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RESEARCH ARTICLE

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# Evaluation of Integrated Pest Management Module in Groundnut Crop at Farmers' Fields in Warangal District of Telangana State

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## ABSTRACT

**Background:** Groundnut is an important legume oilseed crop grown in India. However, a significant gap between potential and actual yield was observed in groundnut production due to destructive pests and diseases, inadequate rainfall and moisture, intensive labour cost and fluctuations in market price. Insect pests act as the major hindrances in attaining higher yield and productivity of groundnut in Warangal district of Telangana.

**Methods:** To warrant insect pests attack in groundnut, Integrated Pest Management (IPM) modules were tested in 10 locations of Warangal district during 2022-23 and 2023-24 as a large scale front line demonstration (FLD) in farmers' fields. Population estimation in IPM and control plot was done as per the standard methodology to assess the impact.

**Result:** IPM demonstrations resulted 58.0, 70.8, 72.4 and 51.5% reduction in thrips, hoppers, leaf minor and tobacco caterpillar, respectively throughout the crop period with an average yield increment of 43.7% (3073.4 kg ha$^{-1}$) and avoidable yield loss of 935.1 kg ha$^{-1}$. The three way correlation of yield with net income and B: C ratio showed a positive correlation (r= 0.9948 and 0.9915), which indicated that the higher returns in the demonstration was due to the impact of IPM components and yield increment. The technology gap in the demonstration ranged from 3.7 to 4.8 q ha$^{-1}$, technological index 10.6 to 13.8 per cent and the extension gap from 9.7 to 9.1 during 2023-24 revealed that scientists attempts to educate farmers on importance of IPM practices was effective in increasing groundnut yield by reducing cost of cultivation.

**Key words:** Demonstration, Extension gap, Groundnut, IPM module, Technological index, Technology gap.

## INTRODUCTION

Groundnut is an important legume oilseed crop grown in India. India stands first in groundnut area (54.20 lakh ha) in the world and second in terms of production (101.00 lakh tones) with productivity 1863 kg ha$^{-1}$ during 2021-22 (Yadav *et al.,* 2023). In Telangana, groundnut have been sown in around 6859.2 ha with a productivity of 2050 kg ha$^{-1}$ (Groundnut Outlook, PJTSAU, 2023). The Gadwal district of Telangana occupies the first position in terms of area coverage 3024.8 ha under groundnut followed by Wanaparthy (1862.0 ha), Kothagudem (707.6 ha), Warangal (407.2 ha) and Suryapet (145.6 ha). However, groundnut productivity is low because of insect pests such as leaf miner, tobacco caterpillar, thrips and leafhoppers which act as major hindrances by causing yield losses ranging from 24 to 92, 16 to 42, 17 to 40 and 9 to 22%, respectively and indirect by transmission of viral diseases as vectors (Atwal and Dhaliwal, 2008). Farmers' total dependence on chemical pesticides has been lethal to the environment, development of other issues like resurgence and resistance to insecticides. However, a significant gap between potential and actual yield was observed in groundnut production due to main hindrances such as lower yield due to destructive pests and diseases and abiotic factors (Ahir *et al.,* 2018). The avoidable yield loss due to major insect pests of groundnut was recorded to the tune of 48.57 per cent in pod and 42.11 per cent in fodder. Lack of technical knowledge about integrated pest management techniques can result in higher pest infestations and crop losses, reducing overall yield. FLDs serve as an effective method to showcase innovative practices across larger areas of farmers' fields, enhancing awareness of sustainable crop production technologies at minimal costs (Amuthaselvi *et al.,* 2023). Consequently, this study was conducted to develop and implement innovative technologies using FLDs to provide farmers in the Warangal district with significant net returns.

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## MATERIALS AND METHODS

### Location of study area

The study was carried out in ten villages adopted by ICAR-Krishi Vigyan Kendra (KVK), Mamnoor in the Warangal district of Telangana state. Evaluation of IPM module was carried out in ground nut (Variety-Kadiri-6) in sandy loamy soils with rainfed conditions.

