**Evaluation of Soybean Varieties for Pod Borers Resistance Under Field Conditions**

**Abstract**

A screening experiment was conducted to evaluate the resistance of nine soybean varieties against pod borers *Cydia ptychora* (Meyrick) and *Etiella zinckenella* (Treitschke) under field conditions. Larval population and the damage caused by the two pod borers were assessed at 60, 75 and 90 days after sowing. Significant variations were observed in the susceptibility of the nine soybean genotypes. Hardee genotype exhibited the least larval population and less pod damage (19.69 %), categorizing it as highly resistant. DSb 23, KHS23, MAVS2, and DSb21 were categorized into moderately resistant, while karuna, KHSB2 and JS 335 were intermediate. KB79 showed the maximum larval population and pod damage (61.10%) making it the susceptible genotype. Biochemical analysis revealed a negative correlation between the phenol content and pod damage, where total sugars and proteins showed a positive correlation. The finding highlights the role of biochemical defense mechanisms in soybean resistance.

**1. Introduction**

Soybean (*Glycine max* (L.) Merrill) is the world’s leading oilseed crop, widely grown for its edible beans, which serve as a primary source of vegetable protein. Known as the "Golden Bean" of the 20th century, it is cultivated in tropical, subtropical, and temperate climates and is the most widely grown oilseed crop globally (Agarwal *et al*., 2013). In Karnataka, soybean is primarily grown in Belgaum, Dharwad, Bidar, Bagalkot, Haveri, and more recently, Shivamogga districts (Parashuram and Patil, 2021). Over time, soybean cultivation has significantly improved the socio-economic status of small and marginal farmers in rainfed regions of central and peninsular India. The crop also holds promise in addressing protein-energy malnutrition and providing various nutraceutical and functional benefits. However, the continuous cultivation of soybean has led to an increase in insect pest populations (Anderson *et al*., 2019).

Among the various insect pests that affect soybean from sowing to harvest, those that infest the crop during flowering and post-flowering stages cause the most significant yield losses. Pod borers, in particular, are of great concern due to their considerable impact on yield. Notable pod borer species include *Helicoverpa armigera* (Hübner), *Maruca testulalis* (Geyer), *Etiella zinckenella* (Treitschke) and *Cydia ptychora* (Meyrick). The pod borers *C. ptychora* and *E. zinckenella* are major soybean pests in Karnataka, causing severe damage, particularly in the Shivamogga region (Naik *et al*., 2020).

The larvae of Soyabean Pink Pod Borer *C. ptychora* bores into the seeds, producing whitish, dry frass and creating exit holes on the pods. The feeding damage, combined with the production of frass and webbing within the pods, leads to seeds with reduced nutritional value and poor germination. As early as 1975, studies showed that damage from *C. ptychora* could range from 10.5% to 91.29% on soybean pods, depending on the planting season, with the highest damage occurring in crops sown in July (Adimani, 1976).

*E. zinckenella* larvae enter the pods and feed on the developing soybean seeds, creating irregular holes and leaving behind faeces that accumulate inside. This feeding damage results in shrivelled or missing seeds, ultimately reducing overall grain quality. Infested pods often appear discoloured, deformed, or shrivelled, while the pod walls become thin and fragile, making them more susceptible to cracking (Ginting *et al*.,2022).

The adoption of resistant varieties, coupled with minimal insecticide use and enhanced cultural practices suited to farmers' economic and managerial capacities, holds significant potential for achieving stable, increased yields. However, this approach has received limited attention in the management of the pod borers. Accordingly, the present investigation was conducted to develop a management program based on the use of resistant varieties to control this pest.

**2. Materials and methods**

A field experiment was conducted during Kharif 2021 at the Agricultural and Horticultural Research Station (AHRS), Bavikere, Karnataka, to screen nine soybean varieties—JS 335, Hardee, DSb 21, KHSB2, KHSB 23, Karune, KB 79, MAVS2, and DSb 23—for their resistance against the pod borers, *Cydia ptychora* and *Etiella zinckenella*. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, nine treatments, and a net plot size of 500 sq.m., with each treatment occupying 10 sq.m.

Observations on the number of larvae per plant was recorded from ten randomly selected plants from each variety, which were then averaged to represent the number of larvaee per plant. Similarly, pod damage observations were taken from ten randomly selected plants, in each plot. The number of damaged pods and total number of pods were counted in each variety. The per cent pod damage was worked out using the following formula given by Jackai (1982).

