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INTEGRATED MANAGEMENT OF STEM FLY AND GIRDLE BEETLE IN SOYBEAN THROUGH A NEED-BASED PEST MANAGEMENT APPROACH

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ABSTRACT:
A three-season farmer-field evaluation was conducted during 2023–24 to 2025–26 to assess an integrated, need-based management approach against stem fly and girdle beetle in soybean. Thirteen farmer-field replications were evaluated during each season through paired comparisons of farmers' practice and an integrated demonstrated technology. The demonstrated technology comprised seed treatment with thiamethoxam 30% FS, removal of infested plant parts, application of 5% neem seed kernel extract (NSKE), and need-based insecticide application based on pest incidence. Pooled farmer-wise observations showed that stem fly infestation decreased from 15.40% under farmers' practice to 6.98% under demonstrated technology, a reduction of 54.66%. Girdle beetle infestation declined from 12.48% to 4.51%, a reduction of 63.85%. Grain yield increased from 15.89 to 18.03 q ha-1, an increase of 13.45%. The paired comparisons indicated significant differences between practices for all three parameters ($P < 0.001$). The demonstrated technology also recorded higher gross and net returns and a higher benefit:cost ratio than farmers' practice. The findings show that combining preventive, cultural, botanical and need-based chemical measures can improve the management of soybean stem fly and girdle beetle under farmer-field conditions.

KEYWORDS: Glycine max; Melanagromyza sojae; Obereopsis brevis; integrated pest management; stem fly; girdle beetle

INTRODUCTION

Soybean [Glycine max (L.) Merrill] is an important oilseed and protein crop in India. Its seed is valued for edible oil and high-quality protein, while the crop also contributes to soil fertility through biological nitrogen fixation. Insect pests occurring at different crop-growth stages can limit soybean productivity. The pest complex includes stem-infesting insects, defoliators, pod borers and sap-feeding species (Mondal et al., 2023).

Among the stem-associated pests, soybean stem fly, Melanagromyza sojae Zehntner, is important during early crop growth. The larvae feed within stem and petiole tissues, producing mines that may weaken plants and affect crop development. Earlier studies have examined the relationship between stem fly infestation and yield and have highlighted the importance of determining economically damaging pest levels (Venkatesan and Kundu, 1994).

The girdle beetle, Obereopsis brevis Swed., is another important pest of soybean. Adult females girdle stems or branches, and larval feeding within affected plant parts can interfere with translocation, leading to drying or breakage. Insecticidal interventions against this pest have been evaluated under field conditions (Upadhyay and Sharma, 2000).

Management of these pests often involves insecticide applications. However, calendar-based spraying without reference to pest incidence can increase cultivation costs and expose pest populations and non-target organisms to unnecessary pesticide use. Research on soybean stem fly has emphasized the importance of appropriate spray timing and economic considerations (Singh and Singh, 1990).

Integrated pest management combines preventive, cultural, mechanical, botanical and chemical tactics. Within this approach, insecticides are applied when field observations indicate a need for intervention. Farmer-field evaluations provide an opportunity to assess such combinations under practical production conditions. The present study therefore evaluated an integrated, need-based management approach against stem fly and girdle beetle in soybean over three consecutive seasons.

MATERIALS AND METHODS

Study period and farmer participation

The field evaluation was conducted under farmer-field conditions for three consecutive soybean seasons (2023–24, 2024–25 and 2025–26) in Mahmadpur village, Babhulgaon Taluka, Yavatmal District, Maharashtra, India (20.5567° N, 78.1666° E). Thirteen farmers' fields were selected for evaluation during each season, with the same farmers participating in all three years. Within each participating field, farmers' practice and the integrated demonstrated technology were evaluated side by side, allowing paired comparisons of the two management practices under similar field conditions.

