ASSESSMENT OF INSECTO-ACARICIDES AGAINST SUCKING PESTS OF GROUNDNUT

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ABSTRACT

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| Groundnut, a predominant oilseed crop is prevalently attacked by sucking pests contributing to a greater yield loss in Odisha. To mitigate this problem, a field investigation has been carried out in OUAT by the combination of seed treatment and insecto-acaricides against major sucking pests of groundnut. Imidacloprid 600FS@10ml/kg was used for seed treatment and chemicals such as Diafenthiuron 50%WP@600g/ha, Spiromesifen 22.9%SC@400ml/ha, Chlorfenapyr 10% SC@1000ml/ha¬, Fenpyroximate 5% EC@1000ml/ha, Pyriproxifen 10% EC @500ml/ha and Hexythiazox 5.4%EC @500ml/ha were applied as foliar spray on 30 and 45 days after sowing. The treatment comprising of Seed treatment with Imidacloprid 600FS@10ml/kg of seeds followed by two foliar spray applications of Diafenthiuron 50%WP@600g/ha recorded significantly lower population of 0.93 thrips/leaf, 0.80 whiteflies/leaf, 1.00 jassids/leaf, 0.91 aphids/leaf and 0.41 red spider mites/leaf. This treatment was also found relatively safer to natural enemies and it produced the highest yield of 3.40 tonnes/ha with an ICBR ratio of 1:4.94. |

*Keywords: Seed treatment, Imidacloprid, Diafenthiuron, thrips, whiteflies, aphids, jassids, red spider mites, natural enemies, yield*

1. INTRODUCTION

Groundnut (Arachis hypogaea), an important legume family crop was domesticated and cultivated earlier in Paraguay. It is a cash crop for millions of small-scale farmers in semi-arid tropical regions (Kumbhar et al., 2021). It covers 5.57 million acres in India with an annual production of 10.2 million tonnes (Meghana et al., 2023). Predominantly in India, Odisha ranks sixth in groundnut production (358.03 MMT in 2017-18) (Shasani et al.,2020) and dominates all oil seed crops. Groundnut is cultivated in three seasons namely Kharif, pre-rabi, rabi or summer season (Gangadhara et al., 2023). This crop is severely infested by 52 insects and two mite species. Among insect pest complex, sucking pests such as Aphids, A. craccivora, leafhoppers, E. kerri, whiteflies, B. tabaci and thrips, T. dorsalis causes severe damage to the crop resulting in low productivity of groundnut (Gocher et al., 2020). Red spider mite attack occurs only in localized areas of groundnut in India where mites infestation causes foliage drying in moistrure stress conditions (Nandagopal and Gedia, 1995). Recently in Odisha, sucking pests and mites incidence occur simultaneously which causes major yield losses. To minimise pest attack, an integrated pest management method is essential. Keeping this in view, the present study evaluates few insecto-acaricides and its potential to reduce sucking pest population and its effect on predatory population. This study also emphasize the estimation of yield and economics of groundnut after the adoption of management practices.

2. material and methods

This experiment was conducted as a field trial at the Regional Research and Technology Transfer Station (RRTTS), Coastal Zone (CZ), OUAT, Bhubaneswar, Odisha (20⁰ 26” N latitude and 85⁰ 79” E longitude) during the Rabi season of 2022-2023. The treatments taken under this experiment were T1 - Seed treatment with Imidacloprid 600 FS @10ml kg 1 (ST) + Foliar spray of Diafenthiuron 50% WP @600g ha-1, T2- ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1, T3- ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1, T4- ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1, T5- ST + Foliar spray of Pyriproxyfen 10% EC @500ml ha-1, T6- ST + Foliar spray of Hexythiazox 5.4% EC @500ml ha-1 and T7- Untreated control. These seven treatments were tested and evaluated in a Randomized Complete Block Design (RCBD) and each treatment was replicated thrice. The field layout has 21 sub-plots and each subplot has an area of 7m x 3m. Groundnut variety “Devi (ICGV 91114)” has been used in this experiment with an equal spacing of 30 cm x 10 cm.

