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Biochemical and Morphological Basis of Resistance in Groundnut to Groundnut Bruchid, *Caryedon gonagra*

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Abstract: Seven groundnut (*Arachis hypogaea* L.) genotypes were evaluated for resistance against the groundnut bruchid, *Caryedon gonagra*, under storage conditions at the Department of Entomology, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati. Key parameters recorded were fecundity, adult emergence, developmental period, pod damage, weight loss and susceptibility index. Based on the susceptibility index, groundnut genotypes were classified as moderately resistant (Kadiri Chitravathi, K-1687), moderately susceptible (K-1677, Dharani, Kadiri Lepakshi), susceptible (K-6), and highly susceptible (K-7 Bold). The moderately resistant genotypes recorded the lowest number of eggs (24.33–34.00 eggs/100 pods), reduced adult emergence (45.67–48.00%), extended developmental period (76.02–76.27 days), and minimal pod damage (20.67–25.33%) with low weight loss (4.14–4.34%). Bruchid resistance was associated with lower protein (18.46–18.81%) and lower total soluble sugars (5.03–5.27%), and higher phenol content (243.07–265.01 mg/100 g). In contrast, the highly susceptible genotype K-7 Bold recorded the highest oviposition (227.67 eggs/100 pods), adult emergence (195.67), pod damage (100%), and weight loss (30.27%). Susceptibility was correlated with higher pod and seed weights, greater intergranular space, and higher protein (23.68%) and sugars (6.76%), coupled with lower phenol content (172.67 mg/100 g).The findings suggest that both morphological and biochemical traits significantly influence resistance in groundnut genotypes to groundnut bruchid, offering valuable insights for breeding programs targeting bruchid resistance.

Keywords: *Arachis hypogaea*, Groundnut bruchid. Biochemical traits, Resistance, *Caryedon gonagra*

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops grown across tropical and subtropical regions. It plays an important role in human nutrition as a rich source of proteins, fats, vitamins and minerals. In India, groundnut is extensively cultivated and holds significant economic and nutritional value, serving as a major source of edible oil and a source of income for millions of farmers. However, storage pests pose a serious threat to groundnut quality and quantity during storage. Among them, the groundnut bruchid, *Caryedon gonagra* is a major pest. The larvae bore into the pods and feed on the seeds, leading to substantial losses, which reduce seed viability, market value, and nutritional quality. Infestations can even result in total pod destruction under prolonged storage conditions. It was estimated that losses of 6-10 % in groundnut have been attributed to storage pests (Ahir et al., 2018). In recent years, increasing attention has been paid to identifying resistant genotypes as a sustainable alternative to chemical based storage protection (Devi and Rao 2005). In this context, the evaluation of biochemical traits such as protein content, total soluble sugars and phenol has emerged as a valuable approach. These biochemical parameters often play a key role in influencing the pest's feeding behavior, development and survival. Studying the traits linked to pest resistance helps in identifying and developing groundnut varieties that can naturally withstand pests during storage. By focusing on genotypes that already show resistance, it is possible to reduce the need for chemical treatments and develop more sustainable pest management strategies.

MATERIAL AND METHODS

The mother culture of groundnut bruchid was collected from groundnut storage godowns of RARS, Tirupati, ANGRAU, Andhra Pradesh. The bruchids were mass multiplied in the laboratory for about 4-5 generations and the freshly emerged adults were used for the study.

Screening of groundnut varieties: Seven groundnut genotypes (Dharani, Kadiri Lepakshi, K6, K-1677, K-1687, K7 Bold and Kadiri Chitravathi) were used in screening studies. The test varieties were subjected to disinfestation by keeping them in the hot air oven at a temperature of 55 °C for 4 hours. About 250 g disinfested groundnut pods of each test variety were placed in plastic jars of 500g capacity separately with three replications. Five pairs of freshly emerged adult bruchids were released into each jar and kept undisturbed for a period of ten days for oviposition. After 10 days, the adult beetles were removed from the jars and the jars with the pods were kept undisturbed for the emergence of F_1 adults. The performance of the test varieties was assessed based on various parameters. After removing the adult beetles from test varieties the number of eggs laid on the surface of the pods were counted with the help of a hand lens and the mean number of eggs laid by the test insect per 100 pods was calculated and expressed as fecundity. The F_1 adults emerged from each treatment were counted and discarded daily to avoid further mating and egg laying. The process was continued till the adults ceased to emerge from all the treatments. The total number of adults emerged was recorded. The mean developmental period of the test insect in each test variety was calculated by using 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

