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Antibiosis mechanism of resistance to *Helicoverpa armigera* (Hub.) in chickpea (*Cicer arietinum* Linn.)

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ABSTRACT

To study the antibiosis component of resistance, neonate *H. armigera* were fed on 18 test genotypes of chickpea. Chickpea leaves, pods, artificial diet of *H. armigera* impregnated with freeze dried powder of leaves and pods of chickpea was used to conduct the study. Differences in duration of larval and pupal development of insects reared on leaves, pods and lyophilized leaf and pod powder of different genotypes were significant. Reduced larval and pupal weights and prolonged larval and pupal periods (ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 14876, ICC 12490, ICC 12491 and ICC 12495) compared to susceptible genotypes (ICC 12426, ICC 3137, ICC 4973 and ICC 4962) indicated that antibiosis is one of the component of resistance to *H. armigera* in chickpea. These results suggested that a growth inhibitor or antifeedent substance or both existed in the resistant genotypes.

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INTRODUCTION

Plant resistance to pests is an economically and ecologically preferred alternative to other pest management strategies, particularly synthetic pesticides. During the course of evolution, plants acquire several defense mechanisms against insect pests to reduce the damage. The major mechanisms are antixenosis (non-preference), antibiosis, tolerance and escape potential (Painter, 1951). To date more antibiosis, than antixenosis or tolerance has been reported in legume crops (Clement *et al.*, 1994). Tripathi and Sharma (1985) studied different food plants to *H. armigera* and found that chickpea was the most preferred food plant. High

concentration of malic acid and oxalic acid in chickpea are playing role in host plant resistance (Rembold, 1981; Rembold and Winter, 1982; Srivastava and Srivastava, 1989; Rembold *et al*., 1989 and 1990; Rembold and Weigner, 1990 and Yoshida, 1997).

Yoshida *et al*. (1995) are considered to be one of the mechanisms of *H. armigera* resistance in chickpea. The present study is conducted for the identification of genotypes with different level of resistance to *H. Armigera* for the developmentof resistant varieties. Development of improved cultivars with resistance to *H. armigera* is a cost effective and environmentally benign technology to reduce yield losses (Dua *et al*., 2002). Chickpea varieties differ in their susceptibility to *H. armigera* due to differences in antibiosis mechanism (Singh and Sharma, 1970). Work on antibiosis to *H. armigera* in chickpea has been reported by Dubey *et al*. (1981); Jayaraj (1982); Srivastava and Srivastava (1989 and 1990); Cowgill and Lateef (1996); Sison *et al*.(1996); Yoshida *et al*. (1995) and Yoshida (1997). The present investigation is a further contribution on antibiosis to pod borer in chickpea with selected genotypes.

MATERIAL AND METHODS

Insect culture:

Larvae and adults of *H. armigera* used in feeding tests in the laboratory were obtained from a laboratory culture maintained at ICRISAT, Patancheru, India. The culture was established from, and regularly supplemented with field-collected larvae. Larvae were reared on a chickpea based diet (Armes *et al*., 1993) at 27°C. Adults were kept at 25°C in a cage and mappyliners were provided as a substrate for oviposition. The moths were provided 10 per cent honey solution on absorbent cotton for oviposition.

Survival and development *of H. armigera* on chickpea leaves:

Neonate *H. armigera* were fed on chickpea leaves of 18 test genotypes (ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 4918, ICC 12426, ICC 3137, ICC 12491, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962). The genotypes were selected based on earlier performance. Larvae were held individually in plastic jars (11 cm diameter and 13 cm height) at 25°C and fed on fresh leaves. Larval weights were recorded on 10th and 20th day of release. Data were also recorded on larval duration, number of larvae pupated, pupal weight, pupal period, adult emergence and fecundity. The food was changed everyday. The experiment was conducted in a Completely Randomized Design with 18 genotypes as treatments. There were five replications and each replication had 10 larvae maintained individually.

Survival and development of *H. armigera* on pods:

Neonate larvae were fed with tender chickpea leaves and flowers for seven days and later on with tender pods of 18 test genotypes as described above. There were five replications in CRD and each replication had 10 individual larvae under observation. Observations were recorded as described above.

Artificial diet for *H. armigera:*

To raise the *H armigera* culture in the laboratory; 75 g of chickpea flour, 12 g yeast, 1.175 g L-ascorbic acid, 1.25 g methyl –4-hydroxylbenzoate, 0.75 g sorbic acid and 2.875 g aureomycin were weighed in a electronic balance and were taken in a hand held mixer. 1 ml of formaldehyde, 2.5 ml of vitamin stock solution and 112.5 ml of water were added to it and mixed thoroughly. Meanwhile, 4.375 g of agar-agar was boiled with 200 ml of water and added to the diet and mixed thoroughly to get even consistency. The diet was then poured into small plastic cups and allowed to cool in a laminar flow cabinet.

Impregnation of *H. armigera* artificial diet with lyophilized leaves and pods:

To study the antibiosis component of resistance, freeze dried powder of leaves and pods of chickpea was impregnated in the artificial diet of *H. armigera*. Chickpea branches with tender, green leaves and tender green pods with developing seeds were collected from pesticide-free plots. The leaves and pods were frozen at –20°C and lyophilized. The dried leaves and pods were powdered in a blender to get fine powder (<80µm).

To know the amount of lyophilized leaf or pod powder to be used in antibiosis studies, involving artificial diet different concentrations of resistant (ICC 12475) and susceptible (ICC 4918) checks were incorporated into the artificial diet (10, 15, 20, 25 and 30 g of lyophilized powder + 65, 60, 55, 50 and 45 g of chickpea flour, respectively). Thirty neonate larvae were reared individually at 27°C under photoperiod of 12:12 (L:D)h.

