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The Effectiveness and Economics of various Combination Insecticide Formulations against Defoliators and Sucking Pests of Soybean

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ABSTRACT: The current investigation was carried out at the Regional Sugarcane and Rice Research Station, Rudrur, in the Nizamabad District of Telangana State, with the aim of assessing the effectiveness of various commercially available insecticide combinations against defoliators and sucking pests of the JS-335 Soybean variety. There were eight treatments in all, including the untreated control group. Three replications of each treatment were conducted using a randomized complete block design. When a pest reached the economic threshold, 30 and 50 days after sowing, insecticides were sprayed, and data was collected five and ten days after treatment to compare with pre-treatment pest population data. The results showed that spraying a combination insecticide Chlorantraniliprole 8.8% + Thiomethoxam 17.5% SC @ 500ml ha^{-1} twice, 30 days and 50 days after sowing, reduced the population of defoliators like *Spodoptera litura* & *Chrysodexis acuta* and sucking pests like aphids & whiteflies by 82.13 per cent and 77.10 per cent respectively, over control. Plots treated with the afore mentioned insecticide had a maximum yield of 1328 kg ha^{-1} and a 1.67 benefit-cost ratio. Following the treatment, a yield and benefit cost ratio of 1192 kg ha^{-1} and 1.56 were obtained using Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}.

Keywords: Soybean, combination insecticides, defoliators, aphids, whitefly, yield and benefit cost ratio.

INTRODUCTION

The soybean (*Glycine max* (L.) Merrill) is referred as the "miraculous golden bean" because of its unique chemical composition, which is beneficial to humans, fish, poultry, and other animals. The main advantages are linked to their high amounts of vital fatty acids, various vitamins, minerals, isoflavones, fiber, and great protein content with 8 essential amino acids (Dwevedi and Kayastha 2011). Soybeans now make up about 6% of all agricultural land worldwide, the largest increase in area of any crop since the 1970s (Hartman *et al.*, 2011). The total area under cultivation for soybeans worldwide is 126.95 million ha, with an output volume of 362.64 million MT and an average yield of 2860 kg per ha (USDA, 2020). A total of 13.26 million MT of soybeans were produced in India, with an average yield of 1192 kg per ha (SOPA, 2020). Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Gujarat, Telangana, and Chhattisgarh are the principal soybean-growing states in India. Soybean harbours more than 300 insect pests, among them only a small number of insects qualify as serious pests to the crop. They reduce yield by over 25 per cent and cause damage to the crop from the seedling stage through maturity (Gaur and Mogalapu 2018). Soybeans are harmed by *Spodoptera litura* (Fab), a dangerous and enduring tobacco pest, from mid-August to October during *kharif* and from November to March during *rabi*. They first injure the leaves and then begin feeding on the younger sections, causing damage to 30 to 50% of the pods. *Chrysodexis acuta* causes 19% defoliation in a similar way. Soybean aphids that feed on phloem sap have the ability to decrease both the size and quantity of soybean seeds (Beckendorf *et al.*, 2008). Whitefly is a highly polyphagous sucking pest that spreads over 300 viruses that cause diseases like yellow mosaic virus disease (YMD) in soybeans and uses more than 600 plant species as hosts (Marabi *et al.*, 2017). Apart from the direct harm caused by whiteflies feeding on soybean leaves, they also release honeydew that encourages the growth of sooty mold fungi (*Capnodium* sp.) and reduces the area of soybean plants that are actively photosynthesizing (Navas *et al*., 2011). For a population density of one whitefly per trifoliate, yield loss from whitefly damage may reach as high as 31 kg ha^{-1} (Padilha *et al*., 2021). Studies show that 15–20 per cent of the yearly soybean crop is lost due to direct or indirect insect pest attacks (Biswas, 2008). Hence, detailed information on the pest complex, their status and sequence of occurrence during the crop period, losses, and type of damage are of great importance in order to develop economically viable, ecologically sound, and socially acceptable pest management strategies (Jayanthi *et al*., 1993). A variety of management strategies have been investigated for the development of integrated pest management (IPM) programs to lower soybean sucking pest population densities. However, the main strategy for outbreak suppression continues to be foliar insecticides (Hodgson *et al*., 2012). Similarly, for suppression of soybean defoliators also chemical control strategies remain the main tool (Meena *et al*., 2014). Thus, with an objective to assess the efficacy of a combination insecticide molecule that can control major defoliators and sucking pests of soybean, thereby avoiding losses in yield, the current study was taken up.

