BEAN ENTOMOLOGY

Activity 1. Developing germplasm with resistance to pests: Bruchids, pod weevil, leafhopper, and *Thrips palmi*

Screening for sources of resistance to major insect pests

Rationale: Identification of sources of resistance to major insect pests of beans is a continuous activity. Additional work is conducted trying to identify and characterize the mechanisms of resistance to specific major pests.

Materials and Methods: Bruchid nurseries are tested in the laboratory simulating normal storage conditions (20^{o} C, 80% R.H., and 14 % seed humidity). Genotypes are tested using 3-5 replications of 50 seeds per genotype. Evaluation units (replicates) are infested with 7 pairs of *Z. subfasciatus* per 50 seeds or two eggs per seed in the case of *A. obtectus*. *T. palmi*, leafhopper and pod weevil nurseries are planted in the field under high levels of natural infestation, usually with 3-4 replicates per genotype in randomized complete block designs. Evaluations for resistance include damage and bean production ratings, insect counts, damage counts, and, in some cases, yield components and yields.

Results and Discussion

Bruchids

Acanthoscelides obtectus: Using a novel Double Congruity Backcross technique developed at CIAT, the Biotechnology Unit has been able to develop fertile insterspecific *Phaseolus vulgaris* x *P. acutifolius* (common x tepary) bean hybrids using the tepary genotype NI576 (a genotype competent to *Agrobacterium*-mediated genetic transformation). Some of these crosses involve the tepary accession G 40199 an excellent source of resistance to the bean weevil, *Acanthoscelides obtectus*. In 2002 and 2003 we identified several progenies containing both *P. vulgaris* and *P. acutifolius* cytoplasm with very high levels of antibiosis resistance to *A. obtectus*. In 2004, emphasis was placed upon the reconfirmation of resistance in previously selected progenies. As shown in **Table 1**, one hybrid containing *P. vulgaris* cytoplasm and seven containing *P. acutifolius* cytoplasm showed high levels of resistance to the insect (< 20% adult emergence). Resistance in some cases was as high as that of G 40199, the resistant check.

Table 1. Resistance to *Acanthoscelides obtectus* in selected $F_{3,5}$ hybrid progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.

Code and Generation	Cross	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. vulgaris* cytoplasm				
T7K – 2F F_3	V-DCBC5 x V-DCBC4	67.5	38.7	66.6
T7K – 2E F_3	V-DCBC5 x V-DCBC4	7.1	71.0	10.0
T7K – 2 8B F_4	V-DCBC5 x V-DCBC4	100.0	39.2	100.0
T7K – 2 8A F_4	V-DCBC4 x GNV	99.2	39.6	100.0
T7K – 2 - 6 F_5	V-DCBC5 x V-DCBC4	100.0	38.6	100.0

Code and Generation	Cross	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm				
GKA – 12R F_3	A-DCBC7-2 x A6	54.8	53.9	86.1
GKA – 12R F_3	A-DCBC7-2 x A6	77.4	44.5	96.0
GKX – 6B F_3	A-DCBC8-2	12.7	48.0	33.3
GNVAV – 200A F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	12.2	44.4	20.7
GNVAV – 200B F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	88.2	42.9	100.0
GNVAV – 200D F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	2.7	41.0	8.7
GNVAV – 200G F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	1.1	67.0	3.3
GNVAV – 200H F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	0.0	N.E	0.0
GVV – 101 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	55.9	47.1	76.7
GVV – 102 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	71.1	47.1	90.0
GVV – 104 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	55.6	49.4	79.3
GVV – 107 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	57.1	45.5	100.0
GVV - 108 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	11.1	56.6	36.1
GVV - 108 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	62.2	44.2	75.0
GVV - 110 F_3	{[(G40022 x NI576)x V5] x A3} x VS42-7	36.3	48.6	57.8
Checks				
G 12882 Arc 1	Susceptible wild *P. vulgaris* accession	78.3	35.8	100.0
G 12952 Arc 4	Susceptible wild *P. vulgaris* accession	75.0	46.3	100.0
G 40168	Susceptible *P. acutifolius* accession	88.3	41.8	100.0
G 25410	Susceptible *P. lunatus* accession	93.3	42.7	100.0
RAZ 44	Susceptible *P. vulgaris* line	98.3	36.9	100.0
ICA Pijao	Susceptible *P. vulgaris* cultivar	96.6	31.7	100.0
G 40199	Resistant *P. acutifolius* accession	3.3	85.7	12.2
G 25042	Resistant *P. lunatus* accession	1.6	80.0	5.3

After multiplication of resistant seeds in the greenhouse, some of these hybrids again showed high resistance to *A. obtectus* (< 20% adult emergence) in replicated tests **(Table 2)**.

Table 2. Resistance to *Acanthoscelides obtectus* in selected $F_{5,6}$ hybrid progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.

Cross Code	Hybrid Number	Cross	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
Hybrids					
GNVAV	200A9 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	18.7	54.0	32.6
GNVAV	200D21 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	47.9	51.2	52.6
GNVAV	200D22 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	31.9	52.7	63.8
GNVAV	200G16 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	14.4	58.1	31.3
GNVAV	200G17 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	30.6	52.0	45.2
GNVAV	200G18 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	0.6	71.0	1.8
GNVAV	200G19 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	13.0	56.0	25.5
GNVAV	200H5 F_6	{[(G40022 x NI576)x V5] x A3} x VS42-7	0.8	71.0	2.8
GVV	110G F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	5.2	58.0	18.8
GVV	110 I F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	21.1	48.9	36.6
GVV	108 N F_5	{[(G40022 x NI576)x V5] x A3} x VS42-7	14.6	55.7	37.0