### Details of treatments

IPM module was demonstrated at 10 different locations in farmer fields during 2022-23 and 2023-24 covering an area of 0.40 ha (1 acre) each along with a control demonstrating farmers practices independently. Each of the demonstrated plots were geo tagged for reference (Fig 1). The observations on pest population dynamics throughout the crop season, starting from 15 days after transplanting up to 15 days before harvest were recorded. A total of 20 plants were randomly selected and tagged each from the demo as well as farmer praactice of each location. The sucking insect pests such as thrips, *Scirtothrips dorsalis* (Hood) were counted as numbers of insect on the terminal bud, leafhoppers, *Empoasca kerri* (Pruthi) on top three leaves and leaf miner, *Aproaerema modicella* (Deventer) was measured as larval population per plant by collecting infested leaves along with galleries separately by bringing into laboratory, while the infestation of tobacco caterpillar, *Spodoptera litura* was recorded as percent leaf damage. The IPM module consisted of summer deep ploughing, planting of traps crops like soybean for leaf minor and castor for tobacco caterpillar, collection and destruction of egg masses of tobacco caterpillar, installation of pheromone traps @ 4-5/acre for tobacco caterpillar and groundnut leaf minor, installation of bird perches @ 8-10/acre, seed treatment with imidacloprid @ 2ml/kg seed, spraying with azadirachtin 1500 ppm @ 5 ml/l, spraying of insecticides like Chlorantraniliprole @ 0.3 ml tobacco caterpillar, poison bait: 5.0 kg rice bran + 0.5 kg jaggery +500g thiodicarb against late stages of tobacco caterpillar, installation blue sticky traps @ 75 No.s/ha and application of thiamethoxam @ 0.5 g and fipronil @ 2 ml/l for managing thrips, hoppers and leaf minor. The farmer practices followed were use of insecticides like profinophos @ 2 ml/l, chloropyriphos @ 2-2.5 ml/l, acephate @ 2 g/l, monocrotophos @ 1.8 ml/l or cypermethrin 1.5 ml/l. Based on the data so recorded, percent reduction in pest population over farmer practice was calculated using following formula as proposed by Ramadevi *et al.* (2020) and subjected to statistical analysis using "t" test to test the significance:

$$\text{Population reduction (\%)} - \left(\frac{Xi - Xo}{Xi}\right) \times 100$$

Where:

Xi= Number of pest population/leaf damage in farmer practice.

Xo= Number of pest population/leaf damage in demonstration plot.

### Economics of IPM module

The technology index, the technology gap, extension gap and benefit-cost ratio were calculated using the following formulas (Samui *et al.,* 2000):

Technology gap = Potential yield-Demonstration yield.

Extension gap = Demonstration yield- Farmers yield.

Technology index =

$$\frac{\text{Potential yield - Demonstration yield}}{\text{Potential yield}} \times 100$$

## RESULTS AND DISCUSSION

### Study on insect pest population in IPM module of groundnut during 2022-23 (First year trial)

Observations on insect population during 2022-23 in groundnut crop were presented in Table 1. The results revealed that IPM module was recorded reduced number of thrips than Economic Threshold Level (ETL) of 5 adults

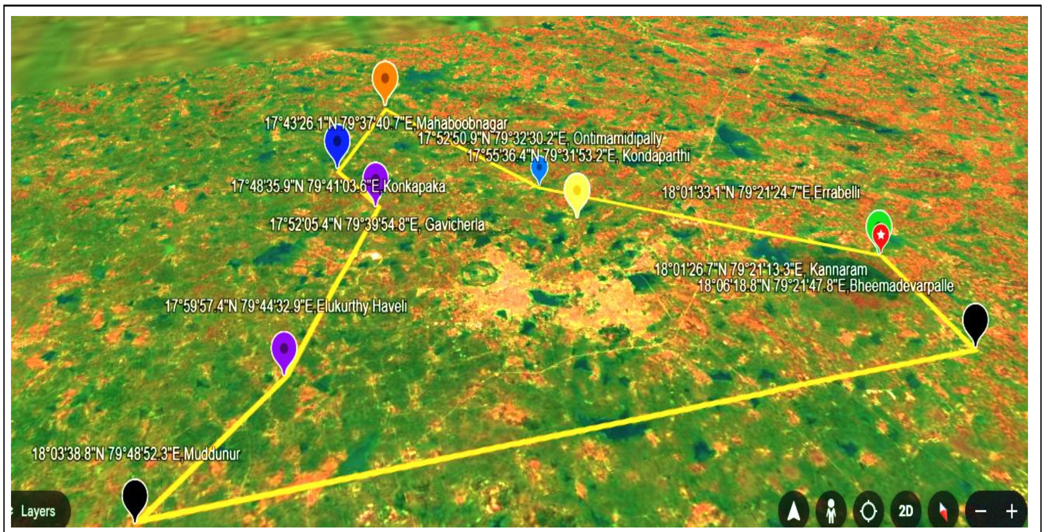


**Fig 1:** Google map of selected locations to implement IPM demonstrations in ground nut crop at Warangal district of Telangana state.

