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Relative Susceptibility of Chickpea Genotypes against Pulse Beetle *Callosobruchus maculatus* (Fab.)

P Chaithanya, T Madhumathi, Ch Chiranjeevi, S Krishnam Raju, K N Sreenivasulu and T Srinivas
Department of Entomology, Agricultural College, ANGRAU, Bapatla, Andhra Pradesh

ABSTRACT

Twenty chickpea genotypes including thirteen *desi* and seven *kabuli* type were screened against pulse bruchid through no choice test at Department of Entomology, Agricultural College, Bapatla during 2020-21. The genotypes were studied for different growth, development and damage parameters of pulse beetle. Among all the chickpea genotypes, the *desi* types *viz*., NBeG 452, NBeG 1129, ICC 86111 and NBeG 776 were categorized as less susceptible and the *kabuli* types *viz*., NBeG 440, NBeG 789 and NBeG 833 were highly susceptible against pulse beetle based on few or all the parameters studied *viz*., number of eggs laid, number of adults emerged, growth index, grain damage, weight loss and number of exit holes per ten grains.

Keywords: *Callosobruchus maculatus, Chickpea, No choice test, Pulse beetle and Screening*

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops widely grown in *rabi* season under dry and rainfed areas of India and having shelf life of more than one year. Grain legumes play an important role in the nutritional security of millions of people as it constitutes a significant portion of the diet with enriched protein and minerals (Mohanapure *et al.*, 2021). During 2020-21, a total of 119.11 lakh tonnes of chickpea was produced in India from an area of 99.96 lakh ha with a productivity of 1192 kg ha^{-1}. Andhra Pradesh stands fifth position in India with 5.33 lakh tonnes of production from an area of 4.69 lakh ha with a productivity of 1136 kg ha^{-1} (MoA & FW, 2021). The total losses of chickpea produce at the national level during harvest and post-harvest handling was 8.41 per cent, with an estimated monetary loss of Rs. 2453 crore, including 1.18 per cent loss with bruchids (Jha *et al.*, 2015), accounting for the majority of storage losses.

Callosobruchus maculatus (Fab.) is a cosmopolitan insect pest that can cause significant losses in stored chickpeas, even up to cent per cent in tropical countries like India, rendering the grain unfit for food or seed within 4-6 months. The considerable damage and economic losses by bruchids are realized mostly during storage where bruchids complete a major part of their life cycle and multiply rapidly in favourable environmental conditions, such as high humidity and optimal temperature (Appleby and Credland, 2004).

Host Plant Resistance (HPR) is one of the most effective methods and is adopted for decades to identify the traits in the host plants that confer resistance against the insect pests. As the seeds of chickpea are vulnerable, both in the field and storage, to pulse beetles there is a need to identify the bruchid resistant sources through proper screening and to develop cultivars with bruchid resistance through breeding methods. Breeding legume crops with identified resistant sources against storage insect pests is an environmentally benign technology that offers a simple and economical approach to minimize bruchid damage (Swamy *et al*., 2019). The present study was taken to identify the resistant sources for bruchids in chickpea.

MATERIAL AND METHODS

The experiment was carried out in the Department of Entomology laboratory, Agricultural College, Bapatla, Andhra Pradesh during 2020-21. The insect culture was developed on chickpea by introducing few pairs of pulse beetles by following the procedure given by Andrewartha (1961). The males and females of *C. maculatus* were distinguished by the shape and size of the abdomen, being shorter in the male, with the dorsal side of terminal segments curved sharply downwards, as compared with that of the female. The females were larger than males and the tergal plate covering the tip of the abdomen (pygidium) was enlarged and darkly coloured on both sides whereas in males it was smaller without stripes.

Disinfestation of Test Genotypes

The twenty genotypes of chickpea were subjected to disinfestation by fumigating with aluminium phosphide tablets @ 3 tablets per ton for seven days to reduce the hidden infestation if any. Then, the grains were well aerated to remove phosphine residues.