MATERIALS AND METHODS

During the *kharif*, 2021, a field experiment was conducted at the Regional Sugarcane and Rice Research Station in Rudrur, Nizamabad, Telangana state. Popular soybean variety JS-335 was sown on a plot measuring 25 square meters, with rows spaced 45cm apart and plants spaced 5cm apart. To compare the effectiveness of combination insecticides against major defoliators and sucking pests of soybean, the experiment was set up using a Randomized Block Design with eight treatments in three replications, including an untreated control. The treatments consisted of Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}, Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}, Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}, Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}, Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}, Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}, Profenophos 50%EC @ 1000 ml ha^{-1} and untreated control (water spray). The spraying was carried out between the hours of 9:00 and 10:00 in the morning, with a total of two knapsack sprayings given at intervals of 30 and 50 days after sowing. A population count of insects was carried out one day before the spraying and again five and ten days after the treatment. The number of defoliator larvae/meter row length (mrl) was recorded at three places in each plot. Aphids and White fly population was recorded from 3 leaves (Top, middle and bottom) on randomly selected ten plants from each plot (Sharma, 1996). The population reduction was calculated by applying a correction factor provided by Henderson and Tilton (1955) to the data collected one day prior to the spray and five and ten days later. According to the method recommended by Gomez and Gomez (1984), the statistical analysis (analysis of variance) of the data was conducted by converting the insect data into square root transformed values. Each plot's individual soybean yield was recorded and calculated on a per-hectare basis.

RESULTS AND DISCUSSION

During the soybean crop's growth period, infestations of the defoliators *Spodoptera litura* and *Chrysodexis acuta*, as well as sucking pests like aphids and whiteflies, were seen starting 20 days after planting.

The comparative effectiveness of various treatments against defoliators after first spray. One day before application and five and ten days later, the prevalence of larval population were recorded in meter row length in all the plots treated with various insecticides, including control plot.

One day before the first insecticide treatment imposition. The number of larvae present per meter of row length was counted in each plot one day prior to the imposition of treatments. Larval populations ranged from 2.30 to 2.72 per mrl in almost all of the plots (Table 1). There was not a statistically significant distinction between the larval populations in the various plots observed.

Five days after the first insecticide treatment imposition. According to the data in Table 1, it was found that five days after the initial spray, all of the treatments significantly outperformed the untreated control. The larval population in plots treated with various insecticides ranged from 0.67 to 1.41 larvae/mrl. The plots treated with Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1} had the lowest population of 0.6 larvae/mrl and the plots treated with Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1} had the highest population of 1.41l arvae/mrl. Control plot that wasn't treated observed 2.80 larvae per mrl.

Ten days after the first insecticide treatment imposition. The data provided in Table 1 showed that, 10 days after the first spray, all the treatments were significantly better than the untreated control in terms of larval population. The maximum incidence of defoliators was observed in the control plot with 3.10larvae/mrl. Among the treated plots, the lowest population of 0.60 larvae/mrl was observed in plots treated with Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}.

Mean number of larval population per mrl after first spray. In all the plots treated with various insecticides, a similar trend was seen in the larval population/mrl Chlorantraniliprole 8.8% + Thiomethoxam 17.5% SC @ 500 ml ha^{-1} was found to be superior to other treatments by lowering the mean larval population per mrl to 0.64 and reducing defoliators by 78.29% over control, followed by plots treated with Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1} with a mean larval population of 0.70 and 76.43 per cent reduction.

The comparative effectiveness of various treatments against aphids after first spray. Aphid occurrence was noticed 20 days after planting until the pod-formation stage, with population fluctuations during the crop growth period. A random sample of 10 plants from all the plots treated with various insecticides was taken to count the number of aphids present on three leaves, one day before application and five & ten days afterwards.

One day before the first insecticide treatment imposition. According to the information in Table 1, there were about 16.80 to 18.40 aphids per every three leaves. There was no discernible difference in the aphid population between any of the treatments, including the untreated control.

Five days after the first insecticide treatment imposition. All of the treatments significantly outperformed the untreated control five days after the initial spray. In plots treated with Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}, the lowest recorded aphid population was 1.50 no./3 leaves, and the highest was 5.80 no./3 leaves in plots treated with Profenophos 50%EC @ 1000 ml ha^{-1}. 19.10 aphids per three leaves were found in the untreated control plot.