per terminal bud throughout the crop season. During seedling stage recorded 1.3±0.6 number of thrips/terminal bud than farmer practice 3.8±0.6 number/terminal bud at 15 days after sowing (DAS), similar trend was continued throughout crop period *i.e.* 3.9±0.4, 2.4±0.4, 1.8±0.5, 1.7±0.6, 0.2±0.1, 1.9±1.2 numbers/terminal bud in IPM module and 5.8±0.6, 6.4±0.4, 5.4±0.3, 4.6±0.4, 2.3±0.2 thrips/terminal bud in farmer practice at 30, 45, 60, 75 and 90 DAS, respectively. The mean number of thrips recorded throughout the season per plant in IPM module was 1.9±1.2 number/terminal bud which was significantly lower than farmer practice 4.7±1.5 thrips/terminal bud (P< t=0.00031) with number of thrips reduction over farmer practice was 60.1%. In the IPM module, the recorded numbers of green leaf hoppers per top three leaves were consistently lower throughout the crop period, with mean of 0.3±0.2, 0.8±0.6, 1.2±0.4, 1.2±0.4, 0.4±0.3 and 0.2±0/ top 3 leaves. In contrast, the farmer practice showed higher means of 1.7±0.6, 2.7±0.2, 3.6±0.4, 3.9±0.4, 2.2±0.4 and 1.3±0.5 hoppers/top 3 leaves from 15 DAS to 90 DAS. The mean green leaf hopper number recorded in IPM module (0.7±0.4 hoppers/ top 3 leaves) were significantly lower than farmer practice (2.6±1.0 hoppers/top 3 leaves) (P< t=0.0048) with 73.4 per cent population reduction over farmer practice. Infestation of leaf minor damage was first noticed at 30 DAS in IPM module, where as in farmer practice recorded 0.4±0.3 larva/ plant at 15 DAS. The lowest number of larvae recorded at 90 DAS were 0.2 ± 0.1 larva/plant, while the highest was observed at 60 DAS, with an average of 0.9 ± 0.3 larvae/ plant. The mean larval load was significantly lower in IPM module (0.4±0.3 larva/plant) than farmer practice (3.9±1.5 larva/plant) with population reduced over farmer practice was 89.3% (P< t=0.0057). No incidence of *Spodoptera litura* noticed up to 15 DAS in both IPM and farmer practice. IPM module was found superior throughout crop period with leaf damage ranged from 5.8±0.3 to 2.8±1.4% from 15 DAS to 90 DAS, respectively. The lowest percentage leaf damage was recorded during 90 DAS (2.8±1.4%) *i.e.* is at the end of crop period and highest during at 60 DAS (9.2±2.3%), which coincides with the peak vegetative period. In farmer practice percent leaf damage due to *S. litura* ranged from 9.3±1.2% to 21.9±2.7%. Significantly lower leaf damage was recorded in IPM module (8.5±4.3%) than farmer practice (15.9±6.7%) with 46.4% leaf damage reduction over farmer practice (r=0.0028).

**Study on insect pest population in IPM module of groundnut during 2023-24 (Second year trial)**

Observations on insect population during 2023-24 in groundnut crop were presented in Table 2. The results revealed that no incidence of thrips, green leaf hopper and leaf damage due to *S. litura* were noticed up to 15 DAS both in IPM module and farmer practice, whereas leaf minor damage was not noticed up to 30 DAS in IPM module. Throughout the crop period recorded a lesser number of thrips per terminal bud in IPM module than in farmer practice. The peak incidence of thrips was recorded during

