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Evaluation of blackgram and greengram genotypes for the resistance against *Callosobruchus chinensis* (L.) and correlation with seed physical parameters

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Abstract
Twenty blackgram and 21 greengram genotypes were screened for resistance against pulse beetle, *Callosobruchus chinensis* (L.) using no-choice tests under laboratory conditions. Significant variations were observed in terms of insect biological characters *viz*., oviposition (NE), percent adult emergence (PAE) and growth index (GI) among both blackgram and greengram genotypes. Based on GI, blackgram genotypes *viz*., IC 281981, IC 343939, IC 382811, IC 634604, IC 634606, IC 634608, IC 634611, IC 634612, IC 634613 and IC 634617 and greengram gentoypes *viz*., KEP 68 and IC 634630 were categorized as moderately resistant to *C. chinensis*. Correlation analysis between growth index (GI) and insect growth parameters on different genotypes indicated that GI had significant negative relationship with mean developmental period (r= -403 and –0.816) and significant positive correlation with percent adult emergence (r= 0.837 and 0.966) for blackgram and greengram respectively. Seed morphological characters like seed width, seed thickness and 100 seed weight significantly affected mean development of the pest in greengram but not so in the case of blackgram. Based on the study, it can be suggested that genotypes categorized as moderately resistant could be used as potential donor for the development of bruchid tolerant cultivars.

Keywords: Bruchids, *Callosobruchus chinensis*, blackgram, greengram, screening, growth index, insect resistance

Introduction
Pulses are one of the core segments of Indian agriculture next to cereals and oilseeds. The present production of pulses in the country hovers around 19 million tonnes from 23 million hectares, which falls short of the present domestic requirement of around 21 million tonnes. Pulses remain in the main focus of Government of India and hence have launched many programmes to encourage farmers to grow more pulses (Raju Guntakala, 2018) [8]. Blackgram, *Vigna mungo* (L.) Hepper and greengram, *Vigna radiata* (L.) Wilczek are important grain legumes grown widely in South and Southeast Asia. Among the various biotic stresses that hamper pulse production, pulse beetle, *Callosobruchus chinensis* (Coleoptera: Bruchidae) is the most important pest in Asia and causes considerable damage to *Vigna* seeds. Infestation starts in the field and carried to store, where sometimes it causes total destruction of the seeds within six months (Srinivasan *et al*. 2010) [12]. Damaged seeds lose its viability and the grain is rendered unfit for human consumption. Developing bruchid resistant improved cultivars of blackgram (urdbean) and greengram (mungbean) remain an economically viable option to reduce heavy post-harvest losses. To date, no or few resistant varieties in these crops have been developed because of lack of reliable resistant sources against bruchids (Lambridges and Imrie, 2000; Somata *et al*. 2008; Duraimurugan Ponnusamy *et al*. 2014; Soumia *et al*. 2015) [4, 10, 2, 11]. To accelerate breeding efforts for developing bruchid resistant cultivars, new sources of resistance need to be identified in *Vigna* species. Keeping this in view, the present study was undertaken to identify the new sources of resistance in blackgram and greengram germplasm maintained at ICAR-National Bureau of Plant Genetic Resources, Regional Station, Hyderabad against *C. chinensis*.

Materials and Methods
Bruchid free seeds of 20 blackgram and 21 greengram genotypes that were harvested during 2018-19 and stored in Medium Term Module (MTM) facility of ICAR-National Bureau of Plant Genetic Resources, Regional Station, Hyderabad were used in the present study.

The insect culture was obtained from Seed Research and Technology Centre, Professor Jayasankhar Telangana State Agricultural University, Hyderabad and mass reared on greengram at Entomology laboratory for two generations at 28±1°C and 65±5.0 per cent RH in a Biological Oxygen Demand incubator by sub-culturing at regular intervals so as to ensure continuous supply of insects for the experiment.