Cross Code	Hybrid Number	Cross	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
		Checks			
G 12882 Arc1	Susceptible wild *P. vulgaris* accession		66.4	36.0	100.0
G 12952 Arc4	Susceptible wild *P. vulgaris* accession		60.0	47.6	100.0
G 40168	Susceptible *P. acutifolius* accession		65.2	43.4	100.0
G 25410	Susceptible *P. lunatus* accession		90.4	42.4	100.0
ICA Pijao	Susceptible *P. vulgaris* cultivar		93.9	30.6	100.0
G 40199	Resistant *P. acutifolius* accession		16.3	58.5	39.0
G 25042	Resistant *P. lunatus* accession		1.5	62.0	7.1

We also tested three interspecific hybrids with *P. vulgaris* cytoplasm (all susceptible) and eight with *P. acutifolius* cytoplasm, three of which (BWG – 5N F_3, BWG – 6Y F_3, and BWG – 1F F_3) showed resistance **(Table 3)**. After multiplication of selected seeds, replicated reconfirmation tests revealed intermediate resistance (20-50% adult emergence) in some of these hybrids **(Table 4)**.

Table 3. Resistance to *Acanthoscelides obtectus* in selected segregating F_3 hybrid progenies derived from *Phaseolus vulgaris* x P. *acutifolius* crosses.

Code and Generation	Type of Material	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
	Hybrids			
TZT – 4A3 F_4	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with P. vulgaris cytoplasm	82.2	35.9	73.3
TZT – 4A1 F_4	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. vulgaris* cytoplasm	73.3	42.1	80.0
TZT – 1E F_4	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. vulgaris* cytoplasm	96.0	40.0	100.0
BWG – 5N F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. acutifolius* cytoplasm	11.3	58.5	31.1
BWG – 5M F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. vulgaris* cytoplasm	52.6	45.9	78.1
BWG – 5S F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. acutifolius* cytoplasm	80.0	50.2	96.7
BWG – 6Y F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm	48.8	52.8	85.0
BWG – 6W F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm	94.5	41.9	100.0
BWG – 1F F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm	39.8	49.3	67.0
BWG – 1A F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm	64.4	46.3	76.7
BWG – 1G F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrids with *P. acutifolius* cytoplasm	95.6	39.2	93.3
	Checks			
G 12882 arc 1	Susceptible wild *P. vulgaris* accession	78.3	35.8	100.0
G 12952 arc 4	Susceptible wild *P. vulgaris* accession	75.0	46.3	100.0

Code and Generation	Type of Material	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
G 40168	Susceptible *P. acutifolius* accession	88.3	41.8	100.0
G 25410	Susceptible *P. lunatus* accession	93.3	42.7	100.0
RAZ 44	Susceptible *P. vulgaris* line	98.3	36.9	100.0
ICA Pijao	Susceptible *P. vulgaris* cultivar	96.6	31.7	100.0
G 40199	Resistant *P. acutifolius* accession	3.3	85.7	12.2
G 25042	Resistant *P. lunatus* accession	1.6	80.0	5.3

Table 4. Resistance to *Acanthoscelides obtectus* in selected segregating F_4 hybrid progenies derived from *Phaseolus vulgaris* x P. *acutifolius* crosses.

Cross Code	Hybrid Number	Percentage Adult Emergence	Days to Adult Emergence	Percentage Seeds Damaged
	Hybrids			
BWG	1F7 F_4	43.2	43.4	70.1
BWG	1F13 F_4	45.4	46.4	90.5
BWG	1F14 F_4	44.4	43.4	73.0
BWG	1F18 F_4	25.6	43.7	53.8
BWG	5N1 F_4	33.8	49.9	64.1
BWG	5N4 F_4	24.4	55.3	55.1
BWG	6Y6 F_4	29.5	50.7	64.8
BWG	6Y15 F_4	17.5	51.4	35.1
	Checks			
G 12882 Arc 1	Susceptible wild *P. vulgaris* accession	66.4	36.0	100.0
G 12952 Arc 4	Susceptible wild *P. vulgaris* accession	60.0	47.6	100.0
G 40168	Susceptible *P. acutifolius* accession	65.2	43.4	100.0
G 25410	Susceptible *P. lunatus* accession	90.4	42.4	100.0
ICA Pijao	Susceptible *P. vulgaris* cultivar	93.9	30.6	100.0
G 40199	Resistant *P. acutifolius* accession	16.3	58.5	39.0
G 25042	Resistant *P. lunatus* accession	1.5	62.0	7.1

The tedious but important process of testing individual seeds to detect segregation in interspecific hybrids continued in 2004 **(Table 5)**. Those selected for resistance were multiplied but the seed did not germinate. One intraspecific *P. lunatus* hybrid that did germinate (coded V5) showed a very high level of resistance comparable to that of the resistant accession G 25042. Two double congruent hybrids with *P. acutifolius* cytoplasm (GKVGAG 1B 4D F_5 and GKVGAG 1E 2C $F_{5)}$ were selected for further testing **(Table 6)**.

Table 5. Reconfirmation of resistance to *Acanthoscelides obtec*tus in pre-selected segregating hybrid progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses and intraspecific *Phaseolus lunatus* crosses