**Table 1:** Evaluation of Integrated Pest Management module in groundnut crop at farmers' field during *Rabi* 2022-23.

| Mean no. of insect pests /Leaf damage/20 plants/10 locations | No. of thrips/ terminal bud | | No. of green leaf hoppers /top three leaves | | No. of Leaf minor larva/plant | | Per cent leaf damage due to tobacco caterpillar/ plant | |
|---|---|---|---|---|---|---|---|---|
| Crop Stage \ Treatments | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice |
| 15 DAS | 1.3±0.6 | 3.8±0.6 | 0.3±0.2 | 1.7±0.6 | 0 | 0.3±0.1 | 5.8±0.3 | 10.1±3.3 |
| 30 DAS | 3.9±0.4 | 5.8±0.6 | 0.8±0.6 | 2.7±0.2 | 0.4±0.3 | 15±0.5 | 9.8±1.7 | 9.9±5.6 |
| 45 DAS | 2.4±0.4 | 6.4±0.4 | 1.2±0.4 | 3.6±0.4 | 0.5±0.2 | 2.6±0.4 | 15.5±3.0 | 22.7±2.7 |
| 60 DAS | 1.8±0.5 | 5.4±0.3 | 1.2±0.4 | 3.9±0.4 | 0.9±0.3 | 2.1±0.4 | 9.2±2.3 | 21.5±2.3 |
| 75 DAS | 1.7±0.6 | 4.6±0.4 | 0.4±0.3 | 2.2±0.4 | 0.5±0.2 | 2.2±0.2 | 8.0±2.0 | 21.9±2.7 |
| 90 DAS | 0.2±0.1 | 2.3±0.2 | 0.2±0.1 | 1.3±0.5 | 0.2±0.1 | 1.2±0.5 | 2.8±1.4 | 9.3±1.2 |
| Mean population/plant | 1.9±1.2 | 4.7±1.5 | 0.7±0.4 | 2.6±1.0 | 0.4±0.3 | 3.9±1.5 | 8.5±4.3 | 15.9±6.7 |
| Insect population/leaf damage reduction over farmer practice (%) | 60.1 | | 73.4 | | 89.3 | | 46.4 | |
| P(T<=t) one-tail | 0.00031* | | 0.0048* | | 0.0057* | | 0.0028* | |

*Significant at P≤0.05; IPM-Integrated Pest Management; DAS-Days after Sowing.

45 DAS both in IPM module (2.6±0.3 number/terminal bud) and farmer practice (6.2±0.6 number/terminal bud). The number of thrips were gradually increased from 15 DAS (1.2±0.4 number/terminal bud) up to 45 DAS (6.2±0.6 number/terminal bud) there onwards decreased up to end of the crop *i.e.* 90 DAS (0.1±0.1 number/terminal bud) with the lowest number throughout the crop period. The mean number of thrips population per season per plant recorded were 1.8±1.1 number per terminal bud, which is significantly lower than farmer practice 4.0±1.8 number per terminal bud (P<t=0.00012). IPM module recorded 55.0% reduction in number of thrips than the farmer practice. Similar trend was recorded in leaf hopper number in IPM module with significantly lower mean (0.8±0.6 number/top tree leaves) than farmer practice (2.5±1.3 number /top tree leaves) (P<t=0.00057). Highest number of leaf hoppers was recorded during 45 DAS (1.5±0.4 number/top 3 leaves) and lowest during 90 DAS (0.1±0.1 number/top 3 leaves) in IPM Module. IPM module recorded 67.1 per cent lower number of hoppers than farmer practice. Less number of leaf minor larva per plant in IPM module (0.1±0.1 to 0.7±0.2 number/top 3 leaves) were recorded throughout crop season than farmer practice (0.1±0.3 to 1.2±0.4 number/ top 3 leaves). Peak larval number were recorded during 75 DAS *i.e.* 0.7±0.2 number/top 3 leaves in IPM module and 45 DAS (0.8±0.3 number/top 3 leaves) in farmer practice. Implementation of IPM practices reduced 54.3% larval population over farmer practice. The per cent leaf damage due to *S. litura* recorded ranged from 3.42±0.7% to 12.88±2% per plant, which is less than farmer practice 8.38±1.5% to 22.84±5.6%. The IPM demonstration achieved a 56.7% reduction in leaf damage compared to the farmer practice.

**Pooled performance of integrated pest management module in groundnut crop at farmers' field for two years from *rabi* 2022-23 to 2023-2024**

Table 3 and Fig 3 depicted the pooled results of insect pests in groundnut crop. The mean number of thrips recorded was significantly lower *i.e.* 1.8±1.1 per terminal bud compared to the farmer practice *i.e.* 4.4±1.6 per terminal bud (P≤0.0001) and ETL (5 adults per terminal bud). This represented a 58.0% reduction of thrips compared to the farmer practice throughout the crop period. These investigations are in agreement with Biradar and Hegde (2016), who reported that azadirechtin found effective against thrips in groundnut by registering maximum reduction of pest population. Jasrotia *et al.* (2018), recorded that the castor as a trap crop for reduced population of thrips. Significantly lower mean number of leaf hoppers was observed in demonstration, with a mean 0.8±0.5 number/top 3 leaves compared to the farmer practice mean 2.6±1.1 number/top 3 leaves (P≤0.0002). Implementation of IPM module in reduced 70.8% of leaf hoppers than farmer practice. The demonstration recorded an average of 0.4± 0.2 leaf minor larvae/plant, which is lower than the farmer practice average of 1.3±0.6 larvae/plant and below the ETL