Ten days after the first insecticide treatment imposition. According to the data in Table 1, it was found that ten days after the initial spray, the plots treated with Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1} had the lowest number aphids (3.30 no. per 3 leaves), while the plots treated with Profenophos 50%EC @ 1000 ml ha^{-1} had the highest aphid population (6.30 no. per 3 leaves). In untreated control plots, the highest insect density was observed, with 19.50 aphids per 3 leaves.

Mean number of aphids per three leaves after the first spray. All of the treatments outperformed the untreated control in a significant way. Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1} was found to be significantly better than all other treatments, with a mean aphid count of 2.40 no. aphids/ 3 leaves and an 87.57% reduction over control. Chlorantraniliprole 8.8% + Thiomethoxam 17.5% SC @ 500 ml ha^{-1} came in second with an 83.93% reduction and an aphid mean count of 3.10 per 3 leaves.

The comparative effectiveness of various treatments against defoliators after second spray. A second application of the same treatments was made 55 days after soybean planting to evaluate the effectiveness of insecticides in light of the incidence of defoliators.

One day before the second insecticide treatment imposition. The number of larvae present per meter of row length was counted in each plot one day before the application of treatments. There was no statistically significant difference in the population of larvae between the various plots. According to Table 2, the larval population per mrl ranged from 2.84 to 3.26.

Five days after the second insecticide treatment imposition. According to the data in Table 2, all of the treatments significantly outperformed the untreated control five days after the second spray. Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1} recorded 0.72 larvae per mrl, while plots treated with Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1} recorded the lowest number of larval count *i.e* 0.53 per mrl.

Ten days after the second insecticide treatment imposition. The information in Table 2 showed that all treatments were significantly better than the untreated control 10 days after the second spray. The plots treated with Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1} had the lowest population of 0.69 larvae/mrl among those exposed to the various insecticides. The treated plots with Profenophos 50%EC @ 1000 ml ha^{-1} had the highest incidence of defoliators at 1.62 larvae per mrl.

Mean number of larval population per mrl after second spray. To compare the effectiveness of the various treatments, the mean larval population was calculated after the second spray. Among the treatments imposed, Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1} was found to be significantly superior over other treatments by reducing larval population per mrl to 0.61 with 85.98 per cent reduction of defoliators over control, followed by Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1} with mean larval population of 0.77 larave per mrl and per cent reduction of 82.41 over control.

The comparative effectiveness of various treatments against whitefly after second spray. Whitefly infestation was observed in soybeans starting 20 days after sowing and continuing throughout the crop period. The number of whiteflies on three leaves was randomly counted from ten plants in each of the plots treated with various insecticides, one day before and five and ten days after the treatments were applied.

One day before the second insecticide treatment imposition. After looking into the information in Table 2, it was found that there were 2.80 to 3.10 no. of whiteflies for every three leaves. The number of whiteflies did not significantly differ between the plots.

Five days after the second insecticide treatment imposition. Five days after the second spray, all of the treatments were significantly better than the untreated control, according to the data shown in Table 2. In plots treated with Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}, the whitefly population ranged from 0.60 no./3 leaves to 1.40 no./3 leaves in plots treated with Profenophos 50%EC @ 1000 ml ha^{-1}. There were a maximum of 3.80 whiteflies per three leaves in the untreated control plot.

Ten days after the second insecticide treatment imposition. Ten days after the second spray, the plots treated with Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1} had the lowest whitefly population (1.30 no. per 3 leaves), followed by Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}, which had the highest whitefly population (1.42 per mrl). Whitefly infestations in untreated control plots reached a maximum of 3.90 per three leaves.

Mean number of whiteflies per three leaves after second spray. When compared to the untreated control, all of the treatments are significantly better. Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1} was found to be the most effective treatment, reducing whiteflies by 71.43 per cent over the control with a mean population of 1.10 no. of whiteflies per 3 leaves. Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1} was the next best treatment, reducing whiteflies by 71.18 per cent with a mean population of 1.11 no. per 3 leaves.