Code and Generation	Type of Material	Number of Seeds Evaluated	Number of Resistant Seeds	Days to Adult Emergence
	Hybrids			
GNVAV-21 F_3	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. acutifolius* cytoplasm	4	3	N.E[a]
GKA 11 F_2	Interspecific *P. vulgaris* x *P. acutifolius* hybrid with *P. acutifolius* cytoplasm	15	3	N.E
Z99ZX6 F_2	Double congruent hybrid with *P. acutifolius* cytoplasm	6	1	N.E
Z99ZX–1A F_3	Double congruent hybrid with *P. acutifolius* cytoplasm	20	8	N.E[1]
Z99ZX–11A F_3	Double congruent hybrid with *P. acutifolius* cytoplasm	7	1	N.E
ZX99-15 F_3	Double congruent hybrid with *P. acutifolius* cytoplasm	7	3	N.E
ZXTG31-4-10 F_4	Double congruent hybrid with *P. acutifolius* cytoplasm	12	5	N.E
GKVGAG-1A F_3	Double congruent hybrid with *P. acutifolius* cytoplasm	31	31	N.E
A6 F_2	Intraspecific *P. lunatus* hybrid	9	7	N.E
VS42-14 F_2	Intraspecific *P. lunatus* hybrid	5	4	N.E
V5 F_2	Intraspecific *P. lunatus* hybrid	31	31	N.E.
VS42-7 F_2	Intraspecific *P. lunatus* hybrid	6	6	N.E
	Checks			
G 40168	Susceptible *P. acutifolius* accession	15	0	42.6
G 25410	Susceptible *P. lunatus* accession	15	0	44.4
RAZ 44	Susceptible *P. vulgaris* line	15	0	38.0
ICA Pijao	Susceptible *P. vulgaris* cultivar	15	0	31.9
G 40199	Resistant *P. acutifolius* accession	15	9	N.E
G 25042	Resistant *P. lunatus* accession	15	9	N.E
G 25713	Resistant *P. lunatus* accession	26	24	N.E

a N.E., no adult emergence from resistant seeds.

Table 6. Reconfirmation of resistance to *Acanthoscelides obtec*tus in pre-selected segregating F_5 hybrid progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.

Code and Generation	Type of Material	Number of Seeds Evaluated	Number of Resistant Seeds	Days to Adult Emergence
	Hybrids			
GKVGAG 1B 4D F_5	Double congruent hybrid with *P. acutifolius* cytoplasm	25	22	N.E[a]
GKVGAG 1E 2C F_5	Double congruent hybrid with *P. acutifolius* cytoplasm	59	58	N.E
	Checks			
G 12882 ARC1	Susceptible wild *P. vulgaris* accession	20	0	37.5
G 12952 ARC 4	Susceptible wild *P. vulgaris* accession	20	0	53.3
G 40168	Susceptible *P. acutifolius* accession	20	0	45.2
G 25410	Susceptible *P. lunatus* accession	19	0	43.7
RAZ 44	Susceptible *P. vulgaris* line	20	0	37.3
ICA Pijao	Susceptible *P. vulgaris* cultivar	20	0	30.5
G 40199	Resistant *P. acutifolius* accession	19	19	N.E
G 25042	Resistant *P. lunatus* accession	20	20	N.E

a N.E., no adult emergence from resistant seeds.

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Pod weevil (*Apion godmani*)

Rationale: The pod weevil is one of the most important pests of beans in Mexico and Central America. As indicated in previous reports, we are attempting to develop a molecular marker for *Apion* resistance. This work has been conducted in close collaboration with Dr. Ramón Garza from INIFAP. In order to support the molecular work, new phenological data were obtained by testing for resistance in the field a set of 54 recombinant inbred lines (RILs) developed in 2002. The lines are derived from a cross between Jamapa (a susceptible cultivar) and J-117 (a highly resistant Mexican landrace). The materials were tested at two locations (Santa Lucía de Prías in Mexico State and Atotonilco in Hidalgo State) in replicated nurseries using three replications per material in a randomized complete block design. The infestation in Santa Lucía was low and unreliable for proper resistance evaluation. That in Atotonilco was high and reliable to discriminate between susceptible and resistance genotypes.

The population of RILs was normally distributed for *Apion* resistance **(Figure 1)**, suggesting that the inheritance of resistance to the pod weevil may be governed by more than a single major resistance gene. Even though overall levels of infestation in 2003 were higher than in 2002, there was a significant correlation (r = 0.423; $P < 0.01$) between damage scores obtained in 2002 and in 2003 **(Figure 2)**. The phenological data obtained in 2003 is being used in the development of a molecular marker for pod weevil resistance (for details see SB-2 Report).

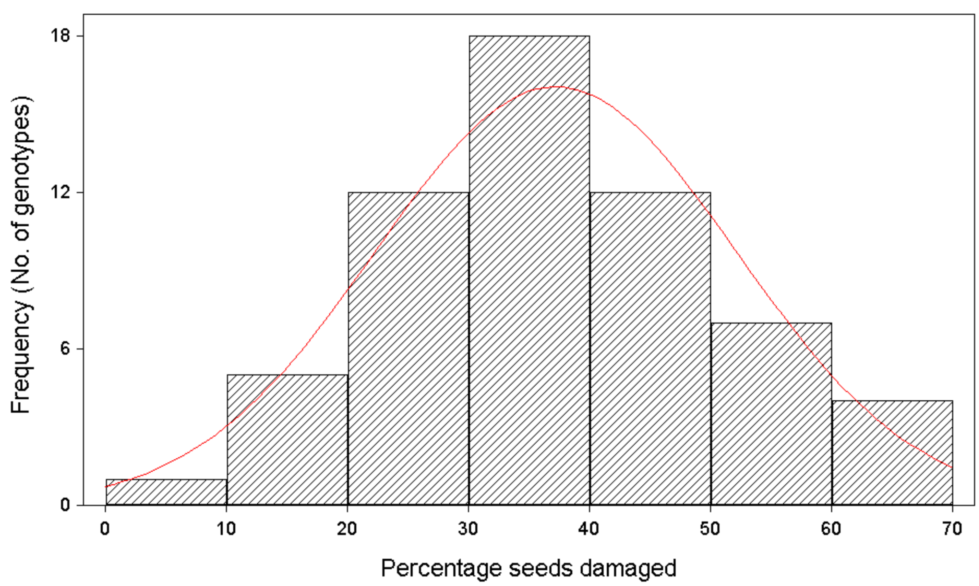

Figure 1. Frequency histogram of percentage seeds damaged by the pod weevil (*Apion godmani*) in a population of 54 recombinant inbred lines derived from a cross between Jamapa (a highly susceptible cultivar) and J-117 (a highly resistant Mexican landrace). The lines were screened under field conditions and high insect populations in a replicated nursery. Atotonilco, Hidalgo State, Mexico, 2003B.

