www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(11): 172-179

www.thepharmajournal.com
Received: 02-09-2023
Accepted: 07-10-2023

NC Mandawi
SG, CARS, Jagdalpur, IGKV, Raipur, Chhattisgarh, India

Shubham Kale
SG, CARS, Jagdalpur, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
NC Mandawi
SG, CARS, Jagdalpur, IGKV, Raipur, Chhattisgarh, India

The efficacy of botanical insecticides against for major insect pests of rice crop

NC Mandawi and Shubham Kale

Abstract
In the evaluation of different botanical insecticides, different botanicals and insecticides were applied at 25, 45 and 65 DAT under a treatment. The experiment was performed at Research cum Instructional farm of SGCARS, Jagdalpur. The results revealed that T_1 (Combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1}) was most effective combination with 40.74%, 63.09%, 54.29% and 56.44% ROC respectively for gall midge, stem borer, leaf folder and whorl maggot infestation. This treatment was superior to T_2 (Neemazal 1% EC @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}) having 36.69%, 59.32%, 52.16% and 47.99% ROC, respectively for gall midge, stem borer, leaf folder and whorl maggot infestation. The least effective combination was T_3 (Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Neemoil @ 10 ml L^{-1}) with 29.19%, 48.75%, 41.27% and 35.81% ROC for gall midge, stem borer, leaf folder and whorl maggot, respectively but it was superior to T_5 (untreated control). The check treatment T_4 (Chlorantraniliprole 0.4G @ 1 g/m^2, Cartap hydrochloride 50% SC @ 2 g L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}) had the highest ROC of 64.52%, 86.60%, 83.08% and 74.61% ROC for gall midge, stem borer, leaf folder and whorl maggot, respectively.

Keywords: Rice, botanical insecticides, gall midge, yellow stem borer, leaf folder whorl maggot, grain yield

Introduction
More than two-thirds of the population of India and more than 65 percent of the world's population depend on rice (*Oryza sativa* L.), a key staple food crop (Mathur *et al*., 1999) [14]. India is the country that produces the largest amount of rice, making up more than 40% of the world's total grain production. The widespread adoption of new rice varieties has increased the prevalence of many insect pests on the rice crop across India. In India, there are approximately 70 pests that infest rice and 20 of them are prevalent. The pests harm the rice production by 25-30% (Lal, 1996) [12]. Nearly 20 insects, including stem borers, gall midges, leaf folders, defoliators, and vectors like leafhoppers and plant hoppers that cause serious damage and spread many diseases, have been recognized as rice pests of economic importance. (Pasalu *et al.*, 2002). From planting to harvest, all plant portions of rice crop are susceptible to insect infestations, which can result in yearly yield losses of between 25 and 30 percent (Khan *et al*., 2003) [16].

Conventional insecticides have intrinsic toxicities that are harmful to the environment, consumers, and the health of farm workers. Negative effects on human health led to a resurgence in interest in botanical insecticides because of their minimal costs and ecological side effects. Traditional pesticides contain inherent toxicities that are hazardous for consumers, the environment, and farm workers' health. Because of this, interest in botanical pesticides has increased. Alternatives to conventional broad-spectrum pesticides include botanicals. Botanicals are preferable to traditional broad-spectrum insecticides. They are effective in very small concentrations, only affect the targeted pest and closely related organisms, degrade quickly, and offer residue-free food and a secure environment to live. When used in integrated pest management programmes, rotational applications, or in combination with other insecticides, botanical pesticides can significantly reduce the use of conventional pesticides. This may result in a reduction in the total amount of pesticides used while potentially preventing or delaying the emergence of pest populations with resistance (Khater, 2012) [10].

With a view to a sustainable strategy, it is necessary to identify new chemicals and plant-based products with selective qualities, low toxicity to non-target insects, and environmental safety in order to reduce the prevalence of insect pests.

Some of these environmentally friendly insecticides are very efficient against these harmful insects (Hannig *et al*., 2009; Marchesini *et al*., 2008) [5, 13]. The present study evaluates such insecticides and botanicals combinations against gall midge, stem borers, leaf folder and whorl maggot of rice.

