LR-5236
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RESEARCH ARTICLE

Legume Research- An International Journal

Influence of Physico-chemical Traits of Chickpea Genotypes on Preference and Non-preference of Pulse Beetle, *Callosobruchus maculatus* (Fab.)

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10.18805/LR-5236

ABSTRACT

Background: Chickpea is one of the most important and nutritionally rich pulse crops widely grown in India. Pulse beetle is a cosmopolitan insect pest that can cause significant losses in stored chickpeas. Host Plant Resistance, one of the most effective methods, being adopted for decades to identify the traits in the host plants that confer resistance against the insect pests. The present study has been undertaken to screen different genotypes of chickpea against pulse beetle and to understand the influence of physico-chemical traits of chickpea genotypes on the population buildup of pulse bruchid.

Methods: Twenty chickpea genotypes including thirteen *desi* and seven *kabuli* type were screened against pulse beetle through free choice test at Department of Entomology, Agricultural College, Bapatla during 2020-21. Certain physical and biochemical parameters of chickpeas were assessed and the level of their influence on growth and development of pulse bruchid was estimated by correlation and regression analyses.

Result: The *desi* chickpea genotypes *viz.*, NBeG 452, NBeG 1129, ICC 86111, NBeG 49 and NBeG 776 with less oviposition, less number of adults emerged, less grain damage were found relatively with less test weight, total soluble sugars and more seed coat thickness, total phenols and tannins, and the *kabuli* genotypes *viz.*, NBeG 440, NBeG 789 and NBeG 833 with more oviposition, more number of adults emerged, more grain damage were found relatively with more test weight, total soluble sugars and less seed coat thickness, total phenols and tannins. Thus, test weight, total soluble sugars exhibited significant positive correlation with growth and damage parameters of pulse beetle, while the seed coat thickness, total phenols and tannins exhibited significant negative correlation. Despite the fact that the biochemical components of the genotypes of chickpea varied significantly, they had little effect on the development of pulse bruchid.

Key words: Biochemical and physical parameters, Chickpea, Pulse beetle, Screening.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops widely grown in *rabi* season under dry and rainfed areas of India, accounting for roughly 70 per cent of total area and 67 per cent of total production and also grown in approximately 57 countries across the globe under diverse agro-climatic conditions (Siddique *et al*., 2000). 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}. It is the most popular food legume with shelf life of more than one year and high in vitamins, minerals, fibre and also contain beneficial phyto-chemicals. 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 100% per cent in tropical countries like India, rendering the grain unfit for food or seed within 4-6 months (Wolfson *et al*., 1991).

Host plant resistance (HPR), one of the most effective methods, being adopted for decades to identify the traits in

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How to cite this article: Chaithanya, P., Madhumathi, T., Chiranjeevi, C., Raju, S.K., Sreenivasulu, K.N. and Srinivas, T. (2024). Influence of Physico-chemical Traits of Chickpea Genotypes on Preference and Non-preference of Pulse Beetle, *Callosobruchus maculatus* (Fab.). Legume Research. doi: 10.18805/LR-5236.

Submitted: 27-08-2023 **Accepted:** 13-01-2024 **Online:** 06-03-2024

the host plants that confer resistance against the insect pests. As the chickpea seeds are vulnerable in both field and storage to pulse beetles, there is a need to identify the bruchid resistant chickpea sources through proper screening methods and develop cultivars with resistance to bruchids through proper 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 grain physical characters, nutritional and anti-nutritional factors of the legumes will also affect the development of bruchids to a greater extent (Rekha *et al*., 2017). Association between insect growth, oviposition preferences and grain parameters would assist in identifying the aspects that should be prioritized during crop breeding programmes (Swamy *et al*., 2020). Assessment of biochemical components in legumes is required to identify the key components aid in resistance against bruchids. Thus, legume cultivars with favourable components can be genetically engineered. In light of these facts, the current investigation was carried out to screen various chickpea genotypes against the pulse beetle, *C. maculatus* and to comprehend the impact of chickpea genotype physico-chemical traits on the growth and development of the pulse bruchid under laboratory storage conditions.

