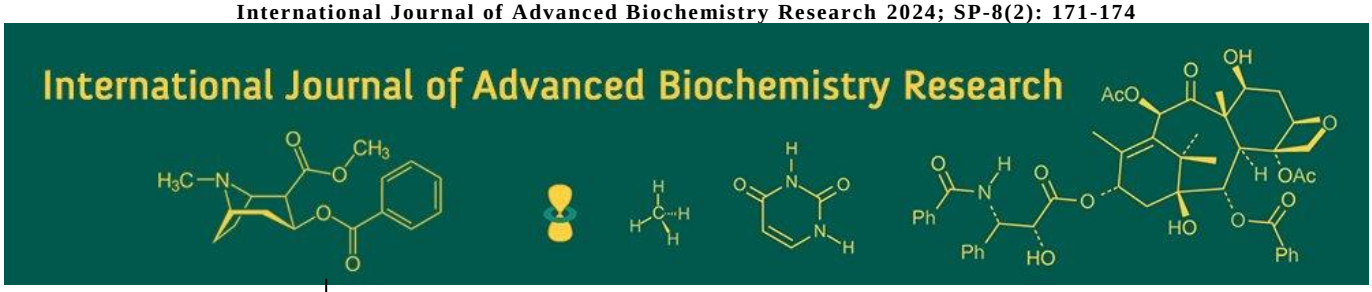

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Amit Kumar
Department of Entomology, PG College of Agriculture, Dr Rajendra Prasad Central Agricultural University, Pusa, Bihar, India

Manoj Kumar
Department of Entomology, PG College of Agriculture, Dr Rajendra Prasad Central Agricultural University, Pusa, Bihar, India

Heenashree Mansion
Department of Entomology, College of Agriculture, Agriculture University, Jodhpur, Rajasthan, India

Corresponding Author:
Amit Kumar
Department of Entomology, PG College of Agriculture, Dr Rajendra Prasad Central Agricultural University, Pusa, Bihar, India

Comparative performance and economic of different botanical insecticides on yield of sweet basil (*Orphanostigma basilicum* L.) Affected by *Ocimum* Leaf Folder, *Orphanostigma abruptalis* (Walker) in Bihar

Amit Kumar, Manoj Kumar and Heenashree Mansion

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Abstract
Sweet basil is often known as "King of the herbs" due to its many uses in the food, pharmaceutical, cosmetic, and medical sectors. A field experiment was conducted in the Herbal Garden, Hi-Tech Unit of Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar in 2021 to evaluate comparative performance and economic efficacy of various plant-based insecticides against *Ocimum* leaf folder and their impact on sweet basil yield performance. This was done in light of the effects of *Ocimum* leaf folder on yield reduction of sweet basil, health hazards due to the use of chemical pesticides, and the high cost of chemical insecticides. The highest seed yield obtained from the treatment *Azadirachtin* 1.5% @ 0.75 litre /ha (129) followed by Neem oil 2% @ 10 litre/ha. (121Kg/ha) after that NSKE 5% @ 25 kg/ha (118 Kg/ha) while, the highest ratio was obtained from the treatment Azadirachtin1500 ppm @ 0.7.5 litre/ha (1: 6.83) followed by NSKE 5% @ 25 kg/ha (1:6.06) after that neem oil 2% @ 10 litre/ha. (1:5.49).

Keywords: Sweet basil, *Ocimum*, leaf folder, botanicals, economic, BCR, Azadirachtin

Introduction
French basil, *Ocimum basilicum* L., is a herbaceous, scented annual plant in the Lamiaceae family. The local name of Sweet basil is Mithhi Tulsi, or Babaui tulsi (Hindi), Damro/Damarvo (Gujarati), Barbari/Arjaka (Sanskrit), Tirunitturupachilai (Tamil), Kamakasturi (Kannada), Bhutulasi (Telugu), Babri (Punjabi), respectively (Anonymous, 2014) [1]. The Greek word "Basileus," which means "Royal" or "King," is the source of the name basil. Because of its many uses in the food, pharmaceutical, cosmetic, and medical industries, basil is frequently referred to as the "King of the herbs." (Bravo *et al*., 2021) [6]. It comes from the tropical regions of South-Eastern Asia, which is why it is grown as a decorative, flavouring, and medicinal plant in many nations worldwide. The fragrant basil blossoms and leaves, along with the essential oil extracted from the plant, are used in medicine, food flavouring, and the creation of perfumes and colognes. Numerous scientific investigations have proved the antibacterial, antioxidant, and psychotherapeutic qualities of the essential oil found in basil, which is linked to the herb's therapeutic characteristics (Wierdak and Borowski, 2011) [22].
The broad spectrum of aromatic and medicinal plants known as basil is comprised of around 160 species. Out of all the species that are cultivated for the purpose of producing essential oils, *Ocimum sanctum* L. and *Ocimum basilicum* L. are the two most widely used species. The extract can be utilized as natural fungicide, pesticide, antifeedant etc.
Ocimum bacilicum, a high, densely branched herb in India, is known for its aromatic basil oil. Its origins are believed to be in India and neighboring regions. Major insect pests include lace bugs, cotton aphids, thrips, mealybugs, false-spider mites, tobacco whiteflies, and leaf miner. Insect infestations limit sweet basil yield and metabolism.