Screening of Chickpea Genotypes through No-choice test

No-choice test was conducted in plastic containers of 200 g capacity covered with caps. Small micro-pin holes were made on the caps for aeration (Duraimurugan *et al.*, 2014 and Swamy *et al.*, 2019). The healthy chickpea grains (100 g) of each genotype were taken in a plastic container separately in three replications. Five pairs of one day old *C. maculatus* beetles were released into each container and kept undisturbed till five days for oviposition. After five days, the beetles were removed from the containers and a sub sample of 100 grains was taken from each replication. The containers were kept undisturbed till the adult emergence. Total number of adults emerged, weight loss was recorded from the main samples at 40 days after release and the number of eggs laid, daily adult emergence and grain damage was recorded from the sub sample. Mean development period (MDP) and growth index (GI) were also calculated.

Observations Recorded

Number of Eggs Laid: After removing the adult beetles from test genotypes after five days, the number of eggs laid on the surface of the grains of each genotype was counted with the help of hand lens and the mean number of eggs laid by the test insect per 100 grains sample of chickpea grains was calculated.

Number of Adults Emerged: The number of adults emerged was recorded from the main sample of each replication.

Mean Development Period: The mean development period of test insect in each test genotype was calculated by using the data obtained from the number of adults emerged on each day and the number of days required for adult emergence from each treatment based on the formula suggested by Howe (1971).

$$D = \frac{\sum (A \times B)}{C}$$

Where, A = Number of adults emerged on n^{th} day; B = 'n' days required for their emergence; C = Total number of adults emerged during the experimental period; and D = Mean development period (days)

Growth Index (GI): The growth index was calculated by following formula,

$$GI = \frac{\text{Per cent adult emergence}}{\text{Mean development period}}$$

Grain Damage: A representative sample of 100 grains from each genotype in three replications was separated. These grains were weighed for calculating per cent grain damage by weight (Lal, 1990).

Per cent grain damage (by weight) =

$$\frac{\text{Weight of bored grains}}{\text{Total weight of grains}} \times 100$$

Weight Loss: The final weight of the grains (including sub sample) was taken and the weight loss due to insect infestation was calculated by the following formula.

Weight Loss (%) =

$$\frac{\text{Initial weight of sample} - \text{Final weight of sample}}{\text{Initial weight of sample}} \times 100$$

Number of Exit Holes per 10 Grains: Ten seeds were selected randomly from each replication and counted the number of exit holes formed due to emergence of adult insect of *C. maculatus*.

Categorization of Test Genotypes

The chickpea genotypes were categorized into less susceptible, moderately susceptible and highly susceptible based on number of eggs laid, number of adults emerged, growth index, grain damage, weight loss and number of exit holes per 10 grains. The values exceeding the sum of mean and standard deviation (>Mean+SD) were grouped into highly susceptible and values less than the difference of mean and standard deviation (<Mean-SD) into less susceptible. Moderately susceptible group the values which fall in between the highly and less susceptible (Mean-SD to Mean+SD) (Shivalingaswamy and Balasubramanian, 1992).

Statistical Analysis

The recorded data were subjected to suitable transformations (Gomez and Gomez, 1984) and then subjected to ANOVA in completely randomized design (CRD) by using SPSS software.

RESULTS AND DISCUSSION

Screening of Chickpea Genotypes

The performance of the chickpea genotypes for number of eggs laid per 100 grains, number of adults emerged per 100 g grains, mean developmental period, growth index, per cent grain damage (by weight), per cent weight loss, number of exit holes per 10 grains due to the damage by *C. maculatus* is presented in Table 1.

The results indicated that the insects showed varied response to chickpea grains of different genotypes for oviposition, consequent population buildup and damage. None of the varieties was free from oviposition by pulse beetle. The number of eggs laid varied from 25.00 to 91.67 per 100 grains in different genotypes. NBeG 49, NBeG 452 and ICC 86111 were found superior over other genotypes by recording the lowest number of eggs (25.00). The genotype, NBeG 789, recorded the highest number of eggs (91.67) which significantly differed with all the genotypes. The number of *C. maculatus* adults emerged from 100 g grains varied from 73.33 (NBeG 49) to 246.00 (NBeG 789).