MATERIALS AND METHODS

Twenty pre released and released chickpea genotypes including thirteen *desi* type *viz*., NBeG 3 (Nandyal Sanaga 1), NBeG 47 (Dheera), NBeG 49 (Nandyal Gram 49), NBeG 452 (Nandyal Gram 452), ICC 86111, JG 11, NBeG 699, NBeG 776, NBeG 779, NBeG 857 (Nandyal Gram 857), NBeG 1129, NBeG 1137 and NBeG 1174; and seven *kabuli* type *viz*., NBeG 119 (Nandyal Gram 119), NBeG 810 (Nandyal Gram 810), KAK 2, Vihar, NBeG 440, NBeG 789 and NBeG 833 procured from Regional Agricultural Research Station (RARS), Nandyal andhra Pradesh were screened against *C. maculatus* under free-choice conditions during 2020-21 (Plate 1). In addition to the screening experiment, the chickpeas' physical characteristics and biochemical parameters that might affect the preference and population growth of the pulse beetle were examined. Later, correlation and regression analyses were used to determine how much each parameter affected the growth and development of the pulse bruchid, both individually and together. Before experimentation, in order to reduce any hidden infestation, the test genotypes were subjected to disinfestation by being fumigated for seven days with aluminum phosphide tablets @ 3 tablets per ton. To get rid of phosphine residues, the grains were then thoroughly aerated.

Rearing of the test insect

The insect culture was established on chickpea by introducing a few pairs of pulse beetles collected from the post-harvest technology centre in Bapatla andhra Pradesh, as described by Andrewartha (1961). *C. maculatus* mother culture was grown in the laboratory on a locally available chickpea variety, JG-11.

Screening of chickpea genotypes through free choice test

Relative preference of pulse bruchid to the different chickpeas genotypes was studied under free-choice test, conducted in artificially designed 'circular screening containers' developed by following modifications over earlier descriptions (Duraimurugan *et al.,* 2014). The circular containers (80 cm diameter and 20 cm H) were made up of a card board with wooden circular base, covered with a transparent polythene cover. The inner flat bottom of the container included 20 plastic cups (5 cm diameter and 2 cm H) arranged at equal distance, where seeds of the genotypes were placed. A single pipe (2.5 cm diameter, 30 cm H) having holes at the bottom was inserted in the center of the flat bottom for insect release. Hundred grains of each chickpea genotype were placed in plastic cups and the circular container was closed with transparent polythene sheet and secured tightly by using cello tape (Plate 2). The pulse beetles (One day old) (80 No.) were released in the middle through the pipe inserted to choose the grains of their choice and the pipe was removed after insects reached their preferred genotypes and closed the hole with cello tape immediately. The adults were carefully removed after five days and the grains were then put into separate plastic containers and left undisturbed until adult emergence. This experiment was replicated thrice, with three circular containers. The observations on number of eggs laid was recorded at five days after release of insects while the adult emergence and grain damage were recorded from the samples after 40 days of insect release. The experiments were conducted in completely randomized block design replicating thrice. The obtained data were subjected to suitable transformations and analysed for comparison.

Physical parameters of chickpea genotypes

Physical parameters of the grains *viz.,* type of grain (*desi/ kabuli*), test weight (100 grain weight) and seed coat thickness were recorded. Test weight of each genotype was measured with the help of analytical balance and expressed in grams and for the thickness of seed coat, the grains were picked at random from each genotype in three replications and soaked for two hours. After soaking, seed coat was removed carefully and dried at 50°C for 24 hours by using hot air oven. Then, it was measured by using digital Vernier's scale. The mean of thickness of seed coat of ten grains was calculated and expressed in millimeters.

Biochemical components in chickpea genotypes

The chickpea genotypes were analysed for the biochemical components, *viz*., total soluble sugars, total phenols, tannins the protocols given by Yemm and Willis (1954), Malik and

Singh (1980) and Schanderi (1970) were followed, respectively. The data were subjected to ANOVA by Completely randomized design, with three replications. Impact of the physical and biochemical parameters was expressed by correlating them separately and also in combination with number of eggs laid, adult emergence and grain damage using the SPSS statistical software version 21.0.