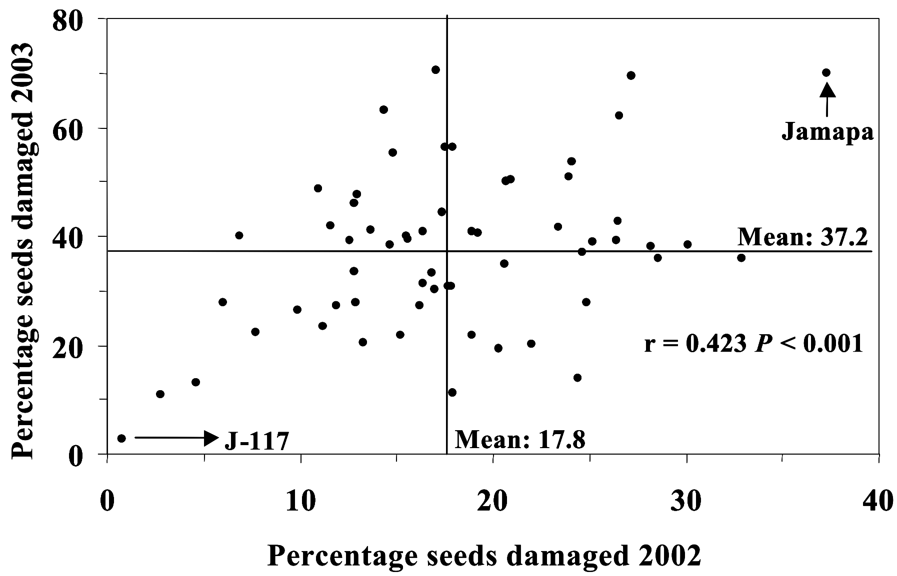

Figure 2. Percentage seed damage in 54 recombinant inbred lines (RILs) tested for resistance to the pod weevil (*Apion godmani*) in two consecutive trials. RILs derived from a cross between Jam apa (a susceptible cultivar) and the resistance source J-117 (a Mexican landrace). Tests conducted in Atotonilco, Estado de Hidalgo, Mexico.

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Leafhopper (*Empoasca kraemeri*)

In 2004 we screened a total of 549 bean germplasm accessions for resistance to the leafhopper. Those selected in 2003 (33) were reconfirmed in replicated nurseries. Of these, 21 were selected for further testing in 2004. We also gave support to the mainstream breeding activities of the Bean Project by screening a series of nurseries. These included 29 selections made in 2003 individual plant selections in Andean crosses performed with selected EMP lines as parents. Thirteen were yield-tested in 2004. Other yield tests included 13 lines derived from crosses with EMP 250 and lines from crosses with Saladin and 16 Andean lines.

We will highlight the work on evaluation of interspecific *P. vulgaris* x *P. acutifolius* hybrids. Similar to the work with bruchids these progenies were obtained by means of the Double Congruity Backcross technique developed at CIAT. We tested 189 progenies (F_2 and F_3) of crosses made with the tepary sources of resistance to leafhopper G 40019 and G 40036. Selected progenies and their reaction to leafhopper are shown in **Tables 7-9**. In general, the best lines show an intermediate level of resistance comparable to that found in the tolerant check, ICA Pijao. It can also be said that resistance to leafhopper in interspecific hybrids is not as good as the resistance found in *P. acutifolius* accessions G 40036, G40019, and G 40019.

Table 7. Resistance to *Empoasca kraemeri* in selected $F_{2\text{-}5}$ progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.

Code	Pedigree[a]	Damage Scores[b]	Reproductive Adaptation Scores[c]	Overall Rating
Hybrids				
KKQ-11 F_5	V-DCBC x V-DCBC	6.8	3.8	Intermediate
A99Y-15 F_4	V-DCBC x (G40199 X A-DCBC)	6.0	5.3	Resistant
A19Y-103 F_5	V-DCBC x (G40019 X A-DCBC)	6.3	4.0	Intermediate
A19Y-117 F_4	V-DCBC x (G40019 X A-DCBC)	6.4	4.8	Intermediate
A36Y-42 F_5	V-DCBC x (G40036 X A-DCBC)	6.1	4.3	Intermediate
A99Y-86 F_4	V-DCBC x (G40199 X A-DCBC)	6.4	4.8	Intermediate
A99Y-90 F_4	V-DCBC x (G40199 X A-DCBC)	5.9	5.0	Resistant
A99Y-91 F_4	V-DCBC x (G40199 X A-DCBC)	6.3	4.3	Intermediate
ANIY-101 F_4	V-DCBC x A-DCBC	6.9	4.0	Intermediate
A36Y-42 F_4	T-6FB x G36NGP-3FL	6.5	-	Intermediate
EMPZ-2 F_3	A99Y-90 x ZXTGS21-9	6.2	-	Intermediate
EMPZ-5 F_3	A36Y-42 x ZXTGS-21-11	6.7	-	Intermediate
EMPZ-8 F_3	A99Y-103 x ZXTGS49-8	7.0	-	Intermediate
EMPZ-9 F_3	A99Y-103 x ZXTGS49-8	7.0	-	Intermediate
TZTE - 9F F_2	TZT-12FL x EMPZ-3FB	7.0	-	Intermediate
TZTE – 11F_2	TZT-3FL x EMPZ-2FB	7.0	-	Intermediate
TZTE - 20B F_2	TZT-3FL x EMPZ-3FB	6.5	-	Intermediate
TZTE - 71B F_2	TZT-4FL x EMPZ-3FB	5.7	-	Intermediate
Checks				
BAT 41	Susceptible *P. vulgaris* line	8.8	3.5	Susceptible
EMP 250	Tolerant *P. vulgaris* line	6.4	6.0	Intermediate
EMP 508	Tolerant *P. vulgaris* line	6.2	6.3	Intermediate
EMP 512	Tolerant *P. vulgaris* line	6.0	5.8	Resistant
G40016	Susceptible *P. acutifolius* accession	8.6	3.0	Susceptible
G40019	Resistant *P. acutifolius* accession	5.6	5.5	Resistant
G40036	Resistant *P. acutifolius* accession	5.3	6.0	Resistant
G40056	Susceptible *P. acutifolius* accession	8.8	2.5	Susceptible
G40065	Susceptible *P. acutifolius* accession	8.1	4.8	Susceptible
G40119	Resistant *P. acutifolius* accession	5.1	6.0	Resistant
ICA Pijao	Tolerant *P. vulgaris* cultivar	7.3	6.0	Intermediate
NI576	Susceptible *P. acutifolius* line	8.8	2.0	Susceptible

