

Evaluation of responses of cowpea (*Vigna unguiculata* Walpers) genotypes to infestation of legume pod borer (*Maruca vitrata* Fabricius)

CHANCHAL SINGH and NN SINGH

Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh), India. Email: chanchalsingh9@gmail.com

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ABSTRACT

Twenty eight genotypes/varieties of cowpea tested against legume pod borer to find out the level of resistance during 2010-11 and 2011-12. Among them eight genotypes/ varieties (EC 394828, ET 116932, Kashi Shyamal, Arka Suman and Arka Sumurudhi) showed resistance against legume pod borer. Rest of the genotypes/ varieties showed tolerant to highly susceptible reactions to natural infestation of legume pod borer. The correlation coefficient values revealed that amount of phenol in flowers and immature pods affects adversely the infestation of legume pod borer, however, concentrations of carbohydrate and protein affects favorably.

Keywords: Cowpea, Genotypes and varieties, Legume pod borer, Responses.

Cowpea, *Vigna unguiculata* (L) Walpers is an indispensable grain legume in West Africa and in many parts of the tropics throughout the world (Singh *et al.* 2002). It provides an economical source of protein and minerals for the urban and rural masses of the region (Alghali 1991). Cowpea also fixes atmospheric nitrogen, allowing it to grow and recover soil health. All the parts of cowpea that are used for food are nutritious. The grains contain 25% protein and 64% carbohydrate and have high potential to reduce malnutrition (Borget 1992; Devis *et al.* 2002). The low yield of this crop is due to a number of insect-pests, diseases, parasitic weeds, poor soil health, drought and lack of input (Ajeigbe and Singh 2006). However, insect-pests are the major constraint to get better production (Singh *et al.* 1990; Jackai and Adalla 1997). Higher infestation of insect-pest can lead to total yield loss (Singh and Allen 1980).

Every stage of its life cycle has infestation of at least one major insect-pest: foliage feeder especially *Othera mutabilis* Sahl and aphid (*Aphis craccivora* Koch) attack at seedling stage, flower thrips (*Megalurothrips sjostedti* Tryb) at flowering, pod borer (*Maruca testulalis* Gey = *Maruca vitrata*) and a complex of pod sucking bugs (*Clavigralla tomentosicollis* Stal, *Riptortus dentipes* F, *Anoplocnemis curvipes* F, *Mirperus jaculus*, *Aspavia armigera* F and *Nazara viridula*) at late flowering and early podding stage and the weevil (*Callosobruchus maculatus*) during storage (Singh and Taylor 1978; Singh and Allen 1980). Damage caused by these insect-pests singly or in combination with fungal,

bacterial, viral diseases and unfavourable weather conditions cause adverse effect on the growth and are responsible for the low grain yield. This was estimated that approximately 350 kg/ha yield loss evidenced from farmer's field or total grain loss (Singh and Allen 1980; Singh *et al.* 1990).

The most damaging of all insect-pests are occur during flowering and podding stages which include flower thrips, legume pod borer and a complex of pod and seed suckers (Jackai and Adalla 1997). Among these, legume pod borer, *Maruca vitrata* Fabricius is an economic pest. The larvae attack the vegetative and reproductive part (Taylor 1978). Yield losses due to this insect vary from 20 to 80% (Singh and Allen 1980). Chemical insecticides are widely used to control insect-pests, which could adversely affect human health and environment (Sodavy *et al.* 2000; Alam *et al.* 2006). Safe, efficient and ecofriendly pest control strategies are warranted to reduce the pesticide misuse in managing legume pod borer. In this regard host plant resistance is one of the promising options, which may prove itself as an alternative of chemical control.

Thomus and Waage (1995) considered host plant resistance as an important part of a sustainable pest management. Painter (1951) considered host plant resistance as heritable quality possessed by a host that enables it to influence the ultimate primary damage done by an insect. Accordingly, expression of resistance is determined by the inherent ability of a plant as dictated by the morphological and biochemical characteristics of the plant. Host plant resistance expressed as non-preference, antibiosis and/or tolerance have been reported by some researchers (Singh 1985; Alabi *et al.* 2003).