RESULTS AND DISCUSSION

The data on number of eggs laid, pulse beetle adults and grain damage of chickpea genotypes under free choice conditions indicated that there were significant differences in insect preference and non-preference towards the genotypes of chickpea grains (Table 1). NBeG 452 was found superior over other genotypes by recording least number of

Plate 1: Chickpea genotypes used in the screening against pulse beetle, *C. maculatus.*

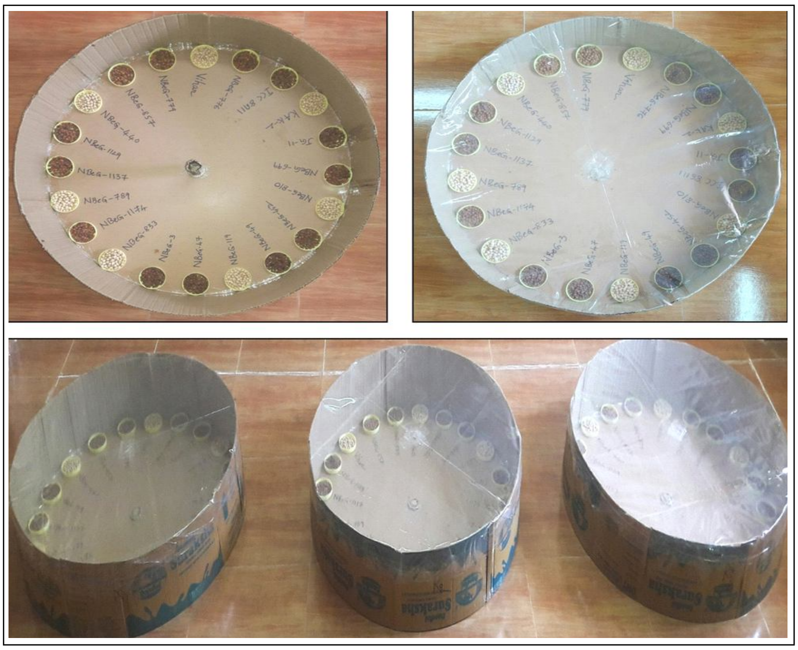

Plate 2: Free-choice test of screening of chickpea genotypes against pulse beetle, *C. maculatus.*

Table 1: Developmental response of pulse beetle, *C. maculatus* to certain chickpea genotypes along with the physical and biochemical parameters.

