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Research article

MORPHOLOGICAL AND BIOCHEMICAL TRAITS ASSOCIATED WITH RESISTANCE TO POD FLY, *MELANAGROMYZA OBTUSA* (MALLOCH) IN PIGEONPEA

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ABSTRACT: Pod fly, *Melanagromyza obtusa* is an important emerging pest and a major constraint to increase the production and productivity of pigeonpea. The concealed mode of life of pod fly within the pod makes it difficult to control. Hence, host plant resistance is an important tool for the management of this pest. Therefore, a set of forty genotypes were screened for resistance to pod fly under field conditions and characterized for morphological and biochemical traits in the pods. The correlation studies revealed that, among morphological and biochemical constituents of pigeonpea, pod length (r=0.389*), pod width (r=0.380*), protein content (r=0.857**), total carbohydrates (r=0.782**), reducing sugars (r=0.848**) and total free amino acids (r=0.832**) in the pod walls were positively correlated with per cent pod damage, whereas pod wall thickness (r= -0.762**), trichome density (r= -0.745**) and phenol content (r= -0.871**) had significant negative correlation with pod fly damage. Therefore, these traits can be used as phenotypic and biochemical markers to identify pigeonpea genotypes with resistance to *M. obtusa*, and use in pod fly resistance breeding program.
Key words: *M. obtusa*, Pigeonpea, Biochemical traits, Morphological traits

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the most important pulse crops grown widely in India which is the world's largest producer contributing 72 per cent of total global production. About 250 insect species belonging to 8 orders and 61 families have been found to infest pigeonpea from seedling to harvesting stage (Upadhyay *et al.*, 1998). Among the insect pests pod fly, *Melanagromyza obtusa* (Malloch) (Diptera: Agromyzidae) is the most obnoxious pest causing the grain damage ranging from 20 to 80 per cent (Subharani and Singh, 2009). The oviposition of pod fly takes place on the inner surface of the pod walls and after hatching the larvae mines into the pods and feeds on the soft seed thus making it unfit for human consumption as well as seed purpose (Lal and Yadava, 1993).

The pod fly attack remains unnoticed by farmer owing to the concealed mode of life within the pods and thus it becomes difficult to manage the pest in time. The identification and development of pod fly resistant cultivars/genotypes would provide an equitable and environmentally sound tool for the sustainable management of this difficult to control insect pest. The morphological and biochemical pod traits can be used as markers to identify the resistance source against pod fly to be used in breeding programme. Therefore, present investigations were conducted to identify the morphological and biochemical basis of resistance to pod fly in pigeonpea pod walls very specifically.

MATERIALS AND METHODS

Evaluation of pigeonpea cultivars for resistance against pod fly, *M. obtusa*

A screening trial was laid out in RBD design against the pod fly in the wetland farm, S.V. Agricultural College, Tirupati during *Kharif,* 2012-13. The experimental material comprised of forty genotypes was procured from ICRISAT, Patancheru and RARS, Tirupati. Each genotype was sown in single row of 4m length with the spacing of 180 cm between the rows and 20 cm within the row likewise three replications were maintained. The crop was raised following all the recommended agronomic practices and kept free from insecticidal sprays. Data on damaged and healthy pods in each cultivar were recorded from the pods after harvest and per cent pod and grain damage was computed.

Studies on morphological and biochemical basis of resistance in pigeonpea against pod fly

Data on certain morphological traits *viz.*, pod length, pod width, trichome density and pod wall thickness was recorded for the variations in incidence of pod fly damage. The uniformly developed ten pods from each genotype were collected randomly and used to assess the length and width of pods with the help of graph paper and expressed in centimeter per pod. The trichome density was measured in accordance with Jackai and Oghiakhe (1989). The pod was cut into bits of 0.25 cm^2 and number of trichomes present on the epidermis of pods was counted under a stereo zoom trinocular microscope. Thickness of pod wall in ten pods was measured by using the vernier calipers and expressed in millimeter per pod.

The pod samples were collected when the pod fly damage was at peak level and subjected to analysis for biochemical components in the pod walls. Estimation of protein content was done as per the method developed by Lowry *et al.* (1951). The phenol content was estimated as per method described by Malick and Singh (1980). The total free amino acid (TFA) content was estimated as per the method described by Moore and Stein (1948). Total carbohydrate content was estimated as per the method developed by Hedge and Hofreiter (1962). The method described by Somogyi (1952) was employed for estimating reducing sugars. The pod fly damage percentage was later correlated with the morphological and biochemical constituents in each cultivar to identify their influence on relatively resistant and susceptible varieties in pigeonpea.

