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DIFFERENCES IN SUSCEPTIBILITY OF CHICKPEA (*CICER ARIETINUM* LINN.) GENOTYPES TO *HELICOVERPA ARMIGERA* (HUB.) UNDER NO-CHOICE CAGED CONDITIONS AND TOWARDS WASHED AND UN-WASHED CHICKPEA LEAVES

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Abstract

The chickpea genotypes were grown in the glasshouse to test the feeding preference by the *H. armigera* larvae. Under no choice caged glasshouse conditions the resistant genotypes recorded reduced damage rating; low larval survival and larval growth indicated that antibiosis is one of the components of resistance. The chickpea genotypes were grown in the glasshouse are used to test the feeding preference by the *H. armigera* larvae on washed and unwashed leaves. Greater feeding in washed leaves compared to unwashed leaves in ICC 12475, ICC 12478, ICC 12479, ICC 14876, ICC 12495 and ICC 12494 suggested that water-soluble compounds in the leaf exudates (malic and oxalic acid) of chickpea were primarily responsible for the resistance of the genotypes to *H. armigera*.

Key words : Chickpea, resistance, susceptibility, *Helicoverpa armigera*, host plant resistance, antibiosis.

Introduction

Chickpea, *Cicer arietinum* Linn. is the third most important food legume worldwide. Chickpea potential seed yield of about 5 t ha^{-1} has been reported. But the realized seed yield is only 850 kg ha^{-1}. Pod borer, *Helicoverpa armigera* (Hub.) (Noctuidae : Lepidoptera) is most important factor limiting chickpea production worldwide. The pod damage due to this pest is reported to be as high as 85% (Sithanantham *et al*., 1984). Insecticide application for pod borer is uneconomical under subsistence farming and is largely beyond the means of resource poor farmers. Therefore, host plant resistance (HPR) assumes a pivot role in controlling *H. armigera* damage either alone or in combination with other methods of control. It has been documented that for each $1 invested in plant resistance, farmers have realized a sum of $300 return (Robinson, 1996). Keeping these in view the present investigation on relative susceptibility of chickpea genotypes to *H. armigera* was performed under glasshouse and laboratory conditions.

Materials 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^{0}C. Adults were kept at 25°C in a cage and mappyliners were provided as a substrate for oviposition. The moths were provided 10% honey solution on absorbent cotton for oviposition.

Relative susceptibility of chickpea genotypes to *H. armigera* under no-choice caged conditions

Chickpea plants were grown in the greenhouse in plastic pots (30 cm diameter, 30 cm deep). The pots were filled with red soil, black soil and farmyard manure (2 : 1 : 1). In each pot, 15 seeds were sown at 7 cm depth. The plants were watered as and when needed. Ten seedlings with similar growth were retained in each pot 10 days after seedling emergence. The greenhouse was cooled by desert coolers to maintain the temperature at 28 ± 5°C and relative humidity of 76 ± 5%.

Eighteen genotypes, ICC 12475 (resistant check), ICC 4918 (susceptible check) and the test genotypes ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490,

ICC 14876, ICC 12426, ICC 3137, ICC12491, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 12968, ICC 4973 and ICC 4962 were screened in this experiment. There were three replications in randomized complete block design.

Five plants in each pot were infested 15 days after seedling emergence. Plants were covered with a plastic jar cage (11 cm diameter and 26 cm height) with two wire mesh screened windows (4 cm diameter) on the sides. The top of the plastic jar cage was covered with the lid fitted with the wire mesh screen. Twenty neonate larvae were counted in the laboratory, placed in 25 ml plastic cups, and taken to the greenhouse for infestation. The larvae were released inside the cage on the plants (4 larvae per plant), and the lower end (up to 2 cm) of the cage was pushed into the soil. Five plants outside the cage in the same pot served as a un-infested control. The cages were removed six days after larval infestation and observations were recorded. The experiment was again repeated during flowering stage (40 days after sowing) of the plants to test their susceptibility.

The first infestation was done 15 days after sowing as mentioned above and the second infestation was done during the flowering stage (40 days after sowing) on the earlier infested plants.

Observations were recorded six days after infestation. The plants were visually rated for leaf feeding on a 1 to 9 damage scale (1 = < 10%, 2 = 11 to 20%, 3 = 21 to 30%, 4 = 31 to 40%, 5 = 41 to 50%, 6 = 51 to 60%, 7 = 61 to 70%, 8 = 71 to 80% and 9 = > 80% leaf area damaged). The plants grown till maturity and data on number of plants survived, and seed yield (g) on infested and un-infested plants was recorded.