Tr. no.	Chickpea genotype	Pulse beetle response: No. of eggs laid per 100 grains*	Pulse beetle response: No. of adults emerged per 100 grains*	Pulse beetle response: Per cent grain damage (by weight)$	Physical parameters: Test weight (g) (Mean±SE)	Physical parameters: Seed coat thickness (mm) (Mean±SE)	Biochemical constituents: TSS (%) (Mean±SE)	Biochemical constituents: Total phenols (mg CAE 100 g^{-1}) (Mean±SE)	Biochemical constituents: Tannins (mg TAE g^{-1}) (Mean±SE)
1.	NBeG 3	31.67 (5.62)^{h}	25.67 (5.06)^{h}	25.22 (30.12)^{h}	28.67±0.09^{f}	0.110±0.006^{g}	65.60±0.21^{g}	100.18 ±0.55^{e}	4.63±0.10^{bcd}
2.	NBeG 47	38.67 (6.22)^{g}	32.67 (5.71)^{fg}	29.75 (33.04)^{fg}	28.20±0.12^{gh}	0.153±0.003^{cde}	64.44±0.09^{gh}	96.47±0.54^{fg}	4.21±0.18^{de}
3.	NBeG 49	27.67 (5.26)^{ij}	20.67 (4.54)^{i}	19.44 (26.15)^{j}	28.63±0.09^{fg}	0.157±0.009^{cd}	65.36±0.15^{g}	118.91±0.42^{a}	5.15±0.18^{ab}
4.	NBeG 452	24.33 (4.93)^{j}	19.67 (4.43)^{i}	17.75 (24.91)^{j}	24.73±0.12^{l}	0.173±0.007^{b}	55.94±0.25^{k}	119.06±0.30^{a}	5.46±0.18^{a}
5.	ICC 86111	25.67 (5.06)^{j}	20.67 (4.54)^{i}	19.89 (26.46)^{ij}	17.27±0.15^{op}	0.143±0.003^{def}	63.98±0.77^{hi}	106.79±0.43^{c}	4.63±0.10^{bcd}
6.	JG 11	29.67 (5.45)^{hi}	25.00 (5.00)^{h}	23.26 (28.83)^{hi}	24.30±0.17^{l}	0.137±0.003^{f}	71.66±0.21^{cd}	100.35±0.54^{e}	4.52±0.18^{cd}
7.	NBeG 699	30.33 (5.51)^{hi}	25.33 (5.03)^{h}	23.71 (29.14)^{h}	27.80±0.06^{hi}	0.147±0.003^{def}	60.77±0.96^{j}	97.99±0.66^{f}	4.42±0.10^{cde}
8.	NBeG 776	25.33 (5.03)^{j}	21.00 (4.58)^{i}	19.22 (25.99)^{j}	28.67±0.09^{f}	0.210±0.006^{a}	60.11±0.13^{j}	101.99±0.76^{d}	4.52±0.18^{cd}
9.	NBeG 779	46.67 (6.83)^{de}	41.00 (6.40)^{cd}	37.47 (37.73)^{cde}	27.23±0.12^{j}	0.147±0.003^{def}	63.00±0.42^{i}	95.95±0.85^{g}	3.59±0.18^{fg}
10.	NBeG 857	49.67 (7.04)^{d}	44.33 (6.65)^{c}	40.70 (39.63)^{c}	23.50±0.12^{m}	0.163±0.003^{bc}	70.39±0.30^{e}	86.92±0.49^{j}	3.59±0.18^{fg}
11.	NBeG 1129	25.33 (5.03)^{j}	19.00 (4.35)^{i}	18.18 (25.22)^{j}	25.27±0.15^{k}	0.207±0.003^{a}	59.9±0.68^{j}	115.71±0.59^{b}	4.94±0.21^{abc}
12.	NBeG 1137	39.67 (6.30)^{fg}	36.00 (6.00)^{ef}	33.13 (35.14)^{ef}	23.27±0.15^{m}	0.147±0.003^{def}	63.14±0.30^{i}	91.44±0.68^{i}	3.90±0.18^{ef}
13.	NBeG 1174	43.67 (6.60)^{ef}	39.67 (6.29)^{cde}	37.67 (37.85)^{cd}	22.63±0.09^{n}	0.140±0.006^{ef}	68.30±0.49^{f}	90.50±0.80^{i}	3.48±0.28^{fg}
14.	NBeG 119	33.33 (5.77)^{h}	29.67 (5.45)^{g}	26.91 (31.24)^{gh}	39.27±0.15^{b}	0.083±0.003^{ij}	70.77±0.15^{de}	91.86±0.49^{hi}	2.23±0.10^{i}
15.	NBeG 810	45.67 (6.76)^{de}	40.33 (6.35)^{cde}	36.65 (37.25)^{cde}	39.23±0.12^{b}	0.093±0.009^{hi}	68.76±0.32^{f}	93.25±0.66^{h}	3.17±0.28^{gh}
16.	KAK 2	46.67 (6.83)^{de}	41.67 (6.45)^{cd}	38.50 (38.34)^{cd}	36.13±0.37^{c}	0.073±0.003^{jk}	68.24±0.57^{f}	81.26±0.43^{l}	2.86±0.21^{h}
17.	Vihar	44.67 (6.68)^{e}	39.33 (6.27)^{de}	36.06 (36.90)^{de}	27.40±0.32^{ij}	0.060±0.006^{k}	67.78±0.35^{f}	86.43±0.47^{j}	2.75±0.28^{hi}
18.	NBeG 440	72.67 (8.52)^{b}	66.67 (8.16)^{b}	52.99 (46.72)^{b}	31.33±0.18^{e}	0.060±0.006^{k}	75.36±0.32^{a}	84.48±0.46^{k}	2.75±0.21^{hi}
19.	NBeG 789	90.33 (9.50)^{a}	84.33 (9.18)^{a}	65.27 (53.91)^{a}	35.67±0.12^{d}	0.103±0.003^{gh}	73.65±0.39^{b}	74.25±0.50^{m}	2.23±0.38^{i}
20.	NBeG 833	66.33 (8.14)^{c}	61.33 (7.83)^{b}	51.60 (45.92)^{b}	44.60±0.06^{a}	0.093±0.003^{hi}	72.53±0.17^{bc}	91.03±0.21^{i}	3.06±0.10^{gh}
	SEm (±)	0.13	0.13	0.93	0.16	0.005	0.43	0.56	0.20
	CD (5% LOS)	0.36	0.38	2.66	0.46	0.014	1.22	1.61	0.58