RESULTS AND DISCUSSION

Per cent pod and grain damage inflicted by pod fly, *M. obtusa* in pigeonpea genotypes

Data assessed on per cent pod and grain damage due to pod fly in all forty genotypes of pigeonpea was presented in Table 1. The pod damage caused by pod fly among the cultivars was significant and ranged from 24.67 to 88.67 per cent. The results showed that ICP 14887 recorded the least damage (24.67%) and this was on par with the ICP 14770 (27.33%) and BDN 2 (28.33%). The highest per cent pod damage was observed in ICP 9150 (88.67%) followed by ICP 12083 (84.33%), ICPL 15225 (81.33%), ICP 15580 (76.33%), TRG 59 (75.67%) and ICP 12082 (75.67%). The remaining cultivars recorded the pod damage ranged from 35.67 per cent in PRG 158 to 60.67 per cent in ICP 12084. The check cultivars, LRG 41 and TRG 22 recorded 57.33 and 60.67 per cent pod damage, respectively. The data on per cent grain damage revealed that there was significant difference among the cultivars and the damage ranged from 15.12 to 45.56 per cent. Mishra *et al*. (2012) also reported the similar results with grain damage ranged from 16.43 to 48.44 per cent. Highest per cent grain damage was recorded in the cultivar ICP 9150 (45.56%) and it was on par with cultivars, ICP 12083, TRG 59, ICPL 15225, ICP 15580 and ICP 12082 which had grain damage of 42.58, 40.59, 40.14, 39.62 and 37.91 per cent, respectively. The lowest per cent grain damage of 15.12 per cent recorded in ICP 14887 and it was found to be on par with the accessions BDN 2 (17.07%), PRG 158 (18.31%), ICP 14770 (18.91%), ICP 8865 (18.89%), Ramapuram Local (19.35%), BRG 23 (19.34%), ICP 14888 (20.09%), ICP 13953 (20.37%), ICPL 87119 (21.38%), TRG 33 (21.69%) and ICP 14890 (22.04%). The other cultivars exhibited the range of grain damage of 24.12 per cent in ICP 14722 to 36.83 per cent in ICP 12084. The two checks LRG 41 and TRG 22 recorded the grain damage to an extent of 29.29 and 31.59 per cent, respectively. Pandey *et al*. (1984) also reported the grain damage in pigeonpea due to pod fly ranged between 16.32 to 44.88 per cent. Similar findings have also been reported by Kumar *et al*. (1998).

Influence of morphological and biochemical characters on the incidence of pod fly, *M. obtusa* in pigeonpea genotypes

Various morphological characters like pod length, pod width, pod wall thickness and trichome density in the pod of pigeonpea genotypes were presented in Table 2. Correlation studies revealed that the pod damage was varying significantly with various morphological characters of pods and the multiple linear regression model fitted was, $y=111.944 + 1.126\ x_1 + 32.605\ x_2 - 162.276\ x_3 - 0.119\ x_4$ with R^2 value of 0.813 (x_1= pod length, x_2= pod width, x_3= pod wall thickness, x_4= trichome density).

Significant positive relationship existed between per cent pod fly damage and pod length as well as pod width (Table 4). The differences in length of pods among the cultivars were significant and among all the cultivars, pods of ICP 12084 were significantly longer (7.2 cm) followed by ICP 12083 (6.94 cm), ICP 7403 (6.86 cm), while the cultivar ICP 8094 had the short pods (4.22cm).

The pod length of remaining cultivars was in the range of 4.81 cm (ICP 8865) to 6.78 cm (Durga). The pod width of ICP 12084 was significantly high (1.32 cm) when compared to other cultivars followed by ICP 7403 (1.21 cm) and TRG 38 (1.09 cm) whereas, width was lowest in the cultivar RGT3 (0.63cm) followed by BDN2 (0.64 cm). The present results are in conformity with the findings of Thakur *et al*. (1989) who observed that grain infestation by *M. obtusa* was positively correlated with length and width of pods. Jayadeep Halder *et al*. (2006) reported that angle between the pods and pod width showed negative correlation with pod damage against *Maruca vitrata* in mungbean.

