Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 19(3), September-December, 2021]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

PANTNAGAR JOURNAL OF RESEARCH

Vol. 19(3) September-December, 2021

CONTENTS

Unrevealing the role of epistasis through Triple Test Cross in Indian mustard **330**
NARENDER SINGH, USHA PANT, NEHA DAHIYA, SHARAD PANDEY, A. K. PANDEY and SAMEER CHATURVEDI

Testing of InfoCrop model to optimize farm resources for mustard crop under *tarai* region of Uttarakhand **335**
MANISHA TAMTA, RAVI KIRAN, ANIL SHUKLA, A. S. NAIN and RAJEEV RANJAN

In vitro **evaluation of endophytes and consortium for their plant growth promoting activities on rice seeds** **342**
DAS, J., DEVI, R.K.T. and BARUAH, J.J.

Effect of subsurface placement of vermicompost manure on growth and yield of wheat (*Triticum aestivum* L. Var. UP 2526) **348**
ABHISHEK KUMAR and JAYANT SINGH

Assessment of different nutrient management approaches for grain yield, gluten content and net income of common bread wheat (*Triticum aestivum* l.) in Western Himalayan region of Uttarakhand **359**
BHAWANA RANA and HIMANSHU VERMA

Suitability assessment of land resources forc assava(*Manihot esculentus* L.) and yam (*Dioscorea spp L.*) cultivation in Khana LGA, Rivers State, Southern Nigeria **367**
PETER, K.D., UMWENI, A.S. and BAKARE, A.O.

Biophysical and biochemical characters conferring resistance against pod borers in pigeonpea **375**
PARUL DOBHAL, R. P. MAURYA, PARUL SUYAL and S.K. VERMA

Population dynamics of major insect pest fauna and their natural enemies in Soybean **385**
SUDHA MATHPAL, NEETA GAUR, RASHMI JOSHI and KAMAL KISHOR

Fumigant toxicity of some essential oils and their combinations against *Rhyzopertha dominica* (Fabricius) and *Sitophilus oryzae* (Linnaeus) **389**
NIDHI TEWARI and S. N. TIWARI

Long term efficacy of some essential oils against *Rhyzopertha dominica* (Fabricius) and *Sitophilus oryzae* (Linnaeus) **400**
NIDHI TEWARI and S. N. TIWARI

Management strategies under chemicals, liquid organic amendments and plant extracts against black scurf of potato caused by *Rhizoctonia solani* Kühn in *tarai* regions of Uttarakhand **408**
SURAJ ADHIKARI, SHAILBALA SHARMA, R. P. SINGH, SUNITA T. PANDEY and VIVEK SINGH

Effective management strategies against ginger rhizome rot caused by *Fusarium solani* by the application of chemicals, bioagents and Herbal *Kunapajala* in mid hills of Uttarakhand **417**
SONAM BHATT, LAXMI RAWAT and T. S. BISHT

Distribution and morphological characterisation of isolates of *Fusarium moniliforme* fsp. *subglutinans* causing Pokkah Boeng disease of sugarcane in different sugarcane growing areas of Udham Singh Nagar district of Uttarakhand 429
HINA KAUSAR, BHAGYASHREE BHATT and GEETA SHARMA

Biointensive management of *Meloidogyne enterolobii* in tomato under glasshouse conditions 435
SHUBHAM KUMAR, ROOPALI SHARMA, SATYA KUMAR and BHUPESH CHANDRA KABDWAL

Effect of pre-harvest application of eco-friendly chemicals and fruit bagging on yield and fruit quality of mango 447
KIRAN KOTHIYAL, A. K. SINGH, K. P. SINGH and PRATIBHA

A valid and reliable nutrition knowledge questionnaire: an aid to assess the nutrition friendliness of schools of Dehradun, Uttarakhand 452
EKTA BELWAL, ARCHANA KUSHWAHA, SARITA SRIVASTAVA, C.S. CHOPRA and ANIL KUMAR SHUKLA

Potential of common leaves of India as a source of Leaf Protein Concentrate 460
RUSHDA ANAM MALIK, SHAYANI BOSE, ANURADHA DUTTA, DEEPA JOSHI, NIVEDITA, N.C. SHAHI, RAMAN MANOHARLALand G.V.S. SAIPRASAD

Job strain and muscle fatigue in small scale unorganized agri enterprises 466
DEEPA VINAY, SEEMA KWATRA, SUNEETA SHARMA and KANCHAN SHILLA

Drudgery reduction of farm women involved in weeding of soybean crop 475
SHALINI CHAKRABORTY

Childhood obesity and its association with hypertension among school-going children of Dehradun, Uttarakhand 482
EKTA BELWAL, K. UMA DEVI and APARNA KUNA

Spring water and it's quality assessment for drinking purpose: A review 489
SURABHI CHAND, H.J. PRASAD and JYOTHI PRASAD

Spatial distribution of water quality for Indo-Gangetic alluvial plain using Q-GIS 497
SONALI KUMARA, VINOD KUMAR and ARVIND SINGH TOMAR

Application of geospatial techniques in morphometric analysis of sub-watersheds of Nanak Sagar Catchment 505
AISHWARYA AWARI, DHEERAJ KUMAR, PANKAJ KUMAR, R. P. SINGH and YOGENDRA KUMAR

Evaluation of selected carbon sources in biofloc production and carps growth performance 516
HAZIQ QAYOOM LONE, ASHUTOSH MISHRA, HEMA TEWARI, R.N. RAM and N.N. PANDEY

Calcium phosphate nanoparticles: a potential vaccine adjuvant 523
YASHPAL SINGH and MUMTESH KUMAR SAXENA

Factors affecting some economic traits in Sahiwal Cattle 528
DEVESH SINGH, C. B. SINGH, SHIVE KUMAR, B.N. SHAHI, BALVIR SINGH KHADDA, S. B. BHARDWAJ and SHIWANSHU TIWARI

The effect of probiotics and growth stimulants on growth performance of Murrah Buffalo 532
SAMEER PANDEY, RAJ KUMAR, D.S. SAHU, SHIWANSHU TIWARI, PAWAN KUMAR, ATUL SHARMAand KARTIK TOMAR

Biophysical and biochemical characters conferring resistance against pod borers in pigeonpea

PARUL DOBHAL, R. P. MAURYA, PARUL SUYAL and S.K. VERMA

Department of Entomology, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar-263145 (U. S. Nagar, Uttarakhand)

ABSTRACT: Sixty-three pigeonpea germplasms were screened for two years at G. B. Pant University of Agriculture and Technology, Pantnagar to study the resistant traits in the germplasm against pod borer complex *viz., Helicoverpa armigera, Maruca vitrata* and *Melanagromyza obtusa*. Lowest mean pod damage was observed in PA 517 (5.05%) followed by PA 526 (7.27%), PA 515 (7.79%), PA 529 (7.83%) and other 38 least susceptible germplasms as promising cultivars of pigeonpea against pod borer complex. Further, selected germplasms were studied for biophysical and biochemical traits of resistance which were substantiated with correlation studies with per cent pod damage by pod borer complex and the results showed that germplasms having lesser pod length, higher pod width, higher pod wall thickness, lower number of seeds per pod, lower number of pods per plant, higher trichome length, higher trichome density, higher phenols, lower sugars and lower proteins were less attacked by the pod borer complex. The combination of these traits of pigeonpea can be used as effective and reliable selection criteria to select resistant germplasm against pod borers.