Values in parenthesis are * square root and $ angular transformed values; In each column values with similar alphabet do not vary significantly at p= 0.05;
SE: Standard error; TSS: Total soluble sugars; CAE: Catechol equivalents; TAE: Tannic acid equivalents.

eggs (24.33) which was on par with NBeG 776, NBeG 1129, ICC 86111 and NBeG 49 which recorded 25.33, 25.33, 25.67 and 27.67 eggs, respectively and the genotype, NBeG 789 recorded higher number of eggs (90.33), which significantly differed with all the genotypes. Similarly, NBeG 1129 was found superior over other genotypes by recording the lowest number of adult emergence (19.00) and was on par with NBeG 452 (19.67), NBeG 49 (20.67), ICC 86111 (20.67) and NBeG 776 (21.00) and significantly different from other genotypes, while NBeG 789 recorded with higher adult emergence (84.33). Lowest per cent grain damage was recorded by NBeG 452 (17.75%) by weight method, on par with NBeG 1129 (18.18%), NBeG 776 (19.22%), NBeG 49 (19.44%) and ICC 86111 (19.89%), while, the per cent grain damage was observed highest in NBeG 789 (65.27%) followed by NBeG 440 (52.99%) and NBeG 833 (51.60%), by differing significantly with the remaining genotypes.

Thus, the genotypes NBeG 452, NBeG 1129 and ICC 86111 were categorised as less susceptible, whereas the genotypes NBeG 440, NBeG 789 and NBeG 833 were placed in the highly susceptible group, based on oviposition, adult emergence and grain damage. Smaller grains and a thicker seed coat characterized the genotypes that were less vulnerable. The results of the biochemical studies revealed substantial differences between the test genotypes of chickpea in the amounts of total soluble sugars, total phenols and tannins.

Physical parameters of chickpea genotypes

The test (100 grains) weight of kabuli type chickpeas ranged from 17.27 (ICC 86111) to 44.60 g (NBeG 833) and was significantly greater than that of desi types. The genotype with the smallest test weight (17.27 g) was ICC 86111. A larger grain size is indicated by a higher test weight, which also guarantees a greater supply of food to feed growing insects. The thickness of the seed coat varied among the chickpea genotypes, ranging from 0.060 mm in NBeG 440 to 0.210 mm in NBeG 776.

Biochemical parameters of chickpea genotypes

Higher quantities of total soluble sugars (TSS) were found in the *kabuli* genotypes; NBeG 440 (75.36%), NBeG 789 (73.65%) and NBeG 833 (72.53%). JG 11 has the highest quantity of carbohydrates (71.66%) of the *desi* types. The TSS concentrations were significantly lower in the genotypes NBeG 452 (55.94%), NBeG 1129 (59.98%) and NBeG 776 (60.11%). The largest amount of total phenol was 119.06 mg CAE 100 g^{-1} in NBeG 452, while the lowest amount was 74.25 mg CAE 100 g^{-1} in NBeG 789.

Correlation analyses

Physical parameters of chickpea grains Vs insect preference and non-preference

Test weight and seed coat thickness of chickpea grains were correlated to the insect response, which included oviposition, the number of adults that emerged and grain damage (Table 2). A substantial positive correlation between test weight and oviposition, adult emergence and percent grain damage was found (r= 0.502, 0.504 and 0.498, respectively). With regard to oviposition (r= -0.577), adult emergence (r= -0.583) and percentage of grain damage (r= -0.607), the seed coat thickness was inversely associated.

Biochemical parameters of chickpea grains Vs insect preference and non-preference

With respect to oviposition (r= 0.730), adult emergence (r= 0.734) and percentage of grain damage (r= 0.745), total soluble sugars exhibited a strong positive correlation. In contrast, there was a strong negative association between total phenols and tannins and oviposition, adult emergence and the percentage of grain damage (r= -0.838, -0.798).

Regression analysis

Physical parameters of chickpea grains Vs insect preference and non-preference

A multiple linear regression equation was fitted to the physical characteristics of the several chickpea genotypes,

Table 2: Correlation between response of *C. maculatus* and grain physico-chemical parameters of chickpea genotypes.