The accessions were evaluated for bruchid resistance under "no-choice test" in a completely randomized design (CRD) with four replications. For this test, 20 healthy and dried seeds of each accession were weighed and placed in small transparent plastic jars having perforated lids to ensure aeration. Two pairs of (male and female) of freshly emerged adults from the stock cultures were released in each jar for oviposition. Each jar was considered as one replication for each accession. After three days of allowance for oviposition, the insects were removed and number of eggs laid by the females on seeds of different accessions was determined. Infested seeds were kept at 28±1°C and 65±5.0 % RH in a B.O.D incubator. The number of emerged adults was counted daily and development period was determined. Observations on adult emergence in each accession were continued until 40 days after insect infestation. The data on per cent adult emergence (PAE), mean developmental period (MDP) and growth index (GI) were worked out as described by Howe (1971) [3]. The accessions were categorized based on GI as resistant (0.040-0.050), moderately resistant (0.051-0.055), moderately susceptible (0.056-0.060), susceptible (0.061-0.065), and highly susceptible (0.066-0.070) as reported by Tripathi *et al*. (2020) [17]. The experimental seeds were weighed (X1) before releasing the insects for egg laying and were re-weighed after the emergence of adults (X2). The loss in seed weight as a result of feeding activity of the bruchid was calculated (X1-X2) and expressed in percentage (PSWL).

Statistical analysis of data was carried out by a single factor ANOVA. Data on number of adults emerged and mean developmental period (MDP) were square root transformed and data on percent seed weight loss (PSWL) and percent adult emergence (PAE) were angular transformed before analysis. Analyses of variance were carried out using DSAASTAT, version, 1.1 statistical package (Onofri, 2007) [6]. The Least Significant Difference (LSD) values at $P = 0.05$ were used to determine the significance of treatment mean differences. One-tailed Pearson's correlation coefficient analysis was performed to indicate the relationship between insect growth characters and seed morphological characters.

Results and Discussion

Blackgram: The results revealed that number of eggs laid (NE), PAE, PSWL and GI significantly differed between 20 blackgram genotypes (Table 1). The genotypes, IC 281993, IC 634615, IC 634610 and IC 634607 recorded less number of eggs (42.25, 43.50, 45.25 and 47.50 eggs/20 seeds) while IC 382811 and IC 343939 recorded highest number of eggs (90.50 and 87.00 eggs/20 seeds). It was found that there was no significant difference among the genotypes in the case of AE. Percent adult emergence (PAE) or otherwise known as percentage survival was recorded less in IC 343939, IC 634608 and IC 382811 (21.53, 23.25 and 23.5 %) while, it was high in IC 281993 followed by IC 634615 (49.28 and 48.20 %). Mean development period for *C. chinensis* did not differ significantly among the genotypes. PSWL was recorded lowest in IC 634606 (19.90) and highest was in IC 426769 (34.35). Based on GI, it was found that none of the genotypes was completely resistant to *C. chinensis*. However, ten genotypes were categorized as moderately resistant (MR), eight were moderately susceptible (MS) and two were susceptible (S) (Table 1).

Greengram: The results revealed that number of eggs laid (NE), AE, PAE and GI significantly differed between 21 green gram genotypes (Table 2). The genotypes, KEP 36 and KEP 38 recorded less number of eggs (42.75 and 43.50 eggs/20 seeds) while KEP 68 and IC 634630 recorded highest number of eggs (93.25 and 91.25 eggs/20 seeds). AE was recorded lowest in KEP 88 (16.25) and highest in IC 634620 (20.50 adults/ 20 seeds). PAE or percentage survival was recorded least in IC 634630 (21.33) and highest in KEP 36 (43.73). Mean development period for *C. chinensis* and PSWL did not differ significantly among the genotypes. However, lowest PSWL was recorded in IC 634626 (34.85) and highest was in IC 634624 (57.14). Based on GI, it was found that none of the genotypes was completely resistant to *C. chinensis*. However, two genotypes *viz*., KEP 68 and IC 634630 were categorized as moderately resistant (MR), eight were moderately susceptible (MS), eight were susceptible (S) and three were highly susceptible (HS) (Table 2).

Since, GI of each accession is based on reaction of bruchids with respect to their biological parameters like oviposition, adult emergence and developmental period, it is a criterion for comparing the growth responses of insects to different plants. Genotypes with a low GI are considered as resistant and those with a high GI are considered as susceptible. GI is widely used by researchers to identify the reaction of various legume crops to bruchid infestation (Duraimugan Ponnusamy *et al*. 2014; Tripathi *et al*. 2015; Mohamed *et al*. 2019; Satheesh Naik *et al*. 2021) [2, 16, 5, 9].

