International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(3): 224-232
www.biochemjournal.com
Received: 06-01-2024
Accepted: 13-02-2024

Mamta Bhagat
College of Agriculture, Raipur, Chhattisgarh, India

Dr. Vikas Singh
College of Agriculture, Raipur, Chhattisgarh, India

Chunni Kumari
College of Agriculture, Raipur, Chhattisgarh, India

Jharna Chaturvedani
College of Agriculture, Raipur, Chhattisgarh, India

Corresponding Author:
Mamta Bhagat
College of Agriculture, Raipur, Chhattisgarh, India

Biochemical characters conferring resistance against pod borers in pigeonpea genotypes

Mamta Bhagat, Dr. Vikas Singh, Chunni Kumari and Jharna Chaturvedani

DOI: https://doi.org/10.33545/26174693.2024.v8.i3c.726

Abstract
An investigation was undertaken to study the biochemical characteristics associated with resistance against pod borers in various pigeonpea genotypes. The research was carried out at the Research cum Instructional farm of Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, during the *Kharif* and *Rabi* seasons of 2021-22 and 2022-23, respectively. Additionally, laboratory studies were conducted at the Biochemical Laboratory, Department of Entomology, IGKV, Raipur. The results of the investigation revealed significant correlations between biochemical characteristics of pigeonpea pods and the extent of damage caused by pod borers. Total phenol content in the pods of early, mid-early, and medium-duration pigeonpea genotypes showed a strong and negative relationship ($r = -0.852$, $r = -0.985$, $r = -0.832$ respectively) with the percentage of pod damage caused by pod borers. This indicates that higher levels of total phenols in the pods are associated with lower levels of pod damage, suggesting a potential role of phenolic compounds in conferring resistance against pod borers. On the other hand, protein content, total soluble sugar content, and reducing sugar content in the pods of early, mid-early, and medium-duration pigeonpea genotypes exhibited significant positive associations (protein content: $r = 0.920$, $r = 0.953$, $r = 0.914$; total soluble sugar: $r = 0.933$, $r = 0.974$, $r = 0.980$; reducing sugar: $r = 0.845$, $r = 0.958$, $r = 0.913$) with the percentage of pod damage caused by pod borers. This suggests that higher levels of protein and sugars in the pods may actually attract pod borers or contribute to increased susceptibility to their damage.

Keywords: Biochemical, characters, pigeonpea, genotypes, pod

Introduction
Pigeonpea (*Cajanus cajan* (L) Millspaugh) holds a significant position among grain legume crops, particularly in the tropical and subtropical regions of Asia and Africa. In India, it stands as the second most important pulse crop following chickpea and is commonly referred to as Arhar, red gram, or tur. India notably emerges as the largest producer of pigeonpea globally, contributing to over 93% of the total production. The cultivation of pigeonpea spans across approximately 4.46 million hectares of land in India. The production output reaches around 4.18 million tonnes annually, indicating the substantial contribution of this crop to the agricultural sector. Despite its widespread cultivation, the productivity levels of pigeonpea have shown variability, with an average productivity of about 937 kg/ha during the 2017-18 period. (DAC, 2018) [15].

The pod borer complex, consisting of *Helicoverpa armigera*, *Etiella atoma*, and *Maruca vitrata*, has been identified as a significant threat to pigeonpea crops. These pests primarily target the reproductive parts of the plant, leading to substantial reductions in grain yield, with losses ranging from 30 to 100 percent. Among the members of the complex, H. armigera alone is responsible for up to 50 percent of the total crop loss in pigeonpea. The damage inflicted by these pests not only affects the quantity but also the quality of the yield, posing a considerable challenge to pigeonpea production and farmer livelihoods. Infestations by the pod borer complex can lead to economic losses and jeopardize food security, particularly in regions where pigeonpea serves as a staple crop. (Thakare, 2001 and Dodia *et al*., 2009) [20, 3].

The indiscriminate use of insecticides in the field has led to several negative consequences, including the development of resistance among pest populations, resurgence of pests, and secondary outbreaks of minor pests.

To address these challenges and ensure sustainable production, it is essential to adopt alternative pest management strategies. (Halder *et al*., 2006) [4]. Host plant resistance involves the use of tolerant cultivars or hybrids that possess inherent resistance to pest attacks. In the context of pigeonpea cultivation, the resistance or susceptibility to the pod borer complex is associated with specific biochemical traits present in the plant. These traits include nitrogen content, protein levels, total soluble sugar concentration, phenol content, and reducing sugar levels.