Observation on the total number of pods per plant and damaged pods per plant were recorded from ten randomly selected plants from each variety from 60, 75 and 90 days after sowing. Seeds harvested from each variety were dried, weighed and seed yield (kg/plot) was recorded in each variety, later converted into kg/ha.

**2.1. Resistance score**

Based on the per cent pod damage, the damage score for each variety of soybean was determined by using a resistance rating of 1-5 as suggested by Jackai (1982).

**Table 1. Categorization of soybean varieties based on per cent pod damage rating scale**

|  |  |  |
| --- | --- | --- |
| **Pod damage (%)** | **Score** | **Resistance rating** |
| 0-20 | 1 | Highly resistant |
| 21-40 | 2 | Moderately resistant |
| 41-60 | 3 | Intermediate |
| 61- 80 | 4 | Susceptible |
| 81-100 | 5 | Highly Susceptible |

**2..2. Biochemical parameters**

The immature pods were collected and brought from the field in ice box and powdered with the help of a grinder to be analysed for the phenols, proteins and total sugars at Referral Soil Testing Laboratory, Zonal Agricultural and Horticultural Research Station, KSNUAHS, Shivamogga. Phenolic compounds were analysed using the estimation of free phenols by Folin - Ciocalteau Reagent at given by Lowry *et al*., 1951. Proteins and Sugars were estimated by Lowry’s method and Anthrone reagent method. The effect of biochemical parameters *viz.,* on damage caused by various pod borers, the multiple linear regression analysis was carried out.

**3. Results**

Screening experiments on nine soybean varieties were carried out for resistance against pod borers such as *C. ptychora* and *E. zinckenella*. Observations on the mean larvae population of pod borers per plant and the per cent pod damage of different genotypes displayed a huge difference in their susceptibility at 60, 75 and 90 DAS.

**60 DAS**

Field observations of soybean varieties against *C. ptychora* and *E. zinckenella* concerning mean larval population per plant are presented on Table 2.

The mean number of *C. ptychora* larvae at 60 DAS ranged from 0.23 to 0.49 per plant. The lowest mean larvae were recorded in the varieties of Hardee and DSb 32(0.23 and 0.23) which are on par with each other. Followed by KBS23 and DSb 21 which recorded the mean larvae of 0.24 and 0.25 per plant. Karune recorded the mean larvae as 0.34 per plant. MAVS2 and KHSB2 recorded the mean larvae of 0.27 and 0.30 per plant, respectively. The highest mean larvae recorded in the varieties of JS 335 and KB79 were 0.44 and 0.49 larvae per plant, respectively.

At 60 DAS, the lowest mean larvae of *E. zinckenella* recorded in the variety Hardee is 0.21, followed by DSb 23 and KBS 23 which recorded mean larvae of 0.23 and 0.24 per plant and were on par with each other. DSb 21, MAVS2 and Karune which recorded mean larvae of 0.26, 2.28 and 0.36 per plant and they are on par with each other. The highest mean larvae 0.41 was noticed in both the varieties JS335 and KB79.

**75** **DAS**

At 75 DAS, the mean larvae of *C. ptychora* indifferent varieties ranged from 2.53 to 1.81. The minimum larval population was recorded in the variety of Hardee and DSb 23 with the larvae of 1.81 and 1.85 per plant and which are in the same line. While in the variety KBS23 which recorded mean larvae of 2.21 per plant. DSb 21, MAVS2, KHSB 2 and JS335 recorded 2.34, 2.40, 2.41 and 2.41 are on par. The highest mean larvae recorded in the variety karune and KB 79 that is 2.51 and 2.53 larvae per plant.

The lowest mean larvae of *E. zinckenella* were noticed in the varieties of Hardee, DSb 23 and KB79 which recorded mean larvae of 0.71, 076 and 0.76, respectively and they are on par with each other. The next lowest mean larvae were noticed in the variety KBS 23 which is 2.08 larvae per plant. In the variety DSb 23, 2.28 mean larvae per plant was noticed. The varieties of KHS2 and Karune recorded mean larvae 2.39 and 2.42 respectively and they are in the same line. The highest mean larvae were recorded in the varieties JS335 and MAVS2, that is 2.47 and 2.51 per plant, respectively which are on par with each other.

**90 DAS**

At 90 DAS, the lowest mean larvae were recorded in the variety Hardee (2.34). In the variety DSB 23 which recorded 2.88 larvae per plant followed by KSB23 and DSB 21 that is 2.97 and 3.01 larvae per plant, respectively and they are on par with each other while in the variety MAVS2 which recorded mean larvae of 3.56 per plant. In the variety KHSB2 which recorded 3.88 larvae per plant which is followed by karune and JS335 that is 4.14 and 4.91 larvae respectively.