Information available on the similar aspects, revealed that, very few genotypes are resistant or immune to bruchids. Duraimurugan Ponnusamy *et al.* (2014) [4] reported that of the 140 black gram genotypes screened; only three were found to be moderately resistant. Similarly, of the 335 greengram genotypes, four were found moderately resistant. Similarly, Soumia *et al*. (2015) [11] reported that of the 85 greengram genotypes screened, none was found to be immune to bruchid attack. Tripathi *et al.* (2020) [17] found that out of 103 cowpea accessions screened based on biological parameters; none of the accessions was found to be immune but only two accessions were found moderately resistant to *C. maculatus*. Satheesh Naik *et al.* (2021) [9] screened 52 pigeonpea genotypes, out of which three genotypes were found to be resistant to the bruchids. In the same line of work, globally too, very few genotypes are reported as resistant to bruchids among pulse crops. Screening of more than 15,000 cowpea accessions at International Institute of Tropical Agriculture (IITA), Nigeria, revealed only three land races, TVu11952, TVu11953 and TVu2027 to be moderately resistant to *C. maculatus* (Srinives *et al*. 2007) [13]. Since, sources of resistance to bruchids are few in the pulse germplasm, continuous and systematic efforts are necessary to evaluate local land races, crop wild relatives, varieties and available accessions in the genebank to find sustainable and durable sources of resistance against bruchids.

In case of green gram, 90.48 per cent of genotypes were grouped in susceptible category (MS, S, HS) while in blackgram 50.00 percent genotypes exhibited susceptible reaction (MS, S) indicating that greengram is more susceptible to *C. chinensis* in comparison to blackgram. Similar observations were reported by Tomooka *et al*. (2012) [15] and Duraimuran Ponnusamy *et al*. (2014) [2].

Correlation co-efficient was worked out between the different biological parameters *viz*., NE, AE, PAE, MDP, PSWL and GI for both blackgram and greengram (Table 3 and 4). Egg laying showed significant negative correlation with PAE and GI in both blackgram and greengram. Raina (1970) [7] observed that oviposition preference was influenced by host seed size; while Dick and Credland (1984) [1] found that it was influenced by host availability to a greater extent and has nothing to do with the actual resistance nature of an accession. Further, it was found that MDP was higher (ranging 27.11-28.18 days) in blackgram in comparison with greengram (ranging 24.0 to 25.0 days). Higher MDP value might be due to the presence of unfavourable chemical constituents in blackgram that directly affect the development of a growing grub resulting in prolongation of developmental period. Sulehrie *et al.* (2003) [14] also reported that a delay in MDP indicates presence of resistance factors; which eventually may lead to a considerable reduction in seed loss during storage. This is in conformity with the present findings of significant negative correlation of GI with MDP (r=-0.403 and r=-0.816) and significant positive correlation with PAE (r=0.837 and r=0.966) for blackgram and greengram respectively.

Present study demonstrated that blackgram and greengram genotypes varied in physical seed characters *viz*., seed length, seed width, seed thickness 100 seed weight. (Table 5 and 6). In case of blackgram accessions, seed length ranged from 4.47 mm (IC 426769) to 5.18 mm (IC 281993) and width ranged from 3.51 mm (IC 343939) to 4.00 mm (IC 634618). Seed thickness ranged from 3.03mm (KEP 149) to 3.52 mm (IC 634608). 100 seed weight (g) ranged from 3.9 g (KEP 149) to 5.4 g (IC 634607). Among the seed characters, seed length alone had significant positive correlation (r= 0.429), while seed width, seed thickness and 100 seed weight did not exert significant effect on insect biological characters. SL, ST and 100 SW caused significant negative effect on PSWL indicating bigger the seeds, lesser the seed weight loss due to bruchid attack. In case of greengram, seed length ranged from 3.73 mm (KEP 36) to 5.16 mm (IC 634626) and width ranged from 2.93 mm (IC 634621) to 3.82 mm (IC 634626). Seed thickness ranged from 2.92 mm (IC 634621) to 3.65 mm (IC 634626). 100 seed weight (g) ranged from 3.4 g (KEP 36) to 6.2 g (IC 634626). SL significantly affected the ovioposition (r=0.398), while SW, ST and 100 SW significantly affected MDP indicating grubs prolonged their development as the seed size and weight increased. It might be due to the availability of more conducive food content. As in the case of blackgram, seed characters of greengram also had significant negative correlation with PSWL. Observations revealed that seed coat texture was smooth for both blackgram and greengram. This could be one of the reasons for the susceptibility all accessions to the beetle in the present study, as Mohamed *et al*. (2019) [5] reported that seeds with smooth seed texture were more preferred for egg laying, percent weight loss and percent adult survival. Studies on correlation analysis showed that seed physical characters did not have significant relationship with GI. Similar to the present findings, Tripathi *et al.* (2020) [17] also reported that seed physical characters had no direct influence on the resistance or susceptibility to bruchids in case of cowpea. Therefore, an absolute relationship could not be established.