Relative preference of *H. armigera* larvae towards washed and unwashed chickpea leaves

The chickpea genotypes were grown in the glasshouse as mentioned above to test the feeding preference by the *H. armigera* larvae. Plastic cups of 9.5 cm diameter were used in the experiment had a filter paper moistened with water attached to the lid to keep the chickpea leaves in a turgid condition. Agar-agar (3.5%) was boiled and poured into cups to a depth of 2.5 cm and allowed to gelate. The solidified agar-agar was used as the substratum for inserting the chickpea branches (5 cm long with 2 fully expanded leaves). A washed (with tap water for 1 minute) and unwashed branch of each genotype was inserted into the agar-agar medium at the opposite ends. Care was taken to see that the branches did not touch the inner walls of the cup. Ten neonate *H. armigera* larvae weighed previously were released on the agar-agar at the center of each cup.

The experiment was conducted in a completely randomized design with 10 replications and 18 genotypes as treatments. Observations pertinent to leaf feeding score on 0 to 9 scale (0 = no damage, 1 = < 10% leaf area damaged and 9 = > 80% leaf area damaged), number of larvae survived and number of larvae present on each twig were recorded three days after initiating the experiment.

The same experiment was repeated separately with washed and unwashed leaves (no-choice conditions) with ten replications. Data were recorded on the number of larvae survived and weight gained by the larvae three days after release.

Statistical analysis

Data was subjected to factorial analysis to know the significance differences between washed and unwashed leaves, and the genotypes tested. Students 't' test was used to know the significance of the differences between the treatments (washed and unwashed) for each genotype.

Results

Relative susceptibility of chickpea genotypes to *H. armigera* under no-choice caged condition

Significantly lower leaf feeding was recorded on ICC 12478 (1.5), ICC 12479 (2.3), ICC 14876 (3.0) and ICC 12968 (3.2), which were on par with the resistant check, ICC 12475 (1.0) during the vegetative stage. In the same experiment, when the larvae were released during the flowering stage, which were also infested at the vegetative stage, the genotypes ICC 12478 (0.8) and ICC 12479 (1.8) were on par with resistant check, ICC 12475 (1.0) (table 1).

When the larvae were released during vegetative stage significantly lower leaf damage was recorded in ICC 12479 (2.3), ICC 14876 (3.0), ICC 12491 (2.8) and check ICC 12475 (1.5) than on ICC 37 (4.5). In another experiment, the genotypes were infested only at the vegetative stage and ICC 12476 (3.0) and ICC 12479 (2.3) were on par with resistant check ICC 12475 (2.2). During flowering time ICC 12476 (2.5), ICC 12479 (1.8) and ICC 14876 (2.6) were on par with resistant check ICC 12475 (1.6). Mean damage rating during flowering stage (3.86) was less than that recorded at the vegetative stage (4.1) (table 3).

During the vegetative stage statistically same number of larvae survived in all the genotypes except on ICC

4962 (93%), ICC 4918 (88%), ICC 4973(85%), ICC 12476 (83%) and ICC 12490 (73%). When the larvae were released on the same plants during the flowering stage, significantly lower number of larvae survived on ICC 12476 (50%), ICC 12477 (55%), ICC 12490 (55%), ICC 12491 (38%), ICC 12492 (45%), ICC 12493 (35%), ICC 12494 (50%), ICC 12495 (45%) and ICC 12475 (50%). than on ICC 14876 (60%), ICC 12426 (71%), ICC 3137 (75%), ICC 12478 (63%), ICC 12479 (71%), ICC 12968 (60%), ICC 4973 (65%), ICC 4962 (71%), and susceptible check ICC 4918 (76%) (table 1).

When the larvae were released at the vegetative and flowering stages separately, significantly lower number of larvae survived on ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 14876, ICC 12491, ICC 12495, and ICC 12475 (table 3).

Larval weight: g larva^{-1}

Significantly lower larval weights were recorded when the larvae were reared on ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 12492, and ICC 12475,than on ICC 12426, ICC3137, ICC 12491, ICC 12493, ICC 12494, ICC 12495, ICC 4973, ICC 4962 and ICC 4918 during vegetative stage and during the flowering stage, no significant differences were observed between the genotypes tested. Mean larval weight during the flowering stage (50.0 mg) was less than that during the vegetative stage (131.0 mg) (table 1).

When the larvae were released during vegetative stage; significantly lower larval weights were recorded in ICC 12475 (resistant check), ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, and ICC12491 than on ICC 12426, ICC 3137, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 12968, ICC

Table 1 : Relative susceptibility of eighteen chickpea genotypes to *H. armigera* (vegetative + flowering stage) under no-choice caged conditions, ICRISAT, Patancheru, 2000-02.