The mean development period of *C. maculatus* on different genotypes of chickpea was in the range of 26.55 to 28.08 days. NBeG 452 was found superior with the longest mean development period (28.08 days) which was on par with ICC 86111 (28.00 days). The shortest mean development period was recorded in NBeG 810 (26.55 days), which was on par with NBeG 440, NBeG 789, NBeG 119, NBeG 833, KAK 2 and Vihar which recorded 26.59, 26.62, 26.68, 26.72, 26.75 and 26.84 days respectively and significantly differed with remaining genotypes. The growth index of *C. maculatus* varied from 2.68 (NBeG 1129) to 3.70 (NBeG 789).

The per cent grain damage (by weight) caused by *C. maculatus* in different genotypes of chickpea was in the range of 18.18 to 68.24 per cent. The genotype, NBeG 1129 recorded the lowest (18.18%) per cent grain damage which was on par with NBeG 452 (18.70%), NBeG 49 (19.44%), ICC 86111 (19.89%) and NBeG 776 (20.82%). The highest per cent grain damage was observed in NBeG 789 with 68.24 per cent. The weight loss of different genotypes of chickpea due to *C. maculatus* varied from 3.78 to 10.98 per cent. The genotype, ICC 86111 recorded minimum per cent weight loss (3.78%) and was on par with NBeG 1129 and NBeG 452 which recorded 4.35 and 4.86 per cent weight loss, respectively. Maximum weight loss was observed in NBeG 789 (10.98%). The number of exit holes per ten grains of different chickpea genotypes due to the damage of *C. maculatus* was in the range of 2.67 (NBeG 49, NBeG 452 and NBeG 1129) to 18.00 (NBeG 789). The above findings are in accordance with the works of Raghuwanshi *et al*. (2016), Eker *et al*. (2018), Swamy *et al*. (2019) and Kumari *et al.* (2020) on different chickpea genotypes.

Categorisation of Chickpea Genotypes

The chickpea genotypes were categorized into less susceptible, moderately susceptible and highly susceptible on the basis of above-mentioned parameters and is presented in table 2.

The genotypes, NBeG 452 and NBeG 1129, were categorised as less susceptible based on all the parameters studied, which may be due to non-preference as well as antibiosis mechanisms of resistance, while, the genotype, NBeG 49, was less susceptible with respect to number of eggs laid per 100 grains, number of adults emerged from 100 g grains, per cent grain damage (by weight) and number of exit holes per ten grains and moderately susceptible with respect to growth index and per cent weight loss.

The genotype ICC 86111 was less susceptible with respect to number of eggs laid per 100 grains, per cent grain damage (by weight), per cent weight loss and number of exit holes per ten grains and moderately susceptible with respect to number of adults emerged from 100 g grains and growth index. Though the number of eggs laid were low, the number of adults emerged and growth index were more on ICC 86111, showing moderate susceptibility to *C. maculatus*, which clearly shows the effect of nutritional parameters on growth and development of *C. maculatus*. The genotype, JG 11, was found to be less susceptible with respect to growth index only, which may be due to antibiosis and moderately susceptible with respect to remaining parameters. The genotype NBeG 776 was less susceptible with respect to number of adults emerged from 100 g grains, growth index and per cent grain damage (by weight) and moderately susceptible with respect to number of eggs laid per 100 grains, per cent weight loss and number of exit holes per ten grains. Though the number of adults emerged from 100 g grains, growth index and per cent grain damage (by weight) due to *C. maculatus* were low, the number of eggs laid per 100 grains was more, which clearly shows the antibiosis mechanism of resistance operating in NBeG 776 towards *C. maculatus*.

The remaining genotypes were categorised as moderately susceptible and highly susceptible to *C. maculatus*. The genotypes, NBeG 440 and NBeG 789, were categorised as highly susceptible on the basis of all parameters and NBeG 833, was highly susceptible based on all parameters except number of adults emerged per 100 g grains and per cent weight loss, whereas the genotype, Vihar was categorised as highly susceptible based on number of adults emerged per 100 g grains. The moderate and high susceptibility of genotypes towards *C. maculatus* is mainly due to high preference and favourable nutritional factors for growth and development of pulse beetle. These findings are in accordance with earlier work done by Swamy *et al*. (2019) on different chickpea genotypes and categorised the *desi* chickpea types as less susceptible to pulse beetle when compared to *kabuli* types.