Maximum differences between susceptible and resistant genotypes in larval survival and larval weight was observed when 20 g of lyophilized leaf or pod powder was incorporated into the artificial diet along with 55 g of chickpea flour. This concentration was used to test 18 genotypes to assess the level of antibiosis towards survival and development of *H. armigera.*

Data was recorded on larval weight, larval duration, number of larvae pupated, pupal weight, pupal period and adult emergence. Data on per cent pupation and per cent adult emergence were converted to respective angular values and subjected to analysis of variance.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Larval and pupal weights:

The mean larval weight of 10-day old larvae reared on leaves different genotypes differed significantly. The highest larval weight was recorded on ICC 4962 (339.0 mg), followed by those reared on ICC 4973 (319.0 mg), ICC 12968 (302.0 mg), ICC 3137(298.0 mg), ICC 12426 (259.0 mg) and ICC 4918 (221.0 mg). ICC 4962 recorded greater weight than susceptible check ICC 4918. The lowest weight was recorded on resistant check, ICC 12475 (145.0 mg), followed by ICC 12479(159.0 mg), and ICC 12490 (169.0 mg) (Table 1).

The larvae fed on the pods of ICC 14876 (151.0 mg), ICC 12475 (157.0 mg), ICC 12479 (161.0 mg) and ICC 12490 (215.0 mg) weighed significantly lower than

Table 1: Growth and development of *H.armigera* on leaves of eighteen chickpea genotypes

Genotype	Unit larval Wt. 10th Day (mg)	Larval period (days)	Pupal period (days)	Pupal Wt. (mg)	Larval Survival (%) 10th day		Pupation (%)		Adult emergence (%)	
					Actual	AT*	Actual	AT*	Actual	AT*
ICC 12475	189^{abc}	21.9^{def}	13.2^{bcd}	224^{ab}	64^{ab}	(53)	56^{ab}	(48)	56^{ab}	(48)
ICC 12477	178^{abc}	20.5^{bcd}	12.0^{abc}	215^{a}	68^{abc}	(55)	58^{abc}	(50)	58^{abc}	(50)
ICC 12478	191^{abc}	23.0^{ef}	11.1^{a}	256^{bc}	66^{abc}	(54)	62^{abc}	(52)	62^{abc}	(52)
ICC 12479	159^{ab}	23.1^{ef}	15.6^{ef}	221^{ab}	68^{abc}	(55)	62^{abc}	(52)	60^{abc}	(51)
ICC 12490	169^{abc}	23.4^{f}	13.3^{cd}	215^{a}	64^{ab}	(53)	62^{abc}	(52)	60^{abc}	(51)
ICC 14876	189^{abc}	23.1^{ef}	14.2^{de}	219^{a}	64^{ab}	(53)	60^{abc}	(51)	60^{abc}	(51)
ICC 12426	259^{def}	19.2^{abc}	10.9^{a}	302^{e}	86de	(68)	86^{d}	(68)	86^{d}	(68)
ICC 3137	298^{efg}	18.6^{ab}	11.2^{a}	321^{f}	88^{e}	(69)	88^{e}	(70)	86^{d}	(68)
ICC 12491	201^{abcd}	20.1^{abcd}	13.6^{cd}	256^{b}	70^{abcd}	(56)	66^{abcd}	(54)	62^{abc}	(52)
ICC 12492	212^{bcd}	19.6^{abc}	14.5^{d}	273^{cde}	74^{abcd}	(59)	62^{abc}	(52)	62^{abc}	(52)
ICC 12493	201^{abcd}	19.33^{abc}	13.5^{cd}	213^{a}	78^{bcde}	(62)	70^{bcde}	(57)	68^{abcd}	(56)
ICC 12494	198^{abc}	19.23^{abc}	15.6^{e}	215^{a}	76^{bcde}	(60)	72^{bcde}	(58)	68^{abcd}	(56)
ICC 12495	182^{abc}	21.22^{a}	14.9^{de}	265^{cd}	76^{bcde}	(60)	70^{bcde}	(57)	70^{bcd}	(57)
ICC 12968	302^{fg}	19.6^{cde}	12.5^{abc}	266^{cd}	82^{cde}	(64)	78^{cde}	(62)	78^{cd}	(62)
ICC 4973	319^{fg}	17.9^{a}	11.2^{a}	312^{f}	88^{e}	(69)	86de	(68)	86^{d}	(68)
ICC 4962	339^{g}	18.3^{ab}	12.0^{ab}	306^{ef}	90^{e}	(71)	86de	(68)	86^{d}	(68)
Controls										
ICC 12475 (R)	145^{a}	23.0^{ef}	17.0^{f}	215^{a}	58^{a}	(49)	48^{a}	(44)	48^{d}	(44)
ICC 4918 (S)	221^{c}	18.9^{abc}	11.2a	299^{def}	88^{e}	(69)	86de	(68)	86^{d}	(68)
Mean	242	21.07	14.5	260.5	74	(60)	67	(56)	67	(56)
F (Prob. at 5%)	<0.001	0.015	0.012	<0.001	0.113	0.078	0.015	0.009	0.02	0.015
SED	29.1	1.11	0.926	19.0	8.85	5.5	10.23	6.4	10.3	6.4
LSD	61.0	2.23	1.82	37.3	17.6	10.9	20.4	12.7	20.4	12.7
CV%	12.9	19.5	18.3	9.8	15.9	9.8	22.6	14.0	22.6	14.0

Means followed by same letters do not differ significantly; Number of larvae=50 neonate larvae, AT* =Angular transformed values;
R – Resistant, check; S – Susceptible check

those that fed on ICC 3137 (333.0 mg), ICC 4962(333.0 mg), and ICC 4973 (332.0 mg) (Table 2).