Host plant resistance has overriding advantage of cost effectiveness and environmental safety among others. Over use of insecticides is embroiled in controversies of adulteration, environmental pollution, insect resistance and resurgence, biomagnifications, drift to adjacent field and high level of technically involve in handling due to its toxicity. Environment friendly methods for pest management are being sought and use of host plant resistance has been identified as one of most economical and environmentally safe method for insect pest control. Considering these facts, the present study was designed with objectives (i) screening of cowpea,

Vigna unguiculata genotypes and varieties to natural infestation of legume pod borer and (ii) determination of basis of resistance/susceptibility to legume pod borer and carried out during cropping seasons of 2010-11 and 2011-12.

MATERIALS AND METHODS

The field trial was performed at the Agricultural Research Farm, Banaras Hindu University, Varanasi (Uttar Pradesh), India located at 25° 15' 51.74" N latitudes 82° 59' 36.56 E longitudes and about 129.23 m above from mean sea level. The field was disc harrowed twice and a basal dose of 25 kg N, 70 kg P₂O₅ and 70 kg K₂O per hectare were applied and ridged prior to sowing. The experiment was laid out in Randomised Complete Block Design (RCBD) replicated four times. Each plot consisted of three rows of 3.0 m long with an inter row spacing of 0.60 m and the plant to plant distance within the row of 0.15 m. The plots were separated by a blank row. Sowings were done on 18th August, 2010 and 13th August, 2011 during both cropping seasons, respectively. To ensure proper stand, four seeds were dibbled at each hill and a week after germination thinning was done to maintain two plants per hill. Twenty eight genotypes and varieties were used in this experiment. Among these, twenty genotypes and five local varieties (Kashi Shyamal, Kashi Gauri, Kashi Unnati, Kashi Kanchan and Kashi Sudha) were obtained from Indian Institute of Vegetable Research (IIVR), Varanasi (Uttar Pradesh), India and remaining three varieties (Arka Suman, Arka Garima and Arka Sumurudhi) were from Indian Institute of Horticultural Research, Hyderabad (Andhra Pradesh), India.

The observations on several aspects were recorded at weekly interval till last plucking of the pods between 6:00 to 10:00 hours GMT. Per cent flowers and pods damage as well as larval density per flower and pod were recorded from ten randomly selected flowers and pods were taken from ten randomly selected plants. Ten flowers at 50% flowering stage and five immature pods were plucked from each genotypes and varieties and kept in paper envelop assigned for each. The samples were brought to laboratory and used for biochemical analysis. The analysis for phenol and carbohydrate was performed as described by Sadasivam and Manickam but protein was quantified by following Lowry's Method. The data were analyzed using appropriate program. Analysis of variance (ANOVA) for Randomised Complete Blok Design (RCBD) was performed and critical difference (CD) at 5% probability level were calculated, where ANOVA showed significant difference. The data of per cent flowers and pods damage, larval density per flower and pod, peduncles and pods lengths and concentrations of biochemical constituents (phenol, carbohydrate & protein) were either square root or angular transformed whichever applicable, before statistical analysis.

RESULTS AND DISCUSSION

The responses of cowpea genotypes and varieties to per cent flower infestation, its biochemical constituents and peduncle lengths during cropping seasons of 2010-11 & 2011-12 are accessible from table 1 and 3, respectively. A highest percentage of flower damage with more mean larval density, higher carbohydrate and protein concentrations as well as lesser amount of phenol were reported in EC 472272, which was at par with most of the genotypes and varieties taken into consideration. The lowest per cent flower damage with lesser average larval density, inferior carbohydrate and protein concentrations as well as superior magnitude of phenol were observed in Kashi Shyamal and Arka Suman, which were at par with EC 394828, ET 116932 and Arka Sumurudhi during cropping season of 2010-11 (Table 1). However, during cropping season of 2011-12, slight variations were observed. The maximum flower damage was observed in EC 390211 with

Table 1: Response of cowpea genotypes and varieties to natural infestation of flowers, its biochemical constituents and peduncle length during *kharif*, 2010-11 at flowering stage

