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Satya Prakash Roul
Department of Entomology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

Ritu Chandravanshi
Department of Entomology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

Sachin Balpande
Department of Entomology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

AK Choudhary
Department of Plant Pathology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

Sabyasachi Samal
Department of Entomology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

Dilip Suryawanshi
Krishi Vigyan Kendra, Manawar, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, ICAR-(ATARI-Zone-9), Jabalpur, Madhya Pradesh, India

Corresponding Author:
Satya Prakash Roul
Department of Entomology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh, India

Screening of soybean [*Glycine max* (L.) Merr.] cultivars for resistance against girdle beetle [*Obereopsis brevis* (Swederus)] and stem fly [*Melanagromyza sojae* (Zehntner)]

Satya Prakash Roul, Ritu Chandravanshi, Sachin Balpande, AK Choudhary, Sabyasachi Samal and Dilip Suryawanshi

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Abstract
Field trials were conducted during *Kharif* 2024 at the Entomological Research Farm, R.A.K. College of Agriculture, Sehore (M.P.) to evaluate nine soybean cultivars *viz*., JS 25-08, JS 25-03, JS 25-06, JS 24-33, NRC-150, NRC-268, NRC-269, NRC-152 and JS-335 (check) along with insecticides against girdle beetle (*Oberea brevis* Swederus) and stem fly (*Melanagromyza sojae* Zehntner). The RBD experiment with three replications assessed percent girdling and stem tunneling. The study generated data on resistance levels and pest incidence dynamics, useful for identifying promising cultivars and effective management strategies for sustainable soybean production. The study revealed significant differences among soybean cultivars in resistance to girdle beetle and stem fly infestation. NRC-268 consistently recorded the lowest infestation (15.01% girdling and 13.33% tunneling), followed by NRC-269 and JS 25-06, categorizing them as highly resistant. In contrast, JS 25-08 was the most susceptible, showing maximum girdling (44.60%) and tunneling (36.70%), followed by JS 24-33 and JS-335. The findings clearly indicate NRC-268 and NRC-269 as promising resistant cultivars for sustainable soybean cultivation, reducing pest damage and minimizing yield losses.

Keywords: Soybean, cultivar, screening, girdle beetle, stem fly

Introduction
Soybean [*Glycine max* (L.) Merrill], belonging to the family Leguminaceae, is one of the most important oilseed and commercial crops in India and the world. It is often called the "Golden Bean" due to its rich nutritional profile, containing 40-45% high-quality protein and 20-22% oil, along with essential amino acids, vitamins, and minerals (Singh *et al*., 2023; Ali & Kumar, 2022) [14, 12]. In India, it is cultivated as a kharif crop, sown during June-July and harvested in September-October, contributing significantly to farmer income and nutritional security (IARI, 2024) [6]. Soybean meal is the most widely used protein source in livestock and poultry feed, while soybean oil is a leading edible oil and industrial raw material (FAO, 2023) [4]. Globally, soybean is a major cash crop with an annual trade value exceeding USD 150 billion, making it crucial to food, feed, and industrial sectors (IISD, 2024) [6].
Globally, the leading soybean producers are Brazil, the USA, Argentina, China, India, Canada, Russia, Paraguay, Bolivia, and Ukraine. Soybean is cultivated on about 136.9 million hectares worldwide, with a total output of 428.9 million tonnes and an average productivity of 3.13 t/ha. In India, the crop occupies nearly 12.38 million hectares, yielding around 13.06 million tonnes (ICAR-IISR, 2023-24) [5]. Madhya Pradesh ranks first in soybean cultivation, covering 5.38 million hectares and producing about 5.53 million tonnes, with an average yield of 1125 kg/ha (Anonymous, 2023) [2].
The stem fly (*Melanagromyza sojae* Zehntner) and girdle beetle (*Obereopsis brevis* Swederus) are among the most destructive stem borers of soybean. The girdle beetle grub bores into the stem and branches, restricting nutrient flow, leading to stunted growth and sometimes complete plant mortality (Choudhary *et al*., 2021) [3]. The stem fly infests the crop throughout its growth period, with seedlings at 3-4 weeks after germination being most susceptible.