After two consecutive sprays on soybean, the combined efficacy of different treatments against defoliators showed that Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}was more effective than the untreated control at suppressing the population of defoliators by 82.13 per cent (Table 3 & Fig 1). On the other hand, table 4's data showed that the treatment Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1} outperformed all other treatments in terms of reducing the populations of sucking pests like aphids and whiteflies by 79.38% over control (Fig. 2). Upon reviewing the combination insecticide's overall effectiveness after two consecutive sprays at controlling both defoliators and sucking pests, Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1} was found to be more effective than all other treatments in suppressing both defoliators and sucking pests, with defoliators being suppressed by 82.13 per cent and sucking pests by 77.10 per cent, respectively.

Although there is a dearth of research on the effectiveness of combination insecticides against soybean insect pests, one of the treatment's components, chlorantaniliprole, has been found to be effective against tobacco caterpillars in soybeans (Rangnatha, 2009; Hardke *et al.*, 2011; Raut *et al.*, 2014; Sonkamble *et al.*, 2018, Bhamare *et al.*, 2020) and defoliators in sunflowers (Muzamil *et al.*, 2017) and larval populations in black gram (Patidar and Kumar 2018). In a similar vein, Dinesh *et al.* (2018) reported that the insecticide Thiomethoxam 25WG had successfully decreased the number of whiteflies in soybean plants and also effective in suppressing aphids population in soybean (Tarun *et al.*, 2019; Zhang *et al.*, 2021).

Effect of different treatments on yield and cost economics. The higher grain yield was obtained in all the insecticidal treatments ranged from 924 to 1328 kg/ha in comparison to control (728 kg ha^{-1}). Plots treated with Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1} has recorded the highest grain yield of 1328 kg ha^{-1}, which is 82.64 per cent higher over control, with benefit cost ratio of 1.67 and net returns amounting Rs. 33,086. Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}, which recorded yield of 1192 kg ha^{-1} with benefit cost ratio of 1.56.

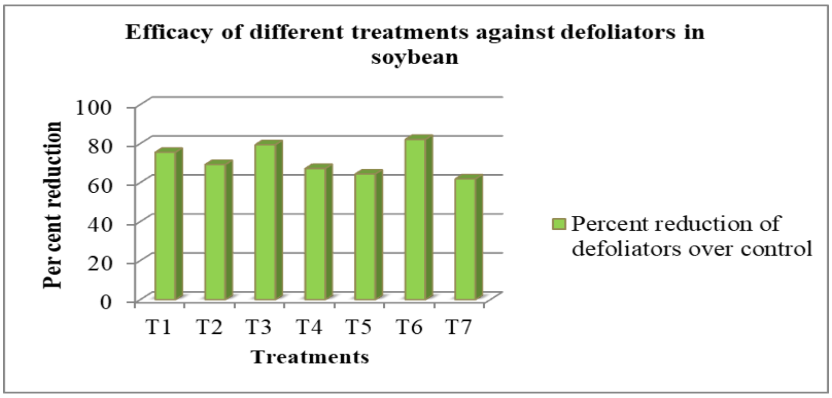

Fig. 1. Mean efficacy of different combination insecticides against soybean defoliators.

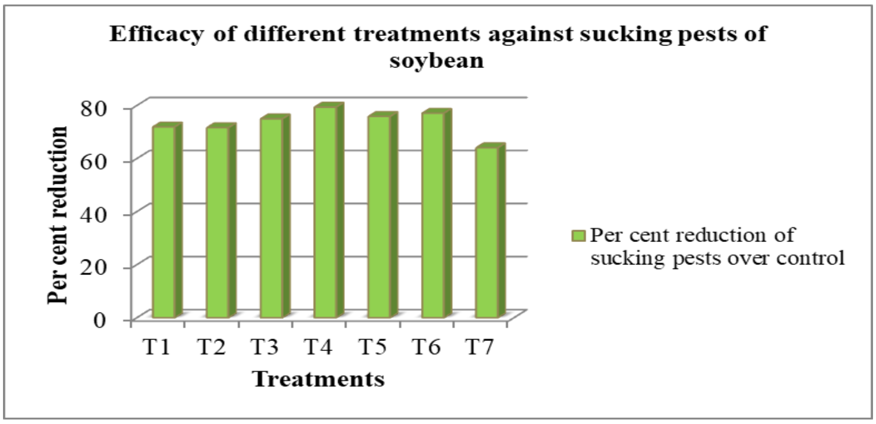

Fig. 2. Mean efficacy of different combination insecticides against sucking pests of soybean.