Key words: Biochemical and biophysical characters, pigeonpea, resistant traits, screening

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important *Kharif* pulse crop grown in India. It ranks sixth in global legume production and worldwide it is cultivated in about 4.70 mha area with an annual production of 3.69 mt and a mean productivity of 783 kg/ha (Anonymous, 2018). It has a high nutritional quality with 20 to 25 Per cent of protein on dry seed basis, which is almost 2.5 to 3.0 times of the value normally found in the cereals (Tamboli and Lolage, 2008). Due to its rich source of protein, pigeonpea is prone to the attack of insect pests. The major constraints for low productivity of pigeonpea are biotic and abiotic stresses and poor crop management. Of the biotic stresses, the insect pests cause a greater loss of 78 Per cent in India (Lateef and Reed, 1983). About 250 species belonging to 8 orders and 61 families are observed to infest pigeonpea from its seedling to harvesting stage (Upadhyay *et al*., 1998). Spotted pod borer (*Maruca vitrata*), gram pod borer (*Helicoverpa armigera*) and pod fly (*Melanagromyza obtusa*) are the major pod borers of pigeonpea which significantly reduce the crop yield to an extent of 60 to 90%. These pod borers have developed resistance against many insecticides (Kranthi *et al*., 2002 and Singh *et al*., 2009). Researchers in many parts of India have confirmed that seed yield and seed quality are being adversely affected by pod borers. Farmers find it very difficult to manage these pod borers with commonly available insecticides and dependence on only these chemicals lead to several ill effects on non-target organisms and environment. Hence, adoption of integrated pest management technology is the need of the hour which utilizes all the suitable technology in compatible manner. The first line of defence against insect pests is the host plant resistance (HPR). It can be considered as the principal component in the pest management besides cultural, mechanical and chemical control measures (Tayo *et al*., 1988; Oghiakhe *et al.,* 1991a, 1991b, 1992).Various biophysical characters of the plants like trichomes on stems, leaves, pods, their length and density, pod length, pod width, pod wall thickness, number of pods or clusters and angle between the pods play an important role by providing resistance to the plants against *M. vitrata* (Halder *et al*., 2006). Among the plant characters, trichomes and trichome exudates on plant surfaces play important role in the host selection process by insect herbivores (Bernays and Chapman, 1994). The type of trichomes and their orientation, density and length have been correlated with reduced insect damage in several crops (Jefree,1986; David and Easwaramoorthy, 1988; Peter, 1995; Lam and Pedigo, 2001; Karkkainen and Agren, 2002; Simmons and Geoff, 2004). Since pigeonpea growers pay huge cost for inputs like pesticides, it becomes significant to search the available germplasms for the sources of resistance against pigeonpea pod borers. The HPR is one of the most viable, adaptable and economically sound component in pest management which involves no extra cost of the farmers (Sharma, 2016). The biochemical constituents present in quantities and proportions to each other in host plants have been reported to exert profound influences on the growth, development, survival and reproduction of insects in various ways. HPR involves screening of available germplasms for sources of resistance against major insect pests and use of such germplasms in breeding programmes to develop an intensified resistant cultivar. For effective selection to improve resistance, it is necessary to have an understanding of various associated traits and nature of their association with host plant resistance.

Thus, in the light of above key problems, present study was conducted to identify the sources of resistance through biophysical and biochemical analysis in selected pigeonpea germplasms under field conditions.

MATERIALS AND METHODS

Varietal screening of 63 pigeonpea germplasms against pod borers was conducted at N.E.B. Crop Research Centre, G.B. Pant University of Agriiculture and Technology, Pantnagar, Uttarakhand for two cropping seasons i.e., 2015-16 and 2016-17 in triplicate RBD. The plots were kept without insecticidal umbrella to allow pod borer complex to thrive throughout the cropping season and test for the pod borer resistant germplasm. Resistance and susceptibility in the germplasms were screened out on the basis of Per cent pod damage and pest susceptibility rating used by Lateef and Reed (1981).

Based on PSR (Lateef and Reed, 1981), the performance of each cultivar was rated on scale from 1 to 9 which are as follow:

Pest Susceptibility	Grade	Category
100%	1	Highly resistant
75 to 90%	2	Resistant
50 to 75%	3	Least susceptible
25 to 50%	4	Least susceptible
10 to 25 %	5	Least susceptible
-10 to 10 %	6	Moderately susceptible
-10 to -25%	7	Moderately susceptible
-25 to -50%	8	Highly susceptible
<50%	9	Highly susceptible

After two years of varietal screening, resistant and least susceptible germplasms were subjected to physiochemical analysis to identify the sources of resistance. Observations taken on biophysical parameters were pod length and pod width using Vernier Calipers, pod wall thickness with the help of screw gauge, number of grains per pod and number of pods per plant were counted from five plants of each germplasm. For trichome length, selected pods were cut into small bits of 0.45 mm size and observed under the binocular microscope to measure them with help of a computer software MG-HDMAX. The trichome density of the pods was measured by cutting the walls of the pods into bits of 1 mm^2 using a hole punching machine and dipping in Dimethyl sulphoxide (DMSO) for overnight. These bits were then used for making slides and number of trichomes present on the epidermis was counted under a binocular microscope. Also, for biochemical analysis fresh green pods of the selected pigeonpea germplasms were collected from three replications and finely grinded to make the extract for further analysis of total sugars, phenol and protein contents.