Table 1. Per cent pod and grain damage inflicted by *M. obtusa* in different accessions of pigeonpea

S. No	Genotype	Per cent pod damage	Per cent grain damage
1	ICP 7403	50.67 (45.405)^{ijklm}	27.71 (31.779)^{hijklmano}
2	ICP 8865	36.33 (37.087)^{pqr}	18.89 (25.775)^{pqr}
3	ICP 8094	54.00 (47.318)^{ghijkl}	28.90 (32.533)^{ghijklmn}
4	ICP 9150	88.67 (70.363)^{a}	45.56 (42.471)^{a}
5	ICP 11948	63.00 (52.562) ^{defg}	32.29 (34.645)^{cdefghijk}
6	ICP 11949	49.33 (44.641)^{jklmn}	25.68 (30.463)^{jklmnop}
7	ICP 12082	75.67 (60.474)^{c}	37.91 (38.020)^{abcdef}
8	ICP 12083	84.33 (66.717)^{ab}	42.58 (40.754)^{ab}
9	ICP 12084	67.67 (55.374)^{d}	36.83 (37.383)^{bcdefg}
10	ICP 12088	58.67 (50.016)^{defghij}	29.68 (33.024)^{fghijkl}
11	ICP 13950	67.00 (54.966)^{de}	36.17 (36.987)^{bcdefgh}
12	ICP 13953	43.00 (40.997)^{mnopq}	20.37 (26.839)^{opqr}
13	ICP 13954	58.00 (49.629)^{efghij}	29.79 (33.096)^{fghijkl}
14	ICP 14722	45.67 (42.536)^{lmnop}	24.12 (29.429)^{klmnopq}
15	ICP 14770	27.33 (31.537)^{s}	18.91 (25.786)^{pqr}
16	ICP 14885	50.33 (45.214)^{ijklm}	27.51(31.647)^{ijklmno}
17	ICP 14887	24.67 (29.794)^{s}	15.12 (22.894)^{r}
18	ICP 14888	39.67 (39.056)^{opq}	20.09(26.643)^{opqr}
19	ICP 14890	44.67 (41.960)^{lmnopq}	22.04 (28.014)^{lmnopqr}
20	TRG 22 (Check)	60.67 (51.185)^{defgh}	31.59 (34.215)^{defghijk}
21	Durga	64.67 (53.556)^{def}	35.41 (36.533)^{bcdefghi}
22	LRG 87	55.33 (48.086)^{fghijk}	30.96 (33.822)^{efghijk}
23	RGT 3	55.67 (48.278)^{fghijk}	32.48 (34.759)^{cdefghijk}
24	PRG 176	52.33 (46.361)^{hijklm}	30.91 (33.791)^{efghijk}
25	WRG 208	58.00 (49.629)^{efghij}	30.79 (33.720)^{fghijk}
26	LRG 80	46.33 (42.919)^{klmno}	25.27 (30.194)^{jklmnop}
27	WRG 140	47.67 (43.685)^{klmno}	24.27 (29.526)^{klmnopq}
28	LRG 86	62.67 (52.364)^{defg}	32.92 (35.028)^{cdefghij}
29	ICPL 85063	59.33 (50.405)^{defghi}	25.68 (30.463)^{jklmnop}
30	LRG 41(Check)	57.33 (49.242)^{fghij}	29.29 (32.782)^{fghijklm}
31	ICPL 87119	40.33 (39.446)^{nopq}	21.38 (27.552)^{nopqr}
32	ICPL 15225	81.33 (64.435)^{bc}	40.14 (39.330)^{abcd}
33	PRG 158	35.67 (36.689)^{qr}	18.31 (25.344) ^{pqr}
34	ICP 15580	76.33 (60.921)^{c}	39.62 (39.029)^{abcde}
35	BDN 2	28.33 (32.177)^{rs}	17.07 (24.416)^{qr}
36	Ramapuram Local	38.33 (38.273)^{opq}	19.35 (26.110)^{pqr}
37	TRG 59	75.67 (60.474)^{c}	40.59 (39.596)^{abc}
38	TRG 33	40.67 (39.641)^{nopq}	21.69 (27.768)^{mnopqr}
39	Perennial(BRG 23)	39.33 (38.861)^{opq}	19.34 (26.099)^{pqr}
40	TRG 38	59.67 (50.599)^{defghi}	31.26 (34.011)^{efghijk}
Mean		**54.11**	**28.46**
SE(m)±		**1.678**	**1.554**
CD (P=0.05)		**4.733**	**4.385**

