Comparative Bio-Efficacy of Neem Formulations and Neem Seed Kernel Extract for Sustainable Management of *Spodoptera Litura* in Soybean (*Glycine max L. Merr.*) in Malwa, Madhya Pradesh

Sandeep Singh Nagar
Asst. Professor
Department of Zoology (HOD)
PMCoE, SKP Govt College
Dewas, Madhya Pradesh, India
sandeepdna@gmail.com

H. S. Rathore
School of Studies in Zoology and Biotechnology
Ujjain (M.P.), India

S. N. Upadhyay
Prof & Head, Department of Entomology
Govt. Agriculture College
Indore, Madhya Pradesh, India

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***Abstract*:** We tested azadirachtin 1 EC, neem oil, neem leaf extract, and Neem Seed Kernel Extract (NSKE; 3% and 5%) against Spodoptera litura in Malwa using a randomized block design. Pooled means indicated that Azadirachtin 1 EC (40 ml/10 L) resulted in the lowest defoliation rate (14.1%) and larvae load (1.21 larvae plant^{-1}), while Neem Seed Kernel Extract (NSKE; Singh & Singh) (3% (w/v)) demonstrated the least efficacy (defoliation 25.2%, 2.12 larvae plant^{-1}). Results show that neem botanicals are important parts of IPM that lower the need for chemicals without hurting performance [1–4]

Keywords: Soybean, *Spodoptera* litura, neem, azadirachtin, NSKE, IPM, Malwa, Madhya Pradesh

I. INTRODUCTION

The tobacco caterpillar *Spodoptera litura* sometimes makes it hard for soybeans (*Glycine max L. Merr.*) to grow in central India. Neem-based botanicals have multiple ways of working, including antifeedant and growth-disruptive effects that can lower the risk of resistance while keeping natural enemies safe [1–7]. This study field-tests a set of neem interventions to find strong, farmer-ready options for the Malwa region of Madhya Pradesh.

II. MATERIALS AND METHODS

2.1 Farm and crop management

In the Dewas district (Malwa region) of Madhya Pradesh, India, field trials were done with the widely grown soybean (*Glycine max*) cultivar JS-95-60. Plots were set up with normal farmer-like management to show how things are done in the area: each experimental unit was 3.0 × 2.25 m, the rows were 0.45 m apart, and the seed was planted at a rate of 100 kg ha^{-1}. No preventive insecticides were used at any point in the crop cycle so that the crop–pest interaction could happen naturally. Land preparation, sowing window, and fertilization were done according to standard regional guidelines so that the effects of the treatment could be understood in a realistic agricultural context [8].

2.2 Treatments and design of the experiment

To account for spatial heterogeneity across the site, the field experiment used a randomized block design (RBD) with three replications. There was one plot of each

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treatment in each block, and the order of the treatments within the blocks was chosen randomly before sowing. The treatment set had five neem-based options: azadirachtin 1 EC at 40 ml per 10 L of water, cold-pressed neem oil at 30 ml per 10 L, neem leaf extract at 5% (w/v), and Neem Seed Kernel Extract (NSKE) at two levels, 3% and 5% (w/v). This design made sure that all treatments were tested in the same field conditions, which made it possible to get an unbiased estimate of their effects.

2.3 Observations and analysis

We kept an eye on two real-world signs of pest pressure when the infestation was at its worst: (i) The percentage of defoliation of the soybean canopy and (ii) The number of *Spodoptera litura* larvae per plant. We calculated pooled means for each treatment to get a stable picture of performance across all the replications. The treatments were then ranked mainly by defoliation (the most visible injury metric in the field) and secondarily by larval density (a direct measure of population pressure). This two-criterion approach is similar to how farmers make decisions, putting visible crop damage first and checking it against pest counts. It also fits with IPM decision theory and the existing neem literature, which stress threshold-based, biorational interventions [1–6,9].

III. RESULTS

Table 1. Average defoliation and larvae plant^{-1} across neem-based treatments.

Code	Treatment	Dose	Defoliation (%)	Larvae plant^{-1}
T1	Azadirachtin 1 EC	40 ml/10 L	14.1	1.21
T4	Neem Seed Kernel Extract (NSKE; Singh and Singh, 2017)	5% (w/v)	19.3	1.34
T2	Neem Oil	30 ml/10 L	22.4	1.55
T6	Neem Leaf Extract (Sridhar and Vijayalakshmi, 2002)	5% (w/v)	15.8	1.24
T3	Neem Seed Kernel Extract (NSKE; Singh and Singh, 2017)	3% (w/v)	25.2	2.12

Table 2. Treatment ranking based on defoliation and larvae per plant.

Code	Treatment	Dose	Defoliation (%)	Larvae plant^{-1}
T1	Azadirachtin 1 EC	40 ml/10 L	14.1	1.21
T6	Neem Leaf Extract (Sridhar and Vijayalakshmi, 2002)	5% (w/v)	15.8	1.24
T4	Neem Seed Kernel Extract (NSKE; Singh and Singh, 2017)	5% (w/v)	19.3	1.34

T2	Neem Oil	30 ml/10 L	22.4	1.55
T3	Neem Seed Kernel Extract (NSKE; Singh and Singh, 2017)	3% (w/v)	25.2	2.12

Figure 1. Treatment code and defoliation (%).