All the subplots excluding untreated control were done with seed treatment. Subsequently, the first and second foliar application has been taken up on 30 and 45 days after sowing by using battery operated knapsack sprayer at the rate of 500 l/ha. Prior to each foliar spray, the pretreatment observations were taken and after spraying, the post-treatment observations were taken on 3rd , 5th , 7th and 10th day for the population of sucking pests such as thrips, whiteflies, jassids, aphids, red spider mites and natural enemies such as coccinellids and spiders. During observation, five plants were chosen randomly from each treatment plot in each replication. Three leaves from the top, middle, and bottom canopy leaves of each plant were selected. The average population was taken to derive the number of insects per leaf in each treatment. Furthermore, the per cent reduction over untreated control in each treatment for insect population was calculated by using the formula,

Per cent reduction = Population in untreated plot – Population in treated plot

 over control \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ x 100

Population in untreated plot

 Five plants were harvested from each treatment plot in each replication in order to collect yield data. The number of pods per plant, weight of pods per plant, kernel weight, and shell weight were all manually quantified in those selected plants. A mechanical harvester was used to determine each plot's yield, and then the yield (kg/plot) for each plot was calculated and converted into tonnes/ha. The per cent improvement of yield over untreated control was computed by the following formula,

Yield = Yield obtained from treated plot –Yield obtained from untreated plot

improvement \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ x100

over control Yield obtained from untreated plot

The Incremental cost-benefit ratio was estimated for all the treatments. The data was interpreted by using online OP STAT software.

3. results and discussion

**Thrips, *Scirtothrips dorsalis***

 With the lowest mean of 0.93 thrips leaf-1 and a significant difference between all treatments, the most effective treatment was "ST+Foliar spray of Diafenthiuron 50% WP @600g ha-1” when taking into account the pooled mean thrips population of two sprays. This treatment reduced the population upto 75.91% over untreated control. This is concurrent with Shruthi et al. (2021), who reported Diafenthiuron 50 WP was the effective insecticide against thrips infesting tomatoes. Sunitha et al. (2021) also reported that diafenthiuron recorded 87% population reduction in chilli during Rabi season. Similarly, Shakya et al. (2020) found that Diafenthiuron 50 WP achieved 77.8% reduction in thrips infested in mungbean. Following Diafenthiuron, "ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1" took place as the second-best effective treatment in which 1.29 thrips leaf-1 and 66.58% reduction were observed. According to Samanta et al. (2017), Spiromesifen 24 SC @ 120 g a.i./ha significantly reduced chilli thrips population which supports the current investigation. Verma et al. (2019) also reported that spiromesifen 22.9% SC at 144g a.i./ha recorded the lowest thrips population in Bt cotton. (Table 1)

**Whitefly, *Bemesia tabaci***

 "ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1" was determined to be highly successful in suppressing whiteflies based on the pooled mean of two sprayings. In response to this treatment, it recorded a minimum population of 0.80 whiteflies per leaf resulting in 77.34% reduction. This was on par with the treatment "ST + Foliar spray of Pyriproxyfen 10% EC @500ml ha-1" in which a reduction of 75.92% with a mean of 0.85 whiteflies per leaf. This is well supported by Zanwar et al. (2022), who found diafenthiuron 50 WP at 625 g/ha was the most effective treatment to suppress whitefly population. As well, Choudhary et al. (2022) reported that Diafenthiuron 50WP and Pyriproxyfen 10.8 EC showed high efficacy in suppressing whiteflies of Indian bean crop. The results of Kumar et al. (2019) indicated that Diafenthiuron 50 WP and Pyriproxifen 10 EC were more effective against various stages of whiteflies. (Table 1)

**Jassids, *Empoasca kerri***

 From the population of two sprays, the pooled mean showed that the treatment "ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1" had significantly fewer jassids of 1.00 leaf-1. This was statistically at par to the treatments "ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha 1" with 1.02 jassids leaf-1 and "ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1" with 1.15 jassids leaf-1. These treatments were determined to be superior. Diafenthiuron had the highest level of efficacy with a 69.51% reduction in mortality, followed next by spiromesifen (68.9% reduction) and chlorfenapyr (64.94% reduction). The research by Kumar et al. (2015) and Sarma et al. (2016) concluded that the most effective treatment against cotton jassid mortality was diafenthiuron 50% WP. Furthermore, Spiromesifen 240 SC at 120 ml a.i./ha was found to be more effective against cotton jassids by Shakya et al. (2020). An experiment by Susheelkumar et al. (2020) found that chlorfenapyr 10% EC @ 1 ml/l was highly effective in controlling Okra leafhoppers resulting in a 56.98% reduction. Table 1)