Genotype	Vegetative stage			Flowering stage		
	Damage rating (0-9)	Larval survival (%)	Unit larval Wt (mg)	Damage rating (0-9)	Larval survival (%)	Unit larval Wt (mg)
ICC 12476	3.6^{bcd}	83^{bcd}	105^{abc}	2.5^{bcd}	50^{abcd}	367.1
ICC 12477	4.8^{d}	67^{ab}	988^{abc}	3.83^{de}	55^{abcde}	332.7
ICC12478	1.5^{ab}	80^{abcd}	787^{ab}	0.8^{a}	63^{cde}	472.3
ICC 12479	2.3^{abc}	58^{a}	641^{a}	1.8^{abc}	71de	379.7
ICC 12490	3.8^{cdef}	73^{cd}	665^{ab}	3.0^{cde}	55^{abcde}	372.7
ICC 14876	3.0^{abcde}	62^{abcd}	907^{abc}	2.6^{bcd}	60^{bcde}	399.0
ICC 12426	4.5^{cdef}	90^{a}	192^{efg}	5.1^{ef}	71de	572.9
ICC 3137	5.6^{f}	72^{abcd}	192^{efg}	6.0^{f}	75^{e}	742.3
ICC 12491	2.6^{abcd}	60^{a}	141^{cde}	1.5^{abc}	38^{ab}	682.3
ICC 12492	5.5^{f}	78^{abcd}	117^{abc}	4.3^{ef}	45^{abc}	355.3
ICC 12493	5.3^{f}	82^{abcd}	142^{cde}	4.8^{f}	35^{a}	401.7
ICC 12494	5.6^{f}	78^{abcd}	120^{bcd}	4.5^{ef}	50^{abcd}	623.7
ICC 12495	5.0^{ef}	75^{abcd}	138^{c}	3.8^{de}	45^{abc}	413.3
ICC 12968	3.1^{abcde}	77^{abcd}	114^{abc}	2.6^{bcd}	60^{bcd}	644.7
ICC 4973	5.0^{e}	85^{e}	212^{fg}	4.5^{ef}	65^{cde}	984.7
ICC 4962	5.6^{f}	93^{d}	229^{g}	5.6^{f}	71de	191.3
Checks						
ICC 12475 (R)	1.0^{a}	77^{abcd}	802^{ab}	1.0^{af}	50^{abcd}	284.2
ICC 4918 (S)	4.0^{bcde}	88^{e}	172^{def}	4.8^{f}	76^{e}	442.2
Mean	4.02	77	131.2	3.53	75	501.0
F (prob. at 5%)	<.001	0.036	<.001	<.001	0.002	0.114
SED ±	1.07	11.52	26.22	0.88	10.3	27.25
LSD ±	2.18	23.656	54.10	1.78	20.9	54.89
CV%	32.7	18.4	24.9	30.6	21.9	61.6

Number of larvae released = 20, Replications = 3; R-Resistant check, S-Susceptible check Damage rating 0-9 scale (0 = no damage, 1 = <10% leaf area damaged, 2 = 11 to 20%, 3 = 21 to 30%, 4 = 31 to 40%, 5 = 41 to 50%, 6 = 51 to 60%, 7 = 61 to 70%, 8 = 71 to 80% and 9 = > 80% leaf area damaged).

Table 2 : Relative recovery of eighteen chickpea genotypes from *H. armigera* damage (vegetative + flowering stage) under no-choice caged condition, ICRISAT, Patancheru, 2000-02.