Among all the insect pests that can cause infestation on sweet basil, the *Ocimum* leaf folder is considered major insect-pest. The larvae attach themselves to the ventral side of the leaf; fold the leaf lengthwise from the midrib and webbing the leaf until it begins to fall off, causing considerable harm to the plants (Anonymous, 2019) [3]. There were several larvae per inflorescence, and the larval infestation can found in every folded leaves and apical branches. The caterpillars feed on chlorophyll by binding the edges of the leaves to form a funnel (Tigvattnanont, 1990) [20]. If the prevalence of leaf folder insect pests increases, it can have a major detrimental effect on plant growth and yield. The major uses for the aromatic basil leaf are in the essential oil distillation process and in flavouring different foods and drinks. The amount of fresh leaves produced by a plant varied from 14 to 713 g, and they were mostly utilized for the extraction of dried and fresh herbs as well as essential oils (Egata 2021) [7]. One of the main concerns for the production and control of insect pests in sweet basil is the residual effect and expense of chemical insecticides. To prevent crop damage and ensure effective management using commercially viable botanicals, research on the effectiveness of plant-based products and an assessment of their economic viability are necessary.

Methods and Materials

The field experiment for present investigation was carried out during *Kharif* 2021 at the Herbal Garden of Hi-Tech Unit, Dr. Rajendra Prasad Central Agricultural University, Pusa (Bihar).

Physiographic situation of the experimental site

Experimental plot was very homogeneous, with deep, well-drained sandy loam soil. The soil pH has ranged between 8.04 and 8.39. On the western and southern banks of the Budhi Gandk River in Bihar, Samastipur district, the experimental site is located at latitude 25.98^0 N, longitude 85.67 ^{0}E, and a height of 52.92 m above mean sea level.

Field preparation and management

Experiment conducted using a Randomized Block Design (RBD) with seven treatments and three replications for each botanical insecticide treatment. Using the proper agronomic packages and techniques, the crops were planted in the main field. Each plot measured 2.5 m by 2.5 m, with a 50 cm 50 cm space between two rows of plants. In the experiment, no insecticides were applied to the soil or to the seeds. This was done to promote the growth of the crop's native insect pest population.

Yield and economics

The benefit-cost ratio was calculated using recorded data to help better understand the economics of treating pest populations using botanical insecticides and managing them, such as *Ocimum* leaf folder. After the seeds were gathered, their total weight was noted. The cost of labour and botanical pesticides were deducted before estimating the gross benefit for each treatment. The value realised in the control plot was subtracted from the gross benefit to determine the additional profit from the application of botanical pesticides for each treatment. The extra profit was divided by the amount realized in control and multiplied by 100 to determine the percent increase over control. To calculate the benefit-cost ratio, the additional revenue gained over the control plot was divided by the extra cost charged for pest management.

Benefit: Cost Ratio

The benefit cost ratio was calculated by formula proposed by Biswas (2015).

BC Ratio= Net Profit/ Cost of Cultivation

Results and Discussions

The field efficacy of several botanical treatments against *Ocimum* leaf folder was evaluated using seven treatments, one of which was a control (untreated plot). The botanical insecticides were applied on incidence of *Ocimum* leaf folder as, neem oil 2% @ 10 litre/ ha, NSKE 5% @ 25 kg/ ha, karanj oil 2% @ 10 litre/ ha, *Azadirachtin* 1.5% @ 0.75 litre/ha, castor oil 2% @ 10 litre/ha, tobacco decoction 5% @25 kg/ha. To evaluate the efficiency of botanical insecticides, the seventh treatment was applied. as a control (untreated). All seven treatments were used in three replications in order to evaluate each botanical insecticide's distinct effect. All treatments were sprayed twice with a specified gap in between to evaluate effectiveness and durability whenever the population exceeded the economic threshold level. The first spray was applied after the 15 days of transplanting to control the infestation of sweet basil *Ocimum* leaf folder, and the second spray was applied 45 days after the transplant.