Table 1. Reaction of blackgram genotypes to *Callosobruchus chinensis*

IC Numbers	Number of eggs laid/20 seeds (NE)	Number of adults emerged/20 seeds (AE)	% Adult emergence (PAE)	Mean developmental period (MDP) (days)	Growth Index (GI)	Percent seed weight loss (PSWL)	Reaction of blackgram genotypes to *C. chinensis* based on GI
IC 281981	66.00±11.97 (8.03)	18.5±0.65 (4.30)	30.90±5.37 (33.49)	28.02±0.25 (5.29)	0.052	32.48 ±0.83 (34.74)	MR
IC 281993	42.25±2.87 (6.49)	20.50±0.65 (4.53)	49.28±3.81 (44.57)	27.22±0.40 (5.22)	0.062	22.40 ±4.17 (27.86)	S
IC 343939	87.00±7.45 (9.29)	18.25±.0.48 (4.27)	21.53±2.14 (27.56)	28.02±0.36 (5.29)	0.051	28.45 ±2.86 (32.15)	MR
IC 382811	90.5±16.45 (9.40)	19.25±0.85 (4.38)	23.35±4.18 (28.62)	27.53±0.10 (5.25)	0.052	30.48 ±3.05 (33.42)	MR
IC 426769	58.25±8.07 (7.58)	19.00±0.41 (4.36)	34.33±4.13 (35.75)	27.80±0.30 (5.27)	0.056	34.35 ±4.65 (35.73)	MS
IC 436717	49.5±4.66 (7.01)	19.50±0.50 (4.41)	40.80±5.09 (39.64)	27.34±0.48 (5.22)	0.059	26.73 ±0.58 (31.12)	MS
IC 634604	75.00±8.77 (8.62)	19.00±0.41 (4.36)	26.05±2.13 (30.63)	27.77±0.19 (5.27)	0.051	30.00 ±4.08 (33.05)	MR
IC 634605	49.25±1.75 (7.01)	18.75±2.02 (4.31)	38.25±4.56 (38.11)	27.87±0.15 (5.28)	0.056	30.15 ±1.23 (33.29)	MS
IC 634606	73.25±2.02 (8.56)	18.5±1.32 (4.29)	25.23±1.61 (30.11)	27.62±0.06 (5.26)	0.051	19.90 ±1.70 (26.44)	MR
IC 634607	47.5±3.43 (6.88)	19.5±1.19 (4.41)	42.05±5.00 (40.35)	27.64±0.13 (5.26)	0.058	25.70 ±2.58 (30.37)	MS
IC 634608	79.5±1.76 (8.91)	18.50±0.87 (4.30)	23.25±0.58 (28.82)	28.14±0.33 (5.30)	0.052	26.15 ±0.66 (30.75)	MR
IC 634609	53.5±10.99 (7.20)	17.75±1.11 (4.15)	36.45±8.06 (36.91)	27.87±0.09 (5.28)	0.060	24.33 ±2.56 (29.46)	MS
IC 634610	45.25±3.20 (6.71)	20.00±0.41 (4.47)	44.80±3.04 (41.99)	27.21±0.30 (5.22)	0.060	28.45 ±2.86 (32.15)	MS
IC 634611	78.5±6.09 (7.49)	19.25±1.31 (4.38)	25.30±3.51 (30.03)	27.73±0.12 (5.27)	0.051	25.93 ±3.89 (30.43)	MR
IC 634612	56.75±7.34 (8.84)	19.25±0.85 (4.36)	35.08±4.59 (36.21)	28.10±0.24 (5.30)	0.055	23.43 ±3.07 (28.80)	MR
IC 634613	53.75±3.64 (7.32)	18.50±0.65 (4.30)	35.05±3.24 (36.24)	27.79±0.20 (5.27)	0.055	31.65±0.95 (34.22)	MR
IC 634615	43.5±6.33 (6.55)	19.75±0.48 (4.44)	48.20±6.67 (43.91)	27.66±0.13 (5.26)	0.060	23.20 ±2.40 (28.70)	MS
IC 634617	66.00±12.12 (8.03)	19.75±0.95 (4.44)	33.53±6.58 (35.03)	27.11±0.69 (5.21)	0.055	27.38 ±1.84 (31.51)	MR
IC 634618	58.25±11.03 (7.52)	19.50±0.87 (4.41)	37.85±8.08 (37.69)	27.72±0.24 (5.26)	0.056	29.98 ±3.33 (33.07)	MS
KEP 149	55.00±5.43 (7.39)	19.25±0.85 (4.38)	36.43±5.08 (37.02)	27.75±0.30 (5.27)	0.065	33.05 ±2.57 (35.05)	S
F	3.67	0.61	3.08	0.99	2.06	1.94	
CV (%)	12.37	4.95	16.30	1.06	10.61	11.51	
SEM	0.48	0.11	2.90	2.79	0,00	1.82	
S.D	0.68	0.15	4.11	3.96	4.17	2.57	
Significance	**	NS	**	NS	*	*	