Genotype	Plants recovered			Total yield (g)			Yield plant^{-1} (g)		
	Damaged	Undamaged	Mean	Damaged	Undamaged	Mean	Damaged	Undamaged	Mean
ICC 12476	2.33b	4.00	3.17	3.20^{bc}	7.70^{cd}	5.79	1.37	1.93	1.84
ICC 12477	2.33b	4.67	3.50	3.89^{ab}	8.20^{bc}	5.83	1.67	1.76	1.36
ICC12478	2.33b	4.67	3.50	3.98^{ab}	7.40^{de}	4.04	1.71	1.58	0.99
ICC 12479	3.67ab	5.00	4.34	4.23^{a}	4.80^{gh}	4.96	1.15	0.96	1.11
ICC 12490	4.00a	5.00	4.50	4.31^{a}	6.80^{e}	4.71	1.08	1.36	1.06
ICC 14876	4.00a	4.67	4.33	3.65^{a}	7.90^{cd}	4.15	0.91	1.69	1.00
ICC 12426	2.67b	4.33	3.00	2.11^{d}	8.90^{ab}	5.55	1.26	2.05	1.77
ICC 3137	2.00b	5.00	3.50	2.69^{cd}	5.90^{f}	4.07	1.35	1.18	0.95
ICC 12491	2.33b	5.00	3.67	2.11^{d}	7.80^{cd}	2.83	0.91	1.56	0.69
ICC 12492	2.33b	4.67	3.50	1.90^{e}	4.80^{gh}	3.03	0.82	1.03	0.81
ICC 12493	2.00b	4.33	3.17	1.70^{e}	5.50^{f}	3.55	0.85	1.27	1.55
ICC 12494	2.00b	4.33	3.17	1.60^{e}	4.60^{h}	3.87	0.80	1.06	0.98
ICC 12495	2.67b	4.67	3.17	2.20^{de}	6.90^{e}	5.17	1.32	1.48	1.26
ICC 12968	2.67b	4.33	3.00	0.80^{f}	2.20^{i}	3.87	0.48	0.51	0.95
ICC 4973	2.33b	5.00	3.17	2.30^{de}	6.80^{e}	4.85	1.73	1.36	1.11
ICC 4962	2.33b	4.33	2.83	2.10^{de}	4.80^{gh}	3.53	1.58	1.11	0.86
Checks									
ICC 12475 (R)	4.00a	5.00	4.50	4.12^{a}	7.90^{cd}	5.29	1.03	1.58	1.17
ICC 4918 (S)	2.00b	5.00	3.50	3.69^{a}	9.20^{a}	5.14	1.85	1.84	1.33
Mean	2.39	4.67		2.81	6.56		1.41	1.16	
	F (prob. at 5%)	SED ±	0.505	F (prob. at 5%)	SED±	0.389	F (prob. at 5%)	SED ±	0.412
Geno	<.001	LSD ±	1.002	<.001	LSD±	0.760	<.001	LSD ±	0.205
Treat	<.001	CV%	19.7	<.001	CV%	19.8	<.001	CV%	15.7
Geno.Treat	0.003			0.098			0.087		

20 neonate larvae released on 5 plants; replications-5; R- Resistant check, S – Susceptible check.

4973, ICC 4962 and ICC 4918. During the flowering stage ICC 12492, ICC 12493, ICC 12495 and ICC 12968 were also on par with the resistant check, ICC 12475 (table 3).

Survival of the plants and grain yield

When the plants were infested with *H. armigera* during vegetative and flowering stages; significantly more number of plants survived in ICC 12479, ICC 12490, ICC 14876 as compared to ICC 12475, grain yield was also higher on ICC 12479, ICC 12490, ICC 14876 than on ICC 12475.

Significantly less number of plants survived in ICC 12477, ICC 12478, ICC 12426, ICC 3137, ICC 12491, ICC 12494, ICC 12495, ICC 12968, ICC 4973, ICC 4962, and ICC 4918 when the plants were infested at the vegetative stage. There were, no significant differences in grain yield in damaged and undamaged plants. Significantly less grain yield was recorded under infested conditions in ICC 12476, ICC 12477, ICC 12478, ICC 12426, ICC 12495, and ICC 4918 (table 2).

Relative feeding preferences and development of *H. armigera* larvae towards washed and unwashed chickpea leaves

When the neonate *H. armigera* larvae were given a choice between washed and unwashed leaves of chickpea inserted in agar-agar, significantly greater leaf feeding

Table 3 : Relative susceptibility of eighteen chickpea genotypes to *H.armigera* under no-choice caged condition in glass house, ICRISAT, Patancheru, 2000-02.

