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Scope and limitations of host plant resistance in pulses for the control of *Helicoverpa* (= *Heliothis*)

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Two important pulse crops, pigeonpea (*Cajanus cajan* Millsp.) and chickpea (*Cicer arietinum* L.) suffer major losses from pod borer (*Helicoverpa armigera* Hüb.) attack at most places and in most years in India. According to Reed (1983), in India alone *H. armigera* causes yield losses to a value of US $ 300 million in chickpea and pigeonpea each year. But these are generally grown without pesticide protection because of the high cost of sprayers and of insecticides, and difficulties in obtaining them, and problems in obtaining and conveying water to the field. Lack of skill in their effective use is another important reason why most farmers do not use insecticides. Other factors such as toxicity, environmental pollution, the extermination of natural enemies and eventually, build-up of insecticide resistance in the pests make chemical control a risky and unsatisfactory pest management strategy. In the future, host plant resistance should be utilized where ever possible as an important component of Integrated Pest Management.

In this paper the scope and limitations of utilizing *Helicoverpa* resistance in pigeonpea and chickpea to increase and stabilize the yields of the two pulse crops are discussed.

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Pigeonpea

In India, there are scattered reports that refer to crop loss assessments on pigeonpea in different areas (Lateef and Reed 1984). These reports emphasize that there is a wide range of losses due to a number of pests on pigeonpea, and that the losses vary according to location, year and cultivar tested. Table 1 summarizes the pod damage data from a series of surveys of farmers' fields in India during 1976-81. It can be seen that pod borer (mainly H. armigera) damage was most important in southern and central India, but that the podfly was the most damaging pest in the North.

In earlier studies it was found that the relative pest status of the lepidopteran and other pod borers was considerably affected by number of days to flowering. Damage caused by the lepidopteran borers to pods of short and medium-maturing cultivars was high, 42-93% in 1982/83 and reached a 100% damage in some years (Reed and Lateef 1990).

In spite of such large reductions in grain yield, very few farmers (<5%) have used insecticides to protect their pigeonpea crop. It therefore follows that the development of less susceptible cultivars would be of great benefit to resource poor farmers.

Since 1976, we have been screening the world collection of pigeonpea germplasm held in the gene bank at ICRISAT Center, for resistance to H. armigera and M. obtusa. To date, more than 10,000 germplasm accessions and breeding lines have been screened for resistance to H. armigera in pesticide-free open-field plots

Lines selected as resistant have been tested for 6-11 years (Table 2). Pigeonpea lines were identified not only for their resistance to pest attack and damage, but also for their ability to yield well and to compensate for early losses. The results of research undertaken during 1985-88 at ICRISAT Center are given in Table 3. The borer-resistant selections and bred lines showed reduced susceptibility to pod borer attack during these years and yielded 20-32% more than the commonly grown control cultivars BDN-1 and C-11.

These selected resistant lines have been tested for several years in different agroecological zones of India by the AICPIP - entomologists. The data from these multilocation trials indicate that the borer's incidence varied considerably between locations. However, data presently available show that the selection ICP 10531 has shown resistance to the pod borer in the South zone (SZ), the Central zone (CZ), the North-west plain zone (NWPZ) and the North-east plain zone (NEPZ). Selections, PPE 45-2, ICPL 6, ICPL 87088, and ICPL 87089 were found to be consistently resistant in the SZ, CZ and NWPZ, whilst ICP 7946 showed resistance in the SZ, CZ and NEPZ. Other selections, such as ICPL 1, 2, 187-1, 84060, 332, MA-2, ICP 7349-1-84, 3009, 3328, 4070, 1691, 4167, 2223, 6982-6, 3615, PPE 50, APAU 2208 and APAU 2725 have shown less susceptibility than commonly grown cultivars in two of the zones. Some of these selections have also yielded more than the control cultivars. Making these resistant cultivars available to farmers in each area would constitute a significant step towards implementing successful pest management.

One of the borer-resistant selections (ICPL 332) was recently released for cultivation in Andhra Pradesh, India. The selections PPE 45-2 (ICP 11964) and MA 2 have been identified as donor parents for the borer resistance breeding program by the AICPIP. Pigeonpea breeders are now incorporating disease resistances and high yielding into the pest resistant lines.

Chickpea

H. armigera is an important field pest of chickpea (Lateef 1985, and Reed et al. 1987) in South Asia. Surveys conducted by ICRISAT entomologists in India during 1977-82 have shown pod damage ranging from 0 to 84.4% with an overall average of <7% in different states, and under different farming systems. The avoidable loss, expressed as a percentage of the yield of the protected crop, was calculated to be from 9 to 60% (Sithanantham et al. 1984).