Its maggot tunnels extensively inside stems, causing wilting, poor pod set, and yield losses up to 33% (Meena & Yadav, 2020) [10]. Similarly, girdle beetle infestation has been reported to reduce yield by 14-42%, depending on crop stage and intensity of attack (Sharma *et al*., 2022) [12]. Even moderate stem tunneling by stem fly (10-15%) can significantly reduce seed weight and grain yield (Rathore *et al*., 2019) [11]. Host plant resistance is an eco-friendly and sustainable approach to manage these pests effectively. Therefore, screening of soybean cultivars is essential to identify resistant genotypes that can be utilized in integrated pest management and breeding programmes.

Materials and Methods

Field experiments were conducted during the *Kharif* season of 2024 at the Entomological Research Farm, R.A.K. College of Agriculture, Sehore, Madhya Pradesh, India, to screen various soybean cultivars against girdle beetle and stem fly. The study was laid out in a Randomized Block Design (RBD) comprising nine soybean cultivars (JS 25-08, JS 25-03, JS 25-06, JS 24-33, NRC-150, NRC-268, NRC-269, NRC-152 and JS-335) with three replications. Each plot measured 5 × 3 m², with row-to-row spacing of 40 cm, plant-to-plant spacing of 5 cm, replication-to-replication distance of 1 m and plot-to-plot distance of 0.80 m, ensuring uniformity and precision in recording observations on pest incidence and varietal performance. The infestation levels of both pests on the different cultivars at various growth stages were statistically analyzed using analysis of variance (ANOVA) at a 5% level of significance to determine the differences in susceptibility among the cultivars. The screening data were calculated by using OPSTAT software.

Observations

Girdle Beetle

Weekly observations were made on the number of plants girdled by the beetle in a one-meter row at three different locations per plot, from crop initiation until harvest. The pest incidence was recorded by counting the number of healthy and damaged plants. The percentage of damage was calculated using the formula:

$$\text{Per cent damage (\%)} = \frac{\text{No. of plants infested}}{\text{Total no. of plants}} \times 100$$

Stem fly

Observation on stem fly was recorded on the ten randomly selected plants per plot at weekly interval from the initiation of infestation till harvest. To record the stem tunnelling caused by the stem fly maggot the plants was uprooted and open vertically. Plant height and tunnel length was measured for calculating percent tunnelling.

$$\text{Per cent damage (\%)} = \frac{\text{No. of plants infested}}{\text{Total no. of plants}} \times 100$$

Results and Discussion

A total of nine soybean cultivars [*viz*., JS 25-08, JS 25-03, JS 25-06, JS 24-33, NRC-150, NRC-268, NRC-269, NRC-152 and JS-335 (check)] were evaluated for their susceptibility to girdle beetle (*Obereopsis brevis* Swederus) and stem fly (*Melanagromyza sojae* Zehntner) during the Kharif 2024 season. Observations on pest infestation across different cultivars and at various growth stages were recorded (Table 1 & 2).

Infestation of Girdle Beetle (*Obereopsis brevis* Swederus)

Table 1 shows girdle beetle infestation across soybean cultivars from the 31st SMW, recorded weekly until harvest. Infestation levels differed significantly among cultivars at various growth stages.