D = Mean development period (days)

Susceptibility index was calculated by using the formula suggested by Dobie (1977).

$$I=\frac{\log_e F}{D}\times 100$$

Where, F = Total number of adults emerged

D = Mean developmental period

I = Index of susceptibility

The test varieties were categorized into five groups based on the index of susceptibility (Mensah 1986).

Category	Index of susceptibility
Resistant	0-2.5
Moderately resistant	2.6-5.0
Moderately susceptible	5.1-7.5
Susceptible	7.6-10.0
Highly susceptible	> 10.0

After the cessation of adult emergence from all the treatments, the number of damaged pods in each replication was counted and converted to per cent damaged pods by using the formula.

$$\text{Damaged pods}(\%)=\frac{\text{Number of damaged pods}}{\text{Total number of pods}}\times 100$$

The final weight of the pods was taken and the weight loss due to insect infestation was calculated by using the formula.

$$\text{Weight Loss}(\%)=\frac{\text{Initial weight of sample - Final weight of sample}}{\text{Initial weight of sample}}\times 100$$

Morphological parameters and biochemical parameters of groundnut varieties: The morphological parameters of groundnut varieties *viz*., pod length, width, test weight, shell thickness, pod reticulation and intergranular space of pods was recorded. The biochemical parameters of the groundnut kernels *viz*., proteins, phenols and total soluble sugars were estimated by using standard procedures. Protein content of the groundnut kernels was estimated by using method given by Lowry (1951). The phenol content of groundnut kernels was estimated by using method of Malick and Singh (1980). Total soluble sugars of the groundnut kernels of each treatment were estimated by using method of Hedge and Hofreiter (1962).

RESULTS AND DISCUSSION

Oviposition and adult emergence: Among the seven groundnut genotypes screened, the mean number of eggs laid differed significantly and the fecundity ranged between 24.33 and 227.67 eggs /100 pods (Table 1). The genotype K-7 Bold with larger size, higher test weight and more intergranular space recorded the highest number of adults (195.67 adults / 250 g of groundnut pods), while Dharani with smaller size, lower test weight and low intergranular space recorded comparatively lesser number of adults (51.00 adults / 250 g of groundnut pods) (Table 1). The plausible reason for the lower adult emergence may be due to restricted movement of adults within limited space affecting the mating behaviour of adult bruchids resulting in lower oviposition and reduce in adult emergence.

Mean developmental period: Lowest mean developmental period was in K-7 Bold (51.88 days). The highest mean developmental period was in Kadiri Chitravathi (76.27) and K-1687(76.02) (Table 1) which were on par with each other. Groundnut genotypes like Kadiri Chitravathi with high shell thickness resulted in increased mean developmental period as shell hardness and testa compactness act as barrier for entry of larvae.

Weight loss and pod damage: The pod damage varied significantly among different groundnut genotypes and ranged between 20.67 to 100 per cent (Table 1). The lowest weight loss of 4.15 per cent was in Kadiri Chitravathi which was on par with K-1687 with 4.34 per cent. The variety K-7 Bold recorded the highest weight loss of 30.27 per cent. The genotype Kadiri Chitravathi recorded lowest (20.67 %) pod damage was on par with K-1687 and Dharani. A total of 100 per cent pod damage was recorded in groundnut genotypes K6 and K7 Bold.