Genotypes	Flower infestation		Peduncle length (cm)
	Damage (%)	Larval density (Avg. No./flower)	
EC 91171A	33.33 (35.57)	2.73 (1.80)	14.75 (3.90)
EC 472283	30.00 (35.52)	3.60 (2.02)	21.59 (4.70)
EC 390211	33.33 (35.57)	3.20 (1.92)	17.91 (4.29)
EC 394828	19.33 (26.45)	1.53 (1.43)	7.37 (2.81)
EC 9739B	34.00 (35.97)	3.67 (2.04)	28.44 (5.38)
EC 472250	30.00 (33.52)	3.20 (1.92)	18.96 (4.41)
EC390226	33.33 (35.57)	3.00 (1.87)	16.85 (4.17)
EC390212	31.33 (34.35)	3.73 (2.06)	12.64 (3.62)
EC 472272	37.33 (37.96)	3.67 (2.04)	11.59 (3.48)
ET 116932	20.00 (26.92)	1.93 (1.56)	9.48 (3.16)
IT 835-728-13	32.00 (34.76)	3.13 (1.91)	25.28 (5.08)
ET 116918	32.67 (35.16)	3.00 (1.87)	9.48 (3.16)
ET 116893	32.67 (35.16)	3.40 (1.97)	13.69 (3.77)
EC 160493	34.00 (35.97)	3.67 (2.04)	20.01 (4.53)
EC 9135B	34.67 (36.37)	2.93 (1.85)	25.28 (5.08)
EC28391	34.00 (35.57)	2.93 (1.85)	30.55 (5.57)
EC472259	31.33 (34.35)	3.40 (1.97)	18.96 (4.41)
EC 47306	34.00 (35.57)	3.33 (1.96)	26.33 (5.18)
EC 1738	35.33 (36.77)	3.80 (2.07)	23.17 (4.87)
EC 37587	35.33 (36.77)	3.00 (1.87)	10.53 (3.32)
KASHI SHYAMAL	17.33 (24.98)	1.67 (1.47)	18.96 (4.41)
KASHI GAURI	27.33 (31.84)	3.13 (1.91)	16.85 (4.17)
KASHI UNNATI	34.00 (35.97)	2.80 (1.82)	22.12 (4.76)
KASHI KANCHAN	28.00 (32.27)	3.40 (1.97)	9.48 (3.16)
KASHI SUDHA	34.67 (36.37)	3.60 (2.02)	13.69 (3.77)
ARKA SUMAN	17.33 (24.98)	1.80 (1.52)	7.37 (2.81)
ARKA GARIMA	36.00 (37.17)	3.27 (1.94)	12.64 (3.62)
ARKA SUMURUDHI	19.33 (26.45)	1.73 (1.49)	18.96 (4.41)
CD _(P=0.05)	4.91	0.33	0.95
SEm±	1.73	0.12	0.33
F-test	**	**	**

Avg. = Average. Figures in parentheses are square root/angular transformed values. ** Significant at P_{0.05}.

Table 2: Response of cowpea genotypes and varieties to natural infestation of pods, its biochemical constituents, pod length and yield during *kharif*, 2010-11 at maturity