Figures in parentheses are angular transformed values

The values followed by same alphabets did not differ significantly as per DMRT

Mean pod wall thickness was 0.32 mm and it was ranged from 0.22 mm (ICPL 15225) to 0.44 mm (ICP 14887 and BRG 23). The differences in the pod wall thickness among all the accessions were significant. The highest trichome density per 0.25 cm^2 was recorded in ICP 87119 (424.20) followed by TRG 33 (417.20), whereas the lowest number of trichomes was recorded in ICPL 15225 (243.71) and it was on par with LRG 86 (253.0) and Durga (258.80). Pod wall thickness and the trichome density on pod walls were found to be negatively associated with the per cent pod damage by pod fly on pigeonpea (Table 4). Moudgal *et al*. (2008) also reported that pod wall thickness and trichome density in the pod walls of pigeonpea genotypes were negatively associated with the susceptibility to pod fly damage. Yadav and Rohilla (2010) revealed that trichome density on green pods was maximum in resistant variety and minimum in susceptible variety.

Table 2. Morphological characters in the pods of different pigeonpea genotypes screened against pod fly, *M. obtusa*

Genotype	Pod length (cm)	Pod width (cm)	Pod wall thickness (mm)	Trichome density (No. / 0.25 cm^2)
ICP 7403	6.86	1.21	0.38	338.20
ICP 8865	4.81	0.80	0.34	393.71
ICP 8094	4.22	0.71	0.31	341.40
ICP 9150	5.81	1.05	0.27	328.60
ICP 11948	4.53	0.76	0.24	347.60
ICP 11949	5.07	0.76	0.32	364.20
ICP 12082	6.70	1.02	0.29	321.00
ICP 12083	6.94	1.00	0.28	312.60
ICP 12084	7.20	1.32	0.29	315.80
ICP 12088	5.70	0.86	0.30	337.20
ICP 13950	5.65	1.06	0.29	346.60
ICP 13953	4.68	0.83	0.33	373.40
ICP 13954	4.91	0.70	0.30	286.40
ICP 14722	4.64	0.88	0.41	365.40
ICP 14770	5.07	0.73	0.39	385.60
ICP 14885	5.59	0.78	0.30	356.00
ICP 14887	5.36	0.73	0.44	378.60
ICP 14888	5.08	0.72	0.33	414.20
ICP 14890	4.88	0.70	0.34	372.20
TRG 22	5.82	0.84	0.30	276.60
Durga	6.78	0.87	0.31	258.80
LRG 87	5.68	0.86	0.28	277.33
RGT 3	5.91	0.63	0.28	306.71
PRG 176	5.12	0.85	0.28	321.00
WRG 208	5.64	0.88	0.32	305.60
LRG 80	5.22	0.70	0.36	357.40
WRG 140	5.88	0.83	0.32	352.60
LRG 86	5.40	0.95	0.28	253.00
ICPL 85063	6.24	0.79	0.29	328.60
LRG 41	6.39	1.00	0.33	347.40
ICPL 87119	6.55	0.99	0.37	424.20
ICPL 15225	6.56	0.75	0.22	243.71
PRG 158	5.32	0.84	0.32	387.20
ICP 15580	5.69	0.95	0.26	278.20
BDN 2	5.02	0.64	0.39	382.56
Ramapuram Local	5.88	0.86	0.33	403.40
TRG 59	5.35	0.90	0.27	278.40
TRG 33	6.29	1.03	0.35	417.20
Perennial (BRG 23)	6.53	1.05	0.44	408.40
TRG 38	6.21	1.09	0.37	324.60
Mean	**5.71**	**0.88**	**0.32**	**341.07**
SE(m)±	**0.392**	**0.022**	**0.013**	**8.824**
CD (P=0.05)	**0.141**	**0.062**	**0.037**	**24.658**

Table 3. Biochemical characters of pod walls of different pigeonpea genotypes screened against pod fly, *M. obtusa*