Physical parameters / Biological parameters	Oviposition	Adult emergence	Per cent grain damage
Test weight	0.502*	0.504*	0.498*
Seed coat thickness	-0.577**	-0.583**	-0.607**
Total soluble sugars	0.730**	0.734**	0.745**
Total phenols	-0.783**	-0.800**	-0.838**

**Significant at 1% level, *Significant at 5% level.

Table 3: Regression equation for developmental response of pulse beetle, *C. maculatus* against grain physical characteristics of chickpea genotypes.

Particulars	Regression equation	R^2 value
Oviposition	$Y= 43.579 + 0.688 X_1 - 167.522 X_2$	0.373
Adult emergence	$Y= 38.789 + 0.678 X_1 - 168.567 X_2$	0.379
Per cent grain damage	$Y= 37.455 + 0.452 X_1 - 138.496 X_2$	0.396

X_1= Test weight (g), X_2= Seed coat thickness (mm).

including test weight and seed coat thickness, adult emergence and percent grain damage (Table 3). The physical characteristics of chickpea grains were found to have a 39.6% influence on grain damage (R^2= 0.396), a 37.9% influence on adult emergence (R^2= 0.379) and a 37.3% influence on oviposition (R^2= 0.373).

Biochemical parameters of chickpea grains Vs insect preference and non-preference

Similarly, a multiple linear regression equation that took into account oviposition, adult emergence, per cent grain damage and total soluble sugars, total phenols and total tannins of the genotypes of chickpea was fitted (Table 4). The biochemical factors had an impact on grain damage to the amount of up to 74.7% (R^2= 0.747), adult emergence to the extent of 69.5 (R^2= 0.695) and oviposition to the extent of 67.5 (R^2= 0.675).

Physical and biochemical parameters Vs insect preference and non-preference

Multiple linear regression was used to quantitatively analyze the combined impact of physical attributes and biochemical components of chickpea grains from various genotypes on the preference and growth of bruchid insects. According to Table 5, the oviposition was strongly influenced by the physical characteristics and biochemical components of chickpea grains to the extents of 70.1% (R^2= 0.701), 72.2% (R^2= 0.722) and 76.6% (R^2= 0.766).

The results of the current study are consistent with those of earlier studies, which found that differences in the morphological and physical characteristics of different legume seeds, such as seed size and shape and seed coat thickness, affect resistance to bruchid infestation. Test weight of the grains showed a positive correlation with oviposition and adult emergence, while seed coat thickness showed a significant negative correlation with oviposition, adult emergence and grain damage (Eker *et al.,* 2018 and Swamy *et al.,* 2020). As per the Neog and Singh (2011), total soluble sugars had positive influence on oviposition of pulse beetle. Sharma and Thakur (2014) reported that high amounts of carbohydrates were present in the susceptible genotypes. Swamy *et al.* (2020) stated that the chickpea genotypes with higher total soluble sugars were susceptible to bruchids. The total soluble sugars favoured the successful development of pulse beetle (Senthilraja and Patel, 2021). In contrast, total phenols and tannins showed significant negative correlation with oviposition (r= -0.783, -0.756), adult emergence (r= -0.800, -0.772), grain damage (%) (r= -0.838, -0.798). The current research findings are in line with Patel *et al.* (2003), reported negative correlation between egg laying behaviour and phenol content of chickpea grains. Swamy *et al.* (2020) reported that the chickpea genotypes with lower phenols were highly susceptible to bruchids. It was reported that significant negative correlation was there in between seed damage and phenol content (Tripathi *et al*., 2020). High phenols and tannins were detrimental to the growth and development of *C. maculatus* (Senthilraja and Patel (2021). Kaur and Gill (2016) reported that of antinutritional factors such as tannins inside pulses offered resistance against *C. maculatus* development. Kaur *et al.* (2016) reported that the tannins were negatively correlated with adult emergence of *C. maculatus*.