[a] V-DCBC = Double congruent hybrid with *P. vulgaris* cytoplasm; A-DCBC = Double congruent hybrid with *P. acutifolius* cytoplasm.

[b] On a 1-9 visual scale (1, no damage; 9, severe damage).

[c] On a 1-9 visual scale (1, no yield, no pod formation; 9, excellent pod formation and filling, excellent yield).

Table 8. Resistance to *Empoasca kraemeri* in selected $F_{3\text{-}6}$ progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.

Code	Pedigree[a]	Damage Scores[b]	Reproductive Adaptation Scores[c]	Overall Rating
Hybrids				
A99Y-15 F_5	V-DCBC x (G40199 X A-DCBC)	6.8	4.5	Intermediate
A19Y-103 F_6	V-DCBC x (G40019 X A-DCBC)	6.8	4.0	Intermediate
A19Y-117 F_5	V-DCBC x (G40019 X A-DCBC)	7.2	4.0	Intermediate
A99Y-86 F_5	V-DCBC x (G40199 X A-DCBC)	6.8	4.5	Intermediate
A99Y-90 F_5	V-DCBC x (G40199 X A-DCBC)	6.6	4.5	Intermediate
A99Y-91 F_5	V-DCBC x (G40199 X A-DCBC)	6.8	4.3	Intermediate
ANIY-101 F_5	V-DCBC x A-DCBC	7.2	3.5	Intermediate
A36Y-42 F_5	T-6FB x G36NGP-3FL	7.0	4.5	Intermediate
EMPZ-8 F_4	A99Y-103 x ZXTGS49-8	7.2	3.5	Intermediate
EMPZ-9 F_4	A99Y-103 x ZXTGS49-8	7.0	3.8	Intermediate
TZTE - 20B F_3	TZT-3FL x EMPZ-3FB	7.4	3.8	Intermediate
EMPZ-2 F_4	A99Y-90 x ZXTGS21-9	6.4	5.0	Resistant
EMPZ-5 F_4	A36Y-42 x ZXTGS-21-11	6.8	4.5	Intermediate
TZTE - 71B F_3	TZT-4FL x EMPZ-3FB	6.5	4.0	Intermediate
Checks				
G40019	Resistant *P. acutifolius* accession	5.6	5.5	Resistant
G40036	Resistant *P. acutifolius* accession	5.6	5.8	Resistant
NI576	Susceptible *P. acutifolius* line	7.8	2.8	Susceptible
G40033	Susceptible *P. acutifolius* accession	8.8	2.3	Susceptible
G40119	Resistant *P. acutifolius* accession	5.7	5.0	Resistant
EMP 512	Tolerant *P. vulgaris* line	6.1	5.3	Resistant
EMP 508	Tolerant *P. vulgaris* line	6.5	4.3	Intermediate
EMP 250	Tolerant *P. vulgaris* line	6.8	4.3	Intermediate
BAT 41	Susceptible *P. vulgaris* line	9.0	2.0	Susceptible
ICA Pijao	Tolerant *P. vulgaris* cultivar	6.8	4.3	Intermediate

[a] V-DCBC = Double congruent hybrid with *P. vulgaris* cytoplasm; A-DCBC = Double congruent hybrid with *P. acutifolius* cytoplasm.
[b] On a 1-9 visual scale (1, no damage; 9, severe damage).
[c] On a 1-9 visual scale (1, no yield, no pod formation; 9, excellent pod formation and filling, excellent yield).

Table 9. **Resistance to *Empoasca kraemeri* in selected F_{3-6} progenies derived from interspecific *Phaseolus vulgaris* x *P. acutifolius* crosses.**