Materials and Methods

Biochemical characters conferring resistance against pod borers in pigeonpea genotypes during *kharif* 2021-2022 and 2022–2023

For the study of biochemical characters related to resistance against pod borers, a total of twenty-one genotypes were selected. Biochemical parameters *viz.*, total nitrogen and total protein contents, total phenols, total soluble sugars and reducing sugar were estimated on three randomly selected samples in 21 genotypes and data were correlated with the damage of pod borers. The procedures adopted for the estimation of biochemical parameters are described as under:

Total nitrogen content

Nitrogen in plant sample was determined by employing KELPLUS Digestion and Distillation systems by Subbiah and Asija (1956) [18]. This procedure essentially involved: (1) alteration of organic N compound to NH4-N form during digestion and (2) evaluation of NH4-N in the plant digest during distillation.

Reagents

a. **Conc:** Sulfuric acid (H_2SO_4)
b. **Catalyst salt mixture:** A mixture of K2SO and $CuSO_4$ salts in 10:1 ratio
c. **2.5% sodium hydroxide solution:** 25g of sodium hydroxide pellets were dissolved in distilled water and the volume made up to 1 lit.
d. **0.02N H_2SO_4:** 0.1N H_2SO_4 solution was prepared by adding 2.8 ml of concentrated H_2SO_4 in to 1 lit of distilled water. Afterwards, 0.02N H_2SO_4 solution was prepared by diluting a suitable volume five times with distilled water. Obtained solution was then standardized against 0.02 N NaOH solution.
e. **4% Boric acid solution:** Firstly 40 g of pure boric acid powder was dissolved in warm distilled water by stirring and 20 ml of mixed indicator was added into the boric acid solution. The pH of solution was adjusted to 4.5 with dil. HCl or NaOH and then the volume was made up to 1 lit.
f. **Mixed indicator:** Both of the indicators; 0.066 g of methyl red and 0.099 g of bromocresol green were dissolved in 100 ml of 95% ethyl alcohol.

Digestion of plant samples by using KELPLUS

After weighing of 0.1 g of plant sample into 100 ml capacity micro digestion test tube, 2 ml conc. H_2SO_4 solution was added by using 2 ml tilt measure/acid dispense and kept it overnight. Next, 1 g of catalyst/ salt mixture was added to the plant sample mixture and the test tube then transferred to the KELPLUS digestion unit. The test tubes initially heated with 200 °C, which gradually increased and set the temperature to 450 °C. The digestion unit was then putted off until half hours after attaining 450 °C. At last the test tubes were removed from the digestion chamber and kept them on stand for cooling to room temperature.

Distillation of digested sample by using KELPLUS

The distilled water tank of the KELPLUS until was filled first up to the given water level. Alakli, Boric acid and $KMnO_4$ solutions were loaded to the system through silicon holes provided at the back of the equipment. 25 ml Boric acid was taken with indicator in a 250 ml conical flask and placed at the receiver end. Next, the sample was diluted with distilled water (dilution 10 ml to 20 ml) and the sample tube was loaded to the sample side. System was pre-updated for the addition to add sodium hydroxide (NaOH 40%) for 25 ml. After completion of all above process, the system was processed to start. Timing of distillation was fixed and set as 9 min. During the process, liquid ammonia collected in boric acid and the colour of boric acid was changed to green as the colour of indicator. After completion of the process, the conical flask was removed from the receiver end and the distilled sample was titrated with 0.02 N H_2SO_4 till the blue colour changed to pinkish colour.

Calculation

The nitrogen content in plant sample was calculated as follows: Weight of sample= 0.1 g Normality of H_2SO_4 = 0.02 Titration value (TV) = Sample titration value – Blank titration value.

$$N\% = \frac{T.V.\times 0.00028\times 100}{0.1} = 0.28\times T.V.$$

Total protein content

Total protein content was estimated by “Nitrogen-Protein (N: P) conversion factor”. Firstly total nitrogen content of each genotype was analyzed by KELPLUS unit by Subbiah and Asija (1956) [18] and then the total nitrogen content was multiplied with Nitrogen-Protein (N: P) conversion factor ‘6.25’.

Total protein content = Total nitrogen × 6.25

Total phenols

The total phenols present in pods of twenty-one pigeonpea genotypes were estimated as per the method developed. From each sample 0.5 g material was weighed and was added with ten times volume of 80% ethanol and the homogenate was centrifuged at 10,000 rpm for 20 minutes. The supernatant was collected and residue was re-extracted with five times the volume of 80% ethanol, then centrifuged and the supernatants were pooled and evaporated to dryness. The residue was then dissolved in 5 ml distilled water and different aliquots ranging from 0.2 to 2.0 ml were pipetted out in to the test tubes and the volume in each tube was made upto 3 ml by adding distilled water. To this extract 0.5 ml of Folin - Ciocalteau reagent was added and after 3 minutes. 2 ml of 20% sodium carbonate solution was added to each tube. The material was mixed thoroughly and tubes were placed in boiling water exactly for one minute. The tubes were then cooled and the absorbance was measured at 650 nm against a reagent blank in spectrophotometer. The standard curve was prepared by plotting the Catechol concentrations on X-axis and absorbance values on Y- axis.