* Significant at 5% level; **Significant at 1% level; NS-Non significant; values followed by means are standard error; values in parentheses for NE, AE and MDP are square root transformed values; values in parentheses for PAE and PSWL are angular transformed values

Table 2: Reaction of greengram genotypes to *Callosobruchus chinensis*

IC Numbers	Number of eggs laid/20 seeds (NE)	Number of adults emerged/20 seeds (AE)	% Adult emergence (PAE)	Mean developmental period (MDP) (days)	Growth Index (GI)	Percent seed weight loss (PSWL)	Reaction of greengram genotypes to *C. chinensis* based on GI
IC 634619	50.25±8.30 (7.01)	18.50±0.65 (4.30)	39.48±5.59 (38.82)	24.30±0.30 (4.93)	0.065	55.91 ±2.56 (48.41)	S
IC 634620	53.75±1.60 (7.33)	20.50±0.65 (4.53)	38.28±2.03 (38.20)	24.1±0.31 (4.90)	0.066	51.39 ±2.66 (45.80)	HS
IC 634621	78.50±9.18 (8.82)	17.00±0.41 (4.12)	22.15±1.99 (28.00)	24.40±0.30 (4.94)	0.058	49.56 ±4.63 (44.76)	MS
IC 634622	58.00±6.24 (7.58)	16.50±1.19 (4.05)	29.80±4.85 (32.90)	24.50±0.40 (4.95)	0.060	45.83 ±4.75 (42.57)	MS
IC 634624	61.50±10.08 (7.76)	19.25±0.48 (4.39)	33.75±5.05 (35.34)	24.30±0.35 (4.92)	0.063	57.14 ±5.05 (49.20)	S
IC 634625	73.00±5.26 (8.53)	19.00±0.41 (4.36)	26.43±1.93 (30.89)	24.50±0.28 (4.95)	0.058	48.89 ±3.24 (44.36)	MS
IC 634626	79.50±16.59 (8.79)	19.75±1.65 (4.43)	28.05±5.19 (31.58)	24.50±0.34 (4.95)	0.061	34.85 ±7.48 (35.84)	S
IC 634627	53.75±2.95 (7.32)	18.25±0.48 (4.27)	34.38±2.62 (35.85)	24.10±0.22 (4.91)	0.064	46.39±5.62 (42.85)	S
IC 634628	57.00±3.81 (7.54)	19.00±0.41 (4.36)	33.85±2.68 (35.53)	24.40±0.16 (4.94)	0.063	55.28 ±2.05 (48.04)	S
IC 634629	52.50±5.24 (7.22)	19.50±0.87 (4.41)	38.58±4.86 (38.29)	24.40±0.09 (4.93)	0.065	47.92 ±2.08 (43.80)	S
IC 634630	91.25±6.37 (9.54)	19.25±1.38 (4.38)	21.33±1.87 (27.44)	24.70±0.30 (4.97)	0.054	52.08 ±2.79 (46.20)	MR
IC 634631	70.25±10.88 (8.31)	18.00±0.82 (4.24)	27.15±3.70 (31.26)	24.40±0.09 (4.94)	0.058	44.32 ±6.12 (41.62)	MS
IC 634632	74.0±4.78 (8.59)	19.25±0.25 (4.39)	26.33±1.59 (30.84)	24.40±0.22 (4.94)	0.058	54.17 ±1.39 (47.39)	MS
IC 634633	55.75±5.76 (7.44)	18.50±0.50 (4.30)	34.03±2.77 (35.63)	24.00±0.25 (4.90)	0.064	42.86±5.05 (40.80)	S
KEP 5	83.25±5.54 (9.11)	19.25±0.63 (4.39)	23.48±1.88 (28.93)	24.30±0.26 (4.93)	0.056	51.74 ±3.82 (46.01)	MS
KEP 36	42.75±5.33 (6.50)	17.75±0.75 (4.21)	43.73±6.07 (41.34)	24.20±0.37 (4.92)	0.067	46.43 ±6.19 (42.85)	HS
KEP 38	43.50±3.28 (6.58)	17.50±0.50 (4.18)	40.70±2.28 (39.62)	24.10±0.30 (4.91)	0.066	47.57 ±6.06 (43.58)	HS
KEP 68	93.25±3.97 (9.65)	17.25±0.63 (4.15)	22.68±1.43 (25.56)	25.00±0.11 (5.00)	0.051	43.37 ±2.89 (41.17)	MR
KEP 88	63.75±11.76 (7.87)	16.25±.1.44 (4.02)	28.15±5.63 (31.76)	24.40±0.23 (4.93)	0.059	39.72 ±6.70 (38.80)	S
KEP 102	70.25±6.87 (8.35)	19.00±0.41 (4.36)	27.90±3.00 (31.78)	24.70±0.21 (4.97)	0.058	44.68 ±1.02 (41.94)	MS
KEP 145	76.50±12.10 (8.67)	19.50±0.29 (4.42)	27.40±4.19 (31.37)	24.70±0.26 (4.97)	0.058	51.74 ±3.82 (46.01)	MS
F	6.48	1.95	5.66	0.93	3.44	1.36	
CV (%)	11.97	4.23	13.76	1.09	9.03	12.46	
SEM	0.47	9.10	2.37	2.69	2.77	2.74	
S.D	0,66	0.13	3.35	3.81	3.91	3.88	
Significance	**	*	**	NS	**	NS	