The data revealed significant differences among soybean cultivars in mean plant infestation by girdle beetle, ranging from 15.01% to 44.60% per plant/mrl. The resistant cultivar NRC-268 recorded the lowest infestation (15.01%), followed by NRC-269 (19.93%). Conversely, the highest infestation was observed in the susceptible cultivar JS 25-08 (44.60%), with other highly infested cultivars being JS 24-33 (41.76%), JS-335 (38.40%), NRC-150 (34.62%), NRC-152 (31.13%), JS 25-03 (29.45%), and JS 25-06 (24.76%). The present result is in consistent with the finding of Khandwe and Nema (2009) [8] found JS 95-60, JS 71-05, JS 93-05 and Samrat moderately resistant, while JS 335 and MAUS 61-2 were low resistant and susceptible, respectively. Kumawat *et al*. (2010) [9] reported Indra Soya 9 and Pratap Soya as least infested, whereas MAUS 47 and MAUS 81 showed highest infestation. Shinde *et al*. (2018) [13] identified RVS 2007-6, JS 93-05, RVS 2001-18, JS 20-53, and MAUS 158 as highly resistant, with KDS 753 showing minimal stem tunneling by stem fly (13.19%), supporting the selection of resistant genotypes for pest management.

Infestation of stem fly (*Melanagromyza sojae* Zehntner)

Table 2 shows the percentage of stem tunneling by stem fly in different cultivars, starting from the 31st SMW, with observations recorded at seven-day intervals until harvest. The data indicate considerable variation in stem tunneling among cultivars at different growth stages.

The data showed significant variation among soybean cultivars regarding mean stem tunneling, which ranged from 13.33% to 36.70%. The resistant cultivar NRC-268 recorded the lowest stem tunneling (13.33%), followed by NRC-269 (16.44%). In contrast, the highest stem tunneling was observed in the susceptible cultivar JS 25-08 (36.70%), followed by JS 24-33 (33.59%), JS-335 (31.89%), NRC-150 (30.30%), NRC-152 (27.85%), JS 25-03 (25.15%) and JS 25-06 (21.04%). The findings align with previous studies on stem fly resistance in soybean. Upadhyay (2017) reported that among nine genotypes and one check (JS 20-29), JS 20-122 showed the lowest stem tunneling (4.67%) and was significantly superior, while JS 20-111 had the highest (20.82%). JS 20-188 was less susceptible, and the check variety was highly susceptible. Similarly, Khandare *et al*. (2021) found that among fifteen genotypes screened during Kharif 2018-2019, NRC-94 recorded the lowest stem fly infestation, followed by RSC-1046, MACS-1520, MACS-1340, and NRC-127, whereas VLS-89, SL1104, and PS-1572 were less effective in reducing stem tunneling.

Resistant/Tolerant cultivars against Girdle Beetle and Stem Fly

The mean percentage of plants infested by Girdle Beetle across the nine soybean cultivars ranged from 15.01% to 44.60% per plant/mrl. Among the cultivars, NRC-268 recorded the lowest infestation (15.01%), followed by NRC-269 (19.93%) and JS 25-06 (24.76%), all of which were

classified as highly resistant (HR). JS 25-03, with 29.45% infestation, was categorized as resistant (R). NRC-152 showed moderate susceptibility (31.13%), falling under moderately resistant (MR). The cultivar JS 25-08 exhibited the highest infestation (44.60%) and was rated as highly susceptible (HS). Other cultivars including JS 24-33 (41.76%), NRC-150 (34.62%), and the check variety JS-335 (38.40%) were also placed in the highly susceptible category, highlighting their vulnerability to Girdle Beetle attack.

The mean stem tunneling caused by stem fly ranged from 13.33% to 36.70% across the nine cultivars. NRC-268 recorded the lowest tunneling (13.33%), followed by NRC-269 (16.44%) and JS 25-06 (21.04%), all categorized as highly resistant (HR). JS 25-03, with 25.15% stem tunneling, was classified as moderately resistant (MR), while NRC-152 (27.85%) fell under low resistant (LR). The highest stem tunneling was observed in JS 25-08 (36.70%), indicating a highly susceptible (HS) reaction. Other cultivars such as JS 24-33 (33.59%), NRC-150 (30.30%), and the check variety JS-335 (31.89%) were also rated as highly susceptible, demonstrating significant susceptibility to stem fly infestation.