Extract preparation: For extract preparation, in a conical flask 10 g of powdered sample was mixed

$$\text{Pest susceptibility rating (PSR)} = \frac{\textit{\%Pod damaged in check cultivar-\%Pod damaged in test cultivar}}{\textit{\%Pod damaged in check cultivar}} \times 100$$

with 90 ml of methanol 80% (v/v) for 48 hours with continuous shaking. The resultant suspension was filtered using Whatman No.1 filter paper. The solvent was evaporated at 50^0 C to obtain crude methanolic extract and finally stored at 4^0 C. Extract was used in concentration 10 mg/ml for further assessment of total phenols, total proteins and total sugars.

Estimation of total phenols: The total phenols in the pigeonpea pods were estimated as per the method given by Swain and Hillis (1959) with slight modifications. The reagents used were: i) Folin-Ciocalteau Reagent: Folin-Ciocalteau reagent was diluted with distilled water in 1:1(v/v) ratio before use. ii) 7 % Saturated sodium carbonate solution**:** Anhydrous sodium carbonate was dissolved in 100 ml of distilled water.

Procedure: The total phenol in the extract was determined by using Folin-Ciocalteu's colorimetric method described by Singleton and Rossi (1965) with some modifications. Different concentrations (10, 50, 100 µg/ml) of the methanol extracts (100µl) were diluted with distilled water (400µl) and mixed with Folin-Ciocalteu's reagent (50µl). After 5 minutes of reaction, the mixture was neutralized by 7% sodium carbonate (500µl) and then left for 90 minutes in the dark at room temperature. The absorbance of the developed blue colour solution was measured at 765 nm using UV- visible spectrophotometer. Quantification of total phenols was done on the basis of standard curve of Gallic acid prepared in 80% (v/v) methanol. The concentration of total phenolic content was determined in mg Gallic acid equivalent (GAE)/g fresh weight in *In vitro* samples using an equation (y= mx+c) obtained from the standard Gallic acid graph. The experiment was performed in triplicates to reduce the error. Total phenolic content (TPC) of extract was calculated.

Estimation of total proteins: Different concentrations (10µl, 50µl and 100µl) of the extract were taken and to this 3ml of Bradford dye reagent were added and absorbance was recorded at 595nm in UV-Visible spectrophotometer against blank reagent. A standard calibration curve is drawn by using Bovine Serum Albumin (BSA) (Bradford, 1976). The protein content was expressed as mg/gm.

Procedure: Bradford dye was prepared by mixing 100 mg Coomassie- Brilliant Blue dye (CBBG-250) in 50 ml ethanol and 100ml (85%) orthophosphoric acid and later volume adjusted upto 1 liter with double distilled water.Solution was filtered and stored at 4ºC in amber coloured bottle. 1000 ppm stock solution of BSA was prepared in methanol. A standard curve was established by using various concentrations of BSA.

Estimation of total sugars: Total soluble carbohydrates were determined with the help of method given by Yemm and Willis (1954). The reagents used were Anthrone reagent prepared by dissolving 0.2 g Anthrone in 100 ml conc. H_2SO_4.

Procedure: To perform this, 0.5 ml of the extract and 1.5 ml of distilled water were taken in a test tube. Then 4 ml of Anthrone reagent was added to it. The tubes were shaken and allowed to cool for 30 minutes and the absorbance was read at 625 nm on Spectrophotometer. The concentration of total sugars was calculated from the standard curve of glucose prepared simultaneously and the data is expressed as mg glucose equivalent g.

The data obtained from field and laboratory experiments were subjected to square root transformation (“x+0.5) and angular transformation using statistical analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Out of 63 pigeonpea germplasms, one germplasm showed resistance, 41 germplasm were found least susceptible, 17 were moderately susceptible and 3 germplasms were found highly susceptible to pod

$$\text{Total phenolic content (TPC)} = \frac{\textit{Concentration from curve (y= mx+c)} \times \textit{Extract volume}}{\textit{Mass of sample in gram (g)}}$$

borers as compared to check. Hence, total 42 germplasm (One resistance and 41 least susceptible germplasm) were selected for further study on the biophysical and biochemical traits of resistance (Table 1, Figure 1). Results of field screening revealed that germplasm PA 517 showed resistance against pod borers with highest mean Pest Susceptibility (76.68%) and 2 grade on PSR. While, remaining 41 (PA 506, PA 508, PA 509, PA 510, PA 511, PA 512, PA 513, PA 514, PA 515, PA 516, PA 518, PA 519, PA 520, PA 521, PA 522, PA 523, PA 524, PA 525, PA 526, PA 527, PA 528, PA 529, PA 530, PA 531, PA 532, PA 533, PA 534, PA 535, PA 551, AL 1495, AL 1735, AL 1747, AL 1770, AL 1790, PA 406, PUSA 2012-1, PA 409, AL 201, PAU 881, MANAK and PA 291) were found to be least susceptible against pod borers damage in which mean Pest Susceptibility was ranged from 11.77% (PSR Grade 5) to 63.58% (PSR Grade 3).

Influence of biophysical traits of pigeonpea on incidence of pod borers: There were significant differences in pod length, pod width, pod wall thickness, number of grains per pod, number of pods per plant, trichome length and trichome density of selected 42 germplasm of pigeonpea (Table 2).

The average pod length, pod width, pod wall thickness of least susceptible pigeonpea germplasms varied from 42.8 mm in PA 531 to 59.2 mm in PA 291, 3.00 mm in PA 551 to 7.86 mm in PA 291 and 0.38 mm in PA 509 and MANAK to 0.54 mm in PUSA-2012-1, respectively. Also, the average number of grains per pod and average pods per plant ranged from 2.66 in PA 527 to 4.66 in PA 509 and 41.00 in PA 535 to 77.50 in PA 509, respectively. Trichome length and trichome density of 42 least susceptible germplasms ranged from 2.15 mm in PA 526 to 4.85 mm in MANAK and 12.22 /mm^2 in PA 522 to 18.06/mm^2 in AL 201, respectively.

The average pod length of tolerant germplasm PA 517 was lower (54.3 mm) in contrast to check cultivar, UPAS 120 (58.7 mm). Also, the average number of grains per pod (4.03) and average number of pods per plant (50.2) were low in PA 517 in contrast to check cultivar UPAS 120 (5.6 and 57.3). The average pod width and pod wall thickness of resistant germplasm PA 517 was significantly higher (6.76 mm and 0.42 mm) than UPAS 120 (6.56 mm and 0.34 mm). The average trichome length and trichome density of pod walls of PA 517 (3.69 mm and 17.86/mm^2) were higher than UPAS 120 (2.52 mm and 14.29/mm^2).

