	I-820	VNZ
G03658	Mexico 27N	I-867	VNZ
G03776	Venezuela 2	I 1062	VNZ
G03807	Brasil 2 Pico de Oro	I 1098	VNZ
G03834	51051	I 1138	VNZ
G03942	Michelite	B-33	CRA
G04000	NEI Bayo 22	C 286	CRA
G04122	S 166-A N	N 555	CRA
G04393	Tlaxcala 62 C		MEX
G04421	S-630-B	C-63	CRA
G04434	Antioquia 11	P 111	CRA
G04435	Diacol Calima	P 146	CRA
G04445	Ex Rico 23		CLB
G04446	Ex Puebla 152 Brown Seeded		MEX
G04449	Pinto UI 114		USA
G04451	9 AI 2		USA

Appe d B (t ued)

CIAT No	Identification	Local register	Source
G04452	ICA Guali		CLB
G04454	ICA Tui		CLB
G04459	NEP 2		CRA
G04460	Pompadour 2		CRA
G04470	Pompadour		DOM
G04482	Zamorano 2		HDR
G04489	Guilapa 72		GTA
G04494	Diacol Calima		CLB
G04495	Porrillo Sintetico		HDR
G04498	San lac		USA
G04503	Widusa		FRC
G04505	Top Crop		USA
G04523	Linea 17		CLB
G04525	Linea 32		CLB
G04727	Ancash 66		PER
G04816	Mulatinho		BZL
G04821	Iguacu (Lote 4)		BZL
G04824	Roxão		BZL
G04825	Carioca		BZL
G04830	Rio Tibagi (Lote 10)		BZL
G04978	Amanda		NLD
G05158	B co de Ouro 1445	BZL 905	BZL
G05270	Sataya 425		MEX
G05653	Ecuador 299		ELS
G05694	Cornell 49 242		USA
G05702	Cargamanto		CLB
G05708	Sangretoro		CLB
G05743	Preto 897		ATL
G05745	Redlands Greenleaf B		ATL
G05768	Pinto No 650		USA
G05773	ICA Pijao		CLB
G05897	Flor de Mayo		MEX
G06361	Great Northern		USA
G06520	AETE 2	CA 21	UTK
G06719	Jubila		NLD
G06721	Double White		NLD
G07932	Nahuizalco Rojo		ELS
G07951	Aroana		BZL
G09446	Imuna	FRC 542	FRC
G11249	Pinto	IVT 771004	NLD
G11274	Brasil 343 Mulatinho	IVT 77039	NLD
G11488	CENA 164-2 CM CM (12 B) F5		BZL
G12631	Ancash 143		PER
G12709	Mortino	Sanudo 45	CLB
G13497	AETE 1/37		BZL
G13499	Petro 132		BZL

Th G od I ccess h mbe ssigned t by th germplasm ba k f the CIAT Geneti R sources Uni BAT A, EMP BAC DOR nd V od bel g ma I imp d by CIAT Bea Program.

ATL A I BZL B I CLB C l mb CRA C ta R ca DOM Dom ic R p bl ELS El Sal d FRC F GTA G m l HDR H d ra MEX M PER Pe UTK U ed Kingd m VNZ V ne uela