Management practices
Two management practices were compared:
T_1 – Farmers' practice. Farmers followed their prevailing insecticide-based pest-management practice. The principal insecticides recorded were profenofos 40% + cypermethrin 4% EC at 2.5 ml per L water and chlorantraniliprole 18.5% SC at 0.25 ml per L water
T_2 – Integrated demonstrated technology. The demonstrated package comprised (i) seed treatment with thiamethoxam 30% FS at 10 ml kg-1 seed; (ii) removal of infested leaves and dried or girdled branches and other visibly affected plant parts; (iii) application of 5% neem seed kernel extract (NSKE) before flowering; and (iv) need-based application of thiamethoxam 12.6% + lambda-cyhalothrin 9.5% ZC at 0.25 ml per L water, based on field observations of pest incidence. The practices were evaluated as management packages; therefore, the response cannot be attributed to any single component of the demonstrated technology.

Observations and economic analysis
Observations on stem fly infestation (%), girdle beetle infestation (%) and grain yield (q ha-1) were recorded for each treatment within each farmer-field replication. Grain yield was recorded at harvest and expressed on a per-hectare basis. Economic parameters included cost of cultivation, gross return, net return and benefit:cost ratio, calculated from the recorded cultivation costs and market returns.

Statistical analysis
Treatment comparisons were made using paired observations from the same farmer field. For each parameter, the difference between the two practices was calculated within each of the 13 farmer-field replications and analysed using a paired t-test (df = 12). Standard error of the paired difference and the 5% critical difference were calculated as the standard error and the corresponding two-sided t critical value, respectively. For pooled analysis, each farmer's corresponding observations from the three seasons were averaged, retaining 13 paired farmer-level replications. Statistical procedures followed Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Stem fly (Melanagromyza sojae) infestation
Stem fly infestation was consistently lower under the integrated demonstrated technology in all three seasons. The seasonal mean infestation under farmers' practice and demonstrated technology was 15.82 and 7.05% in 2023–24, 15.08 and 6.68% in 2024–25, and 15.31 and 7.22% in 2025–26, respectively (Tables 2–4). The pooled farmer-wise means were 15.40% under farmers' practice and 6.98% under demonstrated technology, representing a 54.66% reduction. The paired difference was significant ($t = 53.88$, $P < 0.001$; Table 1).
The lower infestation observed under the demonstrated package may reflect the combined contribution of early-season seed treatment, removal of infested plant material, botanical intervention and insecticide application guided by field incidence. Because the package contained several components, the relative contribution of each component cannot be separated from this field evaluation. The result is consistent with earlier work highlighting the importance of timely and economically justified stem fly management (Venkatesan and Kundu, 1994; Singh and Singh, 1990).

Girdle beetle (Obereopsis brevis) infestation
Girdle beetle infestation was also lower under the integrated demonstrated technology in each season. Mean infestation under farmers' practice and demonstrated technology was 12.86 and 4.57% in 2023–24, 12.05 and 4.21% in 2024–25, and 12.52 and 4.75% in 2025–26 (Tables 2–4). The pooled means were 12.48% and 4.51%, respectively, equivalent to a 63.85% reduction. The paired comparison was significant ($t = 32.06$, $P < 0.001$; Table 1).
Removal of girdled branches and other visibly affected plant parts, together with incidence-based chemical intervention, may have contributed to the lower infestation recorded under the demonstrated package. Earlier field research has reported the efficacy of insecticidal interventions against soybean girdle beetle (Upadhyay and Sharma, 2000). The present evaluation supports the use of a combination of management tactics rather than reliance on a single intervention.

Grain yield
Grain yield was higher under the integrated demonstrated technology in all three seasons. In 2023–24, mean yield was 15.63 q ha-1 under farmers' practice and 17.73 q ha-1 under demonstrated technology. The corresponding yields were 16.04 and 18.27 q ha-1 in 2024–25, and 16.02 and 18.10 q ha-1 in 2025–26 (Tables 2–4). Pooled means were 15.89 and 18.03 q ha-1, indicating a 13.45% yield increase. The paired difference was significant ($t = 103.71$, $P < 0.001$; Table 1).
The yield advantage occurred alongside lower stem fly and girdle beetle infestation. Reduced injury to stems and branches may have helped maintain functional plant tissues and crop growth. The field comparison evaluated the combined management package, however, and does not establish the independent effect of individual components on yield.