Among the twenty chickpea genotypes screened against *C. maculatus*, the *desi* types *viz*., NBeG 452, NBeG 1129, ICC 86111 and NBeG 776 were categorized as less susceptible and the *kabuli* types *viz*., NBeG 440, NBeG 789 and NBeG 833 were grouped as highly susceptible against pulse beetle based on few or all the parameters studied *viz*., number of eggs laid, number of adults emerged, growth index, grain damage, weight loss and number of exit holes per ten grains.

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Table 1. Population growth, developmental and damage parameters of *C. maculatus* on different chickpea genotypes through no-choice test

S. No.	Chickpea genotype	No. of eggs laid per 100 grains*		No. of adultsemerged per 100 g grains#		Mean development period (Days)*		Growth index	Per cent grain damage (by weight) $		Per centweight loss*		No. of exit holes per 10 grains*	
1	NBeG 3	32.67	(5.71)^{hi}	93.67	(1.97)^{jk}	27.63	(5.26)^{bc}	2.96^{efghi}	24.91	(29.90)^{gh}	6.65	(2.58)^{ef}	3.67	(1.91)^{hi}
2	NBeG 47	44	(6.63)^{ef}	136.67	(2.14)^{fg}	27.32	(5.23)^{cd}	3.16^{def}	34.98	(36.25)^{ef}	9.51	(3.08)^{abc}	5.33	(2.31)^{fg}
3	NBeG 49	25	(5.00)^{k}	73.33	(1.86)^{n}	27.36	(5.23)^{cd}	3.03^{efgh}	19.44	(26.15)^{j}	5.96	(2.44)^{fg}	2.67	(1.63)^{i}
4	NBeG 452	25	(4.99)^{k}	82.33	(1.92)^{lm}	28.08	(5.30)^{a}	2.82^{hi}	18.7	(25.61)^{j}	4.86	(2.19)^{gh}	2.67	(1.61)^{i}
5	ICC 86111	25	(5.00)^{k}	121.67	(2.08)^{hi}	28	(5.29)^{ab}	2.94^{efghi}	19.89	(26.46)^{ij}	3.78	(1.94)^{h}	3	(1.72)^{i}
6	JG 11	35.67	(5.97)^{h}	116.67	(2.07)^{i}	27.3	(5.22)^{cd}	2.85^{ghi}	25.64	(30.41)^{gh}	7.36	(2.71)^{def}	4.33	(2.08)^{gh}
7	NBeG 699	31	(5.57)^{i}	98	(1.99)^{j}	27.28	(5.22)^{cd}	3.08^{defgh}	24.33	(29.54)^{ghi}	6.35	(2.51)^{f}	5	(2.24)^{fg}
8	NBeG 776	29.33	(5.41)^{ij}	81	(1.91)^{m}	27.42	(5.24)^{cd}	2.86^{fghi}	20.82	(27.12)^{hij}	9.51	(3.08)^{abc}	4.67	(2.16)^{gh}
9	NBeG 779	47.67	(6.90)^{de}	154	(2.19)^{e}	27.28	(5.22)^{cd}	3.20^{cde}	38.07	(38.09)^{cdef}	8.65	(2.94)^{bcd}	5.67	(2.38)^{efg}
10	NBeG 857	52.67	(7.26)^{cd}	178.67	(2.25)^{d}	27.25	(5.22)^{cde}	3.18^{cde}	41.92	(40.34)^{cd}	8.16	(2.85)^{cde}	6.33	(2.51)^{ef}
11	NBeG 1129	25.67	(5.06)^{jk}	77	(1.89)^{mn}	27.63	(5.26)^{bc}	2.68^{i}	18.18	(25.22)^{j}	4.35	(2.08)^{h}	2.67	(1.63)^{i}
12	NBeG 1137	41	(6.40)^{fg}	155	(2.19)^{e}	27.12	(5.21)^{def}	3.24^{bcde}	33.37	(35.28)^{f}	7.22	(2.68)^{def}	5.33	(2.31)^{fg}
13	NBeG 1174	46.33	(6.80)^{e}	176	(2.25)^{d}	27.32	(5.23)^{cd}	3.16^{def}	36.6	(37.21)^{def}	8.52	(2.92)^{bcd}	7	(2.64)^{de}
14	NBeG 119	36.67	(6.05)^{gh}	89.33	(1.95)^{kl}	26.68	(5.17)^{g}	3.14^{defg}	27.6	(31.69)^{g}	10	(3.16)^{ab}	6.33	(2.51)^{ef}
15	NBeG 810	52	(7.21)^{cd}	113.67	(2.06)^{i}	26.55	(5.15)^{g}	3.21^{bcde}	40.06	(39.26)^{cde}	9.64	(3.10)^{abc}	8.33	(2.89)^{cd}
16	KAK 2	56.33	(7.50)^{c}	132	(2.12)^{gh}	26.75	(5.17)^{fg}	3.05^{defgh}	42.55	(40.71)^{c}	8.18	(2.86)^{cd}	8.67	(2.94)^{cd}
17	Vihar	57.33	(7.57)^{c}	195.33	(2.29)^{c}	26.84	(5.18)^{efg}	3.34^{bcd}	43.37	(41.16)^{c}	9.66	(3.11)^{abc}	10	(3.14)^{c}
18	NBeG 440	74.67	(8.64)^{b}	222	(2.35)^{b}	26.59	(5.16)^{g}	3.51^{ab}	55.22	(48.01)^{b}	10.94	(3.31)^{a}	16	(4.00)^{ab}
19	NBeG 789	91.67	(9.57)^{a}	246	(2.39)^{a}	26.62	(5.16)^{g}	3.70^{a}	68.24	(55.71)^{a}	10.98	(3.31)^{a}	18	(4.24)^{a}
20	NBeG 833	69	(8.31)^{b}	144.67	(2.16)^{ef}	26.72	(5.17)^{fg}	3.49^{abc}	54.99	(47.87)^{b}	7.28	(2.69)^{def}	13.67	(3.69)^{b}
SEm(±)		**0.138**		**0.013**		**0.014**		**0.108**	**1.154**		**0.097**		**0.109**	
CD (5% LOS)		**0.395**		**0.036**		**0.04**		**0.308**	**3.298**		**0.277**		**0.313**	