Data presented in Table 1 and Fig 1. shows that the economic factors and the higher seed production compared to the control. The Field efficacy of different botanical insecticides tested by Foliar spray application and the economics of treatments on sweet basil estimated which revealed that best returns are obtained which varied from 129 Kg/ha to 97 Kg/ha and the treatment yielded the maximum seed yield with *Azadirachtin* 1.5% @ 0.75 litre /ha (129 kg/ha) followed by neem oil 2% @ 10 litre/ha. (121 Kg/ha) after that NSKE 5% @ 25 kg/ha (118 Kg/ha) followed by karanj oil 2 @10 litre/ha (111 Kg/ha) after that castor oil 2% @ 10 litre/ha (102 Kg/ha) followed by tobacco decoction 5% @ 25 kg/ ha (97 Kg/ha) and the untreated check recorded (90 Kg/ha). After subtracting the manpower costs, the initial cost of land preparation, and the cost of botanical insecticidal treatments, the net profits were computed, and the highest ratio was obtained from the treatment Azadirachtin1500 ppm @ 0.7.5 litre/ha (1: 6.83) followed by NSKE 5% @ 25 kg/ha (1:6.06) after that neem oil 2% @ 10 litre/ha. (1:5.49) followed by karanj oil 2 @10 litre/ha (1:5.01) after that castor oil 2% @ 10 litre/ha (1:4.95) followed by tobacco decoction 5% @ 25 kg/ ha (1:4.92) and the untreated check was recorded (1:4.27).

The damage intensity on sweet basil crop due to infestation by *O. abruptalis* was also compared the yield of fresh herbage in treated and untreated plots. In the treated plot, Azadirachtin1.5% was sprayed at 30 days interval. In treated plot yield was 5645 kg ha-1whereasin untreated plot yield was obtained 5260 kg ha-1. The per cent herbage yield loss (7.13) recorded in plot those are free from any treatment as compared with treated plot. Herbage yield loss (7.13) recorded in untreated plot as compared with treated plot. Kumar *et al.* (2022) [14] revealed that the damage intensity on *Ocimum* crop due to infection caused by *Ocimum* leaf folder was assessed by comparing the yield of fresh herbage in treated plots by different insecticides was 5755.5 Kg/ha while in untreated plot it was estimated 5465.5 Kg per ha. The per cent loss of fresh herbage was 5.03

Table 1: Effect of botanical insecticides on seed yield of sweet basil

Botanical insecticide	Dose (Kg/ litre per ha)	Mean seed yield (Kg per ha)	Increased yield over control (Kg per ha)	Increase in yield over control (%)
Neem oil 2%	10	121	31	134.44
NSKE 5%	25	118	28	131.11
Karanj oil 2%	10	111	21	123.33
Azadirachtin 1.5%	0.75	129	39	143.33
Castor oil 2%	10	102	12	113.33
Tobacco decoction 5%	25	97	7	107.77
Control (Untreated)	-	90		

Table 2: Economics of different treatments against *Ocimum* leaf folder on sweet basil

Treatments	Common cost	Variable cost		Total cost	Yield (kg/ ha)	Price/kg	Gross return	Net return	BC Ratio
		Botanical insecticides	Labour						
T_1 - Neem oil 2%	47, 242	7,000	1,680	55,922	121	3000	3,63,000	3,07,078	1:5.49
T_2- NSKE 5%	47, 242	1,250	1,680	50,172	118	3000	3,54,000	3,03,828	1:6.06
T_3- Karanj Oil 2%	47, 242	6,500	1,680	55,422	111	3000	3,33,000	2,77,578	1:5.01
T_4- *Azadirachtin*1500 ppm	47, 242	525	1,680	49,447	129	3000	3,87,000	3,37,553	1:6.83
T_5- Castor Oil 2%	47, 242	2,510	1,680	51,432	102	3000	3,06,000	2,54,568	1:4.95
T_6- Tobacco Decoction 5%	47, 242	250	1,680	49,172	97	3000	2,91,000	2,41,828	1:4.92
T_7- Untreated control	47, 242	0	0	47, 242	90	3000	2,70,000	2,22,758	1:4.72

Cost of inputs: No of labors required per spray- Two
Wage of one labour per day Rs. 377
No. of sprays – 2
Market price of sweet basil seed: Rs. 3000 per kg