**Aphids, *Aphis craccivora***

 While considering the pooled mean of two sprays, the greatest efficacy was shown by the treatment "ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1” as it recorded minimum population of 0.66 aphids/leaf and also demonstrated highest mortality of 77.85% above the untreated control. This result is well supported by Jain et al. (2018), who found that chlorfenapyr 240 SC @ 288 g.a.i./ha was more effective against aphids in chilli field. The next effective treatment was "ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1” which recorded a minimum of 0.91 aphids per leaf thereby resulting in 69.46% mortality above untreated control. Choudhary et al. (2022) reported that Diafenthiuron 50% WP proved as second most effective insecticide in controlling groundnut aphids. Similarly, Kumar et al. (2019) revealed that Diafenthiuron 50% WP reduced a maximum of 95.17% aphids population over control in Indian bean crop. (Table 1)

**Red spider mites, *Tetranychus urticae***

 In table 2, based upon the pooled mean of two sprays, "ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1" was the most effective treatment against red spider mites in groundnut, with a population of 0.37 mites in each leaf. Based on statistical analysis, it was statistically comparable to the effective treatment "ST + foliar spray of Diafenthiuron 50% WP @600g ha-1," which recorded an average of 0.41 mites per leaf. A comparison of these treatments with untreated control revealed 86.5% reduction in Fenpyroximate and 85.04% reduction in Diafenthiuron. This result partially agrees with that of Allam et al. (2022) who determined Fenpyroximate reduced mite populations by the greatest percent during the summer season. Additionally, this confirms the findings of Tilekar et al. (2023), who claimed that Fenpyroximate had the greatest effect in controlling mites on roses. Moreover, according to Jan et al. (2021), Fenpyroximate 5 % SC remains the third most effective insecticide against brinjal mites. A study conducted by Singh et al. (2018) supports the efficacy of Diafenthiuron 50% WP by demonstrating a 68,02 % reduction in mite populations in okra.

**Natural enemies**

 From table 2, "ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1" was found to be both a safer and more effective treatment for coccinellid populations with an average number of 1.06 beetles plant-1 and a minimum reduction of 47.26% compared to untreated control. The results of the best treatment for coccinellid beetles are similar to those reported by Varghese et al. (2013), who found that spiromesifen 45 SC at 100 grams a.i./ha was the safer insecticide in chilli. Following this, a significantly safer insecticide was found as "ST + Foliar spray of Pyriproxyfen 10% EC @500ml ha-1" which had 0.75 beetles per plant and showed a reduction of 62.69% over untreated control. However, Maity et al. (2017) also found that Pyriproxyfen 10 EC was the safer insecticide for coccinellid population in okra. Similarly for spider population, the insecticide Spiromesifen 22.9% SC @400ml ha-1 was found as the least toxic insecticide which recorded 0.77 spiders per plant with only 42.96% mortality over untreated control. This result is in agreement with the findings of Varghese et al. (2013), who found spiromesifen 45 SC at 100 g a.i./ha as a safer insecticide to conserve spider population and other predators in chilli fields. This is also concurrent with the results of Sasmal et al.(2020) who reported spiromesifen 22.9 % SC @ 96 g a.i/ha showed very little insecticidal effects against spider population.

**Pod yield**

 The pod yield obtained from various treatments is represented in Table 3. The pod yield was recorded in different aspects such as kernel weight, shell weight, number of pods per plant and yield per hectare for each treatment. Among all the treatments, the treatment with the better outcome was Diafenthiuron 50% WP @600g ha-1 which exhibited 41 pods per plant that weighed nearly 37 gram in each plant. Plots treated with pyrifoxyfen 10% EC @ 500 ml ha-1 had the largest kernel weight of 26 gram per plant, while the highest shell weight was 11 gram per plant in Fenpyroximate 5% EC @ 1000 ml ha-1. Regarding yield per hectare, Diafenthiuron 50% WP @600g ha-1 demonstrated a maximum output of 3.40 tonnes ha-1 and a 25.46% increase in pod yield compared to the untreated control. Sujay et al. (2015) and Samanta et al. (2017) reported that Diafenthiuron 50% WP treated plots produced the greatest yield of 4.65 q/ha and 17.64 q/ha in chilli field which supports the current findings.