Genotype	Damage rating (0-9 scale)			Larval survival (%)			Weight of the larvae (mg)		
	Vegetative stage		Flow. stage	Vegetative stage		Flow. stage	Vegetative stage		Flow. stage
ICC 12476	3.17^{bcd}	3.00^{abc}	2.50^{abc}	75^{bcd}	75^{bc}	55^{ab}	938.0^{abc}	755.0^{ab}	123.5^{bcdef}
ICC 12477	3.17^{bcd}	3.67^{c}	3.17^{cd}	65^{abc}	75^{bc}	60^{abc}	114.5^{bc}	673.0^{ab}	837.0^{abc}
ICC12478	3.17^{bcd}	3.50^{cd}	3.00^{cd}	68^{abcd}	70^{ab}	67^{bcd}	818.0^{ab}	849.0^{abc}	835.0^{abc}
ICC 12479	2.33^{ab}	2.33^{ab}	1.83^{ab}	68^{abcd}	72^{ab}	62^{abc}	632.0^{a}	576.0^{a}	715.0^{ab}
ICC 12490	3.17^{bcd}	3.33^{c}	3.00^{cd}	75^{bcd}	80^{bcd}	70^{cde}	881.0^{ab}	894.0^{abcd}	105.7^{abcd}
ICC 14876	3.00^{abcd}	3.17^{bc}	2.67^{abc}	75^{bcd}	75^{bc}	60^{abc}	112.0^{bc}	124.8^{cdef}	111.8^{abcde}
ICC 12426	5.00^{eg}	4.83^{e}	5.00^{efg}	80^{cd}	90^{d}	62de	176.4^{ef}	167.5^{gh}	147.7^{def}
ICC 3137	5.67^{gh}	5.83^{gh}	5.67^{g}	87^{d}	90^{d}	70^{cde}	210.4^{f}	164.0^{gh}	173.3^{f}
ICC 12491	2.83^{abc}	3.17^{bc}	3.17^{c}	57^{a}	75^{bc}	60^{abc}	110.5^{f}	103.7^{bcde}	102.6^{abcd}
ICC 12492	4.67^{efg}	4.33^{de}	4.00^{de}	75^{bcd}	75^{bc}	70^{cde}	119.5^{bc}	868.0^{abc}	885.0^{abcd}
ICC 12493	5.17^{efgh}	5.33^{fgh}	5.17^{efg}	60^{abc}	75^{bc}	65^{bcd}	131.5^{cd}	105.4^{bcde}	825.0^{abc}
ICC 12494	5.33^{efgh}	5.83^{gh}	5.33^{fg}	60^{ab}	80^{bcd}	65^{bcd}	132.5^{cd}	125.7^{def}	118.5^{bcdef}
ICC 12495	4.17^{cdef}	3.33^{c}	3.67^{cdd}	65^{abc}	75^{bc}	60^{abc}	122.3^{b}	118.7^{cdef}	83.0^{abc}
ICC 12968	4.00^{cde}	4.67^{ef}	4.17^{def}	80^{cd}	75^{bc}	70^{cde}	120.2^{b}	154.2^{fgh}	102.2^{abcd}
ICC 4973	5.50^{fg}	5.50^{fgh}	5.33^{f}	85^{d}	85^{cd}	75de	211.0^{f}	191.5^{hi}	118.9^{bcdef}
ICC 4962	6.50^{h}	6.50^{h}	6.17^{g}	85^{d}	85^{cd}	80^{e}	216.0^{f}	986.0^{j}	170.7^{e}
Checks									
ICC 12475 (R)	1.51^{a}	2.17^{a}	1.67^{a}	65^{abc}	60^{a}	50^{a}	617.0^{a}	534.0^{a}	566.0^{a}
ICC 4918 (S)	4.33^{def}	4.50^{de}	4.00^{de}	80^{d}	80^{cd}	70^{cde}	169.0^{de}	133.9^{efg}	138.4^{cdef}
Mean	4.04	4.17	3.86	73	75	76	0.13	0.12	0.11
F (prob. at 5%)	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	0.016
SED ±	0.74	0.47	0.63	7.5	5.88	5.98	20.01	20.01	31.22
LSD ±	1.50	0.96	1.28	15.13	11.89	12.01	40.12	40.25	60.01
CV %	22.4	14.2	20	12.5	9.4	11.3	18.3	18.5	33.8

R- Resistant check; S – Susceptible checkDamage rating 0-9 scale (0 = no damage, 1 = < 10% leaf area damaged, 2 = 11 to 20%, 3 = 21 to 30%, 4 = 31 to 40%, 5 = 41 to 50%, 6 = 51 to 60%, 7 = 61 to 70%, 8 = 71 to 80% and 9 = > 80% leaf area damaged).

was recorded on washed leaves of ICC 12478, ICC 12479, ICC 14876, ICC 12494, ICC 12495 and check ICC 12475 compared to unwashed leaves of the same genotype. Mean damage rating on washed leaves were 4.33 as compared to 3.35 on-unwashed leaves (table 5).

Significantly more number of larvae were recorded on washed leaves than on unwashed leaves of ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 12492, ICC 12493, ICC 12494, ICC 12495, ICC 4973 and ICC 12475. Numbers of larvae present on washed and unwashed leaves after three days were significantly different except on ICC 12426, ICC 3137, ICC 12968, ICC 4962 and ICC 4918. There were more (4.22) larvae on washed leaves compared to the unwashed leaves (3.33) (table 5).

There was no significant variation in larval weights when the larvae were reared on washed and unwashed leaves separately for three days. But the leaf feeding rating and number of larvae survived were significantly different for the genotypes tested. Leaf feeding of ICC 12477 on washed leaves was 4.8 compared to unwashed leaves 3.4. Mean damage rating on unwashed leaves 3.01 compared to 4.03 on washed leaves, but the differences were not significant. Significantly less damage was recorded on unwashed leaves of ICC 12476, ICC 12477, ICC 12478, ICC 12491, ICC 12492, ICC 12493 and ICC 12494, which were on par with the resistant check, ICC 12475. Damage ratings on un-washed twigs of all the genotypes were on par with resistant check, ICC 12475 (except ICC 14876, ICC 12426, ICC 3137, ICC 12495, ICC 12968, ICC 4973, ICC 4962 and ICC 4918). No significant variation was observed between washed and unwashed leaves in larval survival, except on ICC 3137. Numbers of larvae survived after three

Table 4 : Relative recovery of eighteen chickpea genotypes from *H.armigera* damage (vegetative stage) under no-choice condition in glass house, ICRISAT, Patancheru, 2000-02.