The significance of these losses led to the initiation of an intensive pest resistance screening program in 1976 at ICRISAT Center (Lateef 1985). Several lines were shown to have good levels of resistance/tolerance to H. armigera (Table 4), and were incorporated in breeding programs to enhance the level of borer resistance and high yielding capacity in the progenies (Table 5). Since 1980, the resistant/tolerant selections and bred lines have been assessed for their performance along with the borer-tolerant selections identified by AICPIP - entomologists in different agroecological zones in India. The data from this multilocation testing indicate that the borer incidence varied greatly between locations and seasons. In some locations the borer's incidence was too low to permit identification of resistant lines. However, selections ICC 506, ICCX 730008 (ICCV 7), ICC 6663, ICC 10817, ICCX 730020-11-2, ICCL 86102, ICCL 86103, PDE 2 and PDE 5 in the desi short duration and ICC 4935 - E 2793 and ICCX 730041 in the desi medium duration group were consistently found resistant to Helicoverpa across agroecological zones, and most of them significantly outyielded the control cultivars, (Lateef and Sachan 1990). Two of these selections, ICCX 730008 (ICCV 7) and PDE 2, were identified as donor parents for the Helicoverpa resistance breeding program in India by the AICPIP in 1986 (Sachan 1990).

Most of the borer-resistant selections are susceptible to such important diseases, as Fusarium wilt and Ascochyta blight. Work is now in progress at ICRISAT Center to incorporate resistances to these diseases into the borer-resistant cultivars. Germplasm enhancement work has also been undertaken to increase the level of borer resistance and the yield potential in the progenies.

Limitations:

Although, several good sources of resistance to H. armigera have been found in pigeonpea and chickpea, and many high yielding lines with borer resistance have been developed through the pest resistance breeding program, most of them are susceptible to diseases. In view of the increase in disease incidence in the pulse growing areas it is essential to incorporate multiple disease resistance into the high yielding, borer-resistant materials to help stabilize yields of the pulses when grown in farmers' fields on a large scale.

The borer-resistant selections are generally small-seeded types, but farmers and millers prefer varieties with larger seed size. Consumer acceptability must also be taken care of while selecting the material.

In some zones certain maturity duration lines are preferred, depending on the climatic conditions and farmers' practices. It is therefore essential to have sources of stable resistance available in all the maturity groups. Intensive and systematic pest resistance screening and breeding programs should be undertaken in the different agroecological zones.

For increasing pulse production, high yielding, *Helicoverpa*-resistant lines adapted to particular environments should be released for cultivation without pesticide application.

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Table 1. Insect pests damage to pigeonpea pods in various zones in India recorded during sample surveys from 1975 to 1981. (Source: Lateef and Reed, 1984)

Zones		Percent pod damage		
		Borer	Podfly	Total
I	North-West Zone Punjab, Haryana, Delhi (short-duration pigeonpea) (n = 49)	29.7	14.5	44.0
II	North Zone Above 23°N (long duration pigeonpea) (n = 359)	13.2	20.8	33.8
III	Central Zone 20° - 23°N (medium and long duration pigeonpea) (n = 446)	24.3	22.3	48.0
IV	South Zone Below 20°N (short and medium-duration pigeonpa) (n = 443)	36.4	11.1	49.9

n = no of samples analysed for pest damage

Table 2. Pigeonpea genotypes identified as resistant to *Helicoverpa armigera* under insecticide-free conditions at two locations, 1979-90. (Source: Lateef and Pimbert 1990)

Pigeonpea genotypes	Mean resistance rating[1]	Borer damage (%) range during 1979-90
Short-duration (Hisar)		
ICPL 1	3.7 (7)[2]	5 - 32
ICPL 2	3.9 (8)	6 - 45
ICPL 269	4.7 (6)	11 - 29
ICPL 187-1	3.7 (7)	8 - 29
Control		
Pant A1	6.0 (9)	14 - 58
Medium and medium-long duration (ICRISAT)		
ICP 909-E3	4.5 (11)	6 - 50
PPE 45-2	4.4 (11)	4 - 37
ICP 1811-E3	4.1 (11)	9 - 50
ICP 1903-E1	3.8 (11)	13 - 67
ICP 10466-E3	3.7 (11)	3 - 67
Controls		
ICP 1691 (susceptible)	7.5 (11)	11 - 100
BDN-1	6.0 (11)	16 - 90
C-11	6.0 (11)	18 - 76
ICP 3615	3.6 (11)	14 - 50
ICP 5036	3.5 (11)	7 - 61
PPE 37-3	4.4 (9)	10 - 29
ICP 8094-2-S2	3.5 (11)	7 - 30
ICP 8102-5-S1	4.7 (11)	11 - 49

1. Rated on a 1-9 scale, where 1 = resistant and 9 = susceptible.
2. Figures in parentheses indicate number of years tested.