Materials and Methods

The experiment was conducted in research cum instructional farm of Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) during *Kharif*, 2021. On Swarna variety of rice, a field experiment was carried out to assess the effectiveness of botanicals and insecticides against gall midge, stem borer, leaf folder, and whorl maggot. The crop was transplanted in four replications with five treatments in a 20 m^2 plot using a randomized block design. The row to row and plant to plat spacing was 20 x 15cm. During the crop growth period, all agronomic operations were followed. The botanicals and chemical insecticides were Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1}, Cartap hydrochloride 50% SC @ 2 g L^{-1}, Triflumezopyrim 10% SC @ 0.48 ml L^{-1}, Chlorantraniliprole 0.4G @ 1 g m^{-2} and untreated control were evaluated for their efficacy against four major insect pests of rice. The complete details of different treatments are provided in Table 1.

Three applications of the test insecticides were applied on need basis.

1. First application was applied in the field at 25 DAT
2. Second application was applied in the field at 45 DAT
3. Third application was applied in the field at 65 DAT

The data recorded were gall midge as silver shoot (SS%), stem borer as dead heart (DH%), leaf folder and whorl maggot as damaged leaf (DL%) were recorded on 30, 50 and 70 days after transplanting and then damage percentages were worked out. Healthy and damaged tillers or leaves per hill were recorded for the percent infestation of major insect pests. Each plot's ten randomly selected hills were inspected for the damage caused by the major insect pests *i.e*., gall midge, stem borer, leaf folder, and whorl maggot. Percent infestations of insect-pests were calculated by given formula:

$$\text{Percent silver shoot (SS \%)} = \frac{\text{Number of silver shoots}}{\text{Total numbers of tillers}} \times 100$$

$$\text{Percent dead heart (DH \%)} = \frac{\text{Number of dead hearts}}{\text{Total numbers of tillers}} \times 100$$

$$\text{Percent damage (LF \%)} = \frac{\text{Number of damaged leaves}}{\text{Total numbers of leaves}} \times 100$$

$$\text{Percent damage (WMD \%)} = \frac{\text{Number of damaged leaves}}{\text{Total numbers of leaves}} \times 100$$

Statistical analysis

The study was carried out in Randomized Block Design. The data were analyzed statistically using appropriate transformation. If most of the values in the data set are small (e.g., less than 10), especially with zeroes present, $\sqrt{x + 0.5}$ should be used instead of $\sqrt{x}$, where x is the original data. This transformed data was then analysed by the method of analysis of variance. The 'F' test was used at 5% level of significance. Critical difference (CD) values were analyzed at 5% level of significance (Gomez and Gomez, 1984; Draper and Smith, 1998) [3].

CD= SE_d (Standard error of deviation) x Table t-value at 5% of significance.

Results and Discussion

Efficacy of insecticides against gall midge (*Orseolia oryzae* Wood mason)

According to the data presented (Table 2), the efficacy of botanicals and insecticidal treatments were significantly superior to the untreated control. The 1st spray was applied at 25 Days after transplanting (DAT) and the observation was recorded at 30 DAT, the treatment T_1 - Neemazal 1% EC @ 2 ml L^{-1} was observed with best results (35.03 SS%) and T_2 - Neemazal 1% EC @ 2 ml L^{-1} with T_3 - Neemazal 1% EC @ 2 ml L^{-1} were at par with T_1 having 35.73 SS% and 40.37 SS% respectively. The highest incidence of silver shoot was received in case of untreated plot T_5 (53.54 SS%). Treatment T_4 - Chlorantraniliprole 0.4 G @ 1 g m^{-2} depicted minimum incidence of silver shoot (23.42 SS%), which was a check.

The 2nd spray was applied at 45 DAT and the observation was recorded at 50 DAT, all the botanicals and insecticidal treatments were significantly superior to the untreated control. Better reduction of silver shoot incidence was observed in T_1 - Eucalyptus oil @ 2 ml L^{-1} (15.56 SS%) and T_2 - Neemazal 1% EC @ 2 ml L^{-1} with T_3 - Neemazal 1% EC @ 2 ml L^{-1} were at par with T_1 having 17.18 SS% and 18.59 SS% respectively. Best results were recorded when applied T_4 - Cartap hydrochloride 50% SC @ 2 g L^{-1} with 7.62 SS%, which was a check. The highest incidence of silver shoot (28.42 SS%) was received in case of untreated plot (T_5).

The 3rd spray was applied at 60 DAT and the observation was recorded 70 DAT, all the botanicals and insecticidal treatments continued to perform significantly superior to the untreated control. Treatment T_1 - Cartap hydrochloride 50% SC @ 2 g L^{-1} (8.59 SS%) showed best results, T_2 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} (10.33 SS%) and T_3 - Neemoil @ 10 ml L^{-1} (11.76 SS%) both were at par with T_1. Plots treated with the check treatment T_4 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} showed the minimum incidence of silver shoot (4.39 SS%). The maximum incidence of silver shoot was received in case of untreated control (T_5) with 17.91 percent.