Genotype	Number of plants recovered			Total yield (g)			Yield per plant (g)		
	Damaged	Un-damaged	Mean	Damaged	Un-damaged	mean	Damaged	Un-damaged	Mean
ICC 12476	2.67^{cd}	4.00^{ab}	3.33	4.20^{ab}	7.37^{ab}	5.79	1.58	1.84	1.74
ICC 12477	2.67^{cd}	5.00^{a}	3.83	4.84^{a}	6.82^{abc}	5.83	1.81	1.36	1.52
ICC12478	2.33^{d}	5.00^{a}	3.67	3.13^{abcd}	4.95^{defg}	4.04	1.34	0.99	1.10
ICC 12479	4.00^{abc}	5.00^{a}	4.50	4.37^{ab}	5.55^{cdef}	4.96	1.09	1.11	1.10
ICC 12490	5.00^{a}	5.00^{a}	5.00	4.13^{ab}	5.29^{cdef}	4.71	0.83	1.06	0.94
ICC 14876	4.33^{abc}	4.67^{a}	4.50	3.62^{abcd}	4.69^{defg}	4.15	0.84	1.00	0.92
ICC 12426	1.00^{de}	4.33^{a}	2.67	3.43^{abcd}	7.67^{a}	5.55	3.43	1.77	2.08
ICC 3137	2.67^{cd}	5.00^{a}	3.83	3.40^{abcd}	4.74^{defg}	4.07	1.27	0.95	1.06
ICC 12491	3.33^{bcd}	5.00^{a}	4.17	2.20^{d}	3.47^{g}	2.83	0.66	0.69	0.68
ICC 12492	3.33^{bcd}	4.67^{a}	4.00	2.27^{cd}	3.80^{fg}	3.03	0.68	0.81	0.76
ICC 12493	1.67^{d}	2.67^{b}	2.17	2.97^{bcd}	4.13^{efg}	3.55	1.78	1.55	1.64
ICC 12494	0.67^{f}	4.33^{a}	2.50	3.50^{abcd}	4.23^{efg}	3.87	5.25	0.98	1.55
ICC 12495	1.33^{d}	5.00^{a}	3.17	4.03^{abc}	6.30^{abcd}	5.17	3.03	1.26	1.63
ICC 12968	1.67^{cd}	4.33^{a}	3.00	3.60^{abcd}	4.13^{g}	3.87	2.16	0.95	1.29
ICC 4973	2.67^{cd}	5.00^{a}	3.83	4.13^{ab}	5.57^{cdef}	4.85	1.55	1.11	1.27
ICC 4962	2.67^{cd}	4.67^{a}	3.67	3.07^{abcd}	4.00^{efg}	3.53	1.15	0.86	0.96
Checks									
ICC 12475 (R)	4.33^{ab}	5.00^{a}	4.67	4.73^{ab}	5.84^{bcde}	5.29	1.09	1.17	1.13
ICC 4918 (S)	2.00^{de}	5.00^{a}	3.50	3.62^{abcd}	6.66^{abc}	5.14	1.81	1.33	1.47
Mean	2.69	4.65		3.62	5.29		1.74	1.16	
Geno		<.001			<.001			<.001	
Treat		<.001			<.001			<.001	
Geno.Treat		0.004			0.341			0.213	
SED ±		0.707			0.903			0.220	
LSD ±		1.410			1.801			0.439	
CV%		23.6			24.8			21.5	

20 neonate larvae released on 5 plants; replications 5; R- Resistant check, S – Susceptible check.

days were significantly lower in washed leaves of ICC 3137 compared to unwashed leaves (table 6).

Discussion and Conclusion

Relative susceptibility of chickpea genotypes to *H. armigera* under no-choice caged condition

Glasshouse screening under no-choice caged conditions is simple, rapid and is not influenced by the external factors and therefore, provides a reliable means of evaluating insect damage on the test genotypes. In this technique, all the test genotypes were exposed to uniform insect pressure, and the cages prevented emigration of the larvae from the plants being evaluated.

The genotypes ICC 12479, ICC 12477, ICC 12476, ICC 12478, ICC 12490, ICC 14876, ICC 12491 and ICC 12495 were found to be resistant and their levels of resistance were comparable to the resistant check, ICC 12475. Reduced damage rating, low larval survival and larval growth in these genotypes indicated that antibiosis is one of the components of resistance. In some of the genotypes, the plants recovered from the leaf feeding and survived. In susceptible genotypes (ICC 12426, ICC 3137, ICC 4973, ICC 4962 and ICC 4918) some plants failed to recover because of heavy damage.