Larvae reared on diet impregnated with lyophilized leaf powder of ICC 12475 (181.4 mg), ICC 12479 (185.5 mg) and ICC 14876 (191.9 mg) weighed significantly lower than the larvae reared on ICC 4962 (394.6 mg), ICC 4973 (357.0 mg), ICC 3137 (357.0 mg), ICC 12426 (316.5 mg) and ICC 4918 (295.0 mg) (Table 5). Larvae fed on diet with lyophilized pod powder of ICC 12475 (275.3 mg), ICC 12495 (278.9 mg), ICC 12476 (293.6 mg), ICC 12494 (298.7 mg) and ICC 12479 (298.8 mg) weighed significantly lower than those fed on ICC 4973 (298.8 mg), ICC 3137(298.7 mg), ICC 12426 (445.0 mg), ICC 4918 (404.6 mg) and ICC 4962 (401.2 mg). Larvae in the control diet (without lyophilized leaf powder) weighed significantly higher (451.2 mg) than those reared on diets with lyophilized leaf powder (Table 5).

Mean pupal weight of one-day old pupae on different genotypes differed significantly. When the larvae were reared on fresh leaves, highest pupal weight was recorded on ICC 3137(321.0 mg) and ICC 4973 (312.0 mg), and lowest on ICC 12475 (215.0 mg), ICC 12490 (215.0 mg) and ICC 12477 (215.0 mg) (Table 1). Pupal weights were highest on ICC 4962 (226.0 mg) and ICC 3137 (331.0 mg) than on ICC 12475 (226.0 mg), ICC 12477 (226.0 mg), and ICC 12479 (236.0 mg) when larvae were reared on fresh pods (Table 2).

The pupae that were formed from larvae reared on artificial diet with lyophilized leaf powder of genotypes ICC 12477 (219.2 mg), ICC 12478 (237.3 mg), ICC 12476 (243.6 mg), ICC 12491 (233.3 mg), ICC 12493 (265.0

Table 2: Growth and development of *H.armigera* on pods of eighteen chickpea genotypes

Genotype	Unit larval Wt. 10th day (mg)	Larval period (days)	Pupal period (days)	Pupal Wt. (mg)	Larval survival (%) (10th day)		Pupation (%)		Adult emergence (%)	
					Actual	AT*	Actual	AT*	Actual	AT*
ICC 12476	191.6ba	21.8bc	12.7b	264.1cd	72	(58)	68ab	(56)	66a	(54)
ICC 12477	188.1^{ba}	20.3^{cd}	13.1^{bc}	225.9^{a}	76	(61)	64^{a}	(53)	64^{a}	(53)
ICC12478	196.4^{ba}	22.6^{ab}	10.9^{ef}	293.1^{ef}	74	(59)	70^{ab}	(57)	70^{ab}	(57)
ICC 12479	160.9^{a}	22.9^{ab}	14.2^{a}	236.2^{ab}	70	(57)	56^{a}	(48)	56^{a}	(48)
ICC 12490	161.3^{a}	23.5^{ab}	11.7^{de}	245.75^{ab}	74	(59)	64^{ab}	(53)	64^{ab}	(53)
ICC 14876	151.2^{a}	24.5^{a}	12.1^{c}	248.5^{bc}	74	(59)	64^{ab}	(53)	62^{ab}	(52)
ICC 12426	291.9^{ed}	18.4^{defg}	10.5^{ef}	315.7^{gh}	88	(70)	88^{b}	(70)	88^{b}	(70)
ICC 3137	332.9^{e}	16.9^{ghi}	10.9^{ef}	331.2^{h}	90	(72)	88^{b}	(70)	88^{b}	(70)
ICC 12491	199.1^{ba}	19.2^{def}	13.0^{a}	269.8^{cd}	72	(58)	70a^{b}	(57)	68^{ab}	(56)
ICC 12492	227.0^{cb}	17.3^{fgh}	12.9^{bd}	244.8^{ab}	80	(63)	74^{ab}	(59)	74^{ab}	(59)
ICC 12493	215.3^{ba}	18.9^{defg}	10.4^{f}	226.3^{a}	76	(61)	72^{ab}	(58)	72^{ab}	(58)
ICC 12494	189.4^{ba}	18.7^{defg}	11.3^{ef}	233.1^{a}	80	(63)	76^{ab}	(61)	76^{ab}	(61)
ICC 12495	193.8^{ba}	19.9^{cde}	10.7^{ef}	254.1^{bcd}	80	(63)	70^{ab}	(57)	70^{ab}	(57)
ICC 12968	288.1^{edc}	18.1efg	11.5^{ef}	277.4^{de}	92	(74)	90^{b}	(72)	90^{b}	(72)
ICC 4973	332.4^{e}	15.1^{i}	10.8^{ef}	320.5^{g}	92	(74)	88^{b}	(70)	88^{b}	(70)
ICC 4962	333.2^{e}	15.5^{hi}	10.8^{ef}	333.9^{h}	94	(76)	88^{b}	(70)	88^{b}	(70)
Controls										
ICC 12475 (R)	156.8	23.3^{ab}	13.7^{ab}	225.8^{a}	68	(56)	54^{a}	(47)	54^{a}	(47)
ICC 4918 (S)	236.9^{dcb}	18.8^{defg}	11.0^{ef}	303.3^{fg}	90	(72)	88^{b}	(70)	88^{b}	(70)
Mean	245.0	19.4	13.24	279.85	81	65.5	71	58.5	71	58.5
F (Pro. at 5%)	<.001	<.001	<.001	<.001	0.106	0.078	0.025	0.008	0.023	0.006
SED	32.58	1.021	0.639	11.4	11.1	8.2	11.5	8.6	11.6	8.7
LSD	65.39	2.061	1.256	22.42	22.2	16.5	23.5	17.6	23.5	17.6
CV%	9.6	9.8	8.5	11.5	20.1	15.1	29.6	22.2	29.9	22.4