According to Patel *et al*. (2003), more adult emergence and grain damage by the pulse beetle were caused by high test weight and thinner seed coat and the egg-laying behaviour of *C. chinensis* on pulses was inversely correlated with phenol content. Kamble *et al*. (2016) noticed resistance in genotypes with lower test weight. Chickpea genotypes with lower test weight and grain size and more seed coat thickness adversely affected the oviposition, grub penetration and growth of *C. maculatus* as there is hard barrier to enter larvae in to the grain and less space for their development inside the grain (Eker *et al.,* 2018 and Swamy *et al*., 2020). Genotypes possessing higher amounts of total soluble sugars had a significant positive effect and phenols and tannins have significant negative effect on the infestation

Table 4: Regression equation for developmental response of pulse beetle, *C. maculatus* against grain biochemical characteristics of chickpea genotypes.

Particulars	Regression equation	R^2 value
Oviposition	$Y= 39.378 + 1.121 X_1 - 0.686 X_2 - 1.573 X_3$	0.675
Adult emergence	$Y= 42.646 + 1.036 X_1 - 0.703 X_2 - 1.891 X_3$	0.695
Per cent grain damage	$Y= 48.618 + 0.708 X_1 - 0.609 X_2 - 1.157 X_3$	0.747

X_1= TSS (%), X_2= Total phenols (mg CAE $100g^{-1}$), X_3= Tannins (mg TAE g^{-1}).

Table 5: Regression equation for developmental response of pulse beetle, *C. maculatus* against grain physico-chemical characteristics of chickpea genotypes.

Particulars	Regression equation	R^2 value
Oviposition	$Y= 15.275 + 0.509 X_1 + 67.225 X_2 + 1.234 X_3 - 0.833 X_4 + 0.297 X_5$	0.701
Adult emergence	$Y= 18.142 + 0.484 X_1 + 69.810 X_2 + 1.161 X_3 - 0.838 X_4 - 0.294 X_5$	0.722
Per cent grain damage	$Y= 33.112 + 0.312 X_1 + 43.935 X_2 + 0.786 X_3 - 0.698 X_4 - 0.097 X_5$	0.766

X_1= Test weight (g), X_2= Seed coat thickness (mm), X_3= TSS (%), X_4= Total phenols (mg CAE $100g^{-1}$), X_5= Tannins (mg TAE g^{-1}).

by pulse bruchid (Tripathi *et al.,* 2020). According to Swamy *et al*. (2020), resistant varieties had higher phenol and tannin contents and lower TSS content and stated that physical and biochemical parameters of chickpea seed together influenced growth and damage parameters of *C. maculatus* to the greater extent.

CONCLUSION

According to current research findings, no single physical or biochemical parameters of chickpea is responsible for imparting resistance/susceptibility to the *C. maculatus*. Preference/ non-preference of chickpea genotypes to *C. maculatus* is determined by collective effect of different physical and biochemical factors of chickpea genotypes. The test weight and seed coat thickness showed some influence on damage caused by pulse beetle but mostly the biochemical parameters like total soluble sugars and antinutritional factors like phenols and tannins contributed to the tolerance of chickpea genotypes against *C. maculatus* damage and development.

NBeG 452, NBeG 1129 and ICC 86111 were among the 20 chickpea genotypes tested for resistance to *C. maculatus*, found to be less susceptible due to lower numbers of eggs and adults per 100 grains, a lower percentage of grain damage. The resistance of chickpea to *C. maculatus* was influenced by genotypes with lower test weight, thicker seed coats, lower total soluble sugar levels and greater levels of phenols and tannins.

It is very helpful for post-harvest management and for subsequent genetic development of the genotypes to screen host grains of various genotypes for their resistance to stored grain pests. It is clear from the research that the physical characteristics of grains, such as a thicker seed coat and a smaller size, had a greater impact on the pulse bruchid resistance reaction than the biochemical components. Therefore, combining both antixenosis and antibiosis mechanisms of resistance genetically could be a feasible technique for reducing bruchid infestations in stored grain legumes.

ACKNOWLEDGEMENT

The authors would like to thank Dr. V. Jayalakshmi, Principal Scientist (Chickpea), Regional Agricultural Research Station, Nandyal, Andhra Pradesh for providing the genotypes to conduct these experiments. The authors are thankful to Acharya N. G. Ranga Agricultural University, Guntur, Andhra Pradesh, India for providing necessary facilities to undertake the studies.

Conflict of interest

All authors declared that there is no conflict of interest.

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