Leaf damage, larval survival and weight gain by the larvae during flowering stage was lower compared to that at the vegetative stage. This may be due to increase in acidity in leaves with age (Koundal and Sinha, 1981). As amount of acid exudates on leaves is responsible for resistance in chickpea (Lateef, 1985; Rembold *et al*., 1989; Patnaik and Senapati, 1995) the resistance levels also increased during the flowering stage.

Table 5 : Relative feeding preference of *H. armigera* larvae towards washed and unwashed leaves of eighteen chickpea genotypes, ICRISAT, Patancheru, 2000-02.

Genotypes	Damage rating (0-9) scale			Relative larval preference (%)		
	Unwashed	Washed	t (value)	Unwashed	Washed	t (value)
ICC 12476	2.8[a]	3.7[a]	-1.52	26[a]	38[b]	-2.55
ICC 12477	3.6[a]	4.1[a]	-.76	32[a]	47[b]	-5.23
ICC12478	2.6[a]	3.7[b]	-2.87	27[a]	38[b]	-2.82
ICC 12479	2.9[a]	4.4[b]	2.57	29[a]	45[b]	-4.95
ICC 12490	3.0[a]	4.0[a]	-1.17	30[a]	39[b]	-2.38
ICC 14876	2.8[a]	4.2[b]	-3.03	29[a]	40[b]	-3.16
ICC 12426	4.7[a]	5.7[a]	-1.01	45[a]	45[a]	0
ICC 3137	4.8[a]	5.8[a]	-1.02	34[a]	38[a]	-.95
ICC 12491	3.0[a]	4.1[a]	-1.14	34[a]	38[a]	-1.1
ICC 12492	3.2[a]	3.5[a]	-.47	37[a]	41[b]	-3.82
ICC 12493	3.5[a]	4.6[a]	-1.16	37[a]	43[b]	4.35
ICC 12494	2.9[a]	3.3[b]	-2.64	34[a]	37[b]	-3.49
ICC 12495	3.2[a]	4.5[b]	-2.42	33[a]	39[b]	-1.86
ICC 12968	3.5[a]	3.8[a]	-1.24	30[a]	35[a]	-1
ICC 4973	3.9[a]	4.9[a]	1.1	45[a]	53[b]	-3.09
ICC 4962	4.0[a]	5.0[a]	-1.16	40[a]	46[a]	-8.4
Checks						
ICC 12475 (R)	2.6[a]	4.3[b]	-3.91	22[a]	38[b]	-3.98
ICC 4918 (S)	3.3[a]	4.4[a]	-1.87	35[a]	41[a]	-1.86
Mean	3.35	4.33		33.33	41.2	

Means followed by same letters within the row do not differ significantly; Number of larvae =100; Damage rating 0-9 scale (0= no damage, 1 = < 10%, 2 = 11 to 20%, 3 = 21 to 30%, 4 = 31 to 40%, 5 = 41 to 50%, 6 = 51 to 60%, 7 = 61 to 70%, 8 = 71 to 80% and 9 = > 80% leaf area damaged).

Table 6 : Relative feeding preference and development of *H armigera* larvae on washed and unwashed leaves of eighteen chickpea genotypes, ICRISAT, Patancheru, 2000-02.