Reagents

a. Ethanol 80% was prepared by adding 80 ml of absolute alcohol in a beaker and made upto 100 ml by using distilled water.

b. Sodium carbonate 20% was prepared by adding 20 g Sodium carbonate in 100 ml of distilled water.

Preparation of Working Standards

The working standards were prepared by dissolving 100 mg catechol was dissolved in 100 ml of distilled water and diluted to 10 times from the working standards, different concentrations ranging from 0.1 to 1.0 ml were prepared. A blank containing all the reagents except plant extract should be used to adjust the absorbance to zero.

Calculation

From the standard curve, concentrations of total phenols in terms of mg phenols / 100 gm plant material was estimated and converted to percent.

Total soluble sugar (TSS)

The concentrations of total soluble sugar (TSS) were determined with the help of hand refractometer by Srivastava and Kumar (1994) [17]. The device was firstly calibrated by using distilled water, where the TSS reading was displayed as zero. Five plant samples that were randomly selected from each genotype were digested in the mortar and pestle. A double layer of muslin fabric was used to filter the final plant extract. A small amount of the plant extract (2-3 drops) was kept on the optical disc/prism region of refractometer and cover plate was secured. After covering the disc region, the TSS measurements were taken by looking through the lens of hand refractometer. The readings of total soluble sugar were determined and expressed in degree brix (° Brix).

Reducing sugar

For the estimation of reducing sugar, the dinitrosalicyclic acid method (Miller, G. L., 1972) [9] was used. Pipette a 3 ml aliquot of the extract into test tubes. Add 3 ml of DNS reagent to each tube. Then heat the mixture for 5 minutes in a boiling water bath. When the colour has developed, add 1 ml of 40 percent warm Rochelle salt to the tubes while the contents are still warm. Cool the tubes under a running tap. Measure the absorbance of the solution at 575 nm. Calculate the amount of reduced sugar using a standard prepared from glucose.

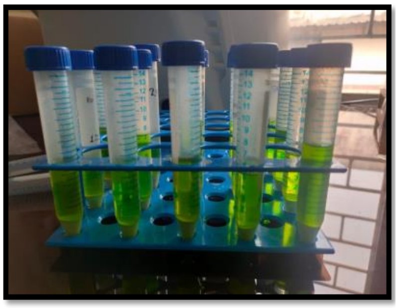
Reagents

- **Dinitrosalicylic (DNS) reagent:** 1 g of dinitrosalicylic acid, 200 mg of crystalline phenol, and 50 mg of sodium sulphate dissolved in 100 ml of a 1% solution of NaOH.
- **Rochelle Salt (Sodium Potassium Tartrate):** 40% solution