Code[a]	Pedigree	Damage Scores[b]	Reproductive Adaptation Scores[c]	Overall Rating
		Hybrids		
TSC	TZTA-1A2L FB x Row 3 FB (A36Y 42)	6.3	4.0	Intermediate
TSC	TZTA-1A2L FB x Row 3 FB (A36Y 42)	6.0	4.3	Intermediate
TSC	TZTA-1A2N FB x Row 3 FB (A36Y 42)	6.3	4.3	Intermediate
TSC	TZTA-1A2N FB x Row 3 FB (A36Y 42)	6.3	4.3	Intermediate
TSC	TZTA-1A2N FB x Row 3 FB (A36Y 42)	6.3	4.3	Intermediate
TSC	TZTA-1A2N FB x Row 3 FB (A36Y 42)	6.3	4.3	Intermediate
TSC	TZTA-1A2L FB x Row 3 FB (A36Y 42)	6.3	4.3	Intermediate
TSC	TZTTZ-85R FB x Row 10 FB (EMPZ2)	6.3	4.3	Intermediate
TSC	TZTTZ78M FB x Row 30 FB (TZTE-71)	6.3	4.3	Intermediate
ZXTGS	ZXTG6FB x Row 49 Entry 70FL	6.3	4.3	Intermediate
ZXTGS	ZXTG6FB x Row 49 Entry 70FL	6.3	4.3	Intermediate
ZXTGS	ZXTG6FB x Row 21 FLG36NGP-3F_2	5.7	4.3	Resistant
SCO	ZXTG6FB x Row 49 Entry 70FL	6.3	4.7	Intermediate
SCO	ZXTG6FB x Row 21 FLG36NGP-3F_2	5.7	4.7	Resistant
TSC	TZTA-1A2L FB	6.3	5.5	Resistant
TSC	TZTTZ-98B FL	6.0	5.0	Resistant
		Checks		
G40019	Resistant *P. acutifolius* accession	4.5	6.0	Resistant
G40036	Resistant *P. acutifolius* accession	4.3	6.1	Resistant
NI576	Susceptible *P. acutifolius* line	8.0	2.8	Susceptible
G40033	Susceptible *P. acutifolius* accession	8.8	2.3	Susceptible
G40119	Resistant *P. acutifolius* accession	4.6	5.6	Resistant
EMP 512	Tolerant *P. vulgaris* line	5.9	6.0	Resistant
EMP 508	Tolerant *P. vulgaris* line	6.5	4.3	Intermediate
EMP 250	Tolerant *P. vulgaris* line	6.2	6.0	Intermediate
BAT 41	Susceptible *P. vulgaris* line	8.3	2.6	Susceptible
ICA Pijao	Tolerant *P. vulgaris* cultivar	6.7	5.3	Intermediate

[a] TSC = Double congruent hybrid with *P. vulgaris* cytoplasm; A-DCBC = Double congruent hybrid with *P. acutifolius* cytoplasm; both ZXTGS and SCO possess *P. acutifolius* cytoplasm.

[b] On a 1-9 visual scale (1, no damage; 9, severe damage).

[c] On a 1-9 visual scale (1, no yield, no pod formation; 9, excellent pod formation and filling, excellent yield).

Contributors: J. M. Bueno, C. Cardona. A. Mejía, J. Tohme.

Developing germplasm resistant to insects

For details of breeding activities, please refer to section 2.2.1. As in 2003, studies were aimed at developing Andean type bean with improved tolerance to the leafhopper, *Empoasca kraemeri.* We will highlight results of the work trying to develop Andean type beans (crosses with PVA 773 and CAL 143) with improved tolerance to the leafhopper, *Empoasca kraemeri.* Lines selected for lower damage scores and higher reproductive adaptation scores in previous years performed relatively well under moderate levels of leafhopper infestation (4.3 nymphs per leaf, seasonal average) **(Figure 3)**. Given that susceptibility to leafhopper is usually very high in large-seeded Andean beans, these results indicate that substantial progress has been made in incorporating resistance to leafhopper in these types of beans. Another set of lines derived from crosses between Saladin and selected EMP lines did not perform so well **(Figure 4)**, possibly due to the inherent susceptibility of Pompadour-type beans. Nevertheless, eight lines that showed moderate tolerance were selected for further testing

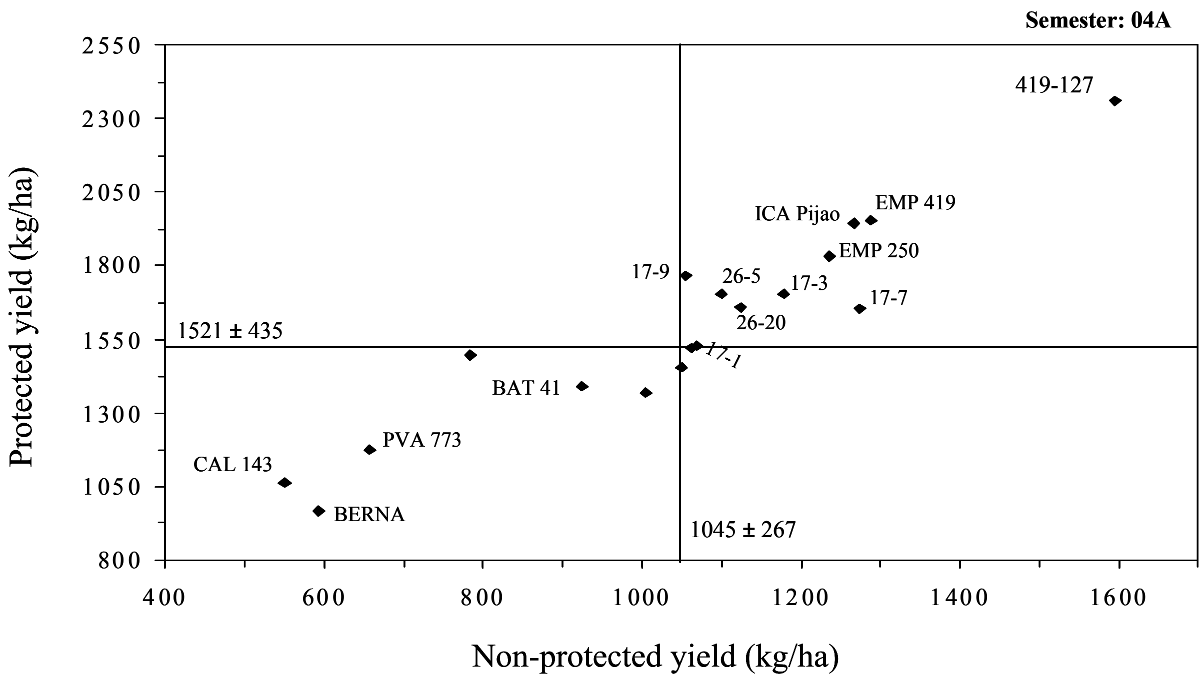

Figure 3. The relationship between protected and non-protected yield in selected Andean bean lines bred for tolerance to *Empoasca kraemeri*. PVA 773 and CAL 143 are susceptible parents. EMP 250 is the tolerant parent. BAT 41 and Pijao are susceptible and tolerant checks, respectively.