Genotypes	Pod infestation		Pod length (cm)	Yield (q/ha)	
	Damage (%)	Larval density (Avg. No./flower)		Pods	Seeds
EC 91171A	22.67 (28.77)	0.47 (0.99)	18.30 (4.34)	15.75	3.75
EC 472283	28.00 (32.27)	0.56 (1.03)	16.15 (4.08)	14.94	4.11
EC 390211	23.33 (29.22)	0.52 (1.01)	14.00 (3.81)	16.31	3.14
EC 394828	12.67 (21.28)	0.18 (0.82)	8.61 (3.02)	20.11	5.28
EC 9739B	24.00 (29.67)	0.57 (1.03)	11.84 (3.51)	12.61	4.19
EC 472250	26.00 (30.98)	0.52 (1.01)	10.77 (3.36)	15.53	4.28
EC390226	27.33 (31.84)	0.50 (1.00)	20.46 (4.58)	17.31	3.14
EC390212	23.33 (29.22)	0.57 (1.04)	8.61 (3.02)	17.03	3.47
EC 472272	20.00 (26.92)	0.57 (1.04)	9.69 (3.19)	13.06	4.14
ET 116932	16.67 (24.48)	0.15 (0.81)	18.30 (4.34)	18.75	5.42
IT 835-728-13	22.67 (28.77)	0.51 (1.01)	5.38 (2.43)	16.17	3.81
ET 116918	18.00 (25.47)	0.50 (1.00)	10.77 (3.36)	15.47	3.14
ET 116893	16.00 (23.97)	0.54 (1.02)	12.92 (3.66)	15.83	4.31
EC 160493	18.00 (25.47)	0.57 (1.03)	10.77 (3.36)	14.14	4.08
EC 9135B	12.00 (20.70)	0.49 (1.00)	12.92 (3.66)	15.17	4.61
EC28391	24.00 (29.67)	0.49 (1.00)	17.23 (4.21)	14.86	4.03
EC472259	17.33 (24.98)	0.54 (1.02)	12.92 (3.66)	13.42	4.44
EC 47306	20.00 (26.92)	0.53 (1.02)	16.15 (4.08)	15.75	4.33
EC 1738	24.00 (29.67)	0.58 (1.04)	21.53 (4.69)	16.39	4.39
EC 37587	21.33 (27.86)	0.50 (1.00)	19.38 (4.46)	15.89	3.61
KASHI SHYAMAL	18.67 (25.96)	0.19 (0.83)	19.38 (4.46)	19.03	5.14
KASHI GAURI	25.33 (30.55)	0.51 (1.01)	22.61 (4.81)	13.97	4.03
KASHI UNNATI	25.33 (30.55)	0.48 (0.99)	22.61 (4.81)	16.58	3.94
KASHI KANCHAN	20.00 (26.92)	0.54 (1.02)	23.69 (4.92)	20.39	5.14
KASHI SUDHA	22.00 (28.32)	0.56 (1.03)	17.23 (4.21)	14.50	3.72
ARKA SUMAN	13.33 (21.93)	0.21 (0.84)	14.00 (3.81)	19.25	5.28
ARKA GARIMA	25.33 (30.55)	0.53 (1.01)	15.07 (3.95)	15.17	3.61
ARKA SUMURUDHI	14.00 (22.38)	0.22 (0.850)	10.77 (3.36)	19.56	5.22
CD _{P=0.05}	3.99	0.14	0.89	2.49	0.61
SEm±	1.41	0.05	0.31	0.88	0.21
F-test	**	**	**	**	**

Avg. = Average. Figures in parentheses are square root/angular transformed values. ** Significant at P_{0.05}.

greater larval density, carbohydrate and protein content and lesser phenol concentration, which was at par with EC 91171A, EC 472283, EC 9739B and EC 472250, while minimum percentage of flower damage, lower population density with lesser extent of carbohydrate as well as protein and higher phenol concentration were recorded in Arka Sumurudhi, which differed nonsignificantly from ET 116932, Kashi Shyamal and Arka Suman (Table 3). The biochemical constituents of flowers and immature pods from tested genotypes and varieties revealed that carbohydrate and protein concentrations were positively associated with percent damage and larval density, whereas phenol concentration had significant negative impact on the same. The results of present experiments are supported by Macfoy et al. (1983) who reported that higher concentration of phenols in the stems of cowpea variety TVu 946, which was resistant to the *Maruca*, than susceptible varieties. Sucrose has been reported to be the strongest feeding stimulant for herbivorous insects (Ishikawa et al. 1969).