Values in parenthesis are * square root, # log, and $ angular transformed values; In each column values with similar alphabet do not vary significantly at p=0.05

Table 2. Relative susceptibility of chickpea genotypes to *C. maculatus* through no-choice test

Parameter	Less susceptible (<Mean–SD)	Moderately susceptible (Mean–SD to Mean+SD)	Highly susceptible (>Mean+SD)
No. of eggs per 100 grains **Mean=6.58** **SD=1.28**	NBeG 49, NBeG 452, ICC 86111, NBeG 1129	NBeG 3, NBeG 47, JG 11, NBeG 699, NBeG 776, NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, Vihar	NBeG 440, NBeG 789, NBeG 833
No. of adultsemerged per 100 g grains **Mean= 2.10** **SD=0.15**	NBeG 49, NBeG 452, NBeG 776, NBeG 1129	NBeG 3, NBeG 47, ICC 86111, JG 11, NBeG 699, NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, NBeG 833	Vihar, NBeG 440, NBeG 789
Growth index **Mean=3.13** **SD= 0.25**	NBeG 452, JG 11, NBeG 776, NBeG 1129	NBeG 3, NBeG 47, NBeG 49, ICC 86111, NBeG 699, NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, Vihar	NBeG 440, NBeG 789, NBeG 833
Per cent grain damage (by weight) **Mean= 35.60** **SD= 8.29**	NBeG 49, NBeG 452, ICC 86111, NBeG 776, NBeG 1129	NBeG 3, NBeG 47, JG 11, NBeG 699, NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, Vihar	NBeG 440, NBeG 789, NBeG 833
Per cent weight loss **Mean= 2.78** **SD= 0.38**	NBeG 452, ICC 86111, NBeG 1129	NBeG 3, NBeG 47, NBeG 49, JG 11, NBeG 699, NBeG 776,NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, Vihar, NBeG 833	NBeG 440, NBeG 789
No. of exit holes per 10 grains **Mean= 2.53** **SD= 0.75**	NBeG 49, NBeG 452, ICC 86111, NBeG 1129	NBeG 3, NBeG 47, JG 11, NBeG 699, NBeG 776, NBeG 779, NBeG 857, NBeG 1137, NBeG 1174, NBeG 119, NBeG 810, KAK 2, Vihar	NBeG 440, NBeG 789, NBeG 833

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