Economic performance
The demonstrated technology recorded a higher gross return (₹96,437 ha-1) than farmers' practice (₹86,314 ha-1). Its cultivation cost was also lower (₹40,700 ha-1) than that recorded under farmers' practice (₹42,210 ha-1). Consequently, net return was ₹55,737 ha-1 under the demonstrated technology compared with ₹44,104 ha-1 under farmers' practice. The benefit:cost ratios were 2.37 and 2.04, respectively (Table 5). These economic results indicate that the demonstrated package was associated with both higher yield and lower recorded cultivation expenditure in the participating fields.

Table 1. Pooled farmer-wise observations and paired comparison of farmers' practice and integrated demonstrated technology across three seasons (2023–24 to 2025–26)

Replication	Stem fly T_1 (%)	Stem fly T_2 (%)	Girdle beetle T_1 (%)	Girdle beetle T_2 (%)	Yield T_1 (q ha^{-1})	Yield T_2 (q ha^{-1})
R1	13.10	5.43	9.90	3.20	14.87	17.07
R2	18.33	8.87	15.53	5.97	17.03	19.00
R3	14.63	6.47	11.90	4.10	15.53	17.73
R4	13.60	5.77	10.77	3.53	15.13	17.33
R5	16.87	8.13	13.97	5.40	16.60	18.70
R6	15.17	6.87	12.27	4.30	15.77	17.90
R7	17.70	8.47	14.80	5.73	16.83	18.90
R8	13.27	5.40	10.17	3.33	15.00	17.20
R9	16.03	7.43	13.03	4.77	16.17	18.33
R10	17.20	8.23	14.37	5.50	16.70	18.77
R11	13.50	5.60	10.43	3.50	15.13	17.37
R12	15.60	7.10	12.70	4.63	16.00	18.13
R13	15.20	7.00	12.37	4.67	15.87	18.00
Mean	15.40	6.98	12.48	4.51	15.89	18.03
SE of paired difference	0.156	—	0.248	—	0.021	—
CD at 5%	0.340	—	0.541	—	0.045	—
t-value	53.879	—	32.059	—	103.711	—
P-value	<0.001	—	<0.001	—	<0.001	—

T_1: farmers' practice; T_2: integrated demonstrated technology. For pest infestation, paired differences were calculated as $T_1 - T_2$; for grain yield, as $T_2 - T_1$. The pooled values are the means of each farmer's corresponding observations across the three seasons.

Table 2. Farmer-wise observations during 2023–24

Replication	Stem fly T_1 (%)	Stem fly T_2 (%)	Girdle beetle T_1 (%)	Girdle beetle T_2 (%)	Yield T_1 (q ha^{-1})	Yield T_2 (q ha^{-1})
R1	13.60	5.80	10.20	3.40	14.60	16.80
R2	18.80	8.90	16.10	6.00	16.80	18.70
R3	15.10	6.50	12.30	4.10	15.20	17.40
R4	14.00	5.90	11.10	3.60	14.90	17.00
R5	17.20	8.10	14.30	5.40	16.30	18.40
R6	15.60	6.90	12.70	4.40	15.50	17.60
R7	18.10	8.50	15.20	5.80	16.60	18.60
R8	13.80	5.60	10.50	3.50	14.80	16.90
R9	16.40	7.40	13.40	4.80	15.90	18.00
R10	17.50	8.20	14.80	5.50	16.40	18.40
R11	13.90	5.70	10.70	3.60	14.90	17.10
R12	15.90	7.10	13.00	4.70	15.70	17.90
R13	15.70	7.00	12.90	4.60	15.60	17.70
Mean	15.82	7.05	12.86	4.57	15.63	17.73
SE of paired difference	0.170	—	0.277	—	0.025	—
CD at 5%	0.370	—	0.603	—	0.055	—
t-value	51.70	—	29.99	—	82.94	—
P-value	<0.001	—	<0.001	—	<0.001	—

Table 3. Farmer-wise observations during 2024–25

Replication	Stem fly T_1 (%)	Stem fly T_2 (%)	Girdle beetle T_1 (%)	Girdle beetle T_2 (%)	Yield T_1 (q ha^{-1})	Yield T_2 (q ha^{-1})
R1	12.90	5.30	9.70	3.10	15.10	17.40
R2	17.80	8.40	14.80	5.50	17.10	19.20
R3	14.20	6.10	11.50	3.90	15.80	18.00