The feedbacks of cowpea genotypes and varieties to natural infestation of pods, their biochemical constituents, pod length and yield during cropping seasons of 2010-11 and

2011-12 were available in table 2 and 4. Among these genotypes and varieties, the most susceptible reaction was represented by EC 472283 with maximum pod damage, higher mean larval density, intermediate phenol and protein concentrations as well as higher carbohydrate extent and higher pod yield. This variety had non-significant differences from the maximum genotypes and varieties taken into consideration during cropping season of 2010-11. The genotype, EC 9135B showed resistant response with lowest percentage of pod damage and average larval density, major proportion of carbohydrate and protein, minor proportion of phenol and higher pods as well as seeds yield, which was at par with EC 394828, ET 116893, Arka Suman and Arka Sumurudhi (Table 2). In the cropping season of 2011-12, the greatest pod damage with eminent average larval density per pod, lowest phenol content, higher quantity of carbohydrate and protein and intermediate yield of pods and seeds were recorded in EC 472293. This was at par with EC 390211, EC 9739B, EC 472250, Kashi Unnati and Arka Garima. The least pod damage was observed in Kashi Shyamal with lower average larval density and phenol magnitude, lower carbohydrate and highest pods and seeds

Table 3: Cowpea genotypes and varieties to natural infestation of flowers, its biochemical constituents and peduncle length during *kharif*, 2011-12 at flowering stage

Genotypes	Flower infestation		Peduncle length (cm)
	Damage (%)	Larval density (Avg. No./flower)	
EC 91171A	30.00 (33.52)	2.73 (1.80)	13.87 (13.87)
EC 472283	36.00 (37.17)	4.13 (2.15)	20.27 (4.56)
EC 390211	37.33 (37.96)	3.27 (1.94)	19.20 (4.44)
EC 394828	18.67 (25.96)	1.80 (1.52)	17.07 (4.19)
EC 9739B	36.00 (37.17)	4.20 (2.17)	29.87 (5.51)
EC 472250	34.00 (35.97)	3.67 (2.04)	12.80 (3.65)
EC390226	33.33 (35.57)	3.80 (2.07)	24.53 (5.00)
EC390212	26.00 (30.98)	3.67 (2.04)	7.47 (2.82)
EC 472272	30.00 (33.52)	3.40 (1.97)	9.60 (3.18)
ET 116932	17.33 (24.98)	2.60 (1.76)	11.73 (3.50)
IT 835-728-13	32.00 (34.76)	3.67 (2.04)	22.40 (4.79)
ET 116918	31.33 (34.35)	3.33 (1.96)	7.47 (2.82)
ET 116893	33.33 (35.57)	3.73 (2.06)	18.13 (4.32)
EC 160493	29.33 (33.11)	2.60 (1.76)	34.13 (5.89)
EC 9135B	28.67 (32.69)	3.40 (1.97)	13.87 (3.79)
EC28391	28.00 (32.27)	3.20 (1.92)	26.67 (5.21)
EC472259	29.33 (33.11)	3.73 (2.06)	25.60 (5.11)
EC 47306	32.00 (34.76)	3.60 (2.02)	27.73 (5.31)
EC 1738	28.67 (32.96)	2.93 (1.85)	25.60 (5.11)
EC 37587	25.33 (30.55)	3.27 (1.94)	11.73 (3.50)
KASHI SHYAMAL	16.67 (24.48)	1.87 (1.54)	21.33 (4.67)
KASHI GAURI	24.67 (30.11)	3.80 (2.07)	7.47 (2.82)
KASHI UNNATI	30.00 (33.52)	3.33 (1.96)	19.20 (4.44)
KASHI KANCHAN	27.33 (31.84)	3.67 (2.04)	10.67 (3.34)
KASHI SUDHA	25.33 (30.55)	3.93 (2.11)	19.20 (4.44)
ARKA SUMAN	17.33 (24.98)	1.87 (1.54)	9.60 (3.18)
ARKA GARIMA	28.00 (32.27)	3.47 (1.99)	16.00 (4.06)
ARKA SUMURUDHI	16.00 (23.97)	2.00 (1.58)	21.33 (4.67)
CD _{p,0.05}	4.62	0.24	0.93
SE _{m±}	1.63	0.08	0.33
F-test	**	**	**

Avg. = Average. Figures in parentheses are square root/angular transformed values. ** Significant at $P_{0.05}$.

yields. It differed nonsignificantly from Arka Suman only (Table 4). According to Halder and Srinivasan (2007) the relation between total sugar and pod damage were significant positive. From Nigeria a contradictory report was made by Oghiakhe et al. (1993) who reported that phenol does not play any significant role in cowpea resistance to *M. vitrata*. In present study, pod and peduncle length did not play any consistent significant role in infestation caused by legume pod borer. An experiment conducted at Hyderabad revealed that the differences in pod length among different cultivars were found to influence pod damage by *M. vitrata*. Lengthy pods were found more suitable for damage by this insect as they harboured more larvae per pod (Halder and Srinivasan, 2011).