Pod sample and ethanol

Crushing of pod sample

Centrifugation



Centrifuged samples

Evaporation of ethanol

Aliquots

Fig 1: Aliquot (plant extract) preparation

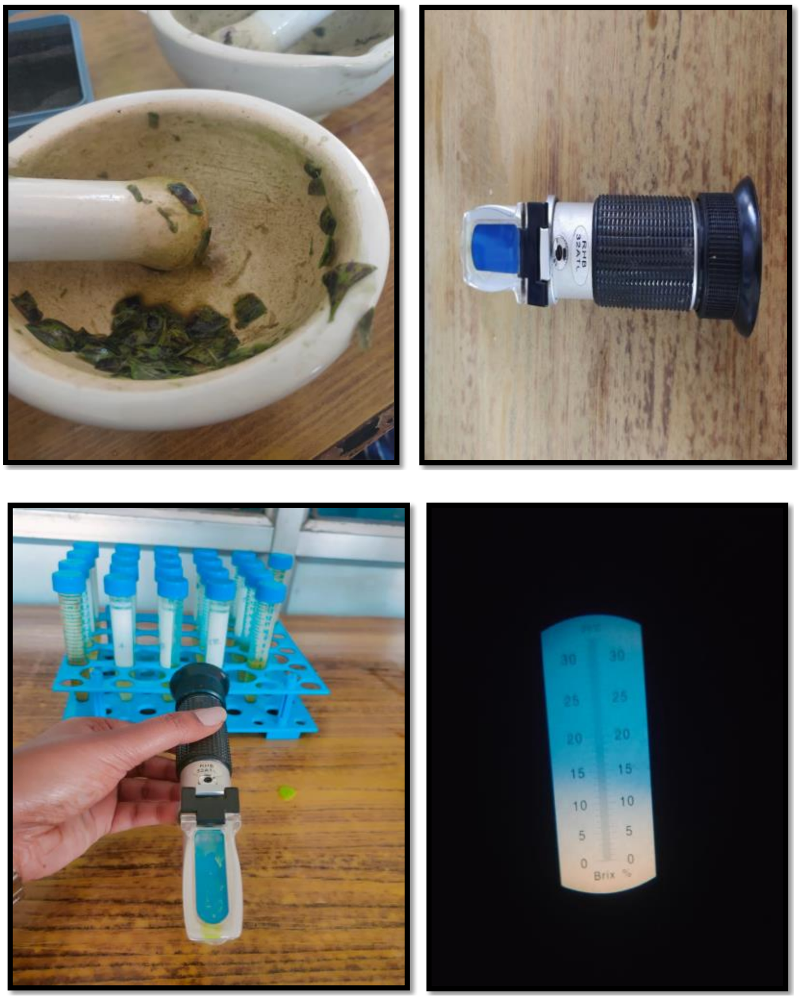


Fig 2: Analysis of Total soluble sugar (TSS) through hand refract meter

Fig 3: Analysis of nitrogen and protein by using KELPLUS UNIT

Statistical Analysis
The data obtained from all the characters has been subjected to the following statistical analyses.

Mean: It was calculated by using following formula.

Mean = ∑x/n

Where,
Σx = sum of all the observation
n = Number of observations

Test of significance of correlation coefficient
The test of significance of correlation coefficient, t- test value n-2 degree of freedom was calculated on the following formula:

$$t = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}}$$

The coefficient of correlation

$$r = \frac{\Sigma XY - nxy}{\sqrt{\Sigma X^2 - nX^2} \times \sqrt{\Sigma Y^2 - nY^2}}$$

Where,
X = Mean of first factor
Y= Mean of second factor
n = Total no. of observations
r = Correlation coefficient

Results and Discussion
To investigate the biochemical basis of resistance in pigeonpea genotypes against pod borers, various biochemical parameters were analyzed. These parameters included: Total nitrogen content, Total protein content, Total phenol content, Total soluble sugar content, Reducing sugar content. These biochemical parameters were selected based on their potential roles in plant defense mechanisms and their previous associations with resistance against insect pests. The analysis involved estimating the levels of each biochemical parameter in the pigeonpea genotypes and correlating these levels with the percentage of pod damage caused by pod borers.

Biochemical characters conferring resistance against pod borers in early genotypes of pigeonpea
A. Protein content (%)
As per the data represented in Table 1, the protein content ranged from 17.52 to 31.26 percent in the pod of 6 selected pigeonpea genotypes. The presences of considerable differences in the protein percent among all the genotypes of pigeonpea were tested for the resistance to pod borers. The maximum protein percent was recorded in highly susceptible genotype CRG 16-12 (31.26%). Whereas the least protein percent was recorded in RVKT 333 (17.52%).
Correlation analysis of protein percent and percent pod damage caused by pod borers conferred positively significant with r value 0.920* (Table 2). This indicates that with increase protein percent, there will be increase in infestation level too.
The studies conducted by Kamakshi *et al.* (2008) [7] and Sujithra and Srinivasan (2012) [19] revealed a significant positive association between protein content and pod borer incidence in field bean genotypes. This suggests that higher levels of protein in field beans may contribute to increased susceptibility to pod borer infestations. Similarly, Tiwari *et al*. (2017) [21] reported a positive association between protein content and pod damage in pigeon pea. They observed that protein content decreased in infested pods compared to healthy ones, indicating a potential link between protein levels and susceptibility to pod borers in pigeon pea crops.

B. Total Phenols (mg/g)
The phenol content was showed significant variation among different genotypes. The total phenol content of different genotypes varied from 3.35-4.65 mg/g, as presented in Table 1 in the pod of pigeonpea genotypes. The highest phenol content was measured in RVKT 333 (4.65 mg/g), whereas lowest phenolic content was observed in CRG 1612 (3.35 mg/g).
The correlation studies conducted between phenolic content and pod damage caused by pod borers revealed a highly significant negative association, with correlation coefficients (r values) of -0.852*. These findings indicate that higher phenol content is associated with reduced pod damage by pod borers in field conditions. The results reported in these studies are consistent with findings from Cheboi *et al.*, (2019) [2], who also observed a significant negative correlation between total phenol content and pod damage, with a correlation coefficient of -0.923**. This further supports the notion that phenolic compounds play a crucial role in mediating resistance against pod borers in legume crops.
The present findings align closely with those of Parre *et al.* (2018) [11], who also observed a high negative correlation (-0.9508) between phenol content and susceptibility to pod borer infestation. This indicates that genotypes with higher phenol content are less susceptible to pod borer infestation, as they are less preferred by the larvae of *Helicoverpa*.