Replication	Stem fly T_1 (%)	Stem fly T_2 (%)	Girdle beetle T_1 (%)	Girdle beetle T_2 (%)	Yield T_1 (q ha^{-1})	Yield T_2 (q ha^{-1})
R4	13.30	5.50	10.40	3.30	15.30	17.60
R5	16.50	7.80	13.50	5.00	16.70	18.90
R6	14.80	6.60	11.90	4.00	15.90	18.10
R7	17.20	8.00	14.20	5.30	16.90	19.10
R8	13.10	5.20	9.90	3.20	15.20	17.50
R9	15.70	7.10	12.50	4.40	16.20	18.50
R10	16.90	7.90	13.80	5.10	16.80	19.00
R11	13.40	5.40	10.10	3.40	15.40	17.70
R12	15.20	6.80	12.20	4.30	16.10	18.30
R13	15.00	6.70	12.10	4.20	16.00	18.20
Mean	15.08	6.68	12.05	4.21	16.04	18.27
SE of paired difference	0.154	—	0.244	—	0.017	—
CD at 5%	0.335	—	0.531	—	0.038	—
t-value	54.69	—	32.19	—	127.58	—
P-value	<0.001	—	<0.001	—	<0.001	—

Table 4. Farmer-wise observations during 2025–26

Replication	Stem fly T_1 (%)	Stem fly T_2 (%)	Girdle beetle T_1 (%)	Girdle beetle T_2 (%)	Yield T_1 (q ha^{-1})	Yield T_2 (q ha^{-1})
R1	12.80	5.20	9.80	3.10	14.90	17.00
R2	18.40	9.30	15.70	6.40	17.20	19.10
R3	14.60	6.80	11.90	4.30	15.60	17.80
R4	13.50	5.90	10.80	3.70	15.20	17.40
R5	16.90	8.50	14.10	5.80	16.80	18.80
R6	15.10	7.10	12.20	4.50	15.90	18.00
R7	17.80	8.90	15.00	6.10	17.00	19.00
R8	12.90	5.40	10.10	3.30	15.00	17.20
R9	16.00	7.80	13.20	5.10	16.40	18.50
R10	17.20	8.60	14.50	5.90	16.90	18.90
R11	13.20	5.70	10.50	3.50	15.10	17.30
R12	15.70	7.40	12.90	4.90	16.20	18.20
R13	14.90	7.30	12.10	5.20	16.00	18.10
Mean	15.31	7.22	12.52	4.75	16.02	18.10
SE of paired difference	0.152	—	0.236	—	0.027	—
CD at 5%	0.331	—	0.514	—	0.060	—
t-value	53.24	—	32.96	—	76.14	—
P-value	<0.001	—	<0.001	—	<0.001	—

Table 5. Economic performance of farmers' practice and integrated demonstrated technology in soybean

Particulars	T_1 – Farmers' practice	T_2 – Demonstrated technology
Grain yield (q ha^{-1})	15.89	18.03
Cost of cultivation (₹ ha^{-1})	42,210	40,700
Gross return (₹ ha^{-1})	86,314	96,437
Net return (₹ ha^{-1})	44,104	55,737
Benefit:cost ratio	2.04	2.37
Increase in yield over farmers' practice (%)	—	13.45

CONCLUSION

The three-season farmer-field evaluation showed that the integrated, need-based management package was associated with lower soybean stem fly and girdle beetle infestation and higher grain yield than farmers' practice. Pooled farmer-wise observations indicated reductions of 54.66% in stem fly infestation and 63.85% in girdle beetle infestation, together with a 13.45% increase in grain yield. The demonstrated technology also recorded higher net returns and a higher benefit:cost ratio. The results support combining seed treatment, removal of infested plant parts, botanical intervention

and need-based insecticide use as a practical integrated approach under farmer-field conditions. Since the interventions were evaluated as a package, further component-wise trials would be required to quantify the contribution of individual practices.

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CONFLICT OF INTEREST
The authors declare that they have no conflict of interest.

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DATA AVAILABILITY
The data supporting the findings are presented in the tables of this article.

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