Genotypes	Damage rating (0-9 scale)			Larvae survival (%)			Unit larval weight (mg)		
	Unwashed	Washed	Mean	Unwashed	Washed	Mean	Unwashed	Washed	Mean
ICC 12476	A 3.6[abc]	A3.7a	3.7	A40ab	A 54[bcdef]	47	6.8	9.9	8.4
ICC 12477	A 6.2[f]	A 4.4[abc]	5.3	A 45[ab]	A 55[bcdefg]	50	8.8	12.3	10.6
ICC 12478	A 4.2[abcd]	A 4.4[abc]	4.3	A 40[ab]	A 53[bcde]	46	7.3	9.7	8.5
ICC 12479	A 3.4[bcd]	A 4.4[abc]	4.4	A 46[abc]	A 50[abcde]	48	4.1	5.4	4.8
ICC 12490	A 5.0[def]	A 4.0[ab]	4.5	A 44[ab]	A 56[bcdefg]	50	9.6	13.4	11.5
ICC 14876	A 6.2[f]	A 5.7[def]	6.0	A 60[de]	A 61[de]	61	9.0	12.1	10.6
ICC 12426	A 8.6[g]	B 5.3[cd]	7.0	A 82[fh]	A 71[g]	77	11.9	9.2	10.6
ICC 3137	A 8.6[g]	B 6.1[e]	7.4	A 88[gh]	B 64[ef]	76	13.3	12.1	12.7
ICC 12491	A 3.4[ab]	A 3.8[a]	3.6	A 44[ab]	A 46[abc]	45	7.2	9.2	8.2
ICC 12492	A 3.3[ab]	A 4.0[ab]	3.7	A 33[a]	A 45[ab]	39	4.4	5.9	5.2
ICC 12493	A 3.9[abcd]	A 4.0[ab]	4.0	A 39[a]	A 49[ab]	44	7.2	9.8	8.5
ICC 12494	A 4.1[abcd]	A 4.7[ab]	4.4	A 40[ab]	A 50[ab]	45	5.2	6.5	5.9
ICC 12495	A 4.6[cd]	A 5.1[bcde]	4.9	A 54[bc]	A 60[cdef]	57	7.6	9.1	8.4
ICC 12968	A 4.9[de]	B 6.2[fg]	5.6	A 55[bc]	A 68[c]	62	8.1	11.4	4.6
ICC 4973	A 6.0[cf]	A 5.4[cde]	5.7	A 70[ef]	A 60[cdef]	65	10.3	12.8	11.6
ICC 4962	A 7.0[f]	A 6.8[f]	6.9	A 79[fh]	A 72[g]	76	10.5	13.2	11.9

Table 6 continued...

Table 6 continued...

Checks									
ICC 12475 (R)	A 3.2[a]	A 3.7[a]	3.5	A 36[a]	A 38[a]	37	4.3	5.3	4.8
ICC 4918 (S)	A 6.8[f]	B 5.0[bcde]	5.9	A 62[e]	A 68[e]	63	11.5	10.1	10.8
Mean	A 5.013	A 4.836	4.93	A52.69	A 55.97	54.33	8.2	9.2	8.7
	F (prob. at 5%)	SED	LSD	F (prob. at 5%)	SED	LSD	F (prob. at 5%)	SED	LSD
Treat	0.066	0.121	0.243	0.066	1.771	3.50	0.399	0.0016	0.003
Ent	<.001	0.427	0.845	<.001	5.313	10.50	0.048	0.0050	0.009
Treat*Ent	<.001	0.601	1.200	0.018	7.514	14.85	0.054	0.0071	0.014
CV%	19.3			21.9			25.1		

Number of larvae=100; Means followed by same capital letters within the row do not differ significantly; Means followed by same lower case subscript within the column do not differ significantly, S – Susceptible check; R – Resistant check; Damage rating 0-9 scale (0= no damage, 1 = < 10% leaf area damaged, 2 = 11 to 20%, 3 = 21 to 30%, 4 = 31 to 40%, 5 = 41 to 50%, 6 = 51 to 60%, 7 = 61 to 70%, 8 = 71 to 80% and 9 = > 80% leaf area damaged).

Relative preference of *H. armigera* larvae towards washed and un-washed chickpea leaves

Significantly greater feeding was recorded on washed leaves compared to unwashed leaves in ICC 12475, ICC 12478, ICC 12479, ICC 14876, ICC 12495 and ICC 12494. This suggested that water-soluble compounds in the leaf exudates (malic and oxalic acid) were primarily responsible for the resistance of the genotypes to *H. armigera*. Leaf exudate plays an important role in *H. armigera* resistance in chickpea (Rembold, 1981; Rembold *et al*., 1989 and 1990; Rembold and Weigner, 1990 and Yoshida, 1997).

Presence of significantly more number of larvae on washed leaves of ICC 12475, ICC 12476, ICC 12477, ICC 12478, ICC 12479, ICC 12490, ICC 14876, ICC 12492, ICC 12493, ICC 12495 and ICC 4973 indicated that the larvae preferred washed leaves than unwashed leaves. Non-significant difference between washed and unwashed leaves of ICC 12426, ICC 3137, ICC 12968, ICC 4962 and ICC 4918 suggested that the amounts of leaf exudates in these genotypes were quite low. Lateef (1985) suggested amount of acid exudates on leaves could be used as criteria for distinguishing chickpea genotypes for resistance to *H. armigera*. Low amount of acidity in the leaf extracts of genotypes was associated with susceptibility to *H. armigera* (Srivastava and Srivastava, 1989; Bhagwat *et al*., 1995 and Yoshida, 1997). When the larvae were reared on washed and unwashed leaves separately, mean damage rating was high on unwashed leaves compared to the washed leaves.

Non-significant difference between washed and unwashed leaves of ICC 12426, ICC 3137, ICC 12968, ICC 4962 and ICC 4918 suggested that the amounts of leaf exudates in these genotypes were quite low.

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