Influence of bio-chemical traits of pigeonpea on incidence of pod borers: There were significant differences in total phenols, total sugars and total protein of selected 42 germplasms of pigeonpea (Table 2). The total phenols in the pod walls of least susceptible germplasms significantly varied from 24.00 mg/g in PA 517 to 14.00 mg/g in PA 508. The total sugars present in the pod walls of least susceptible pigeonpea germplasms ranged from 17 mg/g in PA 517 to 3.3 mg/g in PA 518 and PA 524. Also, the total proteins present in the least susceptible germplasms varied from 18 mg/g in PA 517 to 9.8 mg/g in PA 406, respectively. Tolerant germplasm PA 517 showed higher phenols (24.00 mg/g) in comparison with check cultivar UPAS 120 (12.00 mg/g). Also, the total sugars and proteins in the pod walls of PA 517 were significantly lower (17 mg/g and 18 mg/g) in comparison with UPAS 120 (22.1 mg/g and 15.4 mg/g).

To substantiate the physiochemical results, correlation studies between Per cent pod damage by pod borers *viz*., *H. armigera, M. vitrata and M. obtusa* and physiochemical traits was performed which also showed that pod width (-0.061, -0.422 and -0.099) pod wall thickness (-0.394, -0.369 and -0.646), trichome length (-0.140, -0.168 and -0.155), trichome density(-0.067, -0.171 and -0.180) and total phenols (0.016, -0.164 and -0.344) were negatively correlated with Per cent pod damage by respective pod borers. Whereas, it was observed that pod length (0.389, 0.325 and 0.539) was positively correlated with Per cent pod damage by *H.armigera, M. vitrata and M. obtusa*, respectively. Also, it was observed that number of grains per pod (0.007) was positively correlated with Per cent pod damage by Per cent pod damage by *M. vitrata* and number of pods per plant (0.315 and 0.228) was in positive correlation with *H.armigera* and *M. vitrata*incidence. Similarly, total sugars (0.211, 0.300 and 0.300) and total proteins (0.003, 0.650 and 0.053) were also

Table 1: Per cent pod damage and Pest Susceptibility Rating of pigeonpea germplasm against pod borers during 2015-16 and 2016-17