C. Total soluble sugar (°Brix)
As per the data represented in Table 1, the presences of considerable differences in the TSS among all the genotypes of pigeonpea were tested for the resistance to pod borers and the total soluble sugar content ranged from 6.17 to 9.68 °Brix in the pod of 6 selected pigeonpea genotypes. The maximum TSS was recorded in highly susceptible genotype CRG 1612 (9.68 °Brix), whereas the least TSS was recorded in least susceptible genotype RVKT 333 (6.17 °Brix).
The results presented in Table 2 demonstrate a significant and positive correlation between total soluble sugar (TSS) content and pod damage caused by pod borers, with a correlation coefficient (r value) of 0.933**. This indicates that higher levels of total soluble sugars are associated with increased infestation by pod borers.
The results are consistent with the findings reported by Sai *et al*. (2018) [14], who observed a strong positive correlation between the sugars present in pod walls and pod damage caused by *Maruca vitrata*, with a correlation coefficient (r value) of 0.642. This similarity suggests that higher sugar content in pod walls is associated with increased susceptibility to pod damage by *Maruca vitrata*. The results presented in the study align with the findings reported by Tiwari *et al*. (2017) [21], who demonstrated a positive association between total sugars and pod damage in pigeon pea. Additionally, Tiwari *et al*. found that total sugar content decreased in infested pods compared to healthy ones.

D. Reducing sugar (mg/g)

The total reducing sugar content in pod samples of different genotypes exhibited significant variation, ranging from 0.89 to 1.59 mg/g. Among the genotypes studied, CRG 1612 had a high percentage of pod damage (14.04%) and possessed relatively higher reducing sugar content (1.59 mg/g). On the other hand, genotype RVKT 333 experienced the least pod damage (8.89%) by pod borers and had significantly lower reducing sugar content (0.89 mg/g).

Correlation analysis of reducing sugar and percent pod damage caused by pod borers conferred positively significant with r value 0.845* (Table 2). This indicates that with increase reducing sugar content, there will be increase in infestation level too.

The present findings are in concurrent with Kamakshi *et al*. (2008) [7] who reported that higher reducing sugar content was present in highly susceptible cultivars compared to highly resistant cultivars. Similarly, Halder and Srinivasan (2007) [5] and Kumar *et al*. (2015) [8] demonstrated a significant positive relationship between pod damage and reducing sugar content.

Biochemical characters conferring resistance against pod borers in mid-early genotypes of pigeonpea

A. Protein content (%)

As per the data represented in Table 1, the protein content ranged from 16.73 to 29.82 percent in the pod of 9 selected pigeonpea genotypes. The presences of considerable differences in the protein percent among all the genotypes of pigeonpea were tested for the resistance to pod borers. The maximum protein percent was recorded in highly susceptible genotype BDN 711(29.82%). Whereas the least protein percent was recorded in WRGE 138 (16.73%)

Correlation analysis of protein percent and percent pod damage caused by pod borers conferred positively significant with r value 0.953* (Table 2). This indicates that with increase protein percent, there will be increase in infestation level too.

The results presented in study are consistent with the findings reported by Tiwari *et al*., (2017) [19] who observed a highly significant positive correlation (r = 0.86**) between protein content and infestation due to the pod borer complex. This indicates that as protein content increases, so does the infestation of the pod borer complex, suggesting a potential association between protein content and susceptibility to pod borer infestations.

B. Total phenols (mg/g)

The phenol content was showed significant variation among different genotypes. The total phenol content of different genotypes varied from 2.70-4.50 mg/g, as presented in Table 1 in the pod of pigeonpea genotypes. The highest phenol content was measured in WRGE 138 (4.50 mg/g), whereas lowest phenolic content was observed in BDN 711(2.70 mg/g).

The results presented in Table 2 demonstrate a highly significant negative association between phenolic content and pod damage caused by pod borers, with a correlation coefficient (r value) of -0.985**. This strong negative correlation indicates that higher phenol content is associated with reduced pod damage by pod borers in field conditions. The negative correlation suggests that increased phenolic content in pigeon pea pods plays a critical role in offering resistance to pod borers.

The findings presented in this study are consistent with V. Ambidi *et al*., (2021) [1] who observed that the highest phenolic content was measured in ICPH 3461 (61.67 mg/g), followed by the resistant check ICPL 332 WR (59.17 mg/g), while the lowest phenolic content was observed in ICPH-4503 (12.80 mg/g). Correlation studies reported a highly significant negative association between phenolic content and pod damage caused by the pod borer complex, with a correlation coefficient (r value) of -0.729**. This indicates that higher phenol content is associated with reduced pod damage by pod borers in field conditions, confirming the critical role of phenolic compounds in offering resistance to pod borers.

C. Total soluble sugar (°Brix)

As per the data represented in Table 1, the presences of considerable differences in the TSS among all the genotypes of pigeonpea were tested for the resistance to pod borers and the total soluble sugar content ranged from 2.20 to 4.50 °Brix in the pod of 9 selected pigeonpea genotypes. The maximum TSS was recorded in highly susceptible genotype BDN 711 (4.50 °Brix), whereas the least TSS was recorded in least susceptible genotype WRGE 138(2.20 °Brix).