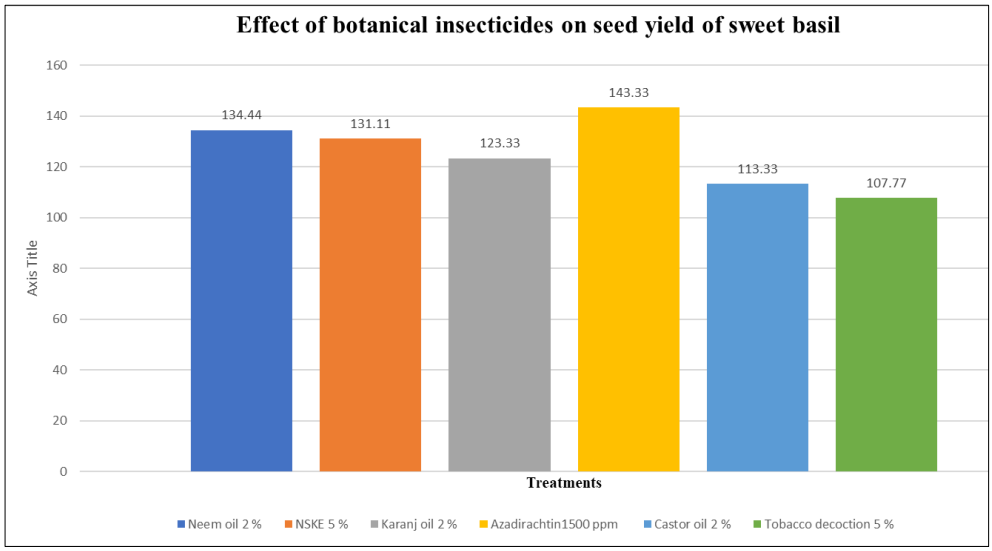

Fig 1: Per cent increase in seed yield over control

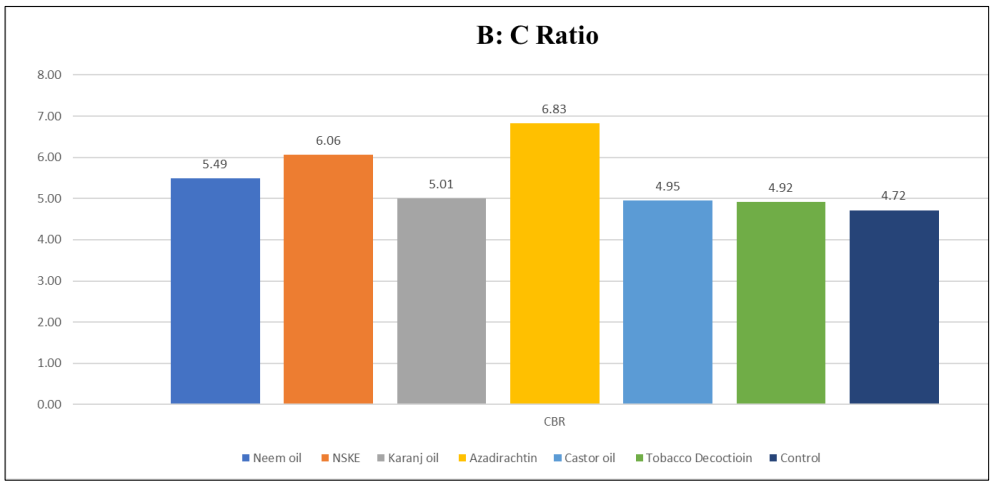

Fig 2: Benefit cost ratio against different botanical insecticidal treatments on sweet basil

T_1 Neem oil 2%; T_2 NSKE 5%; T_3 Karanj oil 2%; T_4 *Azadirachtin*1.5%; T_5 Castor oil 2%; T_6 Tobacco decoction; T_7 Control

Conclusion

The current study concludes that azadirachtin was very successful in controlling the population of *Ocimum* leaf folders and produced the highest yield (129 kg/ha). Azadirachtin (6.83), NSKE 5% (6.06), and neem oil (5.49) have the greatest BC ratios. It is recommended that Bihar and Neem-based products be used by those who produce basil in order to minimize the number of *Ocimum* leaf folders while leaving no trace in the dry matter of the plant's sections. When there aren't many leaf folders, neem-based botanical insecticides could be used. For a higher yield without the use of chemical pesticides, Azadirachtin may be recommended. It may also be recommended if the farmers, due to their high BC ratio, are looking for a more economical control. Thus, for the environmentally benign and economically viable management of *Ocimum* leaf folder, azadirachtin, NSKE, and neem oil may be utilised as insecticides.

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