Germplasm	Pod Damage % 2015-16					Pod Damage % 2016-17					Mean PSR (Category of germplasm based on PSR)	Yield (kg/ha)
	M. vitrata	*M. obtusa*	*H. armigera*	Mean pod damage %	Pest susceptibility rating(PSR)	*M. vitrata*	*M. obtusa*	*H. armigera*	Mean pod damage %	Pest susceptibility rating(PSR)		
PA 504	19.26*(2.76)	32.36(3.15)	7.46(1.74)	19.69	1.65	22.09(2.76)	67.95(3.33)	2.95(1.23)	31.00	-55.94	-27.1 (HS)	1221.90
PA 505	23.93(1.87)	45.77(1.81)	5.30(0.48)	25.00	-24.85	25.77(1.81)	63.20(2.01)	0.86(0.14)	29.94	-50.65	-37.75 (HS)	1247.70
PA 506	11.63(1.98)	12.10(2.48)	1.35(0.57)	8.36	58.25	9.69(2.31)	15.12(2.72)	0.89(0.33)	8.57	56.90	57.57 (LS)	1106.90
PA 507	15.23(2.78)	32.20(3.42)	4.21(1.05)	17.21	14.03	16.78(2.84)	40.25(3.70)	1.47(0.65)	19.50	1.90	7.96 (MS)	1116.60
PA 508	11.62(1.98)	27.25(3.24)	4.31(1.71)	14.39	28.12	9.68(2.31)	34.05(3.42)	2.87(1.15)	15.53	21.85	24.98 (LS)	1000.00
PA 509	6.36(1.85)	20.35(2.64)	0.81(0.31)	9.17	54.19	5.29(1.73)	25.43(3.22)	0.54(0.57)	10.42	47.58	50.88 (LS)	1085.60
PA 510	9.00(2.18)	24.75(3.22)	2.18(0.97)	11.98	40.19	7.49(2.06)	30.94(3.44)	1.45 (0.66)	13.29	33.12	36.65 (LS)	1155.30
PA 511	9.12(2.19)	31.95(3.52)	0.82(0.14)	13.96	30.26	7.59(2.03)	39.93(3.66)	0.54 (0.20)	16.02	19.40	24.83 (LS)	1034.20
PA 512	12.51(2.45)	24.98(3.27)	2.78(1.12)	13.42	32.96	10.42(2.35)	31.22(3.42)	1.85 (0.81)	14.50	27.07	30.01 (LS)	909.40
PA 513	9.09(2.18)	19.08(2.81)	1.92(0.82)	10.03	49.91	7.57(2.05)	23.84(3.17)	1.27(0.48)	10.89	45.20	47.55 (LS)	822.30
PA 514	17.05(2.75)	13.26(2.51)	5.45(1.81)	11.92	40.47	16.70(2.74)	16.57(2.80)	4.96 (1.64)	12.74	35.89	38.18 (LS)	1097.30
PA 515	9.46(2.28)	13.21(2.49)	2.79(1.13)	8.49	57.62	2.88(1.12)	16.51(2.72)	1.85 (0.83)	7.08	64.38	61.00 (LS)	1049.80
PA 516	7.30(1.75)	14.58(2.47)	1.56 (0.61)	7.81	60.98	6.08(1.83)	18.22(2.89)	1.03 (0.22)	8.44	57.52	59.25 (LS)	1136.30
PA 517	3.50(1.22)	8.63(2.56)	2.60(1.15)	4.91	75.48	4.57(1.62)	9.28(2.92)	1.73 (0.77)	5.19	73.87	76.68 (R)	1449.80
PA 518	7.90(2.04)	16.48(2.72)	1.19(0.42)	8.52	57.43	6.58(1.94)	20.60(3.03)	0.79 (0.82)	9.32	53.09	55.26 (LS)	1288.70
PA 519	9.01(2.17)	14.44(2.55)	1.20(0.42)	8.22	58.96	7.51(2.07)	18.05(2.86)	0.80 (0.25)	8.79	55.79	57.38 (LS)	1283.30
PA 520	5.22(1.73)	15.88(2.75)	2.47(1.18)	7.86	60.76	7.18(1.72)	19.84(3.00)	1.64 (0.76)	9.55	51.94	56.35 (LS)	1377.80
PA 521	5.23(1.74)	17.05(2.68)	2.83(1.19)	8.37	58.20	7.19(1.73)	21.31(3.03)	1.88 (0.74)	10.13	49.05	53.63 (LS)	1138.90
PA 522	8.35(2.11)	17.28(2.79)	1.59(0.61)	9.07	54.69	6.96(1.99)	21.59(3.08)	1.05 (0.42)	9.87	50.36	52.52 (LS)	1466.70
PA 523	13.19(2.45)	19.78(2.95)	1.37(0.48)	11.45	42.83	10.98(2.42)	24.72(3.22)	0.91 (0.12)	12.20	38.60	40.72 (LS)	998.50
PA 524	8.46(2.16)	27.05(3.15)	1.74(0.81)	12.42	37.99	7.04(2.01)	33.81(3.53)	1.16 (0.48)	14.00	29.55	33.77 (LS)	1283.30
PA 525	7.51(2.07)	18.53(2.34)	1.25(0.42)	9.10	54.57	6.25(1.89)	18.66(2.41)	0.83 (0.14)	8.58	56.83	55.70 (LS)	1322.20
PA 526	6.46(1.94)	12.56(2.53)	2.10(1.14)	7.04	64.84	5.38(1.75)	15.70(2.74)	1.39 (0.59)	7.49	62.32	63.58 (LS)	1027.80
PA 527	13.86(2.23)	12.40(2.48)	1.88(0.82)	9.38	53.15	11.55(2.43)	15.50(2.76)	1.25 (0.50)	9.43	52.54	52.85 (LS)	1227.80
PA 528	13.79(2.23)	8.57(2.17)	1.99(0.82)	8.12	59.46	11.48(2.44)	15.71(2.40)	1.32 (0.57)	9.50	52.19	55.83 (LS)	1333.30
PA 529	13.85(2.24)	4.16(1.28)	1.72(0.81)	6.58	67.15	11.53(2.47)	15.19(1.71)	0.48 (0.23)	9.07	54.39	60.77 (LS)	1461.10
PA 530	6.46(1.91)	17.48(2.63)	1.35(0.43)	8.43	57.90	5.38(1.75)	21.85(3.09)	0.89 (0.32)	9.37	52.84	55.37 (LS)	1300.00
PA 531	11.99(2.31)	13.35(2.41)	2.07(0.97)	9.14	54.37	9.99(2.33)	16.68(2.81)	1.37 (0.55)	9.35	52.98	53.67 (LS)	1372.20
PA 532	7.25(2.01)	22.08(3.01)	1.38(0.48)	10.24	48.88	6.04(1.86)	27.59(3.33)	0.92 (0.35)	11.52	42.06	45.47 (LS)	1266.70
PA 533	9.61(2.31)	22.53(3.04)	1.07(0.40)	11.07	44.71	8.00(2.09)	28.15(3.34)	0.71 (0.19)	12.29	38.19	41.45 (LS)	1461.10
PA 534	7.45(2.06)	14.25(2.53)	1.47(0.49)	7.72	61.43	6.20(1.86)	17.81(2.87)	0.98 (0.19)	8.33	58.09	59.76 (LS)	1055.60
PA 535	10.26(2.33)	36.00(3.46)	3.11(1.19)	16.46	17.81	8.55(2.16)	44.99(3.81)	2.07 (0.93)	18.54	6.74	12.28 (LS)	1427.80
PA 536	19.32(2.81)	33.63(3.51)	1.57(0.61)	18.17	9.24	16.10(2.77)	42.04(3.74)	1.04 (0.40)	19.73	0.75	5.00 (MS)	1266.70
PA 537	25.19(3.24)	41.81(3.54)	5.38(1.18)	24.13	-20.49	20.99(2.87)	49.76(3.66)	1.58 (0.68)	24.11	-21.30	-20.90 (MS)	1105.60
PA 538	12.37(2.43)	38.17(3.71)	2.29(1.17)	17.61	12.05	10.30(1.95)	47.71(3.87)	1.52 (0.68)	19.84	0.17	6.11 (MS)	1672.20
PA 539	16.74(2.74)	36.82(3.66)	1.71(0.81)	18.42	7.99	13.94(2.50)	58.52(4.03)	1.13 (0.28)	24.53	-23.41	-7.71 (MS)	1288.90
PA 540	12.09(2.25)	37.95(3.65)	4.46(1.81)	18.17	9.27	30.07(2.13)	47.43(3.86)	4.97 (1.69)	27.49	-38.30	-14.52 (MS)	1092.50