During the pod developing stage, *i.e.* 90DAS the mean larvae of *E. zinckenella* range was recorded. The minimum (2.18) and maximum (4.18) larvae range were recorded in the varieties Hardee and KSB79 respectively. While, in the other varieties such as DSB 23, KBS23, DSB21, MAVS2, KHSB2, karuna and JS335 showed 2.68, 2.87, 2.99, 3.26, 3.57 and 3.96 respectively

**Mean larvae at 60, 75 and 90 DAS**

The lowest mean larvae of *C. ptychora* perplant at 60, 70 and 90 DAS was recorded in the varieties Hardee (1.41), DSb 23(1.65), KHSB23(1.81), DSb21(1.87) and MAVS2 (1.94) , respectively. Followed by KHSB2 (2.20), Karune (2.33), KB79 (2.43) and JS 335 (2.59), respectively.

The mean larvae of *E. zinckenella* at 60.75 and 90 DAS ranged between 1.44 to 2.56. In the varieties KBS23, Hardee, DSB21, MAVS2, DSB23, KHSB2, Karune, JS335 and KB79 the mean larvae were 1.44, 1.56, 1.59, 1.82, 1.87, 2.02, 2.05, 2.07 and 2.11 respectively

**Per cent pod damage**

The per cent pod damage by pod borers on soybean varieties is presented in Table 3. The overall data on the mean per cent pod damage revealed minimum per cent pod damage in Hardee (19.69%) followed by DSb 23, KHS23, MAVS2 and DSb21 with the per cent pod damage of 30.83, 32.37, 33.17 and 33.14, respectively. The highest mean per cent pod damage of 44.90, 43.22, and 41.34 per cent was observed in Karune, KHSB2 and JS 335, followed by KB79 (61.10%).

**Categorization of varieties based on scale of resistance**

Based on the damage score, soybean varieties were categorized as highly resistant, moderately resistant, intermediate and susceptible by using scale of resistance given by Jackai (1982). According to this scale, the variety Hardee was categorized as highly resistant with per cent pod damage of 19.69 per cent. The variety DSb 23, KHS23, MAVS2 and DSb21 with the per cent pod damage of 30.83, 32.37, 33.17 and 33.14 were categorized as moderately resistant, whereas Karune, KHSB2 and JS 335 were categorized as intermediate were KB79(61.10%) categorized as susceptible (Table 4).

**Seed yield kg per hector**

The highest seed yield was recorded in the variety DSb 21(16472 kg/ha) followed by DSb 23(1478 kg/ha) and JS335 (1385kg/ha). Whereas in varieties like Harde, MAVS2 and KBS23 recorded the yield 1250.0, 1249 and 1147 kg per hectare. The lowest yield was noticed in the varieties like KB79 (1093 kg/ha), Kreune (1076 kg/ha) and KHSB2 (1073 kg/ha).

**Biochemical traits of the plant**

The influence of various biochemical constituents of soybean varieties was studied and analyzed for the resistance to pod borer complex is presented below

**Total Phenols**

Phenol content estimated in pods and flowers of soybean varieties differed significantly (Table 5). The results indicated significant differences in the phenol concentrations among all the varieties screened for resistance against pod borers. The maximum phenol concentration was noticed in variety, Hardee (5.31 %) followed by DSb 23 (3.94 %). The varieties like DSb 21(3.19 %), MAVS2 (2.93 %), KB 79 (2.42 %), Karune (2.42 %) and KHAB2 (2.39 %) have low phenol content and were on par with each other. The minimum phenol contents were observed in variety JS 335 (2.21 %)

**Total sugars**

The total sugar content in soybean varieties flowers and pods differ significantly. The total sugar content found in the flowers was more than pods (Table 4).

The total sugar content recorded in varieties ranged from 14.33 to 9.02 per cent. The maximum total sugar was recorded in the varieties like JS 335 (14.33 %), followed by KB79 (12.43%), KHSB2 (12.32%), MAVS2 (11.61%) and Karune (11.76%) are in the same line. The lowest total sugar was recorded in varieties like DSb 21(11.19 %), Hardee (11.17 %) and KBS23 (10.56 %), which was on par with DSb 23 (9.02 %).