Means followed by same letters do not differ significantly; Number of larvae=50 neonate larvae; AT*=Angular transformed values;
R – Resistance check; S – Susceptible check

Table 3 : Growth of *H. armigera* on artificial diet impregnated with different concentrations of lyophilized chickpea leaf powder

Genotype	Leaf powder (g)	Unit larval Wt. 10th day (mg)	Larval period (days)	Pupal period (days)	Pupal Wt. (mg)	Larval survival (%) (10th day)		Pupation (%)		Adult emergence (%)	
						Actual	AT*	Actual	AT*	Actual	AT*
ICC 4918 (S)	10	391.0^{e}	16.9^{e}	10.9^{ef}	312.4^{ef}	90^{cd}	(72)	83^{e}	(66)	83^{f}	(66)
ICC 4918 (S)	15	398.0^{e}	17.8^{de}	11.2^{def}	313.1^{ef}	83^{c}	(72)	73^{cd}	(64)	73de	(64)
ICC 4918 (S)	20	291.9^{d}	17.8^{de}	11.7^{cde}	286.0^{de}	80^{bc}	(64)	63^{b}	(53)	63^{c}	(53)
ICC 4918 (S)	25	204.3^{fc}	19.3^{c}	11.8^{bcd}	266.0^{cd}	80^{bc}	(66)	67^{bc}	(55)	67^{cd}	(55)
ICC 4918 (S)	30	260.1^{cd}	20.9^{b}	11.8^{bcd}	250.0^{bc}	70^{ab}	(57)	60^{ab}	(51)	53^{a}	(47)
ICC 12475 (R)	10	276.6^{d}	18.2^{cd}	12.1^{abc}	295.0^{de}	70^{ab}	(69)	80de	(63)	77^{cf}	(61)
ICC 12475 (R)	15	255.0^{cd}	21.8^{b}	12.5^{abc}	288.0^{de}	80^{bc}	(64)	73^{cd}	(59)	70^{cd}	(57)
ICC 12475 (R)	20	153.9^{ab}	24.1^{a}	12.6^{ab}	266.9^{cd}	67^{a}	(55)	63^{b}	(53)	63^{c}	(53)
ICC 12475 (R)	25	127.4^{a}	25.1^{a}	12.6^{ab}	235.8^{b}	63^{a}	(53)	60^{ab}	(51)	53^{a}	(47)
ICC 12475 (R)	30	125.0^{a}	24.8^{a}	12.9^{a}	204.9^{a}	63^{a}	(49)	53^{a}	(47)	50^{a}	(45)
Standard diet		544.5^{f}	14.7^{f}	10.7^{f}	332.5^{f}	100^{d}	(90)	97^{f}	(79)	97^{g}	(79)
Mean		270.0	20.12	11.88	280.1	76.9	(64)	70	(58)	68	(57)
F (prob. at 5%)		<0.001	<0.001	0.028	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SED		35.0	0.59	0.44	15.0	6.3	5.3	4.5	2.7	4.7	3.0
LSD		70.1	1.16	0.87	30.1	12.7	10.9	9.3	5.7	9.8	6.2
CV%		50.7	11.3	15.4	20.5	10.5	10.1	8.1	6.0	8.9	6.8

Means followed by same letters do not differ significantly; Number of larvae=30 neonate larvae; AT*=Angular transformed values

Table 4 : Growth of *H. armigera* on artificial diet impregnated with different concentrations of lyophilized chickpea pod powder

Genotype	Pod powder (g)	Unit larval Wt. 10th day (mg)	Larval period (days)	Pupal period (days)	Pupal wt. (mg)	Larval survival (%) (10th day)		Pupation (%)		Adult emergence (%)	
						Actual	AT*	Actual	AT*	Actual	AT*
ICC 4918	10	415.9^{f}	16.4^{e}	11.2^{d}	321.4^{b}	93^{gh}	(75)	90^{fg}	(72)	90^{ef}	(72)
ICC 4918	15	382.6^{ef}	16.7^{e}	11.4^{cd}	318.9^{b}	90^{efgh}	(72)	83^{ef}	(66)	83de	(66)
ICC 4918	20	335.4^{de}	17.0^{d}	12.0^{abcd}	286.6^{ab}	83^{ef}	(66)	63^{bcd}	(53)	63^{bc}	(53)
ICC 4918	25	289.5^{cd}	18.0^{c}	12.0^{abcd}	278.9^{ab}	77^{cd}	(61)	69^{c}	(56)	69^{c}	(56)
ICC 4918	30	221.4^{bc}	19.0^{c}	11.2^{d}	269.8^{ab}	70^{cd}	(57)	60^{abc}	(51)	50^{ab}	(45)
ICC 12475	10	332.4^{de}	17.3^{de}	12.0^{abcd}	289.8^{ab}	87^{efg}	(69)	73de	(59)	73^{c}	(59)
ICC 12475	15	285.9^{cd}	18.2^{cd}	12.7^{ab}	284.1^{ab}	80de	(63)	73de	(59)	70^{cd}	(57)
ICC 12475	20	189.1^{ab}	21.2^{b}	11.7^{bcd}	211.8^{a}	67^{abc}	(55)	53^{ab}	(47)	53^{ab}	(47)
ICC 12475	25	169.8^{ab}	22.1^{a}	13.0^{a}	210.3^{a}	63^{ab}	(53)	53^{ab}	(47)	53^{ab}	(47)
ICC 12475	30	123.6^{a}	22.8^{ab}	12.6^{abc}	205.6^{a}	57^{a}	(49)	50^{a}	(45)	43^{a}	(41)
Standard diet		512.9^{g}	15.1^{f}	11.0^{d}	362.1^{b}	100^{h}	(90)	100^{g}	(90)	100^{f}	(90)
Mean		296.11	18.53	11.87	276.20	78.79	64.37	69.89	55.38	68.07	54.21
F (Prob. at 5%)		<0.001	<0.001	0.059	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SED		41.51	0.69	0.60	56.23	5.69	3.11	5.69	4.26	6.12	4.36
LSD		83.10	1.25	1.27	101.20	11.79	6.22	12.1	8.52	13.2	8.72
CV%		36.8	13.9	16.8	19.2	14.4	10.1	16.3	12.3	18.2	14.5