Genotype	Phenols (%)	Proteins (%)	Total Carbohydrates (%)	Reducing sugars (%)	TFA (mg g^{-1})
ICP 7403	8.42	14.21	9.02	2.45	0.593
ICP 8865	8.62	13.02	6.92	1.88	0.622
ICP 8094	8.95	15.56	9.63	2.63	0.619
ICP 9150	3.56	17.02	10.92	3.03	0.888
ICP 11948	5.48	15.52	11.98	3.32	0.774
ICP 11949	6.86	14.62	12.05	3.16	0.366
ICP 12082	4.44	16.35	11.52	3.19	0.948
ICP 12083	5.58	16.86	9.14	3.33	0.877
ICP 12084	5.56	16.10	10.86	3.24	0.892
ICP 12088	6.78	14.43	9.43	2.63	0.334
ICP 13950	5.35	15.83	9.63	2.67	0.975
ICP 13953	7.43	14.06	7.58	2.00	0.486
ICP 13954	6.54	16.45	9.51	2.51	0.631
ICP 14722	7.26	15.48	7.97	2.11	0.524
ICP 14770	9.26	13.34	7.10	1.88	0.389
ICP 14885	7.80	15.30	9.35	2.47	0.572
ICP 14887	9.46	12.84	7.15	1.79	0.41
ICP 14888	9.14	13.09	6.78	1.89	0.453
ICP 14890	8.76	14.94	7.97	2.17	0.342
TRG 22	5.65	15.38	10.85	3.08	0.754
Durga	6.91	16.29	10.57	3.00	0.784
LRG 87	6.84	13.31	10.18	2.89	0.738
RGT 3	6.24	14.87	10.62	3.01	0.587
PRG 176	7.56	15.54	10.57	3.00	0.636
WRG 208	6.72	15.17	10.20	2.85	0.655
LRG 80	7.83	14.00	7.76	2.20	0.537
WRG 140	6.62	14.37	9.26	2.61	0.538
LRG 86	5.35	16.03	11.48	3.26	0.786
ICPL 85063	6.89	15.96	9.89	2.81	0.847
LRG 41	6.65	14.27	9.74	2.76	0.456
ICPL 87119	8.35	15.45	6.50	1.76	0.464
ICPL 15225	4.47	16.51	10.73	2.91	0.913
PRG 158	8.38	13.27	6.48	1.72	0.393
ICP 15580	7.29	16.32	12.43	3.37	0.935
BDN 2	8.63	12.74	7.37	2.00	0.362
Ramapuram Local	8.59	14.33	6.24	1.69	0.433
TRG 59	4.18	16.48	12.08	3.28	0.908
TRG 33	7.79	14.57	8.16	2.20	0.468
Perennial (BRG 23)	9.12	13.85	8.27	2.23	0.435
TRG 38	7.08	15.05	9.68	2.78	0.475
Mean	**7.07**	**15.00**	**9.29**	**2.58**	**0.613**
SE(m)±	**0.156**	**0.136**	**0.085**	**0.046**	**0.005**
CD (P=0.05)	**0.446**	**0.389**	**0.243**	**0.133**	**0.014**

Various biochemical components *viz*., proteins, phenols, total carbohydrates, reducing sugars and total free amino acids (TFA) were estimated in the pod walls of different pigeonpea genotypes and presented in Table 3. Correlation studies revealed that the pod damage with various biochemical characters were significant and the multiple linear regression model fitted was, $y= -9.256 – 3.143 x_1 + 4.041 x_2 – 2.823 x_3 + 16.628 x_4 + 13.367 x_5$ with R^2 value of 0.911 (x_1= phenols, x_2= proteins, x_3= total carbohydrates, x_4= reducing sugars, x_5= TFA).

The protein content in the pod walls was found to be positively associated with the pod fly infestation on pigeonpea (Table 5).

The protein content in the pod walls of moderately resistant genotypes were significantly lower (12.74% in BDN 2 to 15.45% in ICPL 87119) and in highly susceptible genotypes it ranged between 16.51 per cent in ICPL 15225 and 17.02 per cent in ICP 9150. The results of present investigation are in conformity with the findings of Moudgal *et al*. (2008) who reported that protein content in the pod walls of pigeonpea genotypes was significantly and positively associated with the susceptibility to pod fly damage in short and extra short duration genotypes. Sunitha *et al*. (2008) also observed similar trend that protein content in pods was significantly higher (25.5%) in susceptible ICPL 88034 when compared with resistant ICPL 98003 (16.5%) against the *Maruca* in short duration pigeonpea cultivars.

Table 4. Correlation studies of morphological parameters with pod damage due to pod fly, *M. obtusa* in pigeonpea

S.No	Variable	Correlation coefficient	Regression equation	R^2 value
a.	Pod length (x) Vs Pod damage(y)	0.389*	y = 8.1532x + 7.8021	0.151
b.	Pod width (x) Vs pod damage(y)	0.380*	y = 38.382x + 20.601	0.144
c.	Pod wall thickness (x) Vs Pod damage(y)	-0.762**	y = -237.11x + 130.1	0.580
d.	Trichome density (x) Vs Pod damage(y)	-0.745**	y = -0.2429x + 136.77	0.554

* Significant at $p < 0.05$; ** Significant at $p < 0.01$.