Index of susceptibility: Groundnut genotypes were categorized into five groups based on index of susceptibility as suggested by Mensah (1986) (Table 2). The genotypes Kadiri Chitravathi and K-1687 with index of susceptibility of 4.09 and 4.35, respectively, were categorized as moderately resistant. The K-1677, Dharani and Kadiri Lepakshi with index of susceptibility in the range of 5.57 to 7.47 were categorized as moderately susceptible. K-6 with index of susceptibility in the range of 7.72 to 8.69 was categorized as susceptible genotype and K-7 Bold with index of susceptibility greater than 10 was categorized as highly susceptible.

Premkumar et al. (2020) also reported that, groundnut genotypes with significant reticulation recorded a greater number of eggs. Similarly, Prasad et al. (2012) found that the varieties which are highly preferred by the bruchid for oviposition and adult emergence showed the highest per cent weight loss, indicating the differential preference of *C. gonagra* to different groundnut genotypes. Jyothsna (2015) further reported that treatments that favoured the emergence of more number of adults with short developing time recorded a high index of susceptibility, as observed in K-6. Comparable findings were also reported by Mishra (2005) and Sharma and Thakur (2014).

Physical parameters of groundnut genotypes: Various physical parameters of groundnut pods like length (L), width (W), length × width (L × W), shell thickness, seed weight, pod weight, intergranular space and pod reticulation were measured (Table 3).

Biochemical parameters of groundnut genotypes: Biochemical parameters like proteins, total soluble sugars and phenols were estimated for the groundnut genotypes (Table 4). The protein content in kernels of groundnut genotypes ranged from 18.46 to 23.68%. The highest protein content was in K-7 Bold followed by K6 while the lowest protein content was recorded in Kadiri Chitravathi (18.46 %) which was on par with K-1687 . Total soluble sugars ranged from 5.03 to 6.76 per cent and significantly differed among the genotypes. The highest total soluble sugars of 6.76 per cent was in K7 Bold followed by K6 (6.38 %). The lowest total soluble sugars was in Kadiri Chitravathi (5.03 %). Significant differences also observed in phenol content, which ranged between 172.67 and 265.01 mg / 100g. Kadiri Chitravathi recorded the highest phenol content whereas K-7 Bold recorded the lowest.

Correlation between physical parameters of genotypes and biological parameters of groundnut bruchid: Physical parameters of groundnut genotypes such as pod length, width, length × width, shell thickness, pod weight, seed weight and intergranular space were correlated with the biological parameters of groundnut bruchid, *C. gonagra* such as oviposition, adult emergence, mean developmental period, weight loss, pod damage and index of susceptibility (Table 5). Pod length did not exhibit any correlation with biological parameters of bruchid. Pod width showed significant positive correlation with mean developmental period (0.579) and a significant negative correlation with pod damage (-0.401). Pod length × width showed significant positive correlation with mean developmental period (0.474).

Correlation between biochemical parameters of genotypes and biological parameters of groundnut bruchid: The estimated biochemical components of selected groundnut genotypes such as protein content, total soluble sugars and phenols were correlated with the biological parameters of groundnut bruchid, *C. gonagra* such

Table 2. Categorization of groundnut genotypes against *C. gonagra* based on index of susceptibility

Index of susceptibility	Groundnut genotypes	Category
1.0 to 2.5	Nil	Resistant
2.6 to 5.0	Kadiri Chitravathi and K-1687	Moderately resistant
5.1 to 7.5	K-1677, Dharani and Kadiri Lepakshi	Moderately susceptible
7.6 to 10.0	K-6	Susceptible
>10.0	K-7 Bold	Highly susceptible

Mensah (1986): Resistant (0 – 2.5), Moderately Resistant (2.6 – 5.0), Moderately Susceptible (5.1 – 7.5), Susceptible (7.6 – 10.0) and Highly Susceptible (> 10.0)

Table 1. Screening of groundnut genotypes against groundnut bruchid, *Caryedon gonagra*