The per cent flower and pod damage as well as mean larval density per flower and pod were correlated with concentrations of phenol, carbohydrate, protein and length of peduncles and pods and presented in table 5. The correlation coefficient values revealed that phenol concentration in flowers and immature pods had significant negative correlation with percent flowers and pods damage and larval densities, whereas amount of carbohydrate and

protein affects significant positively during both the cropping seasons. The peduncle and pod length did not have any consistent significant association with percent flowers and pods damage and mean larval density during cropping seasons.

On the basis of above discussion, the present study concluded as among twenty eight cowpea genotypes and varieties tested for its level of resistance and susceptibility, EC 394828, ET 116932, Kashi Shyamal, Arka Suman and Arka Sumurudhi were found more resistant than others. Except these, all the genotypes and varieties showed tolerant to highly susceptible reactions to natural infestation of legume pod borer. The correlation coefficient values of percent flowers and pods damage and average larval density with biochemical constituents (phenol, carbohydrate and protein) and lengths of peduncles and pods revealed that amount of phenol in flowers and immature pods affects adversely the infestation of legume pod borer, however, concentrations of carbohydrate and protein in flowers and pods affects favorably. The peduncle length was positively associated with percent pod damage and average larval density per pod, whereas the

Table 4: Cowpea genotypes and varieties to natural infestation of pods, its biochemical constituents, pod length and yield during *khariif*, 2011-12 at maturity

Genotypes	Pod infestation		Pod length (cm)	Yield (q/ha)	
	Damage (%)	Larval density (Avg. No./flower)		Pods	Seeds
EC 91171A	19.33 (26.45)	0.46 (0.98)	12.28 (3.58)	14.47	4.08
EC 472283	30.67 (33.94)	0.49 (0.99)	20.10 (4.54)	15.31	4.36
EC 390211	27.33 (31.84)	0.47 (0.99)	16.75 (4.15)	11.64	4.64
EC 394828	14.67 (22.92)	0.19 (0.83)	14.52 (3.88)	17.64	3.53
EC 9739B	26.67 (31.41)	0.53 (1.01)	20.10 (4.54)	14.03	5.56
EC 472250	30.00 (33.52)	0.51 (1.00)	12.28 (3.58)	13.69	3.92
EC390226	22.00 (28.32)	0.47 (0.98)	4.47 (2.23)	16.44	4.03
EC390212	18.00 (25.47)	0.51 (1.00)	10.05 (3.25)	15.14	3.89
EC 472272	22.67 (28.77)	0.45 (0.98)	17.87 (4.29)	12.22	4.36
ET 116932	15.33 (23.45)	0.21 (0.84)	21.22 (4.66)	17.92	4.31
IT 835-728-13	19.33 (26.45)	0.55 (1.02)	6.70 (2.68)	14.86	3.47
ET 116918	16.00 (23.97)	0.45 (0.97)	16.75 (4.15)	14.08	4.03
ET 116893	21.33 (27.86)	0.48 (0.99)	17.87 (4.29)	15.78	3.83
EC 160493	22.00 (28.32)	0.49 (1.00)	14.52 (3.88)	15.45	4.00
EC 9135B	17.33 (24.98)	0.43 (0.97)	18.98 (4.41)	11.44	4.19
EC28391	18.00 (25.47)	0.47 (0.99)	15.63 (4.02)	13.49	4.31
EC472259	16.00 (23.97)	0.48 (0.99)	17.87 (4.29)	12.75	4.00
EC 47306	18.00 (25.47)	0.53 (1.02)	12.28 (3.58)	16.50	4.14
EC 1738	18.67 (25.96)	0.45 (0.98)	18.98 (4.41)	12.33	4.33
EC 37587	21.33 (27.86)	0.53 (1.02)	11.17 (3.42)	16.33	4.31
KASHI SHYAMAL	8.67 (17.62)	0.20 (0.84)	17.87 (4.29)	20.69	5.28
KASHI GAURI	17.33 (24.98)	0.49 (0.99)	18.98 (4.41)	14.92	3.19
KASHI UNNATI	27.33 (31.84)	0.49 (0.99)	27.92 (5.33)	15.19	3.89
KASHI KANCHAN	16.67 (24.48)	0.51 (1.00)	26.80 (5.22)	17.75	5.28
KASHI SUDHA	18.00 (25.47)	0.53 (1.02)	21.22 (4.66)	10.56	3.39
ARKA SUMAN	10.00 (18.91)	0.18 (0.82)	18.98 (4.41)	18.61	5.00
ARKA GARIMA	26.00 (30.98)	0.53 (1.02)	21.22 (4.66)	10.33	3.19
ARKA SUMURUDHI	14.67 (22.92)	0.19 (0.83)	13.40 (3.73)	17.78	4.94
CD _r (P=0.05)	3.72	0.12	0.77	2.29	0.53
SEm±	1.31	0.04	0.27	0.81	0.19
F-test	**	**	**	**	**