* Significant at 5% level; **Significant at 1% level; NS-Non significant; values followed by means are standard error; values in parentheses for NE, AE and MDP are square root transformed values; values in parentheses for PAE and PSWL are angular transformed values

Table 3: Correlation matrix of growth parameters of *Callosobruchus chinensis* and seed physical parameters of blackgram accessions

	NE	AE	PAE	MDP	GI	PSWL	SL	SW	ST	100 SW
NE	-	-0.377	-0.974**	0.352	-0.826**	0.132	-0.324	-0.107	-0.110	-0.237
AE		-	0.539**	-0.711**	0.374	-0.090	0.429*	-0.117	-0.156	0.130
PAE			-	-0.476*	0.837**	-0.172	0.374	0.058	0.067	0.252
MDP				-	-0.403*	0.150	-0.266	0.038	0.065	-0.113
GI					-	-0.029	0.343	-0.018	-0.090	-0.015
PSWL						-	-0.499*	-0.216	-0.533**	-0.812**
SL							-	0.344	-0.508*	0.501*
SW								-	0.482*	0.452*
ST									-	0.61**
100 SW										-

Table 4: Correlation matrix of growth parameters of *Callosobruchus chinensis* and seed physical parameters of greengram accessions

	NE	AE	PAE	MDP	GI	PSWL	SL	SW	ST	100 SW
NE	-	0.114	-0.962**	0.745**	-0.937**	-0.085	0.398*	0.302	0.304	0.307
AE		-	0.123	-0.085	0.144	0.369*	0.355	0.263	0.244	0.246
PAE			-	-0.728**	0.966**	0.152	-0.290	-0.209	-0.208	-0.247
MDP				-	-0.816**	-0.114	0.315	0.452*	0.432*	0.462*
GI					-	0.105	-0.220	-0.244	-0.271	-0.269
PSWL						-	-0.423*	-0.553**	-0.581**	-0.398*
SL							-	0.824**	0.718**	0.808**
SW								-	0.939**	-0.842**
ST									-	0.799**
100 SW										-