The results presented in Table 2, revealed that the TSS (r= 0.974**) showed significant and positive correlation with pod damage caused by pod borers, indicating that higher the sugar content higher is the infestation.

The findings presented in this study are consistent with those reported by Jat *et al*., (2021) [6] who observed that the expression of resistance to *Helicoverpa armigera* was associated with a high amount of total soluble sugar content, which in turn was responsible for higher pod infestation. The findings presented in this study are consistent with those reported by Reddy *et al*., (2018) [13] who observed a non-significant positive relation between sugar content and podfly infestation. The correlation coefficient values (r) of 0.178 for sugar content with pod damage and 0.159 with grain damage suggest that there is a weak positive correlation between sugar content and both pod and grain damage caused by podfly infestation. However, these correlation coefficients indicate a relatively weak relationship, and they are not statistically significant.

D. Reducing sugar (mg/g)

The total reducing sugar content in pod samples of different genotypes exhibited significant variation, ranging from 0.82 to 1.39 mg/g. Among the genotypes studied, BDN 711 had a high percentage of pod damage (21.68%) and possessed relatively higher reducing sugar content (1.39 mg/g). Conversely, genotype WRGE 138 experienced the least pod damage (13.75%) by pod borers and had significantly lower reducing sugar content (0.82 mg/g). Correlation analysis of reducing sugar and percent pod damage caused by pod borers conferred positively significant with r value 0.958* (Table 2). This indicates that with increase reducing sugar content, there will be increase in infestation level too.

The findings of this study align with those reported by Pandey *et al*., (2011) [10] who observed that reducing sugars were significantly higher in susceptible genotypes, with values ranging from 18.31 mg/g in Bahar to 15.31 mg/g in green pod walls of MA 24. In contrast, reducing sugar values were significantly lower in resistant genotypes, ranging from 8.80 mg/g in PDA 88-2E to 13.67 mg/g in MA3.

Biochemical characters conferring resistance against pod borers in medium genotypes of pigeonpea

A. Protein content (%)

As per the pooled data represented in Table 1, the protein content ranged from 16.78 to 18.94 percent in the pod of 6 selected medium pigeonpea genotypes. The presences of considerable differences in the protein percent among all the genotypes of pigeonpea were tested for the resistance to pod borers. The maximum protein percent was recorded in highly susceptible genotype AKTM 1637 (18.94%). Whereas the least protein percent was recorded in CG Arhar-2 (16.78%).

Correlation analysis of protein percent and percent pod damage caused by pod borers conferred positively significant with r value 0.914*(Table 2). This indicates that with increase protein percent, there will be increase in infestation level too.

The present findings are in coordination with Parre *et al*., (2018) [11] who reported that the protein content showed positive correlation with percent of pod borer damage (0.8035) indicating that genotypes with more protein content are more susceptible to *Helicoverpa* infestation.

B. Total phenols (mg/g)

The phenol content exhibited significant variation among different medium genotypes. The total phenol content of different medium genotypes varied from 2.95 - 4.94 mg/g, as presented in Table 1 in the pod of pigeonpea genotypes. The highest phenol content was measured in CG Arhar-2 (4.94 mg/g), whereas lowest phenolic content was observed in AKTM 1637 (2.95 mg/g).

The correlation studies conducted between phenolic content and pod damage caused by pod borers revealed a highly significant negative association, with a correlation coefficient (r value) of -0.832*. This indicates that higher phenol content is associated with reduced pod damage by pod borers in field conditions.

The present findings are consistent with previous research conducted by Rashmi *et al*., (2020) [12] and Tyagi *et al*., (2021) [20] who reported a negative and significant correlation between pod damage and phenol content in pods of different genotypes. This indicates that an increase in phenol content led to less pod damage by pod borers.

C. Total soluble sugar (°Brix)

As per the data represented in Table 1, the presences of considerable differences in the TSS among all the medium genotypes of pigeonpea were tested for the resistance to pod borers and the total soluble sugar content ranged from 5.16 to 9.40○Brix in the pod of 6 selected pigeonpea genotypes. The maximum TSS was recorded in highly susceptible genotype AKTM 1637 (9.40°Brix), whereas the least TSS was recorded in least susceptible genotype CG Arhar-2 (5.16 °Brix).

The results presented in Table 2, revealed that the Total soluble sugar (r= 0.980**) showed significant and positive correlation with pod damage caused by pod borers, indicating that higher the sugar content higher is the infestation.

The current findings are in alignment with the research conducted by Parre *et al*., (2018) [11] who reported a positive association between total sugars (including reducing and non-reducing sugars) and the percentage of pod borer damage. This indicates that genotypes with higher sugar content are more preferred by *Helicoverpa species*, leading to increased pod borer damage.