**Crude proteins**

The protein content of soybean varieties varied from 41.12 to 28.19 per cent. Significantly higher and maximum protein content was noticed in varieties, JS 335 (41.12 %), KB79 (39.42 %), Hardee (37.18 %) and KHSB2 (37.18%), are on par with each other, followed by DSb 23 (34.46 %) DSb 21, (31.18 %), KBS23 (31.18), and (Karune (29.99 %), which is on par with MAVS2 (28.19 %).

**Impact of biochemical parameters soybean against borers**

Multiple correlation and regression analysis was used to determine the magnitude and direction of the relationship between key biochemical plant parameters of soybean and pod damage caused by borers. The outcomes of these are shown below (Table 5).

There was a significant negative correlation between the pod damage induced by borers and the phenols (r = -0.807\*\*), whereas it positively correlated with the total sugars (0.499) and proteins (0.425).

Multiple linear regression analysis was used to determine the association between all of the biochemical features and pod damage. The overall contribution of biochemical components to resistance against pod borers was 85% (R2 = 0.85). The regression equation for pod damage and other biochemical features was Y= 75.703+10.511X1-14.511X2-3.677X3, which is a multiple linear regression model.

**4. Discussion**

Plant resistance to insect pests is a complicated phenomenon that develops as a result of a series of interactions between insects and plants. It is governed by numerous biochemical ingredients like sugars, phenols, proteins and others, which hinder normal insect-eating, oviposition, development, and survival.

**Larval population of pod borer, *C. ptychora* in different soybean varieties**

A study on larval density of *C. ptychora* was conducted on nine different varieties of soybean during *Kharif* 2021. The study revealed that the pod borer infestation gradually increased with the age of the crop attained peak of 0.23 and 4.91 (60 DAS and 90 DAS), respectively. The major cause for pod borer activity from 60 DAS until till harvesting is its eating habit. Pod borer began to infest an experimental crop sowed in July during the crop maturation phase in September. The continual availability of preferred food from September forward resulted in increasing incidence of the pod borer until crop harvest, when it reached peak occurrence. Furthermore, decreased pod borer population incidence was detected in some genotypes with increased pod thickness, suggesting that pod thickness demonstrates an antixenosis mechanism of resistance against pod borer and also increase the phenol content at pod stage which borers not select that pod to consumption. These findings on pest density are consistent with Kumar's (1978) findings that the larvae density per plant was 3.07 (cowpea), 4.55 (green gramme), 3.21 (soybean), and 3.21 (black gramme) (3.73). According to Dawoodi *et al.* (2010), black gramme genotype SKNU-03-03 was resistant to pod borer, with a minimum larval population of 0.42 larvae per plant, but genotypes SKNU-03-08, SKNU-9915 and SKNU-05-06 were very vulnerable, with a range of 2.49 to 3.13 larvae per plant. Hutke *et al*. (2014) discovered that larval density ranged from 1.28 to 1.47 larvae/plant in 18 cowpea genotypes tested against *C. ptychora* cultivars, namely JCP-22, GC-31, JCP-28, CP-55, and ACS-9. Furthermore, cultivar JCP-27 was discovered to be very sensitive, having the largest larvae population.

**Larval population of pod borer, *E. zinckenella* in different soybean varieties**

A study on larval density of *E. zinckenella*was conducted by sowing nine different varieties of soybean during *Kharif* 2021. The present study revealed that the pod borer infestation gradually increased with age of the crop attained peak of 0.20 and 4.18 (60 DAS and 90 DAS) respectively.The present results were in agreement with Naroz *et al.* (2019) experiment which included six soybean varieties (Giza 21, Giza 22, Giza 35, Giza 111, Crawford and Dr-101). It was observed that there was a significant difference in natural infestation of soybean varieties by *E. zinckenella*. The soybean varieties Giza 35, Crawford and Giza 22 had higher infestation by the insect, meanwhile soybean variety Dr-101 showed a higher potential for resistance to *Etiella zinckenella.*

Among different varieties screened the overall data on the mean per cent pod damage was recorded, that the minimum per cent pod damage was noticed in Hardee (19.69%) followed by DSb 23, KHS23, MAVS2 and DSb21 with the per cent pod damage of 30.83, 32.37, 33.17 and 33.14, respectively. The highest mean per cent pod damage of 44.90, 43.22 and 41.34 per cent was observed in Karune, KHSB2 and JS 335, followed by KB79 (61.10%).