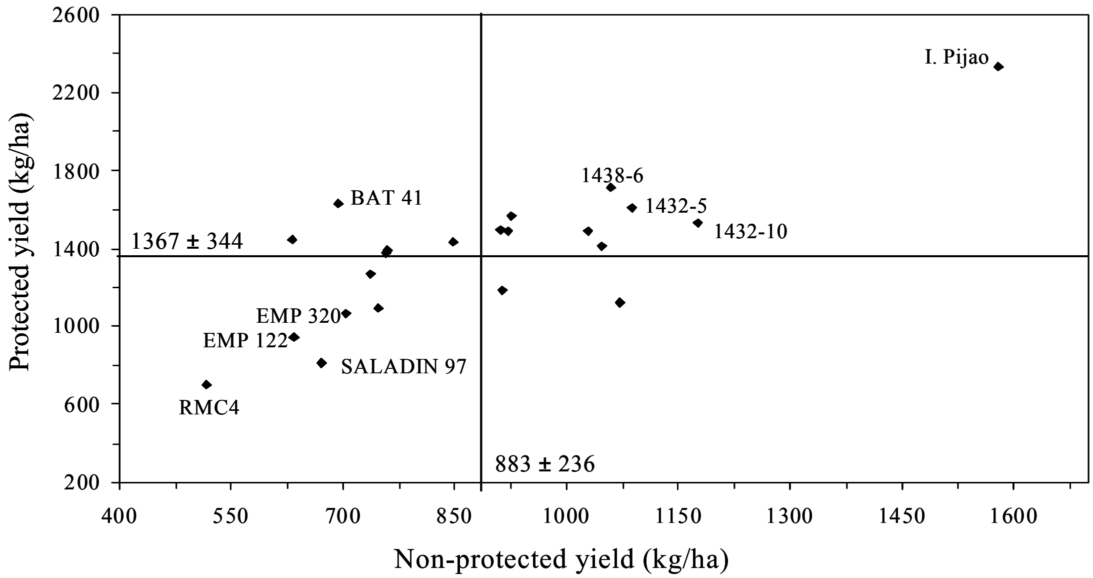

Figure 4. The relationship between protected and non-protected yield in selected Andean bean lines for tolerance to *Empoasca kraemeri*. Saladin 97 is a commercial variety in Dominican Republic.

Contributors: J. M. Bueno, C. Cardona, M. Blair.

Tolerance to leafhopper studies

In 2004 we finished our studies on progress in incorporating tolerance to leafhopper. We performed the combined analysis of variance for the five consecutive trials aimed at measuring the response of EMP lines (bred for leafhopper resistance) and checks to two levels of infestation (3 and 6 nymphs per leaf). These were obtained by exercising chemical control at pre-established action levels. There was not a significant interaction between trials and treatments. At all levels of infestation, EMP 250, EMP 542, EMP 544, and EMP 588 yielded significantly better than the susceptible check BAT 41 and EMP 124. None performed better than ICA Pijao, the tolerant check **(Figure 5).** However, in terms of percentage yield losses, new lines (the EMP 500 series) performed better at all levels of infestation than the improved checks EMP 124 and EMP 250, and, in some cases, better than the standard tolerant check, ICA Pijao. At very high levels of infestation (6 nymphs per leaf) average yield losses in EMP lines was above the 30% level, meaning that even tolerant materials would benefit from integration with chemical control exercised at pre-established action levels.

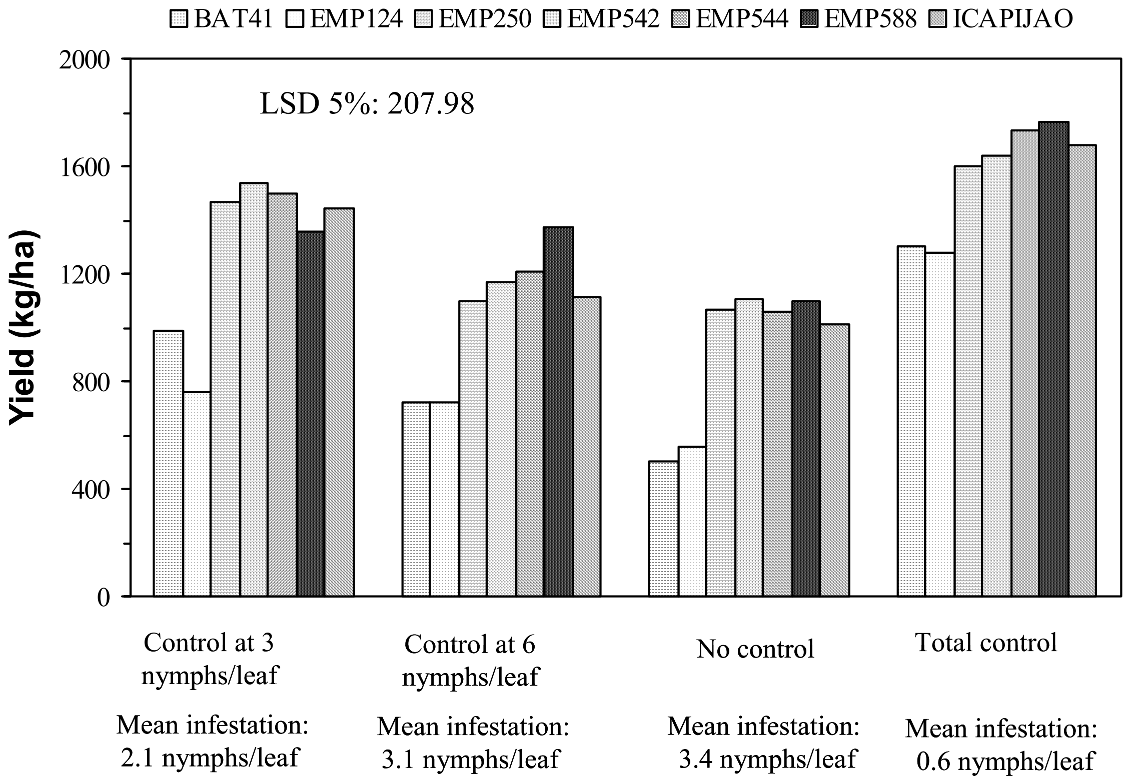

Figure 5. Yields of selected EMP lines and checks (BAT 41, ICA Pijao) at different levels of infestation with the leafhopper *Empoasca kraemeri*. Means of five trials.