Avg. = Average. Figures in parentheses are square root/angular transformed values. ** Significant at P_{0.005}.

Table 5: Associations of percent damage and larval density with some biochemical and biophysical constituents during cropping seasons

Plant parts affected	Cropping seasons	Parameters	Phenol	Carbohydrate	Protein	Length	
						Peduncles	Pods
Flowers	<i>Khariif</i> , 2010-11	Percent damage	-0.6449*	0.6338*	0.5643*	0.3519*	-
		Avg. no. of larvae	-0.5738*	0.6197*	0.5629*	0.2986	-
	<i>Khariif</i> , 2011-12	Percent damage	-0.6567*	0.5708*	0.6981*	0.2704	-
		Avg. no. of larvae	-0.5803*	0.4535*	0.6597*	0.0378	-
Pods	<i>Khariif</i> , 2010-11	Percent damage	-0.4747*	0.5118*	0.3935*	0.3214*	0.3444*
		Avg. no. of larvae	-0.7236*	0.6863*	0.6172*	0.3461*	0.0186
	<i>Khariif</i> , 2011-12	Percent damage	-0.5184*	0.4821*	0.5611*	0.1680	0.0466
		Avg. no. of larvae	-0.7891*	0.6570*	0.6274*	0.1539	-0.0609

*Significant at P_{0.005}.

peduncle and pod length did not play any significant role in natural buildup of legume pod borer population under cowpea agro-ecosystem.

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REFERENCES

- Ajeibe HA and Singh BB. 2006. Integrated pest management in cowpea: Effect of time and frequency of insecticides application on productivity. *Crop Protection* 25: 920-925.
- Alabi OY, Odebiyi JA and Tamo M. 2003. Effects of host plant resistance