Groundnut varieties	Eggs laid/ 100 pods*	No. of adults emerged /250 g pods*	Mean developmental period (Days)*	% Weight loss*	% Pod damage**	Index of susceptibility
Dharani	24.33[a]	51.00 (7.17)[a]	63.76 (8.05)[c]	4.58 (2.36)[a]	27.33 (31.34)[a]	6.13
Kadiri Lepakshi	44.67[b]	79.00 (8.88)[b]	64.70 (8.10)[c]	8.16 (2.93)[a]	62.67 (52.41)[b]	6.71
K-6	54.3 (7.43)[c]	142.33 (11.97)[c]	57.03 (7.62)[b]	28.56 (5.42)[b]	100.00 (90.00)[c]	8.69
K-1687	34.00 (5.89)[ab]	48.00 (7.00)[a]	76.02 (8.78)[e]	4.34 (2.30)[a]	25.33 (30.10)[a]	4.35
K-1677	48.00 (6.99)[b]	57.67 (7.66)[ab]	71.49 (8.51)[d]	8.77 (3.12)[a]	53.00 (46.73)[b]	5.67
K-7 Bold	227.67 (15.11)[d]	195.67 (13.99)[d]	51.88 (7.27)[a]	30.27 (5.59)[b]	100.00 (90.00)[c]	10.16
Kadiri Chitravathi	24.33 (4.97)[a]	45.67 (6.83)[a]	76.27 (8.79)[e]	4.15 (2.27)[a]	20.67 (26.95)[a]	4.09

Means followed by same letters are not significantly different by DMRT as oviposition, adult emergence, mean developmental period, weight loss, pod damage and index of susceptibility and discussed hereunder (Table 6).

Proteins and total soluble sugars of groundnut genotypes showed significant positive correlation with oviposition, adult emergence, weight loss, pod damage and index of susceptibility. Proteins and total soluble sugars showed highly significant negative correlation with mean developmental period (-0.949 and -0.964), respectively. Phenols showed significant negative correlation with oviposition, adult emergence, per cent weight loss, per cent pod damage and index of susceptibility. Conversely phenols show significant positive correlation with mean developmental period (0.943) of *C. gonagra*.

Sreedhar et al. (2020) reported that greater pod length × width increases susceptibility to groundnut bruchids. Jyothsna (2015 observed that high shell thickness offered resistance of groundnut genotypes to groundnut bruchid infestation. Pod weight showed significant positive correlation with mean developmental period (0.537). Seed weight showed significant positive correlation with mean developmental period and significant negative correlation with pod damage. Rekha et al. (2017) also mentioned resistance in groundnut genotypes with less pod weight. Intergranular space did not exhibit any significant correlation with biological parameters of bruchid however weak positive correlations were observed, adult emergence and mean developmental period. Similarly, Nadaf (2008) reported that susceptibility is high in groundnut genotypes having more intergranular space. According to present findings all the biochemical parameters *viz.,* proteins, total soluble sugars and phenols had significant effect on development of *C. gonagra.* Venugopal et al. (2000) also reported that the varieties possessing higher amounts of primary metabolites

Table 4. Biochemical parameters of groundnut genotypes

Groundnut genotypes	Protein %	Total soluble sugar %	Phenol (mg/100g)
Dharani	20.28^{b}	5.94^{d}	224.01^{d}
Kadiri Lepakshi	21.23^{c}	6.16^{e}	213.60^{c}
K6	22.31^{d}	6.38^{f}	201.81^{b}
K-1687	18.81^{a}	5.27^{b}	243.07^{f}
K-1677	19.79^{b}	5.59^{c}	231.61^{e}
K7 Bold	23.68^{e}	6.76^{g}	172.67^{a}
Kadiri Chitravathi	18.46^{a}	5.03^{a}	265.01^{g}

Values are average of three replications
Means followed by same letters are not significantly different by DMRT(p=o.95)