The current findings are in general agreement with Adimani (1976), who found that the percentage damage caused by *C. ptychora* to soybean pods right before harvest ranged from 10.50 to 91.29 on crops seeded in October and July, respectively. When the crop was planted late, the damage was more severe (2nd week of July). Furthermore, Lal (1990) tested for resistant sources against *C. ptychora* in green gram, black gram and cowpea at different locations, which resulted in the identification of resistant lines in green gram J1, LM 11, P 336 and P 526, and Co-3 among black gram cultivar Kalai, 338-3, and among cowpea cultivars Banswara, C-55, G-20, and CR 2-55 and G-7 showed resistance all were lesser percentage of pod damage.

According to Amarnath (2000), under field conditions, the percentage of pod damage in soybean ranged from 6.67 to 56.08 per cent. Under unprotected conditions, he recorded the maximum percent pod damage of 56.08. Gupta *et al.* (2004) discovered that soybean cultivars JS 77-81, PK 472, JS 86-24, JS 81-335, JS 87-59, JS 76-205, JS 86-26 and JS 86-23 were resistant to pod borer, with pod damage ranging from 3.50-4.90 per cent.

The variety Hardee was categorized as highly resistant with per cent pod damage of 19.69 per cent. The variety DSb 23, KHS23, MAVS2 and DSb21 with the per cent pod damage of 30.83, 32.37, 33.17 and 33.14, respectively were categorized as moderately resistant, whereas, Karune, KHSB2 and JS 335 were categorized as intermediate and KB79 (61.10%) categorized as susceptible. Vinod and Patil (2015) discovered that soybean genotypes DSb 21, DSb 23, RKS 18 and MACS 1394 were moderately resistant to *C. ptychora*, but genotypes JS 335, JS 93-05, KHSb 2, DSb 1 and JS 95-60 were very sensitive. AICRP published a study on soybean genotypes SL 744 and MACS 1184 as resistant sources for pod borer *C. ptychora*, as well as genotypes MAUS 295, JS 20-09, RKS 45, JS 20-06, NRC 80, AMS 1 and DSb 12 as prospective donors for multiple resistances against important insect pests.

The biochemical foundation of plant resistance is the most important feature because it provides a solid defensive mechanism to avoid herbivore harm via the antibiosis mechanism. Antibiosis can occur owing to the presence of harmful chemicals or developmental inhibitors in the plant, as well as nutritional imbalance or a lack of critical nutrients (Smith, 2005).

The maximum phenol concentration was noticed in variety, Hardee (5.31%) followed by DSb 23 (3.94%). The current findings are consistent with those of Cheboi *et al*. (2019), who found a substantial negative association between total phenols in pigeon pea and pod damage, with a correlation coefficient of -0.923\*\*. The current study's findings may be compared to those of Divija *et al*. (2020) discovered that resistant genotype ICC4484 (4.73 mg/g) had the highest phenol content with the least amount of pod damage on chickpea. Lower phenol concentration was reported in susceptible genotype PG186 (2.47 mg/g), with the highest percentage of pod damage. The phenol concentration had a negative connection (r= -0.387) with the percentage of pod damage caused by *H. armigera* and other pod borers.

These findings are consistent with those of Ambidi *et al*. (2021), who discovered that total phenols in pigeon pea showed a strongly negative connection (r = -0.729) with percent pod damage.

The total sugars content recorded in varieties ranged from 14.33 to 9.02 per cent. The maximum total sugar was recorded in the varieties like JS 335 (14.33 %), followed by Hardee (11.17 %) and KBS23 (10.56 %), which was on par with DSb 23 (9.02 %) which had low sugars. The overall sugar level of soybeans was discovered to have a strong and positive relationship with pod damage produced by pod borers (r = 0.499). The current findings are consistent with the findings of Bhatnagar *et al.* (2000), who discovered that pod borer vulnerable chickpea cultivars had greater amounts of total sugars in pods than resistant varieties with low sugar content in pods. Total sugar exhibited a substantial positive link with pod borers infestation in this study as well (r = 0.838\*\*). Tiwari *et al*. (2017) also showed a link between total sugars and pod damage, with total sugar concentration decreasing in healthy pods. The protein content of soybean varieties varied from 41.12 to 28.19 per cent.

Plant proteins are the herbivore's primary source of dietary nitrogen. Pest infestation was consistently greater in genotypes with higher protein content, while varieties with lower protein content, such as JS 335 (41.12 %) and KB79 (39.42 %), had minimal pod damage. The considerable positive connection (r= 0.425 between pod damage and protein content was verified by correlation analysis. The current findings support the findings of Halder *et al* (2007), Sunita *et al*. (2008) and Sai *et al*. (2018) discovered that protein content in pigeon pea pods had a very significant connection (r = 0.717) against pod damage caused by *M. vitrata*. San *et al*. (2021) discovered that chickpea genotype GL-13042 was resistant to *H. armigera* while having a reduced protein content.