Means followed by same letters do not differ significantly; Number of larvae=30 neonate larvae; AT*=Angular transformed values

mg) and ICC 12494 (256.8 mg) and the resistant check, ICC 12475 (260.1 mg) weighed significantly less than the other genotypes tested. Pupal weight of larvae reared on ICC 4973 (344.2 mg) was on par with those reared on standard diet (380.7 mg) (Table 5).

Weights of pupae from lyophilized pod powder of ICC 12479 (241.8 mg), ICC 12478 (242.1 mg), ICC 12475 (253.3 mg) and ICC 12476 (263.6 mg) were significantly lower than the insect reared on ICC 12426 (312.0 mg), ICC 3137 (320.1 mg), ICC 4973 (314.0 mg), ICC 4918 (332.4 mg) and the standard diet (330.3 mg) (Table 6).

Post embryonic development larval and pupal periods :

Differences in duration of larval and pupal development of insects reared on leaves, pods, and lyophilized leaf and pod powder of different genotypes were significant. When larvae were reared on leaves the larval period was longest on ICC 12475, ICC 12478, ICC 12479, ICC 12490 and ICC 14876 (23 days). Larval period was shorter on ICC 4973 (17.9), ICC 3137 (18.6 days), ICC 4918 (18.9 days), ICC 12494 (19.2 days), ICC 12426 (19.2 days), ICC 12493 (19.3 days), ICC 12492 (19.6 days) and ICC 12491 (20.1 days).

Table 5: Growth and development of *H.armigera* on artificial diet impregnated with 20g of lyophilized leaf powder, of eighteen chickpea genotypes

Genotype	Unit larval Wt. 10th day (g)	Larval period (days)	Pupal period (days)	Unit Pupal Wt. (g)	Larval survival (%) (10 th day)		Pupation (%)		Adult emergence (%)	
					Actual	AT*	Actual	AT*	Actual	AT*
ICC 12476	193.8^{a}	21.8^{bc}	10.7^{abcd}	243.6^{ab}	77^{abc}	(61)	57^{ab}	(49)	57^{ab}	(49)
ICC 12477	196.9^{a}	20.3^{ac}	11.1^{abc}	219.2^{a}	73^{ab}	(59)	63^{abc}	(53)	63^{abc}	(53)
ICC12478	221.0^{abc}	22.6^{ab}	11.0^{abcd}	237.3^{ab}	77^{abc}	(61)	67^{abcd}	(55)	67^{abcd}	(55)
ICC 12479	185.5^{a}	22.9^{ab}	12.0^{a}	259.9^{b}	77^{abc}	(61)	70^{bcd}	(57)	70^{bcd}	(57)
ICC 12490	195.9^{a}	23.5^{a}	9.0^{d}	269.4^{b}	70^{a}	(57)	57^{ab}	(49)	57^{ab}	(49)
ICC 14876	191.9^{a}	20.1^{cd}	11.5^{ab}	272.2^{bc}	73^{ab}	(59)	60^{ab}	(51)	60^{ab}	(51)
ICC 12426	316.5^{ef}	18.4^{de}	9.4^{cd}	339.4^{de}	90^{bcd}	(72)	83^{def}	(66)	83^{def}	(66)
ICC 3137	357.5^{fg}	16.9^{fg}	10.9^{abcd}	308.9^{cde}	93^{cd}	(75)	93^{ef}	(75)	90^{ef}	(72)
ICC 12491	201.4^{ab}	19.2^{d}	10.5^{abcd}	233.3^{ab}	77^{abc}	(61)	70^{bcd}	(57)	70^{bcd}	(57)
ICC 12492	251.6^{cd}	17.3^{ef}	10.8^{abcd}	268.5^{b}	83^{abcd}	(66)	80^{cde}	(63)	80^{cde}	(63)
ICC 12493	239.9^{be}	18.9^{de}	10.4^{abcd}	250.0^{ab}	80^{abc}	(63)	73^{bcd}	(59)	73^{bcd}	(59)
ICC 12494	259.8^{cd}	18.7^{de}	11.3^{abe}	256.8^{ab}	80^{abc}	(63)	73^{bcd}	(59)	73^{bcd}	(59)
ICC 12495	195.6^{a}	19.9^{d}	10.7^{abcd}	315.3^{de}	73^{abc}	(59)	63^{abc}	(53)	63^{abc}	(53)
ICC 12968	241.0^{bc}	18.5^{de}	11.1^{abcd}	301.1^{cd}	80^{abc}	(63)	73^{bcd}	(59)	70^{bcd}	(57)
ICC 4973	357.0^{fg}	16.1^{fg}	9.8^{bcd}	344.2^{ef}	90^{bcd}	(72)	83^{def}	(66)	83^{def}	(66)
ICC 4962	394.6^{g}	16.1^{fg}	10.2^{abcd}	315.9^{de}	93^{cd}	(75)	83^{def}	(66)	83^{def}	(66)
Checks										
ICC 12475 (R)	181.4^{a}	23.3^{ab}	12.0^{a}	260.1^{b}	73^{ab}	(59)	50^{a}	(45)	50^{a}	(45)
ICC 4918 (S)	291.5^{de}	18.8^{de}	10.0^{abcd}	327.0^{de}	90^{bcd}	(72)	83^{def}	(66)	83^{def}	(66)
Standard diet	518.2^{h}	15.5^{g}	9.9^{bcd}	380.7^{f}	100^{d}	(90)	100^{f}	(90)	100^{f}	(90)
Mean	263.11	19.401	10.6	284.12	81.6	65.7	72.8	59.8	72.5	59.5
F (Prob)	<.001	<.001	<.001	<.001	0.102	0.069	0.012	0.006	0.025	0.009
SED	21.55	0.90	1.08	20.21	8.8	6.1	9.2	6.5	9.3	6.5
LSD	42.90	1.71	2.13	40.63	17.4	12.2	18.5	13.0	18.6	13.0
CV%	15.5	9.8	14.3	10.5	18.6	13.0	24.8	17.3	24.9	17.4