The data pertaining to the efficacy of botanicals and insecticides against rice gall midge has been pooled and presented in Table 2, showing that all the treatments were significantly superior over untreated control and they were reducing silver shoot percentage. Among treatments, the best result was shown by treatment T_1 (19.73 SS%), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, with 40.74 percent reduction over control (ROC) followed by T_2 (21.08 SS%) with 36.69% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}, T_3 (23.57 SS%) with 29.19% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Neemoil @ 10 ml L^{-1} applied at 25, 45 and 65 DAT respectively. T_2 and T_3 were at par with T_1. Check treatment was T_4 (11.81 SS%) with 64.52 percent reduction over control (ROC), which was combination of

different chemicals *viz*., Chlorantraniliprole 0.4G @ 1 g m^{-2}, Cartap hydrochloride 50% SC @ 2 g L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1} applied at 25, 45 and 65 DAT respectively.

Earlier, Mohapatra (2018) revealed that Handi Ausadha (pot mixture of 5 L fermented cow urine + 1 kg fresh cow dung + 1 kg Karanj + 1 kg Neem + 1 kg Calotropis + 50 g Gur) @ 20 mlL^{-1} was found to be significantly superior in reducing gall midge (61.93% SS). Sen (2019) [18] also reported that cedar wood oil at 1000 ml ha^{-1} proved successful in lowering gall midge occurrence.

Similarly, Karthikeyan and Swathy (2020) [7] revealed that cholantraniliprole was the most effective insecticide against the gall midge with 1.82% silver shoot, while Neemazal treated plots had decreased gall midge with 5.38% silver shoot.

Efficacy of insecticides against yellow stem borer (*Scirpophaga Incertulas* Walker)

From the data presented (Table 3), the efficacy of botanicals and insecticidal treatments were significantly superior to the untreated control. The 1st spray was applied at 25 DAT and the observation was recorded at 30 DAT. The treatment T_1 - Neemazal 1% EC @ 2 ml L^{-1} was observed with best results (2.51% DH) and T_2 - Neemazal 1% EC @ 2 ml L^{-1} with T_3 - Neemazal 1% EC @ 2 ml L^{-1} were at par with T_1 having 2.64% DH and 3.08% DH respectively. Treatment T_4 - Chlorantraniliprole 0.4 G @ 1 g m^{-2} depicted minimum incidence of stem borer (0.54% DH), which was a check. The highest incidence of dead heart was received in case of untreated plot T_5 (7.38% DH).

The 2nd spray was applied at 45 DAT and the observation was recorded at 50 DAT, all the botanicals and insecticidal treatments were significantly superior to the untreated control. Better reduction of stem borer incidence was observed in T_1 - Eucalyptus oil @ 2 ml L^{-1} (2.93% DH) and T_2 - Neem oil @ 10 ml L^{-1} (3.24% DH) and T_3 - Eucalyptus oil @ 2 ml L^{-1} (4.41% DH). T_2 and T_3 were at par with T_1. Best results were recorded in check treatment T_4 - Cartap hydrochloride 50% SC @ 2 g L^{-1} with 1.43% DH. The highest incidence of stem borer (8.69% DH) was received in case of untreated plot (T_5).

The 3rd spray was applied at 65 DAT and the observation was recorded at 70 DAT, all the botanicals and insecticidal treatments continued to perform significantly superior to the untreated control. Treatment T_1 - Cartap hydrochloride 50% SC @ 2 g L^{-1} (3.18% DH) showed best results, T_2 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} (3.62% DH) and T_3 - Neem oil @ 10 ml L^{-1} (4.48% DH) both were at par with T_1. Plots treated with the check treatment T_4 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} showed the minimum incidence of dead heart (1.16% DH), the maximum incidence of stem borer (DH) was received in case of untreated control (T_5) with 7.26 percent.

The data pertaining to the efficacy of botanicals and insecticides against rice yellow stem borer has been collaborated and presented in Table 3, showing that all the treatments were significantly superior over untreated control and they were reducing dead heart percentage. Among treatments, the best result was shown by treatment T_1 (2.87% DH), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, with 63.09 percent reduction over control (ROC), T_2 (3.16% DH) with 59.32% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}, T_3 (3.99% DH) with 48.75% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Neemoil @ 10 ml L^{-1} applied at 25, 45 and 65 DAT respectively, both were at par with T_1. Check treatment was T_4 (1.04% DH) with 86.60 percent reduction over control (ROC), which was combination of different chemicals *viz*., Chlorantraniliprole 0.4G @ 1 g m^{-2}, Cartap hydrochloride 50% SC @ 2 g L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1} applied at 25, 45 and 65 DAT respectively.