Table 1: Infested plant due to Girdle beetle on different soybean cultivars during *Kharif* 2024

Sr. No.	Cultivars	Percentage plant/mrl[#]										
		31 SMW	32 SMW	33 SMW	34 SMW	35 SMW	36 SMW	37 SMW	38 SMW	39 SMW	40 SMW	Mean
1	JS 25-08	2.87 (9.68)	6.53 (14.80)	14.07 (22.02)	11.93 (20.21)	23.70 (29.13)	57.00 (49.03)	58.30 (49.78)	59.40 (50.42)	61.33 (51.55)	61.67 (51.75)	44.60 (41.90)
2	JS 25-03	2.00 (8.12)	2.33 (8.74)	8.07 (16.48)	5.37 (13.38)	14.30 (22.21)	35.87 (36.76)	38.67 (38.45)	41.83 (40.30)	43.43 (41.22)	43.77 (41.42)	29.45 (32.87)
3	JS 25-06	1.78 (7.55)	2.27 (8.60)	5.77 (13.89)	5.00 (12.92)	12.40 (20.60)	25.10 (30.06)	32.00 (34.44)	37.43 (37.72)	38.00 (38.05)	38.33 (38.24)	24.76 (29.84)
4	JS 24-33	2.73 (9.50)	5.67 (13.77)	12.10 (20.33)	11.00 (19.37)	21.20 (27.41)	51.43 (45.83)	52.94 (46.69)	57.33 (49.22)	59.67 (50.58)	60.00 (50.77)	41.76 (40.26)
5	NRC-150	2.60 (9.23)	5.30 (13.30)	10.93 (19.31)	8.87 (17.32)	18.93 (25.79)	42.80 (40.86)	45.93 (42.66)	46.20 (42.82)	47.53 (43.59)	47.87 (43.78)	34.62 (36.04)
6	NRC-268	0.00 (0.00)	1.13 (6.07)	3.47 (10.72)	3.37 (10.45)	5.63 (13.70)	11.97 (20.23)	20.00 (26.52)	24.07 (29.35)	25.10 (30.06)	25.33 (30.21)	15.01 (22.79)
7	NRC-269	1.00 (5.61)	2.03 (8.19)	4.57 (12.31)	4.33 (12.00)	10.00 (18.37)	20.97 (27.19)	26.90 (31.24)	28.67 (32.36)	30.33 (33.42)	30.67 (33.63)	19.93 (26.52)
8	NRC-152	2.43 (8.96)	4.20 (11.76)	9.00 (17.43)	7.17 (15.51)	16.67 (24.09)	37.00 (37.46)	40.17 (39.33)	43.37 (41.19)	44.33 (41.75)	44.67 (41.94)	31.13 (33.91)
9	JS-335	2.63 (9.20)	5.50 (13.55)	11.93 (20.20)	10.17 (18.59)	19.80 (26.42)	43.70 (41.38)	49.37 (44.64)	52.73 (46.57)	55.53 (48.18)	55.83 (48.35)	38.40 (38.29)
SE(m)±		0.71	0.55	0.56	0.51	0.63	0.98	0.76	0.75	0.55	0.56	0.25
CD at 5%		2.12	1.66	1.69	1.52	1.90	2.92	2.27	2.26	1.64	1.66	0.76

SMW: Standard Meteorological Week; mrl: meter row length; #-Figure in parentheses are angular transformed values

Table 2: Stem tunneling due to stem fly on different soybean cultivars during *Kharif* 2024