PA 541	14.75(2.54)	43.19(3.55)	5.32(1.64)	21.09	-5.31	12.28(2.43)	53.99(3.99)	3.84 (1.24)	23.37	-17.58	-11.44 (MS)	1130.10
PA 542	13.57(2.40)	41.92(3.32)	2.29(1.16)	19.26	3.81	11.30(2.28)	52.39(3.93)	1.52 (0.58)	21.74	-9.36	-2.77 (MS)	1094.40
PA 543	17.92(2.71)	42.78(3.41)	3.41(1.21)	21.37	-6.73	14.93(2.55)	53.47(3.96)	2.27 (0.99)	23.56	-18.51	-12.62 (MS)	927.80
PA 544	28.96(3.35)	43.17(3.54)	4.09(1.14)	25.41	-26.89	24.13(3.10)	53.96(3.98)	1.37 (0.59)	26.49	-33.26	-30.07 (HS)	1127.80
PA 545	31.67(3.42)	38.68(3.54)	1.37(0.48)	23.91	-19.39	26.38(3.26)	48.34(3.86)	0.91 (0.14)	25.21	-26.83	-23.11 (MS)	950.00
PA 546	19.48(2.82)	42.80(3.78)	1.93(0.82)	21.40	-6.89	16.23(2.80)	53.50(3.97)	1.28 (0.35)	23.67	-19.08	-12.99 (MS)	856.60
PA 547	16.58(2.80)	34.75(3.48)	1.79(0.81)	17.71	11.57	13.82(2.23)	43.43(3.76)	1.19(0.49)	19.48	2.00	6.78 (MS)	933.30
PA 548	22.45(3.09)	40.00(3.62)	4.37(1.34)	22.27	-11.24	18.70(2.90)	50.00(3.89)	2.91 (1.03)	23.87	-20.09	-15.66 (MS)	786.10
PA 549	12.98(2.35)	38.70(3.54)	2.21(1.17)	17.96	10.29	10.81(2.34)	48.37(3.88)	1.47 (0.24)	20.22	-1.71	4.29 (MS)	1033.30
PA 550	17.32(2.78)	35.41(3.51)	3.46(1.21)	18.73	6.46	14.43(2.40)	44.25(3.79)	2.30 (0.94)	20.33	-2.26	2.10 (MS)	1022.40
PA 551	7.75(2.03)	29.43(3.47)	2.73(1.18)	13.30	33.56	6.45(1.88)	36.78(3.53)	1.82 (0.73)	15.02	24.45	29.01 (LS)	1100.00
AL 1495	1.85(0.82)	40.49(4.57)	1.36(0.61)	14.57	27.25	2.70 (0.17)	64.08(4.15)^^	0.90 (0.34)	1.50	92.45	59.85 (LS)	1277.80
AL 1735	3.16(1.20)	64.67(4.57)	2.73(1.15)	23.52	-17.46	2.63 (1.02)	67.88(4.33)	1.82 (0.72)	2.09	89.49	36.01 (LS)	950.00
AL 1747	2.03(0.46)	67.73(4.32)	2.51(1.68)	24.09	-20.31	0.85 (0.13)	61.57(4.06)	5.01 (1.57)	3.62	81.77	30.73 (LS)	923.60
AL 1770	2.29(0.62)	59.41(4.01)	2.34(1.12)	21.35	-6.61	1.15 (0.50)	54.01(3.99)	1.55 (0.63)	1.42	92.87	43.13 (LS)	1277.80
AL 1790	7.72(1.94)	45.40(3.75)	4.14(1.57	19.09	4.68	6.43 (1.84)	41.27(3.57)	2.37 (1.02)	3.72	81.27	42.97 (LS)	895.90
PA 406	2.25(1.12)	59.98(4.06)	1.89(0.73)	21.37	-6.74	1.87 (0.86)	54.53(3.98)	1.26 (0.51)	1.46	92.64	42.95 (LS)	1105.60
PUSA 2012-1	8.96(0.14)	74.05(3.31)	6.55(1.52)	29.85	-49.09	6.80 (0.12)	30.95(3.43)	4.76 (1.14)	5.44	72.63	11.77 (LS)	991.40
PA 409	1.66(0.72)	48.62(3.85)	1.16(1.18)	17.15	14.37	1.38 (0.62)	44.20(3.73)	1.43 (0.58)	1.41	92.89	53.63 (LS)	961.10
AL 201	1.82(0.70)	78.69(4.54)	1.03(0.34)	27.18	-35.74	1.51 (0.69)	71.54(4.27)	0.69 (0.15)	0.96	95.15	29.71 (LS)	1007.80
PAU 881	2.16(0.84)	54.01(3.99)	2.23(1.10)	19.47	2.78	1.80 (0.75)	49.10(3.90)	1.48 (0.67)	1.59	92.02	47.40 (LS)	1168.20
MANAK	3.29(1.22)	65.73(4.18)	4.74(1.15)	24.59	-22.79	2.74 (1.16)	59.75(4.05)	3.16 (1.20)	3.02	84.81	31.01 (LS)	952.80
PA 291	10.01(2.30)	9.08(2.12)	2.80(1.19)	7.30	63.56	8.34(1.92)	16.34(2.44)	1.86 (0.68)	8.85	55.49	59.53 (LS)	1090.20
PUSA 992	16.80(2.74)	40.13(3.71)	3.78(1.22)	20.24	-1.07	14.00(2.38)	50.15(3.90)	2.52 (0.73)	22.22	-11.81	-6.44 (MS)	988.80
PARAS	25.47(3.24)	37.23(3.67)	2.37(1.18)	21.69	-8.32	21.22(2.96)	46.53(3.84)	1.58 (0.58)	23.11	-16.27	-12.30 (MS)	1027.80
UPAS 120 (Check)	4.28(1.62)	57.11(3.32)	2.54(1.18)	21.31	-	3.57(1.39)	51.92(3.95)	1.93 (0.79)	2.48	-	-	1250.30
SEm±	(0.27)	(0.17)	(0.28)	-	-	(0.25)	(0.15)	(0.31)	-	-	-	-
CD @ 5%	(0.81)	(0.53)	(0.87)	-	-	(0.72)	(0.43)	(0.87)	-	-	-	-

*Indicate that the values in parenthesis are angular transformed values; HR=Highly resistant, R=Resistant, LS=Least susceptible, MS=Moderately susceptible, HS=Highly susceptible