Table 3. Physical parameters assessed in the pods of groundnut genotypes

Groundnut genotypes	Length (L) (mm)	Width (W) (mm)	L × W (mm × mm)	Shell thickness (mm)	100 seed weight (g)	100 pod weight (g)	Inter granular space (cc)	Pod reticulation
Dharani	25.28^{a}	11.63^{a}	294.09^{a}	0.57^{a}	55.92^{a}	85.67^{a}	50.67^{a}	Smooth
Kadiri Lepakshi	29.29^{b}	11.52^{a}	337.79^{b}	0.86^{bc}	56.86^{a}	85.00^{a}	60.33^{bc}	Very prominent
K-6	30.62^{bc}	12.09^{a}	370.18^{b}	0.76^{ab}	62.36^{b}	97.50^{b}	59.33^{b}	Very prominent
K-1687	30.97^{c}	15.50^{b}	480.06^{c}	1.15^{d}	77.16^{c}	145.00^{c}	61.33^{bc}	Moderate
K-1677	29.84^{bc}	15.99^{bc}	477.15^{c}	1.00^{cd}	79.94^{cd}	160.00^{d}	60.00^{b}	Smooth
K-7 Bold	30.63^{bc}	16.70^{c}	511.57^{c}	1.01^{cd}	80.46^{cd}	192.50^{e}	62.33^{c}	Moderate
Kadiri Chitravathi	31.09^{c}	16.02^{bc}	498.67^{c}	1.43^{e}	82.74^{d}	195.00^{e}	60.00^{b}	Smooth

Means followed by same letters are not significantly different by DMRT(p=0.05)

Table 5. Correlation between physical parameters of selected groundnut genotypes and biological parameters of groundnut bruchid

Biological parameters/ Physical parameters	Oviposition	Adult emergence	Mean developmental period	Weight loss	Pod damage	Index of susceptibility
Length	0.009	0.060	0.081	0.000	-0.089	0.003
Width	0.331	0.081	0.579**	-0.340	-0.401*	-0.314
Length × Width	0.241	0.079	0.474**	-0.263	-0.344	-0.243
Shell thickness	0.685*	-0.435*	0.077	0.282	0.280	-0.317
Pod weight	0.268	0.129	0.537**	-0.278	-0.358	-0.261
Seed weight	0.240	0.071	0.544**	-0.336	-0.381*	-0.282
Intergranular space	0.351	0.238	0.242	-0.024	-0.074	0.014

** Significant at the 0.01% level.
* Significant at the 0.05 % level

Table 6. Correlation between biochemical parameters of selected groundnut genotypes and biological parameters of groundnut bruchid

Biological parameters/ Physical parameters	Oviposition	Adult emergence	Mean developmental period	Weight loss	Pod damage	Index of susceptibility
Proteins	0.759***	0.895***	-0.949***	0.891***	0.840***	0.973***
Total soluble sugars	0.694***	0.844***	-0.964***	0.862***	0.789***	0.960***
Phenols	-0.790***	-0.870***	0.943***	-0.869***	-0.809***	-0.962***

*** Significant at the 0.01% level.

such as proteins and carbohydrates exhibited a significant positive effect whereas total phenols showed significant negative effect on the infestation rate. Jyothsna et al. (2015) reported that proteins and total soluble sugars exerted significant positive influence on infestation and development. Similarly, Singh et al. (2024) observed that the resistant genotypes possessed higher pod phenol content.

CONCLUSION

According to these findings, no single physical component or biochemical constituent of groundnut is solely responsible for imparting tolerance / susceptibility to the bruchid pest. Effect of bruchid tolerance / susceptibility is determined by combined effect of different physical and chemical factors of groundnut genotypes. The physical factors like shell thickness, seed weight, pod reticulation and intergranular space showed some influence on damage caused by *C. gonagra* whereas the biochemical factors like phenols and anti-nutritional factors *viz.,* low sugar and low protein contributed more significantly to the tolerance of groundnut genotypes against bruchid damage and development. The variety Kadiri Chitravathi with high phenol content, low sugars and low proteins recorded low oviposition, lower adult emergence, lesser pod damage and lower weight loss with Index of susceptibility of 4.09 was proved tolerant to groundnut bruchid. The highly susceptible entry K-7 Bold with less phenol content, more sugars and proteins, large size and more intergranular space recorded index of susceptibility of 10.16 which was comparable to susceptible check K-6.

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