- in some cowpea (*Vigna unguiculata* [L.]Walp.) cultivars on growth and developmental parameters of the flower bud thrips, *Megalurothrips sjostedti* (Trybom). *Crop Protection* 23: 83-84.
- Alam SN, Ahmed GJU, Khorsheduzzaman AKM, Karim ANMR and Rajotte EG. 2006. Survey of vegetable insect pests in rice-vegetable cropping systems in Bangladesh. In: 5th National IPM Symposium, Delivering on a Promise, April 4-6, 2006, St. Louis, MO.
- Alghali AM. 1991. Studies on cowpea farming practices in Nigeria, with emphasis on pest control. *Tropical Pest Management* 37: 71-74.
- Borget M. 1992. Food legumes. The tropical agriculturist series. Technical Centre for Agriculture and Rural Cooperation (Ede, Netherlands). Wageningen, Netherlands: Macmillan. 103 p.
- Davis DW, Oelke EA, Oplinger ES, Doll JD, Hansonard CV and Putnam DH. 2002. Cowpea. history, use, and cultivation. Field Crops Manual Extension Report, University of Wisconsin, Co-operative Extension.
- Halder J and Srinivasan S. 2007. Biochemical basis of resistance against *Maruca vitrata* (Geyer) in urd bean. *Annals of Plant Protection Sciences* 15(2): 287-290.
- Halder J and Srinivasan S. 2011. Varietal screening and role of morphological factors on distribution and abundance of spotted pod borer, *Maruca vitrata* (Geyer) on cowpea. *Annals of Plant Protection Sciences* 19(1): 71-74.
- Ishikawa S, Hirao T and Arai N. 1969. Chemosensory basis of host plant selection in the silkworm. *Entomologia Experimentalis et Applicata* 12: 145-156.
- Jackai LEW and Adalla CB. 1997. Pest management practices in cowpea. In: Singh BB, Mohan R, Dashiell KE, Jackai LEN, editors. *Advances in cowpea research*. Minnesota: Copublication of IITA and Japan International Research Centre for Agricultural Sciences (JIRCAS). p. 240-258.
- Macfoy CA, Dabrowski ZT and Okech S. 1983. Studies on the legume pod borer, *Maruca testulalis* (Geyer)-4. Cowpea resistance to oviposition and larval feeding. *Insect Science and its Application* 4: 147-152.
- Ogliakhe S, Makanjuola WA and Jackai LEN. 1993. The relationship between the concentration of phenol in cowpea and field resistance to the legume pod borer, *Maruca testulalis* Geyer (Lepidoptera: Pyralidae). *International Journal of Pest Management* 39(3): 261-264.
- Painter RH. 1951. *Insect resistance in crop plants*. New York: Macmillan. p. 520.
- Sadasivam S and Manikkam A. 1996. *Biochemical Methods*, 2nd Edition. New Age International (P) Limited Publisher, New Delhi. pp. 20-21, 193-194.
- Singh SR and Allen DJ. 1980. Pests, diseases, resistance and protection in cowpea. In: Summerfield RJ, Bunting AJ, editors. *Advances in legume science*. In: *Proceeding of the International Legume Conference, 31 July-4 August 1978*, Vol. 1. London: Royal Botanical Gardens, Kew and Ministry of Agriculture, Fisheries and food. p. 419-443.
- Singh SR, Jackai LEN, Dos Santos JHR and Adalla CB. 1990. Insect pests of cowpeas. In: Singh SR, editor. *Insects pest of tropical food legumes*. New York: John Wiley. p. 43-89.
- Singh SR and Taylor TA. 1978. Pests of grain legumes and their control in Nigeria. In: Singh HF, Van Emden, Taylor TA, editors. *Pests of grain legumes: ecology and control*. New York: Academic Press. p. 99-111.
- Singh SR. 1985. *Grain legume entomology*. Ibadan, Nigeria: International Institute of Tropical Agriculture. p. 48.
- Singh BB, Ehlers JD, Sharma B and Freire FR. 2002. Recent progress in cowpea breeding. In: Fatokun CA, Tarawali SA, Singh BB, Kornawa PM, Tamo M (Eds.), *Challenges and opportunity for enhancing sustainable cowpea production*. *Proceedings of the World Cowpea Conference III held at International Institute of Tropical Agriculture (IITA)*, Ibadan, Nigeria, 4-8 September 2000. IITA, Ibadan, Nigeria.
- Sodavy P, Sitha M, Nugent R and Murphy H. 2000. Situation analysis on farmers' awareness and perceptions of the effect of pesticides on their health. *FAO Community IPM Programme*. Field Document. p. 16.
- Taylor TA. 1978. Observations on the bionomics of *Laspeyresia pychora* Meyr. (Lepidoptera, Euscomidae) infesting cowpea in Nigeria. *Bulletin of Entomological Research* 55: 761-774.
- Thomas MB and Waage JK. 1995. Integration of biological control and host plant resistance breeding for control of insect pest. In: CTA-IAR-IIBC Seminar; Oct 9-14; Addis Ababa, Ethiopia.