Treatment details : T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}
T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}
T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}
T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}
T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}
T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}
T7 : Profenophos 50%EC @ 1000 ml ha^{-1}

Table 1: I Spray - Bioefficacy of different insecticides against defoliators and aphids (*Kharif*, 2021).

Sr. No.	Treatments	Defoliators (No./mrl)					Aphids (No./3leaves)				
		Pre-count (No.)	5DAT (No.)	10DAT (No.)	Mean	Per cent reduction over control	Pre-count (No.)	5DAT (No.)	10DAT (No.)	Mean	Per cent reduction over control
1.	T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}	2.47	0.92 (0.96)	0.72(0.85)	0.82(0.91)ef	72.12	17.4	3.80(1.95)	4.30(2.07)	4.05(2.01)c	79.03
2.	T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}	2.72	1.12 (1.06)	0.93(0.96)	1.03(1.01)de	65.31	17.2	3.90(1.97)	3.70(1.92)	3.80(1.95)cd	80.31
3.	T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}	2.30	0.67 (0.82)	0.72(0.85)	0.70(0.83)f	76.43	17.8	2.80(1.67)	3.80(1.95)	3.30(1.82)de	82.90
4.	T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}	2.67	1.11 (1.13)	1.12(1.06)	1.12(1.06)bcd	62.13	16.8	1.50(1.22)	3.30(1.82)	2.40(1.55)f	87.57
5.	T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}	2.50	1.41(1.12)	1.11(1.05)	1.26(1.12)bc	57.33	18.1	2.60(1.61)	5.00(2.24)	3.80(1.95)cd	80.31
6.	T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}	2.47	0.68(0.87)	0.60(0.77)	0.64(0.80)f	78.29	17.9	2.10(1.45)	4.10(2.02)	3.10(1.76)e	83.93
7.	T7 : Profenophos 50%EC @ 1000 ml ha^{-1}	2.33	1.20(1.09)	1.30(1.14)	1.25(1.12)b	57.55	18.4	5.80(2.41)	6.30(2.51)	6.05(2.46)b	68.66
8.	T8 : Untreated control	2.60	2.80(1.65)	3.10(1.76)	2.95(1.72)a	-	18.2	19.10(4.37)	19.50(4.42)	19.30(4.39)a	-
	S.Em(±)	-	0.09	0.06	0.07	-	-	0.29	0.20	0.17	-
	CD (5%)	NS	0.28	0.19	0.21	-	NS	0.87	0.61	0.52	-
	CV	-	12.66	9.00	9.64	-	-	9.54	5.56	5.21	-

Values in the parenthesis are square root transformed values

Table 2 : II Spray - Bioefficacy of different insecticides against defoliators and whitefly (*Kharif*, 2021).

Sr. No.	Treatments	Defoliators (No./mrl)					Whitefly (No./3leaves)				
		Pre-count (No.)	5DAT (No.)	10DAT (No.)	Mean	Per cent reduction over control	Pre-count (No.)	5DAT (No.)	10DAT (No.)	Mean	Per cent reduction over control
1	T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}	3.12	0.88(0.94)	0.95(0.97)	0.92(0.96)d	78.97	2.70	1.11(1.05)	1.60(1.26)	1.36(1.16)c	64.79
2	T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}	2.91	1.12(1.06)	1.21(1.10)	1.17(1.08)c	73.22	3.10	1.20(1.10)	1.65(1.28)	1.43(1.19)bc	62.98
3	T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}	2.64	0.72(0.85)	0.81(0.90)	0.77(0.87)e	82.41	2.75	1.12(1.06)	1.42(1.19)	1.27(1.13)cd	66.99
4	T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}	3.00	1.10(1.05)	1.31(1.14)	1.21(1.10)c	72.30	2.84	0.60(0.77)	1.62(1.27)	1.11(1.05)e	71.18
5	T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}	3.26	1.21(1.10)	1.27(1.13)	1.24(1.11)c	71.49	2.80	0.90(0.95)	1.30(1.14)	1.10(1.05)e	71.43
6	T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}	2.88	0.53(0.73)	0.69(0.83)	0.61(0.78)f	85.98	3.10	0.74(0.86)	1.55(1.24)	1.15(1.07)de	70.26
7	T7 : Profenophos 50%EC @ 1000 ml ha^{-1}	2.84	1.32(1.15)	1.62(1.27)	1.47(1.21)b	66.21	2.85	1.40(1.18)	1.72(1.31)	1.56(1.25)b	59.48
8	T8 : Untreated control	3.21	4.27(2.07)	4.43(2.10)	4.35(2.09)a	-	3.20	3.80(1.95)	3.90(1.97)	3.85(1.96)a	-
	S.Em(±)	-	0.08	0.10	0.05	-	-	0.09	0.05	0.05	-
	CD (5%)	NS	0.23	0.29	0.15	-	NS	0.28	0.17	0.17	-
	CV	-	9.47	10.74	6.00	-	-	11.65	5.16	5.16	-