**Table 2:** Evaluation of integrated pest management module in ground nut crop at farmers' field during *Rabi* 2023-24.

| Mean no. of insect pests /Leaf damage/20 plants/10 locations | No. of thrips /terminal bud | | No. of Green leaf hoppers /top three leaves | | No. of Leaf minor larva/plant | | Per cent leaf damage due to tobacco caterpillar/ plant | |
|---|---|---|---|---|---|---|---|---|
| Crop stage / Treatments | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice |
| 15 DAS | 1.2±0.4 | 2.4±0.3 | 0.2±0.2 | 1.2±0.3 | 0 | 0 | 3.92±0.3 | 8.7±0.5 |
| 30 DAS | 3.3±0.7 | 4.4±0.4 | 1.4±0.4 | 2.2±0.3 | 0 | 0.7±0.3 | 5.9±0.8 | 18.6±6.4 |
| 45 DAS | 2.6±0.3 | 6.2±0.6 | 1.5±0.4 | 3.7±0.6 | 0.2±0.2 | 0.8±0.3 | 12.9±2.0 | 19.0±3.8 |
| 60 DAS | 2.3±0.4 | 5.5±0.5 | 1.3±0.3 | 4.2±0.3 | 0.6±0.3 | 0.1±0.3 | 8.9±2.2 | 22.8±5.6 |
| 75 DAS | 1.4±0.3 | 4.1±0.3 | 0.5±0.3 | 2.7±0.6 | 0.7±0.2 | 1.2±0.4 | 5.9±1.5 | 16.9±2.2 |
| 90 DAS | 0.1±0.1 | 1.6±0.3 | 0.1±0.1 | 1.2±0.3 | 0.1±0.1 | 0.7±0.3 | 3.4±0.7 | 8.4±1.5 |
| Mean population/plant | 1.8±1.1 | 4±1.8 | 0.8±0.6 | 2.5±1.3 | 0.3±0.1 | 0.6±0.2 | 6.8±1.5 | 15.8±2.6 |
| Insect population/leaf damage reduction over farmer practice (%) | 55.0 | | 67.1 | | 54.3 | | 56.7 | |
| P(T<=t) one-tail | 0.00012* | | 0.00057* | | 0.0042* | | 0.00213* | |

* Significant at P≤0.05; IPM-Integrated Pest Management; DAS-Days after Sowing.

*i.e.* 2 larvae/plant. Implementation of IPM practices reduced 72.4% leaf minor larval population in over the farmer practice (P<=t 0.0005). Leaf damage was significantly reduced from the seedling stage at 15 DAS to 30 DAS, when compared to the farmers practice and the ETL (10%). The demonstration recorded the highest percentage of leaf damage caused by *S.litura* 14.2±0.9% at 45 DAS, which was lower than both the ETL (20%) at 40 DAS and the farmer practice 20.9±2.6%. In comparison to farmer practice, there has been a 51.5% decrease in leaf damage caused by *S.litura* in the IPM demonstration. Results revealed that no incidence of thrips, leaf minor and green leaf hoppers were noticed up to 15 days after sowing (DAS) and also recorded low incidence up to 30 DAS, it might be due to the negative effect of seed treatment with chemical in IPM module up to 15 DAS and influence of trap crops, cow pea and soybean for leaf minor, which attracts different predators and parasitoids. The results of present study are also in line with Ranga Rao and Shanower, (1999), who reported that utilization of cultural practices like deep summer ploughing, trap crops, collection and destruction of egg masses are directly or indirectly know to insect pest control such as *Spodoptera*, thrips and leaf hoppers in groundnut. The results also confirmed with Pravalika *et al.* (2023) that application of systemic insecticides such as seed treatment with imidacloprid 600 FS @ 2.0 ml $kg^{-1}$ (+ 4 ml water) to seed was found more effective in reduction of thrips and leafhopper up to 30 DAS. Seetharamu *et al*. (2020) also reported identical results, confirming that imidacloprid 17.8 SL was effective in decreasing the number