Means followed by same letters do not differ significantly; Number of larvae=30 neonate larvae; AT*= Angular transformed values, R-Resistant check, S-susceptible check

Significantly longer larval period was recorded on ICC 12475 and ICC 12479 (15.6 days). Mean larval and pupal periods (19.4 and 13.2 days, respectively) were shorter on pods than on leaves (21.0 and 14.5 days, respectively).

Larvae reared on diets using lyophilized leaf powder of ICC 12478 (22.6 days), ICC 12479 (22.9 days), ICC 12490 (23.5 days) and ICC 12475 (23.3 days) had significantly longer larval periods than in diets having leaf powder of ICC 3137 (16.9 days), ICC 4973 (16.1 days) and ICC 4962 (16.1 days) and the standard diet (15.5 days) (Table 5).

When the larvae were reared on diets having lyophilized pod powder, significantly shorter larval periods were recorded on ICC 12476 (16.6 days) and ICC 4962 (16.4 days), which were on par with the standard diet (16.8 days). Significantly longer larval period was recorded in diets having ICC 14876 (19.2 days) pod powder. Longest pupal period was recorded in diets having pod powder of ICC 12475 (13.1 days) and shortest in diets with pod powder of ICC 4973 (9.9 days), which was on par with the standard diet (9.9 days) (Table 6).

When data from all the four experiments were compared, mean larval and pupal periods were longest (21.1 days and 14.5 days, respectively) when the larvae reared on leaves, while shortest larval period was recorded on diet having lyophilized pod powder (17.4 days). Shortest pupal period was recorded on diet with lyophilized leaf powder (10.6 days).

Table 6: Growth and development of *H.armigera* on artificial diet impregnated with 20g of lyophilized pod powder of eighteen chickpea genotypes

Genotype	Unit larval Wt.10th day (mg)	Larval period (days)	Pupal period (days)	Pupal Wt. (g)	Larval survival (%) 10h day		Pupation (%)		Adult emergence (%)	
					Actual	AT*	Actual	AT*	Actual	AT*
ICC 12476	293.6^{a}	16.6^{e}	12.5^{ab}	263.6^{abc}	83^{ab}	(66)	67^{ab}	(55)	67^{ab}	(55)
ICC 12477	361.4^{bcd}	17.6^{abcde}	12.1^{abc}	268.2^{bc}	83^{ab}	(66)	70^{ab}	(57)	70^{ab}	(57)
ICC12478	339.1^{abc}	18.1^{abcde}	11.9^{abc}	252.1^{ab}	83^{ab}	(66)	70^{ab}	(57)	70^{ab}	(57)
ICC 12479	298.8^{ab}	17.5^{abcde}	12.2^{abc}	241.8^{ab}	80^{a}	(63)	73^{bc}	(59)	70^{bc}	(57)
ICC 12490	312.5^{ab}	19.2^{abc}	11.0^{cdefg}	256.4^{ab}	80^{a}	(63)	77^{bcd}	(61)	77^{bcd}	(61)
ICC 14876	301.1^{ab}	19.8^{a}	11.4^{bcd}	264.1^{bc}	83^{ab}	(66)	83^{cde}	(66)	83^{cde}	(66)
ICC 12426	445.0^{ef}	17.4	10.3^{efg}	312.0^{fgh}	97^{abc}	(79)	87^{def}	(69)	87^{def}	(69)
ICC 3137	480.1^{f}	18.0^{bcde}	10.5^{defg}	320.1^{gh}	97^{c}	(79)	93^{e}	(75)	93^{e}	(75)
ICC 12491	325.8^{ab}	19.2^{abcde}	11.2^{cdef}	296.6^{def}	83^{ab}	(66)	77^{bcd}	(61)	77^{bcd}	(61)
ICC 12492	301.2^{ab}	19.6^{abc}	10.3^{efg}	298.9^{def}	87^{abc}	(69)	87^{def}	(69)	87^{def}	(69)
ICC 12493	301.2^{ab}	18.2^{abc}	11.9^{bc}	280.9^{cd}	87^{abc}	(69)	73^{bc}	(59)	73^{bc}	(59)
ICC 12494	298.7^{ab}	18.2^{abcde}	11.7^{bcd}	274.1^{bc}	83^{ab}	(66)	77^{bcd}	(61)	77^{bcd}	(61)
ICC 12495	278.9^{a}	18.2^{abcde}	12.6^{ab}	279.4^{cd}	87^{abc}	(69)	70^{ab}	(57)	70^{ab}	(57)
ICC 12968	439.8^{ef}	18.8^{abcd}	10.0^{fg}	267.9^{bc}	90^{abc}	(72)	83^{cde}	(66)	83^{cde}	(66)
ICC 4973	451.2^{ef}	17.2^{cde}	9.9^{g}	314.0^{fgh}	93^{bc}	(75)	87^{def}	(69)	87^{def}	(69)
ICC 4962	401.2^{cde}	16.4^{e}	10.1^{fg}	301.1^{def}	97^{c}	(79)	87^{def}	(69)	87	(69)
Checks										
ICC 12475 (R)	275.3^{a}	18.0^{abcd}	13.1^{e}	253.3^{ab}	80^{a}	(63)	60^{a}	(51)	57	(49)
ICC 4918 (S)	404.6^{de}	17.5b^{cde}	10.6^{defg}	332.4^{h}	97^{c}	(79)	87^{def}	(69)	87	(69)
Standard diet	550.4^{g}	16.84^{de}	9.98^{fg}	330.3^{h}	97^{c}	(79)	97^{f}	(79)	97	(79)
Mean	412.9	17.42	11.6	0.2918	88	71	78	65	77	64
F (Prob. at 5%)	<.001	<.001	<.001	<.001	0.010	0.007	0.003	<.001	0.003	<.001
SED	32.58	1.02	0.64	11.41	5.55	3.89	6.39	4.47	6.39	4.47
LSD	65.4	2.06	1.26	22.42	10.10	7.07	12.8	8.96	12.9	9.03
CV%	9.6	9.8	8.5	11.5	18.1	12.67	12.5	8.75	12.9	10.2