Values in the parenthesis are square root transformed values

Table 3 : Bio-efficacy of different insecticides against defoliators (*kharif*, 2021).

Sr. No.	Treatments	Per cent reduction over control I Spray	Per cent reduction over control II Spray	Mean
1.	T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}	72.12	78.97	75.54
2.	T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}	65.31	73.22	69.27
3.	T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}	76.43	82.41	79.42
4.	T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}	62.13	72.30	67.21
5.	T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}	57.33	71.49	64.41
6.	T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}	78.29	85.98	82.13
7.	T7 : Profenophos 50%EC @ 1000 ml ha^{-1}	57.55	66.21	61.86
8.	T8 : Untreated control	-	-	-

Table 4: Bioefficacy of different insecticides against sucking pests (*kharif*, 2021).

Sr. No.	Treatments	Per cent reduction over control I Spray	Per cent reduction over control II Spray	Mean
1.	T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}	79.03	64.79	71.91
2.	T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}	80.31	62.98	71.64
3.	T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}	82.90	66.99	74.95
4.	T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}	87.57	71.18	79.38
5.	T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}	80.31	71.43	75.87
6.	T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}	83.93	70.26	77.10
7.	T7 : Profenophos 50%EC @ 1000 ml ha^{-1}	68.66	59.48	64.07
8.	T8 : Untreated control	-	-	-

Table 5: Yield and cost-effectiveness of various combination insecticides in soybean during *kharif*, 2021.

Sr. No.	Treatments	Yield (kg ha^{-1})	Additional yield over control (kg ha^{-1})	Per cent yield increase over control	Gross returns (Rs)	Total expenditure (Rs)	Net returns	B:C
1.	T1 : Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1}	1148	420	57.69	71,176	49,800	21,376	1.43
2.	T2 : Thiomethoxam 12.6% + Lambda cyhalothrin 9.5% ZC @ 200 ml ha^{-1}	972	244	33.51	60,264	47,800	12,464	1.26
3.	T3 : Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}	1192	464	63.73	73,904	47,500	26,404	1.56
4.	T4 : Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1}	1096	368	50.54	67,952	47,400	20,552	1.43
5.	T5 : Fipronil 4% + Acetamiprid 4% SC @ 1000 ml ha^{-1}	1044	316	43.40	64,728	46,500	18,228	1.39
6.	T6 : Chlorantraniliprole 8.8% + Thiomethoxam 17.5%SC @ 500 ml ha^{-1}	1328	600	82.64	82,336	49,250	33,086	1.67
7.	T7 : Profenophos 50%EC @ 1000 ml ha^{-1}	924	196	26.92	57,288	47,000	10,288	1.22
8.	T8 : Untreated control	728	-	-	45,136	45,000	136	1.00

CONCLUSIONS

The current study has shown that spraying soybean crops with Chlorantraniliprole 8.8% + Thiomethoxam 17.5% SC @ 500 ml ha^{-1} twice at 30 and 50 days after sowing has decreased sucking pests like aphids and whiteflies as well as defoliators like *Spodoptera litura* and *Chrysodexis acuta*. The highest possible soybean yield with benefit cost ratio of 1.43 was attained. The next effective treatment, Emamectin benzoate 3% + Thiomethoxam 12% WG @ 312.5 g ha^{-1}, has a high B:C of 1.56. Both the treatments Beta-cyfluthrin 8.49 + Imidacloprid 19.81% w/w @ 350 ml ha^{-1} and Acephate 50% + Imidacloprid 1.8% SP @ 1000 g ha^{-1} have recoded 1.43 benefit cost ratio.

FUTURE SCOPE

The results of this study demonstrate the potential to apply combined insecticides as the most effective chemical measure for managing sucking pests and defoliators in an economical manner, resulting in higher net returns by lowering costs associated with repeated spraying.

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