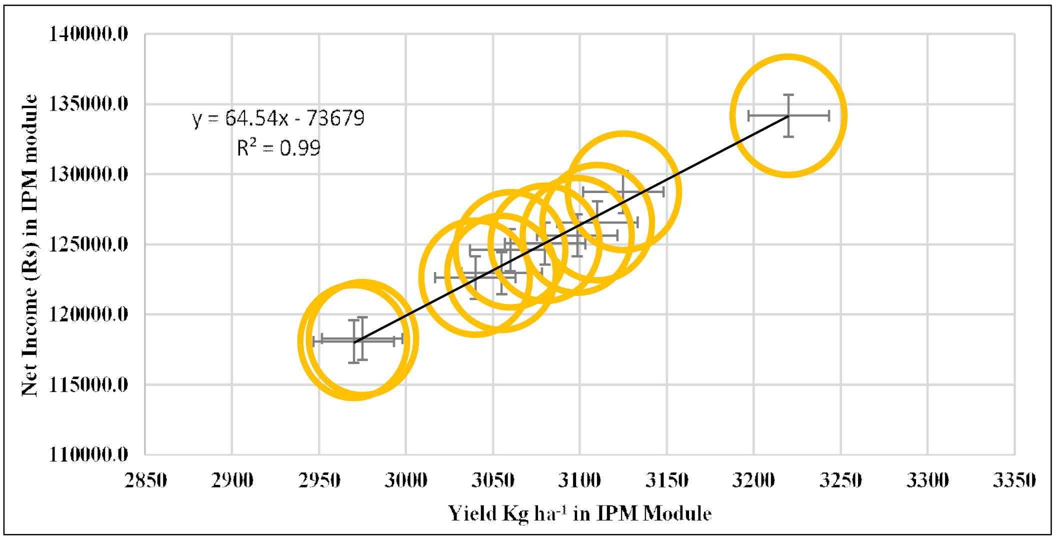


**Fig 2:** Three way correlation between Yield, Net Income and B:C ratio of IPM Demonstration in groundnut during 2022-23 to 2023-24.

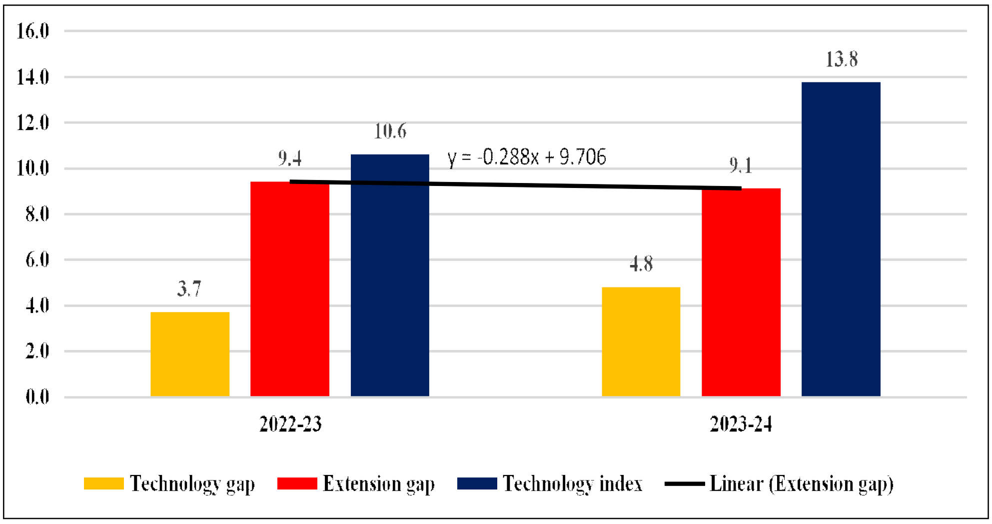


**Fig 3:** Technology gap, extension gap and technology index in adopting IPM strategy under front line demonstration in groundnut crop of farmers' field (2022-2024).

of thrips, aphids and leaf hoppers. It is used to control a variety of sucking insects. Application of poison bait *i.e.* 5 kg rice bran, 0.5 kg Jaggery and 500 g of thiodicarb found effective in controlling the fourth instar larva of *Spodoptera*.