Means followed by same letters do not differ significantly; R-Resistant check; S-Susceptible check; Number of larvae=90 neonate larvae, AT*=Angular transformed values

Larval and pupal survival:

When the larvae were reared on lyophilized leaf powder, per cent pupation and per cent adult emergence differed significantly. Per cent adult emergence was almost same as per cent pupation. Average larval survival was higher on diets with lyophilized pod powder than on diets having lyophilized leaf powder. Lowest survival was recorded when the larvae were reared on leaves.

Significantly lower survival was recorded on resistant check ICC 12475. Larval survival was lower when the insects were reared on leaves of ICC 12476 (56%), ICC 12477 (63%), ICC 12478 (67%), ICC 12490 (57%), ICC 14876 (60%), ICC 12495 (63%) and ICC 12475 (50%). There were no significant differences in larval of pupal survival when the larval reared on pods of ICC 12476 (67%), ICC 12477 (70%), ICC 12478 (70%), ICC 12478 (70%) , ICC 12495 (70%), and ICC 12475 (60%).

Larval survival was lower when the insects were reared on diets with lyophilized leaf powder of ICC 12476 (56%), ICC 12477 (58%), ICC 12478 (62%), ICC 12479 (62%), ICC 14876 (60%), ICC 12490 (62%), ICC 12491 (66%) and ICC 12475 (48%). When the larvae were reared on diets with lyophilized pod powder, ICC 12476 (67%), ICC 12477 (70%), ICC 12478 (70%) and ICC 12494 (77%) and ICC 12495 (70%), were on par with the resistant check ICC 12475 (60%).

Fecundity and egg viability of insect reared on different genotypes did not differ significantly.

Conclusion:

The current study has shown significant variation in growth and survival of *H. armigera* reared on chickpea leaves and pods. This is similar to the observations of Sison *et al.* (1993) showed that *H. armigera* larvae reared on leaves and flowers of pigeonpea had lower larval weights and longer development times than those reared on pods. Differences in nutrient availability of different plant parts may affect the growth and survival of *H. armigera* on chickpea. However, differences in the amount of acidic exudates consumed by first-instar to third-instar may also be important. Larger larvae consume the whole pod and seeds. In comparison, the larvae that were reared on leaves ingested plant material with surface exudates throughout their development and thus exhibited low survival and slower rates of growth and development (Dias *et al*., 1983).

Larval period was longer in resistant genotypes compared to susceptible ones, and the standard diet. These results suggested that a growth inhibitor or antifeadent substance or both existed in the resistant genotypes. The larval survival, larval weight, pupal weights, pupation and adult emergence were consistently lower in the resistant genotypes than the susceptible ones, and the standard diet (Yoshida and Shanower, 2000). Slower larval growth, which results in prolonged development may increase the probability of predation, parasitism, and infection by pathogens, results in reduced population of the pest on the crop (Shanower, 1990).

The mean larval weights, pupal weights and larval survival were high when the larvae were reared on lyophilized leaf and pod powder compared to those reared on leaves and pods. This may be because of more nutrients available in the artificial diet. When the larvae were reared on lyophilized pod powder the larval survival and weight grain were high suggesting that chickpea pods were more nutritious than leaves. Reduced larval and pupal weights, and prolonged larval and pupal periods (ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 14876, ICC 12490, ICC 12491 and ICC 12495) compared to susceptible genotypes (ICC 12426, ICC 3137, ICC 4973 and ICC 4962) indicated that antibiosis is one of the component of resistance to *H. armigera* in chickpea.