D. Reducing sugar (mg/g)

The total reducing sugar content in pod samples of different medium genotypes exhibited significant variation, ranging from 0.87 to 1.44 percent. Among the genotypes studied, AKTM 1637 had a high percentage of pod damage (14.63 mg/g) and possessed relatively higher reducing sugar content (1.44 mg/g). Conversely, genotype CG Arhar-2 experienced the least pod damage (10.08 mg/g) by pod borers and had significantly lower reducing sugar content (0.87 mg/g).

Correlation analysis of reducing sugar and percent pod damage caused by pod borers conferred positively significant with r value 0.913*(Table 2). This indicates that with increase reducing sugar content, there will be increase in infestation level too.

The current findings align with the research conducted by Parre *et al*., (2018) [11] who reported a positive association between total sugars (including reducing and non-reducing sugars) and the percentage of pod borer damage. This indicates that genotypes with higher sugar content are more preferred by *Helicoverpa species*, leading to increased pod borer damage. The similar findings reported by Siva Kumar *et al*., (2015) [8] Siva who observed a positive and significant correlation between reducing sugars and pod damage caused by pod fly infestation. This suggests that an increase in reducing sugar content is associated with a higher incidence of pest infestation.

Table 1: Influence of biochemical contents on pod damage by pod borers during *kharif* 2021-2022 and 2022-2023

S. No.	Genotypes	Total% Pod Damage	Protein content%	Total phenol (mg/g)	Total soluble sugar (°Brix)	Reducing sugar (mg/g)
	Early					
1	RVKT 333	8.89	17.52	4.65	6.17	0.89
2	CRG 16-12	14.04	31.26	3.35	9.68	1.59
3	IPAE 15-08	11.31	19.69	3.71	6.30	1.07
4	IPAE 15-05	12.31	22.25	4.16	6.92	1.19
5	UPAS 120(RC)	12.41	25.45	4.04	7.35	1.44
6	CG Arhar-1	13.03	26.88	3.63	8.35	1.46
7	C.D. @ 5%		0.55	0.44	0.86	0.49
	Mid-Early					
1	WRGE 138	13.75	16.73	4.50	2.20	0.82
2	RVSA 14-2	20.98	24.99	2.74	2.51	1.26
3	PT 2017-2	16.73	19.97	3.84	3.71	0.96
4	WRGE 124	14.80	19.81	2.75	2.91	0.90
5	PT 2017-1	17.53	20.86	3.22	3.22	1.08
6	BDN 2013-2	18.46	21.00	3.26	3.26	1.06

7	PT 10-1-1-2	14.53	19.13	4.27	4.27	0.86
8	BDN 711	21.68	29.82	2.70	4.50	1.39
9	PT 0012 (RC)	17.09	20.07	2.92	3.05	1.01
10	C.D. @ 5%		1.08	0.45	0.40	0.53
	Medium					
1	GRG 622	11.98	17.97	3.98	7.87	1.24
2	AKTM 1637	14.63	18.94	2.95	9.40	1.44
3	GJP 1915	11.45	16.98	4.43	7.25	1.07
4	PT 11-16	13.78	18.83	3.41	9.27	1.37
5	BDN 716	13.25	18.14	3.32	8.10	1.32
6	CG Arhar-2(RC)	10.08	16.78	4.94	5.16	0.87
7	C.D. @ 5%		0.55	0.40	0.79	0.59

Table 2: Correlation coefficient between biochemical characters of pigeonpea genotypes and percent pod damage by pod borers

S. No.	Biochemical characters	Correlation coefficient (r)		
		Early duration genotypes	Mid - early duration genotypes	Medium duration genotypes
1	Protein content	0.920**	0.953**	0.914*
2	Total phenol	-0.852*	-0.985**	-0.832*
3	Total soluble sugar	0.933**	0.974**	0.980**
4	Reducing sugar	0.845*	0.958**	0.913*

*Significant at 5% (p=0.05) level Table value: Mid-early(r) = .666 Early and Medium (r) = .811
** Significant at 1% (p=0.01) level, Mid-early (r) =.798, Early and Medium (r) =.917

Conclusion

The study highlights the significance of plant-herbivore interactions, emphasizing that these interactions are not only influenced by environmental conditions but also by various physico-chemical traits of plants and the physiological status of the herbivores. Specifically, the research demonstrates variations among different plant genotypes regarding several biochemical traits such as total phenol, nitrogen content, protein content, total soluble sugar, and reducing sugar. These variations suggest the potential utility of genetic resources in enhancing host plant resistance against herbivores. By identifying genotypes that exhibit differences in these biochemical traits, the study suggests that it may be possible to improve host plant resistance through selective breeding or genetic modification. Host plant resistance, in this context, refers to the ability of plants to resist damage from herbivores, either through chemical defenses or other mechanisms. The association of multiple biochemical traits with host plant resistance underscores the complex nature of plant-herbivore interactions and the importance of considering various factors in efforts to enhance plant resistance.