Table 5. Correlation studies of biochemical parameters with pod damage due to pod fly, *M. obtusa* in pigeonpea

S.No	Variable	Correlation coefficient	Regression equation	R^2 value
a.	Protein content (x) Vs Pod damage(y)	0.857**	y = 11.07x - 111.6	0.734
b.	Phenol content(x) Vs Pod damage(y)	-0.871**	y = -8.8847x + 116.84	0.758
c.	Total carbohydrates (x) Vs Pod damage(y)	0.782**	y = 6.9157x - 10.479	0.611
d.	Reducing sugars (x) Vs Pod damage(y)	0.848**	y = 24.821x - 10.282	0.718
e.	Total free amino acids (x) Vs Pod damage(y)	0.832**	y = 64.889x + 13.879	0.692

** Significant at $p < 0.01$.

The phenol content in the pod walls of pigeonpea was found to be negatively associated with the pod fly infestation (Table 5). Pod fly resistant genotype ICP 14887 with 24.57 per cent pod damage possessed high phenol content (9.46%) as compared to ICP 9150 (3.56%) which exhibited maximum pod damage (88.91%). These results are in accordance with the findings of Vageesh Pandey *et al*. (2011) that the genotypes with more phenol content suffered less pod and grain damage by pod fly. Moudgal *et al*. (2008) also noticed that total phenols in the pod walls of pod fly resistant pigeonpea genotypes of extra early and early group were significantly more than that in susceptible genotypes. The expression of resistance to *H. armigera* in wild relatives of pigeonpea has been reported to be associated with high amounts of polyphenols (Sharma *et al*., 2009**)**.

The total carbohydrates were significantly higher in susceptible genotypes (12.43% in ICP 15580 to 7.58% in ICP 13953) and in resistant genotypes these values were significantly lower (6.24% in Ramapuram Local to 7.15% in ICP 14887) and it was evident that there was significant positive association between total carbohydrate content and per cent pod damage (Table 5). Omkar Singh (2003) also stated that susceptible varieties (Bihar and ICPL 5036) showed the highest percent pod damage (71.93), total sugar (6.80%) and total phenols (1.39%) against pod fly on pigeonpea. Similar results were offered by Jaydeep Halder and Srinivasan (2007) that in urdbean there was a significant positive correlation existed between total sugars with pod damage.

The correlation between the reducing sugars and pod damage (Table 5) due to pod fly was positive and significant, which indicated that increase in reducing sugar increased the infestation of pest incidence. Among the genotypes Ramapuram Local contained lower amount of reducing sugars (1.69%) and it was on par with PRG 158 (1.72%), ICPL 87119 (1.76%) and ICP 14887 (1.79%), while the pod walls of ICP 15580 had higher amounts (3.37%). These results are in agreement with Vageesh Pandey *et al*. (2011). Moudgal *et al*. (2008) also observed that reducing sugars in pod walls of pod fly susceptible genotypes were significantly higher than the resistant group of genotypes across plant type and maturity groups. Expression of resistance to *H. armigera* has been reported to be associated with low amounts of sugar in wild relatives of pigeonpea (Sharma *et al*., 2009).

The total amino acids were found to be positively associated with the pod fly infestation on pigeonpea (Table 5). The total amino acids in the pod walls of resistant genotypes were significantly lower and higher in susceptible genotypes. Among the genotypes ICP 13950 possessed highest amount of amino acids (0.975 mg g^{-1}) followed by ICP 15580 (0.935 mg g^{-1}), and the genotype ICP 12088 (0.334 mg g^{-1}) showing lesser amount of amino acid content and it was on par with ICP 14890 (0.342 mg g^{-1}). Similar results were observed by Vageesh Pandey *et al*. (2011) that genotypes with less total amino acids suffered with less pod and grain damage by pod fly. Anantharaju and Muthaiah (2008) identified that biochemical basis of resistance may be due to low amount of total free amino acid, crude protein content and high amount of total phenols in the pigeonpea genotypes against spotted pod borer.

CONCLUSION

The present investigation clearly suggested that pigeonpea cultivars with more phenols and less proteins, total carbohydrates, reducing sugars and total free amino acids in the pod walls suffered less pod and grain damage by pod fly. Therefore, these biochemical pod traits can be used as markers to identify the resistance sources of pigeonpea with different mechanism of resistance against pod fly. This finding can be used very effectively in pod fly resistant breeding programme.

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