Former researcher, Dhaliwal *et al*. (2002) [2] evaluated four high potency azadirachtin-based neem formulations, including Rakshak 1%, Neemazal 1% and 5%, and Nimbecidine 0.03% against the yellow stem borer, monocrotophos had the lowest incidence of YSB and was on par with Neemazal at 5% @ 0.50 ml L^{-1}.

Correspondingly, Islam *et al*. (2013) [6] also reported that white head and dead heart were both reduced by 58.08% and 38.38%, respectively, when botanical extracts, namely Tobacco, Neem, and Karanja extracts at a concentration of 15 ml L^{-1} each, as well as two insecticides, Acephate 75 SP at a concentration of 2 g L^{-1} and Fipronil (Nema 50 SC) at a concentration of 2 ml L^{-1}, were included in the treatment's concentrations against the yellow stem borer, *Scirpophaga Incertulas*.

Efficacy of insecticides against leaf folder (*Cnaphalocrosis medinalis* Guenee)

It is evident from the data presented (Table 4), that the efficacy of botanicals and insecticidal treatments were significantly superior to the untreated control. The 1st spray was applied at 25 Days after transplanting (DAT) and the observation was recorded at 30 DAT. The treatment T_2 - Neemazal 1% EC @ 2 ml L^{-1} recorded best results (2.53% DL) and T_1 - Neemazal 1% EC @ 2 ml L^{-1} with T_3 - Neemazal 1% EC @ 2 ml L^{-1} were at par with T_2, having 2.96% DL and 3.46% DL respectively. In the check T_4 - Chlorantraniliprole 0.4 G @ 1 g m^{-2} had minimum incidence of leaf folder (0.54% Damaged Leaves), the highest incidence of leaf folder was received in case of untreated plot T_5 (5.45% DL).

The 2nd spray was applied at 45 DAT and the observation was recorded at 50 DAT, all the botanicals and insecticidal treatments were significantly superior to the untreated control. Good reduction of leaf folder incidence was observed in T_1 - Eucalyptus oil @ 2 ml L^{-1} (3.41% DL), T_2 - Neemoil @ 10 ml L^{-1} (3.98% DL) and T_3 - Eucalyptus oil @ 2 ml L^{-1} (4.99% DL), T_2 and T_3 were at par with T_1. Best results were recorded when applied T_4 - Cartap hydrochloride 50% SC @ 2 g L^{-1} with 1.41 DL%, which was a check. The highest incidence of silver shoot (8.43% DL) was recorded in case of untreated plot (T_5).

The 3rd spray was applied at 65 DAT and the observation was recorded at 70 DAT, all the botanicals and insecticidal treatments continued to perform significantly superior to the untreated control. T_1 - Cartap hydrochloride 50% SC @ 2 g L^{-1} (2.87% DL) showed best results, T_2 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} (3.17% DL) and T_3 – Neem oil @ 10 ml L^{-1} (3.42% DL), T_2 and T_3 were at par with T_1. Plots treated with the check treatment T_4 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} showed the minimum incidence of leaf folder (1.47% DL), the maximum incidence of silver shoot was received in case of untreated control (T_5) with 6.34 percent.

The data pertaining to the efficacy of botanicals and insecticides against rice leaf folder has been pooled and presented in Table 4, showing that all the treatments were significantly superior over untreated control and they were reducing damaged leaf percentage. Among treatments, the best result was shown by treatment T_1 (3.08% DL), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, with 54.29 percent reduction over control (ROC) followed by T_2 (3.22% DL) with 52.16% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}, T_3 (3.96% DL) with 41.27% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Neemoil @ 10 ml L^{-1} applied at 25, 45 and 65 DAT respectively. Check treatment was T_4 (1.14% DL) with 83.08 percent reduction over control (ROC), which was combination of different chemicals *viz*., Chlorantraniliprole 0.4G @ 1 g m^{-2}, Cartap hydrochloride 50% SC @ 2 g L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1} applied at 25, 45 and 65 DAT respectively.