**Economics of IPM demonstration in groundnut crop**

The economics on management of insect pests in groundnut crop during *Rabi* 2022-23 and 2023-24 was presented in Table 4. One of the primary factors that contributed to the total cost of cultivation in farmers' practices was the amount of money spent on pesticide treatment. The cost of cultivation in all the modules were calculated based on the prevailing prices at the time of experiment. The average total cost of IPM based groundnut production was ¹ 63280.10 ha$^{-1}$ and ¹ 62856.80 ha$^{-1}$-during 2022-23 and 2023-24, respectively, which was less than that of farmers practice (` 73104.40 ha$^{-1}$ and ` 74169.2 ha$^{-1}$). The groundnut yield was found higher on IPM demonstration (3128.50 Kg ha$^{-1}$ and 3018.20 Kg ha$^{-1}$) in relation to farmer's practice (2186.70 Kg ha$^{-1}$ and 2089.90 Kg ha$^{-1}$) indicating an increase of 43.1 and 44.4% yield, respectively. The net returns on IPM module were `119737.15 ha$^{-1}$ and ` 129613.81 ha$^{-1}$ higher than farmers practice ` 52687.95 ha$^{-1}$ and ` 49154.75 ha$^{-1}$, respectively. The Benefit-Cost ratio comparison showed that IPM practices give more benefit *i.e.* 2.89:1 and 3.06:1 compared to farmers practice 1.70:1 and 1.67:1, respectively. The pooled results of both years indicated that IPM demonstration recorded highest average net returns and B:C ratio *i.e.* `124675.5 ha$^{-1}$ and 2.98:1 compared to farmer practice `50921.4 ha$^{-1}$ and 1.69:1, with 43.7% average yield increment (3073.4 kg ha$^{-1}$). The avoidable yield loss due to insect pest recorded was 935.1 kg ha$^{-1}$ in IPM demonstration (Fig 3). The Pearson correlation interpretation between yield, net income and B:C ratio showed that the relationship was strongly positive correlation with "Pearson correlation coefficient" r= 0.9948 and 0.9915 ($R^2$: 0.99 and 0.99) (Fig 2), which indicated that higher net income depends on lowering cultivation cost and enhancing the yield. Implementation of IPM module was recorded lower cost of cultivation *i.e.* `63068.5 ha$^{-1}$ than farmer practice `74169.2 ha$^{-1}$. Kumbar *et al.* (2021) recorded similar results that yield of groundnut pods obtained from farmers practice and IPM module plots was 1326.07 kg pods ha$^{-1}$ and 1797.64 kg pods ha$^{-1}$ respectively. The avoidable yield losses observed due to pest were 471 kg pods ha$^{-1}$. The per cent reduction in the yield due to pests was computed as 10.82%. Madhushekar *et al.* (2022) recorded yield in the IPM demonstration increased from 3.7 to 4.8 q ha$^{-1}$ over potential yields (35 q ha$^{-1}$) by applying IPM technology. Similarly, the extension gap ranged from 9.7 to 9.1 and was the lowest during 2023-24. Scientists' attempts to educate farmers on important IPM treatments throughout crop growth phase have proven effective in increasing groundnut yield. A lower technological index 10.6% to 13.8% during study period was revealed, which indicates the *via.*bility of advanced

**Table 3:** Pooled results of integrated pest management module in ground nut crop at farmers' field for two years from *Rabi* 2022 to 2024.

| Mean no. of insect pests/Leaf damage/20 plants/10 locations | No. of thrips/terminal bud | | No. of green leaf hoppers /top three leaves | | No. of leaf minor larva/plant | | Per cent leaf damage due to tobacco caterpillar / plant | |
|---|---|---|---|---|---|---|---|---|
| Treatments / Crop Stage | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice | IPM demo | Farmer practice |
| 15 DAS | 1.3±0.1 | 3.1±1.0 | 0.3±0.1 | 1.5±0.2 | 0 | 0.2±0.2 | 4.9±0.3 | 9.4±1.0 |
| 30 DAS | 3.6±0.4 | 5.1±1.0 | 1.1±0.4 | 2.5±0.4 | 0.2±0.3 | 1.5±1.1 | 7.9±2.8 | 14.3±2.2 |
| 45 DAS | 2.4±0.1 | 6.3±0.1 | 1.3±0.2 | 3.6±0 | 0.4±0.2 | 1.7±1.3 | 14.2±0.9 | 20.9±2.6 |
| 60 DAS | 2.1±0.4 | 5.4±0.1 | 1.2±0 | 4.1±0.2 | 0.7±0.3 | 1.5±0.8 | 9.1±0.2 | 22.2±2.0 |
| 75 DAS | 1.5±0.2 | 4.3±0.4 | 0.5±0 | 2.4±0.3 | 0.6±0.1 | 1.7±0.7 | 6.9±0.5 | 19.4±1.5 |
| 90 DAS | 0.1±0 | 2.0±0.5 | 0.1±0.1 | 1.3±0 | 0.2±0 | 1.0±0.4 | 3.1±0.4 | 8.8±0.7 |
| Mean population/plant | 1.8±1.1 | 4.4±1.6 | 0.8±0.5 | 2.6±1.1 | 0.4±0.2 | 1.3±0.6 | 7.7±2.5 | 15.8±2.6 |
| Insect population/leaf damage reduction over farmer practice (%) | 58.0 | | 70.8 | | 72.4 | | 51.5 | |
| P(T<=t) one-tail | 0.0001* | | 0.0002* | | 0.0005* | | 0.0004* | |

*Significant at P≤0.05; IPM-Integrated Pest Management; DAS-Days after Sowing.