**Yield and economics**

 The effects of various treatments on yield and economics in groundnut are represented in table 4. The treatment “ST+Foliar spray of Diafenthiuron 50% WP @600g ha-1” recorded the highest incremental cost-benefit ratio of 1 : 4.94 and incremental profit was Rs.33,567/-. Bharpoda et al. (2014) reported that diafenthiuron 50 WP @ 0.05% had an ICBR ratio of 1: 6.13 in Bt cotton BG-II. Likewise, Patil et al. (2018) concluded that highest ICBR ratio of 1 : 1.17 observed from cowpea field when treated with diafenthiuron against cowpea aphid. The treatment that followed next was “ST+Foliar spray of Pyriproxyfen 10% EC @ 500 ml ha-1” which had an ICBR ratio of 1 : 4.52 and its incremental benefit was Rs.19,162/-. Consequently, the difference in critical input cost as well as varying pod yield between treatments may contribute to the lower benefit-cost ratio and higher incremental benefit, and vice versa.

4. Conclusion

Diafenthiuron 50% WP was found to suppress both sucking pests and mites population simultaneously in groundnut. Among predatory species such as coccinellids and spiders, diafenthiuron treated plots showed a moderately lethal effect. Recently, Red spider mite infestation in groundnut has been increased in groundnut cultivation areas in Odisha where this insecticide may offer a more effective way of controlling sucking pests and mites, and can contribute to a better financial return for farmers.

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**Table 1 : Efficacy of different insecticides against sucking pests of groundnut during *Rabi*, 2022-23**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment details | No. of thrips/leaf | No. of whiteflies/leaf | No. of jassids/leaf | No. of aphids/leaf |
| Mean of 1stspray | Mean of 2nd spray | Pooled mean | % ROC | Mean of 1st spray | Mean of 2nd spray | Pooled mean | % ROC | Mean of 1st spray | Mean of 2nd spray | Pooled mean | % ROC | Mean of 1st spray | Mean of 2nd spray | Pooled mean | % ROC |
| T1 : ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1 | 0.98(1.41) | 0.88(1.37) | 0.93(1.39) | 75.91 | 1.25(1.50) | 0.34(1.16) | 0.80(1.33) | 77.34 | 1.16(1.47) | 0.84(1.36) | 1.00(1.41) | 69.51 | 1.17(1.47) | 0.66(1.29) | 0.91(1.38) | 69.46 |
| T2: ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1 | 1.47(1.57) | 1.11(1.45) | 1.29(1.51) | 66.58 | 1.63(1.62) | 1.06(1.44) | 1.34(1.53) | 62.04 | 1.05(1.43) | 0.99(1.41) | 1.02(1.42) | 68.9 | 1.63(1.62) | 1.03(1.42) | 1.33(1.52) | 55.37 |
| T3: ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1 | 2.70(1.92) | 2.06(1.75) | 2.38(1.84) | 38.34 | 2.64(1.91) | 1.55(1.60) | 2.09(1.75) | 40.79 | 1.23(1.49) | 1.06(1.44) | 1.15(1.46) | 64.94 | 0.72(1.31) | 0.60(1.27) | 0.66(1.29) | 77.85 |
| T4: ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1 | 2.64(1.91) | 2.51(1.87) | 2.58(1.89) | 33.16 | 2.21(1.79) | 1.18(1.48) | 1.69(1.63) | 52.12 | 2.19(1.79) | 1.53(1.59) | 1.86(1.69) | 43.29 | 1.46(1.57) | 1.51(1.58) | 1.48(1.58) | 50.34 |
| T5: ST + Foliar spray of Pyriproxifen 10% EC @500ml ha-1 | 1.42(1.56) | 1.32(1.52) | 1.37(1.54) | 64.51 | 1.22(1.49) | 0.48(1.22) | 0.85(1.35) | 75.92 | 2.24(1.80) | 2.03(1.74) | 2.13(1.77) | 35.06 | 1.67(1.63) | 1.11(1.45) | 1.39(1.54) | 53.36 |
| T6: ST + Foliar spray of Hexythiazox 5.4% EC @500ml ha-1 | 2.76(1.94) | 2.08(1.76) | 2.42(1.85) | 37.31 | 2.35(1.83) | 1.10(1.45) | 1.72(1.64) | 51.27 | 2.51(1.87) | 1.37(1.54) | 1.94(1.71) | 40.85 | 1.60(1.61) | 1.91(1.71) | 1.75(1.66) | 41.28 |
| T7: Untreated control | 3.74(2.18) | 3.98(2.23) | 3.86(2.20) | - | 3.59(2.14) | 3.47(2.11) | 3.53(2.13) | - | 3.21(2.05) | 3.36(2.09) | 3.28(2.07) | - | 2.87(1.97) | 3.10(1.66) | 2.98(2.00) | - |
| SE(m)± | 0.006 | 0.011 | 0.016 |  | 0.006 | 0.012 | 0.017 |  | 0.009 | 0.016 | 0.023 |  | 0.011 | 0.008 | 0.011 |  |
| CD(p=0.05) | 0.02 | 0.03 | 0.05 |  | 0.02 | 0.04 | 0.05 |  | 0.03 | 0.05 | 0.07 |  | 0.03 | 0.02 | 0.03 |  |