Soybean resistance to pod borers were significantly influenced by biochemical factors such as phenol, sugars and proteins. Among the varieties evaluated Hardee emerged as the most resistant variety with the lowest pod damage and highest phenol content, while KB79 was the most susceptible. Along with the use of resistant varieties using integrated nutrient management have also been found to increasing resistance against various pest and disease (Pujar *et al.,* 2018).

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**Reference**

Agarwal, D. K., Billore, S. D., Sharma, A. N., Dupare, B. U. and Srivastava, S. K. (2013). Soybean: introduction, improvement, and utilization in India—problems and prospects. *Agricultural Research*, 2(4), pp.293-300.

Ginting, S., Pujiwati, H., Djoko, U. K., Murcitro, B. G. and Susilo, E., (2022). The attack of *Etiella zinckenella* Treitschke on soybean varieties. *Jurnal Hama dan Penyakit Tumbuhan Tropika*, 22(1): 83-89.

Parashuram, L. and Patil, R. H., (2021). DSSAT model simulates soybean ideotype to cope with projected changes in future climate of north interior Karnataka, India. *FOOD LEGUMES*, *34*(4), 272-276.

Anderson, E. J., Ali, M. L., Beavis, W. D., Chen, P., Clemente, T. E., Diers, B. W., Graef, G. L., Grassini, P., Hyten, D. L., McHale, L. K. and Nelson, R. L. (2019). Soybean [Glycine max (L.) Merr.] breeding: history, improvement, production and future opportunities. *Advances in plant breeding strategies: Legumes:* 7*:* 431-516.

Naik, M. I., Basavadarshan, A. V., Boraiah, B. and Thippaiah, M., (2020). Yield loss estimation and efficacy of biopesticides on the management of *Helicoverpa armigera* (Hubner) in vegetable soybean [Glycine max (L.) Merrill]. *Journal of Pharmacognosy and Phytochemistry*, 9(4): 3421-3425.

Adimani, B. D. (1976). Studies on the insects of soybean (*Glycine max L*.) with special reference to the bionomics and control of pod borer, *Cydia ptychora* (Lepidoptera: Tortricidae). *M.Sc. (Agri.) Thesis*, University of Agricultural Sciences, Bangalore, p. 89-91.

Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. J. (1951). Protein measurement with the Folin phenol reagent.

Jackai, L.E. (1982). A field screening technique for resistance of cowpea (Vigna unguiculata) to the pod-borer *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae). *Bulletin of Entomological Research*, 72(1): 145-156.

Dawoodi, J. T., Parsana, G. J., Jethwa, D. M. and Virani, V. R. (2010). Screening of black gram variety for resistance against pink pod borer, *Cydia ptychora* (Meyrick). *Legume Research-An International Journal,* 33(1): 72-73.

Hutke, S. S., Virani, V. R., Jethva, D. M. and Kalasariya, R. L., (2014). Field screening of cowpea germplasms against pod borer complex. *Pestology.*, 38(8): 40-42.

Naroz, M. H., Abdel-Wahab, E. I and Abd El-Rahman, S. F., (2019). Potential of some soybean varieties for resistance to lima bean pod borer (*Etiella zinckenella*) under field conditions. *Research on Crops*, 20(2). 9

Kumar, N.G. (1978). Studies on the potentiality of the pod borer, *Cydia ptychora* (Meyrick) (Lepidoptera: Tortricidae) as a pest of pulses, its bionomics and control by insecticides. M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Bangalore, p. 24-26.

Lal, S., (1990). Insect pests of mung, urd, cowpea, pea and their management. In: Plant Protection in Field Crops. [M. Veerabhadra Rao and S. Sithanantham (Eds.)]. PPAI, Hyderbad, 185-201.

Amarnath, K., (2000). Management of soybean pod borer, *Cydia ptychora* (Meyrick) (Tortricidae: Lepidoptera). M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad, p. 60.

Vinod, M. and Patil, R.H., (2016) Seasonal incidence of pod borer *Cydia ptychora* (Meyrick) and its correlation with abiotic factors in soybean. *Journal of Experimental Zoology of India,* 1(19): 561-564.