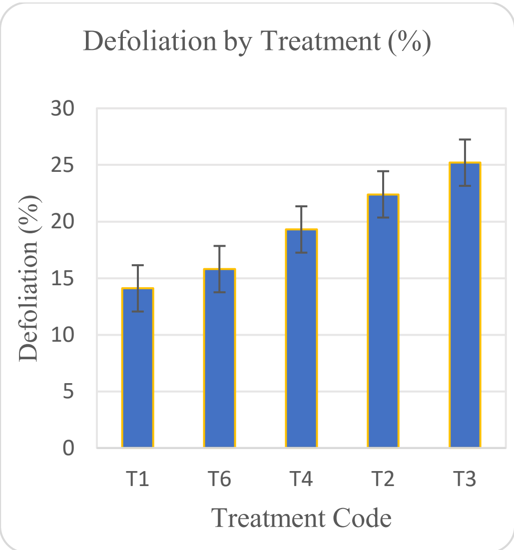


Figure 2. Number of larvae per plant by treatment code.

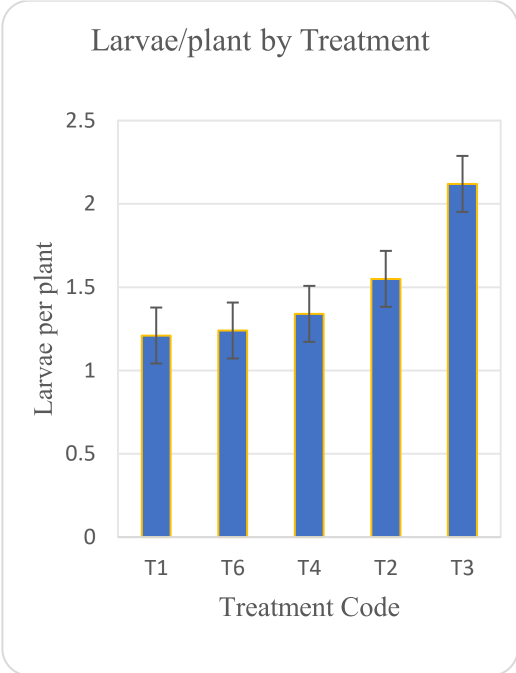
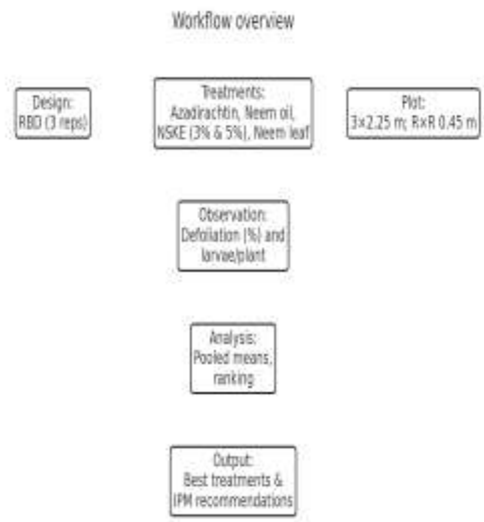


Figure 3. A diagram of the workflow.



Defoliation ranged from 14.1% to 25.2% across botanicals, and the larvae load ranged from 1.21 to 2.12 plant^{-1} (Tables 1–2; Figures 1–2). Azadirachtin 1 EC (40 ml/10 L) was the most effective, followed by Neem Leaf Extract 5%. NSKE 5% did better than NSKE 3%, which suggests that the concentration of kernel actives has an effect [3–6]. These results support the inclusion of neem botanicals in threshold-based integrated pest management (IPM) plans for S. litura [1,10].

IV. DISCUSSION

Azadirachtin-based products mess with molting hormones and feeding. Oils and leaf/kernel extracts, on the other hand, add contact toxicity and deterrence. These are the same mechanisms that were seen in the field response [3,11]. For resistance management and protecting natural enemies, it makes sense to use neem products in rotation with other biorational tools [1]. Additional research may incorporate season-long injury-yield relationships and timing models for Malwa conditions [8,13].

V. CONCLUSION

In the Malwa soybean system, Azadirachtin 1 EC (40 ml per 10 L) was the most effective at stopping *Spodoptera litura.* It caused the least amount of defoliation (14.1%) and the least amount of larval pressure (1.21 larvae plant^{-1}). The performance of neem leaf extract at 5% (w/v) was very close behind, which shows that simple botanicals that are easy for farmers to use can have a big impact on field control. The NSKE treatments showed a clear dose-response, with 5% always doing better than 3%. This shows how important it is to have enough kernel solids in the spray mix. Overall, these results show that neem-based interventions are good for the environment and can be used right away. They offer a practical way to cut back on synthetic insecticides while still being effective in soybean IPM programs [1–4].

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Conflict of Interest: The corresponding author, on behalf of second author, confirms that there are no conflicts of interest to disclose.

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