ST – Seed treatment with Imidacloprid 600 FS @600 ml kg-1 ; ROC – Reduction over control ; Figures in parantheses indicates $\sqrt{x+1 }$ transformed values

**Table 2 : Efficacy of different insecticides against red spider mites and effect on beneficial insects in groundnut during *Rabi*, 2022-23**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment details | No. of red spider mites/leaf | No. of coccinellids/plant | No. of spiders/plant |
| Mean of 1stspray | Mean of 2nd spray | Pooled mean | % ROC | Mean of 1st spray | Mean of 2nd spray | Pooled mean | % ROC | Mean of 1st spray | Mean of 2nd spray | Pooled mean | % ROC |
| T1 : ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1 | 0.42(1.19) | 0.40(1.18) | 0.41(1.19) | 85.04 | 0.47(1.21) | 0.58(1.26) | 0.52(1.23) | 74.13 | 0.43(1.20) | 0.60(1.26) | 0.51(1.23) | 62.22 |
| T2: ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1 | 0.49(1.22) | 0.44(1.20) | 0.46(1.21) | 83.21 | 0.93(1.39) | 1.19(1.48) | 1.06(1.43) | 47.26 | 0.65(1.29) | 0.90(1.38) | 0.77(1.33) | 42.96 |
| T3: ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1 | 1.09(1.45) | 0.86(1.36) | 0.97(1.40) | 64.6 | 0.41(1.19) | 0.47(1.21) | 0.44(1.20) | 78.11 | 0.50(1.22) | 0.61(1.27) | 0.55(1.25) | 59.26 |
| T4: ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1 | 0.48(1.22) | 0.27(1.13) | 0.37(1.17) | 86.5 | 0.16(1.08) | 0.21(1.10) | 0.18(1.09) | 91.04 | 0.26(1.12) | 0.20(1.10) | 0.23(1.11) | 82.96 |
| T5: ST + Foliar spray of Pyriproxifen 10% EC @500ml ha-1 | 1.00(1.42) | 1.22(1.49) | 1.11(1.45) | 59.49 | 0.71(1.31) | 0.80(1.34) | 0.75(1.32) | 62.69 | 0.58(1.26) | 0.68(1.30) | 0.63(1.28) | 53.33 |
| T6: ST + Foliar spray of Hexythiazox 5.4% EC @500ml ha-1 | 0.56(1.25) | 0.43(1.19) | 0.49(1.22) | 82.11 | 0.27(1.13) | 0.41(1.19) | 0.34(1.16) | 83.08 | 0.33(1.15) | 0.29(1.13) | 0.31(1.14) | 77.04 |
| T7: Untreated control | 1.59(1.61) | 3.89(2.21) | 2.74(1.91) | - | 1.56(1.60) | 2.46(1.85) | 2.01(1.73) | - | 0.99(1.41) | 1.72(1.65) | 1.35(1.53) | - |
| SE(m)± | 0.004 | 0.008 | 0.012 |  | 0.017 | 0.007 | 0.009 |  | 0.016 | 0.009 | 0.012 |  |
| CD(p=0.05) | 0.02 | 0.02 | 0.03 |  | 0.05 | 0.02 | 0.03 |  | 0.05 | 0.03 | 0.04 |  |