Sr. No.	Cultivars	Percentage stem tunneling[#]										
		31 SMW	32 SMW	33 SMW	34 SMW	35 SMW	36 SMW	37 SMW	38 SMW	39 SMW	40 SMW	Mean
1	JS 25-08	8.33 (16.69)	14.67 (22.37)	21.00 (27.19)	25.33 (30.14)	29.67 (32.95)	34.00 (35.61)	46.33 (42.88)	48.33 (44.04)	50.67 (45.39)	52.00 (46.15)	36.70 (37.29)
2	JS 25-03	2.33 (8.56)	7.33 (15.66)	7.67 (16.02)	8.33 (16.69)	20.67 (27.01)	24.00 (29.27)	41.00 (39.81)	36.33 (36.95)	38.67 (38.36)	40.00 (39.18)	25.15 (30.07)
3	JS 25-06	2.00 (7.95)	6.67 (14.76)	7.33 (15.57)	8.00 (16.36)	12.67 (20.79)	16.33 (23.81)	30.33 (33.40)	32.00 (34.44)	36.33 (37.05)	37.67 (37.86)	21.04 (27.30)
4	JS 24-33	7.33 (15.66)	15.67 (23.25)	15.00 (22.76)	19.00 (25.72)	25.33 (30.16)	30.00 (33.21)	45.00 (42.12)	46.00 (42.70)	48.67 (44.24)	50.33 (45.19)	33.59 (35.42)
5	NRC-150	5.33 (13.30)	12.33 (20.50)	12.67 (20.84)	16.33 (23.74)	22.67 (28.39)	25.67 (30.36)	41.67 (40.19)	44.00 (41.55)	45.33 (42.32)	46.67 (43.09)	30.30 (33.39)
6	NRC-268	0.00 (0.00)	1.67 (5.76)	3.00 (8.05)	5.33 (13.16)	6.67 (14.62)	11.67 (19.89)	15.67 (23.25)	25.00 (29.98)	25.33 (30.19)	25.67 (30.41)	13.33 (21.41)
7	NRC-269	0.00 (0.00)	5.33 (12.91)	6.00 (14.15)	7.00 (15.14)	9.67 (17.57)	13.00 (21.10)	18.33 (25.31)	28.33 (32.13)	30.00 (33.21)	30.33 (33.42)	16.44 (23.92)
8	NRC-152	3.33 (10.34)	8.67 (17.02)	9.00 (17.40)	9.33 (17.78)	21.00 (27.17)	25.33 (30.17)	41.33 (40.00)	43.67 (41.36)	44.33 (41.73)	44.67 (41.93)	27.85 (31.85)
9	JS-335	6.00 (13.87)	13.67 (21.60)	14.00 (21.96)	17.33 (24.51)	23.33 (28.85)	27.00 (31.25)	43.33 (41.14)	45.33 (42.31)	47.67 (43.66)	49.33 (44.62)	31.89 (34.37)
SE(m)±		1.21	1.99	1.76	1.68	1.68	1.62	1.52	1.40	1.85	1.51	0.70
CD at 5%		3.63	5.96	5.27	5.04	5.05	4.86	4.57	4.20	5.55	4.52	2.09

SMW: Standard Meteorological Week; #: Figure in parentheses are angular transformed values

Table 3: Resistant/Tolerant cultivars against girdle beetle and stem fly

Sr. No.	Cultivars	Girdle beetle		Stem fly	
		% plant/mrl mean	Genotype reaction	% stem tunneling mean	Genotype reaction
1	JS 25-08	44.60	HS	36.70	HS
2	JS 25-03	29.45	R	25.15	MR
3	JS 25-06	24.76	HR	21.04	HR
4	JS 24-33	41.76	HS	33.59	HS
5	NRC-150	34.62	HS	30.30	HS
6	NRC-268	15.01	HR	13.33	HR
7	NRC-269	19.93	HR	16.44	HR
8	NRC-152	31.13	S	27.85	LR
9	JS-335	38.40	HS	31.89	HS

Conclusion

The study revealed significant variation among soybean cultivars in their resistance to girdle beetle and stem fly. The girdle beetle infestation ranged from 15.01% in NRC-268 to 44.60% in JS 25-08, while stem fly-induced stem tunneling varied from 13.33% in NRC-268 to 36.70% in JS 25-08. Cultivars NRC-268, NRC-269, and JS 25-06 consistently showed high resistance to both pests. In contrast, JS 25-08 and JS 24-33 were highly susceptible. These resistant cultivars can serve as valuable genetic resources for breeding programs. Their adoption can support integrated pest management and sustainable soybean production.

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