Contributors: J.M. Bueno, C. Cardona.

Progress toward achieving output milestones

- Identification of sources of resistance, understanding of mechanisms of resistance to insects, and development of insect resistant bean lines contribute to the mainstream breeding objectives of the Bean Project.
- Insect resistant beans may be basic components for management of insect pests in beans.
- The development of molecular markers for pod weevil, thrips, and bruchids should facilitate breeding for resistance.

Activity 2. Publications, book chapters, workshops, conferences and training.

Journals

Frei, A., H. Gu, J. M. Bueno, C. Cardona, S. Dorn. 2003. Antixenosis and antibiosis of common beans to *Thrips palmi* Karny (Thysanoptera: Thripidae). J. Econ. Entomol. 96: 1577-1584.

Manzano, M. R., J. van Lenteren, C. Cardona. 2003. Comportamiento de búsqueda de *Amitus fuscipennis* (Hymenoptera: Platygasteridae): Tiempo de permanencia en la planta hospedera y actividad de búsqueda. Rev. Colombiana Entomol. 29(2): 221-226.

Frei, A., J. M. Bueno, J. Díaz-Montaño, H. Gu, C. Cardona, S. Dorn. 2004. Tolerance as a mechanism of resistance to *Thrips palmi* in beans. Entomol. Experim. et Appl. 112: 73-80.

Murray, J. D., T. E. Michaels, K. P. Pauls, C. Cardona, A. W. Schaafsma. 2004. Yield and insect injury in leafhopper (*Empoasca fabae* Harris and *Empoasca kraemeri* Ross & Moore) infested dry beans in Ontario and Colombia. Canadian J. of Plant Science 84: 891-900.

Rodríguez, I., H. Morales, J. M. Bueno, C. Cardona. 2004. El biotipo B de *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) adquiere mayor importancia en el Valle del Cauca. Rev. Colombiana de Entomología Vol 30 (In press, accepted for publication March 10, 2004)

Accepted for Publication

Frei, A., M. W. Blair, C. Cardona, S. E. Beebe, H. Gu, S. Dorn. 2004. QTL mapping of resistance to *Thrips palmi* in common beans. Crop Science.

Book Chapter

Cardona, C. 2004. Common beans – Latin America. *In*: Hodges R.J. and G. Farrell, (eds). Crop Post-harvest: Science and Technology Volume 2: Durables. Blackwell Science Ltd. London. ISBN 0632057238.

Workshops and Conferences

Cardona, C. 2004. Tendencias actuales y futuras en el manejo de insectos plaga de importancia agrícola. pp. 38-44 *In*: Memorias I Seminario Internacional y II Nacional de Control Biológico de Plagas y Enfermedades de los Cultivos. Abril, 2004. Escuela Politécnica del Ejército, Quito, Ecuador.

Bueno, J. M., C. Cardona, P. Chacón. 2004. Fenología, desarrollo de métodos de muestreo y distribución espacial de Trialeurodes vaporariorum (Homoptera: Aleyrodidae) en habichuela y fríjol. p. 29 *In*: Resúmenes XXXI Congreso Sociedad Colombiana de Entomología, Bogotá, Julio 28-30, 2004.

Students

Name	Degree	Status	University	Title
Frei, Andrea	Ph. D.	Completed	ETH (Switzerland)	Resistance to Thrips palmi in beans
Bueno, Juan Miguel	M. Sc.	Completed	U. del Valle	Sampling methods for whiteflies on beans and snap beans
Prieto, Sergio	B. Sc.	Completed	U. Nacional, Palmira	Molecular markers for arcelin
Montenegro, María Fernanda	B. Sc.	Completed	U. Nacional, Palmira	Effect of insecticides on natural enemies of whiteflies
Valencia, Sandra Jimena	B. Sc.	Continuing	U. Nacional, Palmira	Sub-lethal effects of antibiosis on the demography of *Zabrotes subfasciatus* and *Acanthoscelides obtectus*, storage pests of beans

Trips

Date	Destination	Event or purpose
November, 2003	Texcoco, Mexico	Evaluate Apion nurseries
March, 2004	Chota, Ecuador	Visit whitefly management trials
May, 2004	Beijing, China	Attend International Plant Protection Congress

Special Projects

Title	Donor	Funding period	Total amount
Integrated management of whiteflies in the tropics	DFID	2001 - 2004	US$ 65,000
Biotechnological tools to improve beans	ABOS	2001 – 2004	US$ 15,000
Post-harvest losses in beans	ZIL	2002 – 2004	US$ 36,000

Courses and Workshops

Date	Title	Duration (days)	Total No. Participants	No. of Women Participants	No. of CIAT Instructors
10/17/03	The B biotype in the Cauca Valley	1	25	3	3
12/16/03	The B biotype in the Cauca Valley	1	25	?	3
01/29/04	The B biotype in the Cauca Valley	1	110	?	1
04/10/04	The B biotype in the Cauca Valley	1	35?	?	1
05/05/04	Whiteflies and their control (field day)	1	76	15?	3
06/04/04	Pests of beans and their control	1	60	?	1
07/27/04	Sampling methods for whiteflies	3	275	?	2
08/05/04	The B biotype B in the Cauca Valley	1	197	?	1