NE-Number of eggs laid per 20 seeds; AE-Number of adults emerged per 20 seeds; PAE- Percent adult emergence; MDP-Mean developmental period; GI-Growth index; PSWL-Percent seed weight loss; SL-Seed length, SW-Seed width, ST-Seed thickness; 100SW- 100 Seed weight; * Significant at 5% level; **Significant at 1% level

Table 5: Seed characters of blackgram genotypes used in the study

S. No	IC Number	Seed texture	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100 seed wt (g.)
1	IC 281981	Smooth	4.52	3.72	3.22	4.2
2	IC 281993	Smooth	5.18	3.72	3.44	5.2
3	IC 343939	Smooth	4.49	3.51	3.09	4.4
4	IC 382811	Smooth	4.92	3.95	3.32	4.5
5	IC 426769	Smooth	4.47	3.64	3.02	4.0
6	IC 436717	Smooth	5.05	3.95	3.25	4.8
7	IC 634604	Smooth	4.66	3.93	3.27	4.7
8	IC 634605	Smooth	5.00	3.77	3.46	4.8
9	IC 634606	Smooth	4.96	3.95	3.47	5.3
10	IC 634607	Smooth	5.00	3.92	3.22	5.4
11	IC 634608	Smooth	4.95	3.76	3.52	4.9
12	IC 634609	Smooth	4.65	3.93	3.41	4.8
13	IC 634610	Smooth	4.91	3.78	3.39	4.4
14	IC 634611	Smooth	4.93	3.67	3.21	4.6
15	IC 634612	Smooth	4.87	3.99	3.43	5.2
16	IC 634613	Smooth	4.69	3.86	3.40	4.8
17	IC 634615	Smooth	4.88	3.67	3.25	5.1
18	IC 634617	Smooth	4.53	3.60	3.16	4.8
19	IC 634618	Smooth	4.75	4.00	3.22	4.8
20	KEP 149	Smooth	4.91	3.69	3.03	3.9

Table 6: Seed characters of greengram genotypes used in the study

S. No	IC Number	Seed texture	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	100 seed wt (g.)
1	IC 634619	Smooth	4.08	3.16	3.07	4.3
2	IC 634620	Smooth	4.48	3.42	3.32	4.5
3	IC 634621	Smooth	4.22	2.93	2.92	3.6
4	IC 634622	Smooth	3.92	3.26	3.13	4.8
5	IC 634624	Smooth	3.98	3.01	3.01	3.5
6	IC 634625	Smooth	4.07	3.22	3.30	5.1
7	IC 634626	Smooth	5.16	3.82	3.65	6.2
8	IC 634627	Smooth	4.37	3.22	3.21	5.2
9	IC 634628	Smooth	4.14	3.18	3.08	5.0
10	IC 634629	Smooth	4.73	3.62	3.53	6.1
11	IC 634630	Smooth	4.70	3.50	3.42	5.5
12	IC 634631	Smooth	4.11	3.42	3.48	4.5
13	IC 634632	Smooth	4.05	3.31	3.28	4.7
14	IC 634633	Smooth	4.17	3.25	3.17	4.1
15	KEP 102	Smooth	4.69	3.73	3.55	6.1
16	KEP 145	Smooth	3.87	3.21	3.22	4.1
17	KEP 36	Smooth	3.73	3.19	3.20	3.4
18	KEP 38	Smooth	3.77	3.01	2.95	4.3
19	KEP 5	Smooth	4.03	3.05	3.09	4.3
20	KEP 68	Smooth	4.55	3.59	3.52	5.5
21	KEP 88	Smooth	4.13	3.32	3.27	4.5

Conclusion

This study revealed that based on GI, blackgram genotypes *viz*., IC 281981, IC 343939, IC 382811, IC 634604, IC 634606, IC 634608, IC 634611, IC 634612, IC 634613 and IC 634617 and greengram gentoypes *viz*., KEP 68 and IC 634630 were moderately resistant to *C. chinensis* attack. Further works are needed to elucidate the resistance factor (s) and its mode of action in these genotypes. Such factors may be incorporated into blackgram and greengram varieties having desirable agronomic characters. Further, this study suggests that the tested genotypes could not be stored without appropriate control means for reducing damage and weight loss due to bruchids.

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