Table 2: Biophysical and biochemical parameters of selected Pigeonpea germplasm

Germplasm	Average pod length (mm)	Average pod pod width (mm)	Average pod thickness (mm)	Average no. of grains per pod	Average no. of pods per plant	Average trichome length (mm)	Average trichome density (mm^2)	Total Phenols (mg/g)	Total Sugars (mg/g)	Total Proteins (mg/g)
PA 506	*52.9	5.45	0.40	4.23	71.2	3.21	12.68	22.0	9.2	13.2
PA 508	50.5	6.30	0.44	4.00	67.2	3.2	13.00	14.0	16.2	14.3
PA 509	53.9	6.73	0.38	4.66	77.5	3.41	13.86	20.4	7.4	13.3
PA 510	52.1	5.23	0.48	4.63	43.5	3.00	12.45	21.0	10.0	12.0
PA 511	51.2	5.78	0.43	3.33	45.2	3.23	12.56	19	9.0	14.8
PA 512	50.7	5.50	0.45	3.33	62.0	3.45	13.86	18.2	8.5	14.1
PA 513	52.7	6.49	0.46	3.66	41.2	3.35	12.77	22.3	10.2	14.7
PA 514	56.4	6.23	0.45	3.59	42.2	3.26	13.77	19.5	8.5	12.0
PA 515	50.7	5.22	0.45	3.33	50.2	3.45	13.50	20.0	10.0	11.0
PA 516	53.3	6.22	0.35	4.55	55.3	3.18	13.22	20.5	11.0	10.1
PA 517	54.3	6.76	0.42	4.03	50.2	3.69	17.86	24.0	17.2	18.6
PA 518	54.5	5.43	0.41	3.00	33.6	3.31	12.64	18.0	3.3	10.0
PA 519	51.4	5.44	0.44	3.00	64.8	3.09	12.27	18.5	12.5	13.4
PA 520	50.2	6.05	0.43	3.24	62.4	3.33	12.33	21.0	8.2	12.5
PA 521	55.0	6.28	0.43	3.55	63.4	3.58	13.00	23.2	6.4	12.2
PA 522	52.7	6.44	0.43	3.20	70.2	3.48	12.22	19.5	9.2	13.2
PA 523	52.6	5.66	0.4	3.55	65.3	3.64	13.22	21.3	4.7	10.0
PA 524	54.5	6.06	0.44	3.33	52.6	2.75	13.77	18.8	3.3	11.5
PA 525	55.0	6.11	0.49	3.27	55.2	2.68	13.45	19.0	10.3	12.6
PA 526	56.6	5.68	0.40	4.00	56.4	2.15	11.45	20.4	5.6	12.3
PA 527	52.5	5.90	0.42	2.66	55.6	2.25	12.33	21.2	9.3	13.3
PA 528	54.0	5.82	0.43	4.00	42.9	2.45	13.36	19.6	10.2	12.7
PA 529	56.1	6.55	0.44	4.00	56.4	3.08	13.39	18.5	11.1	11.4
PA 530	50.6	6.03	0.45	3.52	45.2	3.00	12.55	17.4	9.5	10.2
PA 531	42.8	6.64	0.44	4.12	50.8	2.54	13.64	19.3	10.2	13.2
PA 532	53.3	6.40	0.43	4.00	35.6	2.95	13.83	18.6	11.0	14.4
PA 533	56.6	6.26	0.45	4.30	45.2	3.53	14.86	17.3	8.8	13.2
PA 534	52.8	6.40	0.42	4.46	43.2	3.44	15.42	16.5	11.2	15.3
PA 535	52.7	6.49	0.46	3.66	41.0	3.30	13.00	18.0	11.4	15.0
PA 551	56.4	3.00	0.60	3.59	42.2	3.26	13.77	16.5	10.2	13.4
AL 1495	50.7	5.50	0.45	3.33	62.0	3.45	13.5	18.4	11.6	12.2
AL 1735	52.7	6.49	0.500	3.66	41.2	3.02	13.86	17.2	8.4	13.3
AL 1747	50.7	5.22	0.45	3.50	50.2	3.35	12.77	16.4	11.6	14.2
AL 1770	51.4	6.40	0.400	3.20	62.0	3.26	13.00	18.5	10.4	15.0
AL 1790	52.0	6.40	0.46	3.66	41.2	3.45	13.50	17.6	9.6	11.6
PA 406	51.0	5.40	0.44	3.15	55.2	3.66	13.45	20.4	12.4	9.8
PUSA 2012-1	48.8	5.88	0.54	3.60	42.6	3.15	13.80	20.9	13.1	15.2
PA 409	46.1	5.44	0.51	3.60	43.6	3.31	12.05	19.2	10.2	10.4
AL 201	50.5	6.22	0.51	3.30	42.0	2.81	18.06	13.7	10.5	12.5
PAU 881	48.0	6.00	0.40	3.44	65.2	4.67	13.24	19.2	11.2	12.4
MANAK	45.5	5.11	0.38	3.23	66.3	4.85	13.33	23.7	10.7	10.1
PA 291	59.2	7.86	0.34	3.12	62.3	2.83	13.86	18.3	15.0	11.6
UPAS 120 (Check)	58.7	6.56	0.34	5.6	57.3	2.52	14.29	12	22.1	15.4
Sem ±	(0.89)	(0.15)	(0.42)	(0.24)	(0.68)	(0.12)	(0.10)	(0.91)	(0.11)	(0.11)
CD @ 0.05	(0.25)	(0.43)	(0.12)	(0.66)	(0.20)	(0.35)	(0.28)	(0.26)	(0.30)	(0.31)

*Indicate that the values in parenthesis are $\sqrt{X+1}$ transformed values

positively correlated with Per cent pod damage by *H. armigera, M. vitrata and M. obtusa*,respectively (Table 3, Figure 1).

The present findings for correlation with *M. vitrata*Per cent pod damage are partially collaborated with Sunitha *et al.* (2008) among the physical

Table 3: Correlation of physio-chemical parameters of selected pigeonpea germplasm with per cent pod damage by pod borers during 2015-16 and 2016-17

Resistant traits	Per cent pod damage due to *H. armigera* (R value)	Per cent pod damage due to *M. vitrata*(R value)	Per cent pod damage due to *M. obtuse* (R value)
Pod length	0.389*	0.325^{NS}	0.539**
Pod width	-0.061^{NS}	-0.422*	-0.099^{NS}
Pod wall thickness	-0.394*	-0.369^{NS}	-0.646**
No. of grains per pod	-0.231^{NS}	0.007^{NS}	-0.061^{NS}
No. of pods per plant	0.315^{NS}	0.228^{NS}	-0.140^{NS}
Trichome length of pods	-0.140^{NS}	-0.168^{NS}	-0.155^{NS}
Trichome density of pods	-0.067^{NS}	-0.171^{NS}	-0.180^{NS}
Total phenols	0.016^{NS}	-0.164^{NS}	-0.344^{NS}
Total sugars	0.211^{NS}	0.300^{NS}	0.154^{NS}
Total proteins	0.003^{NS}	0.650**	0.053*

characters, pod wall thickness (-0.84), trichomes length on leaves (-0.95) and pods (-0.96) and trichome density on leaves (-0.95) showed a highly significant negative relation with Per cent pod damage. Other physical parameters *viz.,* pod length, width and trichome density on pods did not show significant relation. While, Kumar *et al.* (2015) found that pod length (0.389*) and pod width (0.380*) are significantly positively correlated whereas, trichome density (-0.745**) showed significant negative correlation in correlation between Per cent pod damage by *M. obtuse*. 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.

CONCLUSION

From above results, it can be concluded that varietal screening of 63 pigeonpea germplasm for two consecutive years resulted in an outcome of one resistant germplasm (PA 517) and 41 least susceptible germplasms. With the study of screening of different germplasms, resistant and least susceptible lines can be discovered and further bred for selection of superior germplasms. Identifying the sources of resistance is essential for increasing the levels, broadening the source and transfer mechanisms of such resistance into high yielding cultivars. These sources, be it morphological or biochemical, can be isolated from the respective germplasms and further exploited in the breeding programmes for selection of advanced and superior variety against pod borer complexes. Biophysical and biochemical traits of resistance showed that germplasms having lesser pod length, higher pod width, higher pod wall thickness, lower number of seeds per pod, lower number of pods per plant, higher trichome length, higher trichome density, higher phenols, lower sugars and lower proteins were less attacked by pod borer complexes. The combination of these easily measurable biophysical and biochemical traits can be used effectively as reliable selection criteria to select resistant plants. Genotypes selected through screening process can be used in breeding programmes as sources to enhance resistance/tolerance to pod borer in commercial cultivars. Such resistant and least susceptible lines can be recommended to the farmers to minimize the losses and cost of production.