Table 8. Percentage pod damage by *H. armigera* and grain yield of four pest resistant genotypes and two controls under insecticide-free conditions at ICRISAT Center, Patancheru, A.P., India, 1985-1988.

Pigeonpea genotype	(%) pod damage by *H. armigera*					Yield (kg ha^{-1})					Percent of control yield
	1985	1986	1987	1988	Mean	1985	1986	1987	1988	Mean	
ICPL 84060	8.1	10.3	39.1	23.1	20.3(4)	1400	1560	710	1445	1279	124
ICPL 87088	-	12.7	42.0	13.4	22.7(3)	—	1535	590	1594	1240	120
ICPL 87089	-	14.6	44.0	13.4	24.0(3)	—	1527	860	1498	1312	127
ICPL 332	11.6	22.5	47.1	18.9	25.0(4)	1842	1434	700	1479	1364	132
Controls											
BDN 1	33.4	71.4	79.2	48.1	58.0(4)	1442	1220	120	1340	1030	
C 11	21.4	38.3	86.4	31.1	44.2(4)	1323	1049	110	1679	1040	

NOTE: Figures in parentheses indicate number of years tested

Table 4. Chickpea genotypes identified as resistant to *Helicoverpa armigera* at ICRISAT Center, India. (Source: Lateef and Sachan 1990)

Chickpea genotypes	Mean resistance rating[1]	Borer damage (%) range during 1979-89
Desi short-duration		
ICC 506	3.0 (9)[2]	1.1 - 12.8
ICC 10667	3.1 (9)	1.7 - 14.2
ICC 10619	3.4 (9)	2.7 - 21.0
ICC 6663	3.5(10)	1.1 - 31.8
ICC 10817	3.6 (10)	2.4 - 30.0
ICCV 7 (ICCX 730008-8)	3.8(8)	3.8 - 11.8
Control		
Annigeri	6.0(10)	13.2 - 36.3
Desi medium-duration		
ICC 4935-E2793	2.8(10)	2.3 - 11.9
ICCX 730041-8-1-B-BP-EB	3.8(10)	1.7 - 38.2
ICCX 730094-18-2-1P-BP-EB	4.6(10)	3.8 - 20.0
Control		
K 850	6.0(10)	11.4 - 40.9
Desi/kabuli long-duration		
ICCX 730020-11-1	4.3(10)	2.8 - 26.9
Control		
H 208	6.0(10)	3.8 - 44.3
ICC 10870	4.3(9)	4.4 - 39.3
ICC 5264-E10	3.8(10)	2.5 - 28.3
Control		
L 550	6.0(10)	2.8 - 39.4

1. Rated on a 1-9 scale, where 1 = resistant and 9 = susceptible.
2. Figures in parenthesis indicate number of years tested.

Table 5. **Relative Resistance Ratings (RR) and yields (t ha^{-1}) of chickpea lines bred for Helicoverpa resistance under unprotected conditions at ICRISAT Center, during 1985-1989 (Lateef and Sachan 1990).**

Chickpea lines	1985-86 RR	1985-86 Yield	1986-87 RR	1986-87 Yield	1987-88 RR	1987-88 Yield	1988-89 RR	1988-89 Yield[1]	Mean RR	Mean Yield	Percentage of control yield
ICCL 86101	2	0.97	5	1.18	3	1.26	5	1.04	3.3	1.11	103
ICCL 86102	3	1.16	3	1.26	3	1.12	4	1.02	3.3	1.14	106
ICCL 86103	-	NT	3	1.19	3	1.53	2	0.90	2.7	1.21	112
ICCL 86104	-	NT	4	1.37	4	1.39	8	0.89	5.3	1.22	113
ICCV 7	3	0.81	5	1.19	3	1.28	3	1.01	3.5	1.07	99
Control Annigeri	6	0.86	6	1.16	6	1.19	6	1.12	6.0	1.08	
SE		±0.096 (n=36)		±0.125 (n=20)		±0.113 (n=20)		-			
BD% range in Control										8-19	
ICCL 86105	-	NT	3	2.03	7	1.16	9	0.90	6.3	1.36	108
Control K 850	-	NT	6	1.35	6	1.29	6	1.13	6.0	1.26	
SE				±0.112 (n=24)		±0.113 (n=20)		-			
BD% range in Control										10-36	
ICCL 86106		NT	5	0.95	3	0.84	8	0.95	5.3	0.91	100
Control H 208		NT	6	0.76	6	0.92	6	1.05	6.0	0.91	
SE				±0.120 (n=16)		±0.103 (n=14)		-			
BD% range in Control										4-28	

BD % = Borer damage to pods in percentage; 1 = Yields of large unreplicated plots.