REFERENCES

Armes, N. J., Bond, G. S. and Cooker, R. J. (1993). The laboratory culture and development of *Helicoverpa armigera*. Natural Resources Institute, Chaltam U.K. Bulletin 57.

Clement, S. L., El-Din, Sharaf E. D. N., Weigand, S. and Lateef, S. S. (1994). Research achievements in plant resistance to insect pests of cool season food legumes. *Euphytica* ,**73** : 41-50.

Cowgill, S. E. and Lateef, S. S. (1996). Identification of antibiotic and antixenotic resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea. *J. Econ. Entomol.*, **89** : 224-229.

Dias, C. A. R., Lal, S. S. and Yadava, C. P. (1983). Differences in susceptibility of certain chickpea cultivars and local collections to *Heliothis armigera* (Hubner) *Indian J. Agric. Sci.*, **53** : 842-845.

Dua, P. C. P., Gowda, C. L. L., Shivkumar, Saxena, K. B., Govil, J. N., Singh, B. B., Singh, A. K., Singh, R.P., Singh, V. P. and Kranthi, S. (2002). Breeding for resistance to

Helicoverpa – Effectiveness and Limitations. (*in*) *Helicoverpa armigera* – the Way Ahead (Sharma, H.C., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Dubey, A. K., Mishra, U. S. and Dixit, S. A. (1981). Effect of host plants on the developmental stages of gram pod borer, *Heliothis armigera* (Hubner). *Indian J. Entomol.,* **43**:178-182.

Jayaraj, S. (1982). Biological and ecological studies of *Heliothis* In: Proceedings of the International Conference on *Heliothis* Management 15-20 Nov 1981 at ICRISAT Center (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, Andhra Pradesh, India pp. 241-250.

Painter, R. H. (1951). *Insect resistance in crop plants*, McMillan, New York, USA pp. 289.

Rembold, H. (1981). Malic acid on chickpea exudates a marker for *Heliothis* resistance. *Internat. Chickpea Newsletter,* **4** : 18-19.

Rembold, H. and Winter, E. (1982). The chemist's role is host plant resistance studies. In: proceedings of International Workshop. *Agric. Univ.*, **9** : 417-421.

Rembold, H., Walner, P., Kohne, A., Lateef, S. S., Grune, M. and Weigner, C.L. (1989). Mechanism of host plant resistance with special emphasis on biochemical factors. In: Chickpea in the nineties: Proceedings of the Second International Workshop on Chickpea Improvement 4-8 Dec 1989. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics pp 192-193.

Rembold, H. and Weigner, C. L. (1990). Chemical composition of chickpea, *Cicer arietinum*, exudate *Z. Naturoforsch,* **45**: 922-923.

Rembold, H., Schroth, A., Lateef, S. S. and Weigner, C. L. (1990). Semiochemical and host-plant selection by *Helicoverpa armigera*: basic studies in the laboratory for the field *in* ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). Summary Proceedings of the First Consultative Group Meeting on the Host Selection Behavior of *Helicoverpa armigera* 5-7 March 1990. ICRISAT Center, India. Patancheru, Andhra Pradesh, India. ICRISAT pp 23-26.

Shanower, L. M. (1990). Host selection by Lepidopteran insects. The role of plant chemicals in oviposition and feeding behaviour in host selection behaviour of *Helicoverpa armigera*. Summary Proceedings of the First Consultative Group Meeting 5-7 Mar.1990. ICRISAT pp. 9-11.

Singh, H. and Sharma, S. S. (1970). Relative susceptibility of some important varieties of gram to pod borer *Heliothis armigera*. (IIubner), *Indian J. Entomol.,* **32** : 170-171.

Sison, M. J., Shanower, T.G. and Bhagwat, V. R. (1993). *Helicoverpa (Hubner)* ovipositional and larval feeding preference among 6 short duration pigeonpea genotypes. *Internat. Pigeonpea Newsletter,* **17** : 37-40.

Sison, M. J., Cowgil, E. and Lateef, S. S. (1996). Identification of antibiotic and antixenotic resistance to *Helicoverpa armigera* (Lepidoptera: Noctuidae) in chickpea. *J. Econ. Entomol.,* **89** : 224-228.

Srivastava, C. P. and Srivastava, R.P. (1989). Screening for resistance to the gram pod borer *H. armigera* in chickpea genotypes and obviations on its mechanisms of resistance in India. *Insect Sci. & its Applic.,* **10** : 255-258.

Srivasatava, C. P. and Srivastava, R. P. (1990). Antibiosis in chickpea (*Cicer arietinum L*) to gram pod borer *Heliothis armigera* (*Hubner*) (Noctuidae: Lepidoptera) in India. *Entomon,* **15**: 89-93.

Tripathi, S. R. and Sharma, S. K. (1985). Effect of some food plants on development and growth of gram pod borer *Heliothis armigera* (Hubner) (Lepidoptera: Noctuidae). *Nigerian J. Entomol.,* **6** : 33-38.

Yoshida, M., Cowgill, S. E. and Weightman, J. A. (1995) Mechanisms of resistance to *Helicoverpa armigera* (Lepidopter: Noctuidae) in chickpea. Role of oxalic acid in leaf exudates as an antibiotic factor. *J.Econ. Entomol.,* **8**:112-119.

Yoshida, M. (1997). Mechanisms of resistance to *H. armigera* in chickpea. Report of work, ICRISAT, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.

Yoshida, M. and Shanower, T. G. (2000). *Helicoverpa armigera* larval growth inhabitation in artificial diet containing freeze-dried pigeonpea pod powder. *J. Agric. Urban Entomol.,* **17** : 37-41.