Smith, C. M. (2005). Plant resistance to arthropods: Molecular and conventional approaches. Springer: Dordrecht, pp. 19-22.

Divija, S. D., Agnihotri, M. And Reddy, M. S. (2020). Biophysical and biochemical basis of host plant resistance in chickpea germplasm against gram pod borer, *Helicoverpa armigera* (Hübner). *International Journal of Chemical* *Studies*, 8(5): 353-357.

Ambidi, V., Bantewad, S., Prasad Mishra, S., Hingane, A. and Jaba, J. (2021) Morpho-biochemical parameters associated with resistance to pod borer complex of pigeon pea. Pakistan Journal of Zoology., 1 7.

Bhatnagar, R., Shukla, M., Shukla, B. B., Patel, J. C. and Talati, J. G. (2000). Biochemical composition of susceptible and tolerant genotypes of chickpea for pod borer. Indian Journal of Pulses Research. 13(1): 58-59.

Tiwari, S., Yadav, S. And Nadaf, A. (2017). Influence of some biochemical components on the incidence of *Maruca vitrata* (Geyer) on short duration pigeon pea *Cajanus cajan* (L.) Mill sp. International Journal of Chemical Studies, 5(4): 1339-1341.

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

Sai, Y., Sreekanth, M., Sairam Kumar, D. V. and Manoj Kumar, V. (2018). Morphological and biochemical factors associated with resistance to *Helicoverpa armigera* (Hubner) and Maruca vitrata (Geyer) in Pigeon pea. *Journal of Entomology and Zoology Studies*, 6(2): 3073-3078.

San, S. H., Sagar, D., Kalia, V. K. and Krishnan, V. (2021). Effect of different chickpea genotypes and its biochemical constituents on biological attributes of *Helicoverpa armigera* (Hubner). *Legume Research*, 1: 7-10.

Pujar, A. M., Angadi, V. V. and Jahagirdar, S., (2018). Influence of Integrated Nutrient Management on Red Leaf Index of Cotton and Incidence of Insect Pest and Disease in Cotton and Soybean Intercropping System. *International Journal of Plant & Soil Science*, 21(3), pp.1-8.

Gupta, M. P., Chourasia, S. K. and Rai, H. S., (2004). Field resistance of soybean genotypes against incidence of major insect pests. *Annals of Plant Protection Sciences*, *12*(1), pp.63-66.

Cheboi, J. J., Kimurto, P. K. and Kinyua, M. G., (2019). Variability in morpho-biochemical traits associated with pod borer (*Helicoverpa armigera*) resistance in pigeonpea pods. *Journal of Experimental Agriculture International*, 31: 1-7.

Halder, J., Srinivasan, S. and Muralikrishna, T., (2006). Biochemical basis of resistance to spotted pod borer, *Maruca vitrata* (Geyer) in Mungbean. *Journal of Entomological Research*, *30*(4), pp.313-316.

**Table 2:**  **Incidence of *Cydia ptychora* and *Etiella zinckenella* larvae on different soybean varieties**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Variety** | **Number of larvae per plant** | | | | | | | |
| ***Cydia ptychora*** | | | | ***Etiella zinckenella*** | | | |
| **60 DAS\*** | **75 DAS** | **90 DAS** | **Mean** | **60 DAS\*** | **75 DAS** | **90 DAS** | **Mean** |
| 1 | JS 335 | 0.44  (0.97)b | 2.43  (1.70)abc | 4.91  (2.32)a | 2.59 | 0.41  (0.95)a | 2.47  (1.72)ab | 3.96  (2.11)b | 2.07 |
| 2 | Hardee | 0.23  (0.85)g | 1.81  (1.52)e | 2.34  (1.68)h | 1.46 | 0.20  (0.84)f | 1.71  (1.49)f | 2.18  (1.64)h | 1.56 |
| 3 | DSb 21 | 0.25  (0.87)f | 2.34  (1.68)cd | 3.01  (1.87)f | 1.87 | 0.26  (0.87)d | 2.28  (1.67)d | 2.99  (1.87)e | 1.59 |
| 4 | KHSB2 | 0.30  (0.89)d | 2.41  (1.70)abc | 3.88  (2.09)d | 2.20 | 0.29  (0.89)c | 2.39  (1.70)c | 3.57  (2.02)c | 2.02 |
| 5 | DSb 23 | 0.23  (0.85)g | 1.85  (1.53)e | 2.88  (1.84)g | 1.65 | 0.23  (0.85)e | 1.76  (1.50)f | 2.68  (1.78)g | 1.87 |
| 6 | KBS23 | 0.24  (0.86)fg | 2.21  (1.64)d | 2.97  (1.86)fg | 1.81 | 0.24  (0.86)e | 2.08  (1.60)e | 2.87  (1.83)f | 1.44 |
| 7 | Karune | 0.34  (0.92)c | 2.51  (1.73)ab | 4.14  (2.15)c | 2.33 | 0.36  (0.93)b | 2.42  (1.71)bc | 4.01  (2.12)b | 2.05 |
| 8 | KB79 | 0.49  (0.99)a | 2.53  (1.74)a | 4.27  (2.18)b | 2.43 | 0.41  (0.95)a | 1.76  (1.50)f | 4.18  (2.16)a | 2.11 |
| 9 | MAVS2 | 0.27  (0.88)e | 2.40  (1.70)bc | 3.16  (1.91)e | 1.94 | 0.28  (0.88)c | 2.51  (1.73)a | 3.26  (1.94)d | 1.82 |
| SEm± | | 0.15 | 0.46 | 0.23 | 0.02 | 0.03 | 0.003 | 0.006 | 0.27 |
| CD @ p=0.05 | | 0.45 | 1.40 | 0.71 | 0.08 | 0.09 | 0.01 | 0.02 | 0.07 |