ST – Seed treatment with Imidacloprid 600 FS @600 ml kg-1 ; ROC – Reduction over control ; Figures in parantheses indicates $\sqrt{x+1 }$ transformed values

**Table 3 : Effect of various treatments on groundnut pod yield**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment details** | **Number of pods per plant****(in gram)** | **Weight of pods per plant****(in gram)** | **Kernel weight per plant****(in gram)** | **Shell weight per plant****(in gram)** | **Yield per ha****(in tonnes)** | **% improvement over untreated control** |
| T1 : ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1 | 41 | 36 | 25 | 8 | 3.40 | 25.46 |
| T2: ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha-1 | 36 | 37 | 24 | 8 | 3.28 | 21.03 |
| T3: ST + Foliar spray of Chlorfenapyr 10% SC @1000ml ha-1 | 30 | 34 | 23 | 8 | 3.02 | 11.43 |
| T4: ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1 | 31 | 33 | 24 | 11 | 2.98 | 9.96 |
| T5: ST + Foliar spray of Pyriproxifen 10% EC @500ml ha-1 | 37 | 36 | 26 | 10 | 3.11 | 14.76 |
| T6: ST + Foliar spray of Hexythiazox 5.4% EC @500ml ha-1 | 32 | 33 | 23 | 8 | 3.06 | 12.92 |
| T7: Untreated control | 29 | 31 | 21 | 9 | 2.71 | - |
| SE(m)± | 1.372 | 0.942 | 0.830 | 0.581 | 0.023 |  |
| CD(p=0.05) | 4.28 | 2.94 | 2.59 | 1.81 | 0.07 |  |

**Table 4 : Yield and Incremental Cost-Benefit Ratio of different insecticidal treatments**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tr. No. | TreatmentCodes | Cost of critical inputs of the treatments(Rs.) | Labour charges(Rs./ha) | Total cost[C] | Yield(t/ha) | Increase inyield overcontrol(t/ha) | Value ofincreasedyield (Rs./ha)[A] | Benefit [B=A-C](Rs.) | ICBR[B/C] |
| T1 | ST + Foliar spray of Diafenthiuron 50% WP @600g ha-1 | 4800 | 1998 | 6798 | 3.4 | 0.69 | 40365 | 33567 | 1 : 4.94 |
| T2 | ST + Foliar spray of Spiromesifen 22.9% SC @400ml ha‑1 | 5200 | 1998 | 7198 | 3.28 | 0.57 | 33345 | 26147 | 1 : 3.63 |
| T3 | ST + Foliar spray of Chlorfenapyr 10% SC @1000 ml ha-1 | 8760 | 1998 | 8698 | 3.02 | 0.31 | 18135 | 9437 | 1 : 1.08 |
| T4 | ST + Foliar spray of Fenpyroximate 5% EC @1000ml ha-1 | 4744 | 1998 | 6742 | 2.98 | 0.27 | 15795 | 9053 | 1 : 1.34 |
|  T5 | ST + Foliar spray of Pyriproxifen 10% EC @500ml ha-1 | 2240 | 1998 | 4238 | 3.11 | 0.4 | 23400 | 19162 | 1 : 4.52 |
| T6 | ST + Foliar spray of Hexythiazox 5.4% EC @500ml ha-1 | 2200 | 1998 | 4198 | 3.06 | 0.35 | 20475 | 16277 | 1 : 3.88 |
| T7 | Untreated control | - | - | - | 2.71 |  |  |  |  |

Market price = Rs. 58.5/kg; Labour charge = Rs. 333/ man day