**Table 4**: Economics of evaluation of integrated pest management module in ground nut crop of farmers field (Pooled for the year 2022 to 2024).

| Farmer's name | Yield (Kg ha$^{-1}$) | | Increased yield over farmer practice (%) | Cost of cultivation (Rs. ha$^{-1}$) | | Gross returns (Rs.ha$^{-1}$) | | Net income (Rs. ha$^{-1}$) | | B:C ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | IPM module | FP | | IPM module | FP | IPM module | FP | IPM module | FP | IPM module | FP |
| Demonstration -1 | 3060 | 2140 | 43.0 | 62210.0 | 73860.0 | 186809.6 | 125190.0 | 124599.6 | 51330.0 | 3.00 | 1.61 |
| Demonstration -2 | 2970 | 2105 | 41.1 | 63625.0 | 73152.5 | 181702.7 | 123142.5 | 118077.7 | 49990.0 | 2.86 | 1.70 |
| Demonstration -3 | 3055 | 2154.5 | 41.8 | 63801.5 | 74637.5 | 186767.4 | 126038.3 | 122965.9 | 51400.8 | 2.93 | 1.67 |
| Demonstration -4 | 2975 | 2108.5 | 41.1 | 63586.5 | 74995.0 | 181876.6 | 123347.3 | 118290.1 | 48352.3 | 2.86 | 1.73 |
| Demonstration -5 | 3080 | 2115 | 45.6 | 63093.0 | 73757.0 | 188164.1 | 123727.5 | 125071.1 | 49970.5 | 2.98 | 1.61 |
| Demonstration -6 | 3125 | 2165 | 44.3 | 62106.5 | 73565.0 | 190849.3 | 126652.5 | 128742.8 | 53087.5 | 3.07 | 1.77 |
| Demonstration -7 | 3220 | 2175 | 48.0 | 62605.0 | 74450.0 | 196775.7 | 127237.5 | 134170.7 | 52787.5 | 3.14 | 1.69 |
| Demonstration -8 | 3040 | 2120 | 43.4 | 62825.0 | 73700.0 | 185455.2 | 124020.0 | 122630.2 | 50320.0 | 2.95 | 1.62 |
| Demonstration -9 | 3098.5 | 2100 | 47.5 | 63532.0 | 74040.0 | 189172.5 | 122850.0 | 125640.5 | 48810.0 | 2.98 | 1.63 |
| Demonstration -10 | 3110 | 2200 | 41.4 | 63300.0 | 75535.0 | 189866.4 | 128700.0 | 126566.4 | 53165.0 | 3.00 | 1.69 |
| Mean | 3073.4 | 2138.3 | 43.7 | 63068.5 | 74169.2 | 187743.9 | 125090.6 | 124675.5 | 50921.4 | 2.98 | 1.69 |

FP- Farmer Practice; IPM- Integrated Pest Management; B:C- Benefit: Cost ratio, ha- hectare.

technology in farmer's fields, with a lower number indicating greater visibility.

## CONCLUSION

The outcome of the present study demonstrated that IPM module was significantly superior in reducing the incidence of sucking pests *i.e.* leaf hoppers, thrips and leaf minors due to installation of blue sticky trap, spraying the crop with neem oil at early stage of crop growth. *S. litura* damage also control by installation of pheromone traps, collection of egg masses, spraying the crop with neem oil at early stage of crop growth, poison bait and insecticidal spray at later stage of crop growth. Adopting IPM module developed in the study reduces the 2-3 insecticide insecticidal spray compared to farmer practice. Implementation of IPM module had a more excellent B:C ratio (2.98:1) in demonstrating their economic potential. A lower technical index in the research location suggests more technological *via.*bility in farmer fields, which can be recommended in similar weather conditions. The results indicated that FLD trials had good impact on farming community of Warangal district as they were motivated by IPM technology applied through FLD in larger areas and they followed regularly instead of complete dependence on chemical practices during the succeeding years, resulting in enhancement in productivity and effective management of pests.

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### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy of the information provided.

### Informed consent

This informed consent document ensures that farmers understand their voluntary participation in research conducted by KVK, Mamnoor and ATARI Zone-X, aimed at improving agricultural practices.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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