Note: Figures in the parentheses are transformed values, means followed by same letters do not differ significantly by DMRT (P=0.05)

\*DAS: Days After Sowing.

**Table 3: Categorization of soybean varieties based on per cent pod damage**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sl. No.** | **Variety** | **Mean pod damage (%)** | **Damage score** | **Resistance rating** | **Yield(kg/ha)** |
| 1 | JS 335 | 41.34 | 3 | Intermediate | 1385.00 |
| 2 | Hardee | 19.69 | 1 | Highly resistant | 1250.00 |
| 3 | DSb 21 | 33.14 | 2 | Moderately resistant | 1642.00 |
| 4 | KHSB2 | 43.22 | 3 | Intermediate | 1073.00 |
| 5 | DSb 23 | 30.83 | 2 | Moderately resistant | 1478.00 |
| 6 | KBS23 | 32.37 | 2 | Moderately resistant | 1147.00 |
| 7 | Karune | 44.90 | 3 | Intermediate | 1076.00 |
| 8 | KB79 | 61.10 | 4 | Susceptible | 1093.00 |
| 9 | MAVS2 | 33.17 | 2 | Moderately resistant | 1249.00 |

**Table 4: Response of soybean varieties to different biochemical constituent’s offerings resistance to pod borers**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl. No.** | **variety** | **Crude proteins (%)** | **Total sugars (%)** | **Total phenols (%)** |
| **Pod** | **Pod** | **Pod** |
| 1 | JS 335 | 41.12 a | 14.33a | 2.21e |
| 2 | Hardee | 37.19 abc | 11.17bc | 5.31a |
| 3 | DSb 21 | 31.18 bcd | 11.19bc | 3.19c |
| 4 | KHSB2 | 37.18 abc | 12.32ab | 2.39dc |
| 5 | DSb 23 | 34.46 bcd | 9.02c | 3.94b |
| 6 | KBS23 | 31.18 bcd | 10.56bc | 3.42bc |
| 7 | Karune | 29.99 bcd | 11.76ab | 2.42dc |
| 8 | KB79 | 39.42 ab | 12.43ab | 2.42dc |
| 9 | MAVS2 | 28.19 d | 11.61b | 2.93cd |
| SEm± | | 0.20 | 0.11 | 0.05 |
| CD@ P=0.05 | | 0.61 | 0.35 | 0.17 |
| CV | | 6.19 | 5.92 | 5.37 |

\*Mean values in each column followed by a common letter are not significantly different by DMRT at P=0.05, N=15 plants from each variety

Table 5: Correlation and regression analysis between per cent pod damage and different biochemical traits of soybean varieties

|  |  |
| --- | --- |
| **Correlation coefficient (r) value** | |
| **Category** | **Per cent pod damage** |
| Total sugar (X1) | 0.499 |
| Total phenols (X2) | -0.807\*\* |
| Total crude protein (X3) | 0.425 |
| Regression equation | Y= 75.703+10.511X1-14.511X2-3.677X3 |
| Coefficient of determination (R2) | 0.852 |

\*Correlation is significant at P ≤ 0.05; \*\*Correlation is significant at P ≤ 0.01; N=15