Overall, the findings of this study contribute to our understanding of the mechanisms underlying plant-herbivore interactions and highlight the potential for using genetic resources to develop more resistant crop varieties, thereby reducing the need for chemical pesticides and promoting sustainable agriculture.

References

1. Ambidi V, Bantewad S, Prasad Mishra S, Hingane A, Jaba J. Morpho-biochemical parameters associated with resistance to pod borer complex of pigeonpea. Pakistan Journal of Zoology (TSI); c2021. p. 1-7.
2. Cheboi JJ, Kimurto PK, Kinyua MG. Variability in Morpho-biochemical Traits Associated with Pod Borer (*Helicoverpa armigera*) Resistance in Pigeonpea Pods. Journal of Experimental Agriculture International. 2019;31(3):1-7.
3. Dodia DA, Prajapati BG, Acharya S. Efficacy of Insecticides against gram pod borer, *Helicoverpa armigera* infesting pigeonpea. J of food legumes. 2009;22:144-145.
4. Halder J, Srinivasan S, Muralikrishna T. Biochemical basis of resistance against *Maruca vitrata* (Geyer) in mung bean. Journal of Entomological Research. 2006;30(4):313-316.
5. Halder J, Srinivasan S. Biochemical Basis of Resistance against *Maruca vitrata* (Geyer) in urd. bean. Ann. Pl. Protec. Sci. 2007;15(2):287-290.
6. Jat BL, Dahiya KK, Yadav SS, Mandhania S. Morpho physicochemical components of resistance to pod borer, *Helicoverpa armigera* (Hübner) in pigeonpea [*Cajanus cajan* (L.) Millspaugh]. Legume Research-An International Journal. 2021;44(8):967-976.
7. Kamakshi N, Srinivasan S, Muralikrishna T. Influence of biochemical constituents of pod borer complex in selected field bean genotypes. Ann. Pl. Protec. 2008;16(2):302-305.
8. Kumar GS, Krishna TM, Prasanthi L, Sudhakar P, Devaki K. Morphological and biochemical traits associated with resistance to pod fly, *Melanagromyza obtusa* (malloch) in pigeonpea. Int. J Appl. Biol, Pharm. Technol. 2015;6(3):134-141.
9. Miller GL. Use of dinitrosalicylic acid reagent for the determination of reducing sugar. Anal. Chem. 1972;31:426-428.
10. Pandey V, Srivastava CP, Nath T, Raha P. Chemical traits of pigeonpea pod wall affecting pod fly damage. Indian Journal of Agricultural Sciences. 2011;81(11):1059-1062.
11. Parre Suman, Raje RS, Singh NK, Kumar Joni. Genetic variability and association analysis for morphological and biochemical traits related to pod borer (*Helicoverpa armigera*) resistance in Pigeonpea [*Cajanus cajan* (L) Millspaugh] among recombinant inbred lines. Journal of Entomology and Zoology Studies. 2018;6(3):1570-1575.
12. Rashmi KM, Gowda KM, Tambat B, Kumar NU, Vijayakumar L. The Morphological and Biochemical Components of Resistance in Field Bean against Pod Borers. Int. J Curr. Microbiol. App. Sci. 2020;9(6):3894-3905.

13. Reddy DVC, Sreekanth M, Rani CS, Rama G. Assessment of pigeonpea seed traits for resistance to podfly, *Melanagromyza obtusa* (Malloch); c2018.
14. Sai Y, Sreekanth M, Sairam Kumar DV, Manoj Kumar V. Morphological and biochemical factors associated with resistance to *Helicoverpa armigera* (Hubner) and *Maruca vitrata* (Geyer) in Pigeonpea. Journal of Entomology and zoology studies. 2018;6(2):3073-3078.
15. Srivastava RP, Kumar S. Fruit and vegetable preservation: principles and practices. CBS Publishers & Distributors Pvt. Limited, 1994, 353.
16. Subbiah BV, Asija GL. A rapid method for the estimation of available nitrogen in soils. Curr. Sci. 1956;25:259-260.
17. Sujithra M, Srinivasan S. Biophysical and bio-chemical factors influencing plant resistance in pod borers on field bean, *Lablab purpureus* var. Lignosus Medikus. Ann. Plant Protec. Sci. 2012;20(2):329-333.
18. Thakare SM. Evaluation of some management tactics against pod borer complex of pigeonpea. Ph.D. Thesis, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, India; c2001.
19. Tiwari S, Yadav S, Nadaf A. Influence of some biochemical components on the incidence of *Maruca vitrata* (Geyer) on short duration pigeon pea *Cajanus cajan* (L.) Mill sp. Int. J Chem. Stud. 2017;5(4):1339-1341.
20. Tyagi S, Keval R, Verma S, Kohar DN. Morphological and biochemical basis of resistance to pod borer *Helicoverpa armigera* in pigeonpea. Indian Journal of Entomology; c2022. p. 704-708.