ACKNOWLEDGEMENTS

The authors are thankful to Department of Entomology and Department of Genetics and Plant Breeding, G.B. Pant University of Agriculture & technology, Pantnagar for providing necessary facilities to carry out the study.

REFERENCES

Anonymous, (2018). All India Coordinated Research Project on Pigeonpea: 2017-18; Uttar Pradesh.

Bernays, E.A. and Chapman, R.F. (1994). Host-plant selection by phytophagous insects. Chapman and Hall, New York.

Bradford. (1976).A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal Biochem.,*72:248-54.

David, H. and Easwaramoorthy, S. (1988). Physical resistance mechanisms in insect plant interactions. Dynamics of insect-plant interactions; recent advances and future trends, edited by T. N. Ananthakrishnan, and A. Raman, *Oxford and IBH publishing Co*., New Delhi, India, Pp 45–70.

Halder, J., Srinivasan, S. and Muralikrishna, T. (2007). Role of various biophysical factors on distribution and abundance of spotted pod borer on mungbean. *Annals of Plant Protection Sciences*, 14: 49-51.

Jeffree, C.E. (1986). The cuticle, epicuticular waxes and trichomes of plants, with reference to their structure, functions and evolution. In: Juniper, B.E.; Southwood, T.R.E. (eds) Insects and the plant surface. *Edward Arnold Publishers Ltd., London*, UK, Pp 23–64.

Karkkainen, Katri and Agren, Jon. (2002). Genetic basis of trichome production in *Arabidopsis lyrata*. *Hereditas*, 136(3):219-26.

Kranthi, K.R., Jadhav, D.R., Kranthi, S., Wanjari, R.R. and Ali, S.S. (2002). Insecticide resistance in five major insect pests of cotton in India. *Crop Protection*, 21:449-460.

Kumar, G.S., Krishna, T.M., Prasanthi, L., Sudhakar, P. and Devaki, K. (2015). Morphological and biochemical traits associated with resistance to pod fly, *Melanagromyza obtuse* (Malloch) in pigeonpea. *International Journal of Applied Biology and Pharmaceutical Technology*, 6(3):134-141.

Lam and Pedigo, 2001. Effect of trichome density on soybean pod feeding by adult bean leaf beetles (Coleoptera: Chrysomelidae). *J. Econ. Entomol*., 94(6):1459-63.

Lateef, S. S., and Reed, W. (1983). Review of crop losses caused by insect pests in pigeonpea internationally and in India. *Indian Journal of Entomology*, 2: 284-293.

Lateef, S.S. and Reed, W. (1981). Development of methodology for open field screening for insect resistance in pigeonpea. In proceedings of the International Workshop on Pigeonpea. 15- 19 Dec. 1980. Vol 2 International Crops Research Institute for the Semi-arid Tropics, Patancheru. Andhra Pradesh, 3**:** 15-322.

Moudgal R.K, Lakra R.K., Dahiya B, and Dhillon M.K. (2008). Physico-chemical traits of *Cajanus cajan*(L.) Millsp. pod wall affecting *Melanagromyza obtuse* (Malloch) damage. *Euphytica*, 161(3): 429-436.

Oghiakhe, S. Jackai; L.E.N. and Makanjuola, W.A. (1991a). Cowpea plant architecture in relation to infestation and damage by the legume pod-borer, *Marucatestulalis*(Geyer) (Lepidoptera: Pyralidae): Effect of canopy structure and pod position. *Insect Science and its Application,*12: 193-199.

Oghiakhe, S., Jackai, L.E.N. and Makanjuola, W.A. (1992). A rapid visual field screening technique for resistance of cowpea (*Vigna unguiculata*) to the legume pod borer, *Marucatestulalis*(Lepidoptera: Pyralidae). *Bulletin of Entomological Research,*8: 507-512.

Oghiakhe, S., Jackai, L.E.N. and Makanjuola, W.A. (1991b). Anatomical parameters of cowpea, *Vigna unguiculata* (L.) Walp. Stem and pod wall resistance to the legume pod-borer, *Marucatestulalis* Geyer (Lepidoptera: Pyralidae). *Insect Science and its Application*, 12: 171-176.

Peter, J. A. 1995. Pigeonpea trichomes a promising source for pod borer resistance. IPM and IKM, *News Letter for Legume Crops in Asia*, 2: 4-5.

Sharma, H. C. (2016). Host plant resistance to insect pests in pigeonpea: Potential and limitations. *Legume Perspectives*, 11: 24-29.

Simmons and Geoff. 2004. Entrapment of *Helicoverpaarmigera* (Hübner) (Lepidoptera: Noctuidae) on glandular trichomes of Lycopersicon species. *Australian Journal of Entomology*, 43(2):196-200.

Singh, H., Ujagir, R. and Kumar, A. (2009). Screening of pigeonpea cultivars against pod borer complex. *The Geographical observer*, 39(A): 1-10.

Singleton and Rossi. (1965). Colorimetry of total phenolics with phosphomolybdic-Phosphotungstic Acid Reagents. *American Journal of Enology and Viticulture,*16:144-158.

Sunitha, V., Rao, G.V.R., Vijaya Lakshmi, K., Saxena, K.B., Rao, V.R. and Reddy, Y.V. R. (2008). Morphological and biochemical factors associated with resistance to *Marucavitrata* (Lepidoptera: Pyralidae) in short-duration pigeonpea. *International Journal of Tropical Insect Science,*28(1): 45-52.

Swain and Hillis. (1959). The phenolic constituents of *Prunus domestica*. I.—The quantitative analysis of phenolic constituents, 10(1):63-68.

Tamboli, N.D. and Lolage, G.R. (2008). Bio-efficacy of never newer insecticides against pod borer, *Helicoverpaarmigera* (Noctuidae: Lepidoptera) on Pigeonpea. *Pestology*, 32(10): 29-32.

Tayo, T. O. (1988). Flower and pod development in three cowpea (*Vigna unguiculata* (L.) Walp) varieties with varying susceptibility to the pod borer, *Marucatestulalis*(Geyer).*Insect Science and its Application*, 249-253.

Upadhyay RK, Mukerji KG, Rajak RL. (1998). IPM system in Agriculture, 4 pulses, New Delhi.

Yemm and Willis. (1954). The estimation of carbohydrates in plant extracts by anthrone. *Biochemical Journal,*57(3):508-514.

Received: October 23, 2021
Accepted: December 31, 2021