Preceding investigator, Lai (2001) reported that Neemgold (2%) and Neemazal (0.3%) were shown to be at par with chlorpyrifos in controlling *C. medinalis*, and the larval population was reduced to 1 larva/10 hills from 7/10 hills.

Likewise, according to Bhojane *et al*. (2020), azadirachtin was determined to be the most effective treatment for leaf folders, recording (5.35%) infected leaves per hill compared to untreated control (12.99%).

Efficacy of insecticides against Whorl maggot, (*Hydrellia philippina* Ferino)

From the data presented (Table 5), the efficacy of botanicals and insecticidal treatments were significantly superior to the untreated control. The 1st spray was applied at 25 Days after transplanting (DAT) and the observation was recorded 30 DAT. The treatment T_1 - Neemazal 1% EC @ 2 ml L^{-1} was observed with best results (4.97% DL) and T_2 - Neemazal 1% EC @ 2 ml L^{-1} with T_3 - Neemazal 1% EC @ 2 ml L^{-1} were at par with T_1 having 6.07% DL and 8.12% DL respectively. The treatment T_4 - Chlorantraniliprole 0.4 G @ 1 g m^{-2} recoded minimum incidence of whorl maggot (2.96% DL), which was a check, the highest incidence of dead heart was observed in case of untreated plot T_5 (9.18% DL).

The 2nd spray was applied at 45 DAT and the observation was recorded at 50 DAT, all the botanicals and insecticidal treatments were significantly superior to the untreated control. Better reduction of whorl maggot incidence was observed in T_1 - Eucalyptus oil @ 2 ml L^{-1} (4.15% DL) and T_2 - Neemoil @ 10 ml L^{-1} (4.61% DL) with T_3 - Eucalyptus oil @ 2 ml L^{-1} (5.11% DL) were at par with T_1. Best results were recorded in check treatment T_5 - Cartap hydrochloride 50% SC @ 2 g L^{-1} with 2.49% DL and the highest incidence of whorl maggot (9.90% DL) was received in case of untreated plot (T_5).

The 3rd spray was applied at 65 DAT and the observation was recorded 70 DAT, all the botanicals and insecticidal treatments continued to perform significantly superior to the untreated control. T_1 - Cartap hydrochloride 50% SC @ 2 g L^{-1} (2.65% DL) showed best results, T_2 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} (3.37% DL) and T_3 - Neemoil @ 10 ml L^{-1} (4.12% DL), both were at par with T_1. Plots treated with the check treatment T_4 - Triflumezopyrim 10% SC @ 0.48 ml L^{-1} showed the minimum incidence of whorl maggot (1.41% DL), the maximum incidence of whorl maggot (DL) was received in case of untreated control (T_5) with 7.94 percent.

The data pertaining to the efficacy of botanicals and insecticides against rice whorl maggot has been collaborated and presented in Table 5, showing that all the treatments were significantly superior over untreated control and they were reducing whorl maggot damage percentage. Among treatments, the best result was shown by treatment T_1 (3.92% DL), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, with 56.44 percent reduction over control (ROC) followed by T_2 (4.68% DL) with 47.99% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Neemoil @ 10 ml L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1}, T_3 (5.78% DL) with 35.81% ROC, which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Neemoil @ 10 ml L^{-1}, applied at 25, 45 and 65 DAT respectively. Check treatment was T_4 (2.29% DL) with 74.61 percent reduction over control (ROC), which was combination of different chemicals *viz*., Chlorantraniliprole 0.4G @ 1 g m^{-2}, Cartap hydrochloride 50% SC @ 2 g L^{-1} and Triflumezopyrim 10% SC @ 0.48 ml L^{-1} applied at 25, 45 and 65 DAT respectively.

Earlier, Sudhakar (2000) revealed that Neemorate at 20 kg/ha was more effective in controlling whorl maggot compared to the lower dose of 15 kg ha^{-1}. Repelin and Neemax (spray formulations) were slightly superior in minimizing pests when sprayed alone compared to the control. The effectiveness of the spray formulations increased when applied in combination with chlorpyrifos.

Similarly, Karthikeyan *et al*. (2010) [8] also observed that alternate spraying of neem-based formulation and newer safe insecticides (cartap hydrochloride and spinosad) resulted in significant reduction of whorl maggot (4.10% damaged leaves), whorl maggot infestation indicated 61.03% reduction in this module.

Yield analysis

The results (Table 6) indicated that there was significant yield difference among the treatments after spray. The yield was recorded in all insecticides treatment T4 – (Check) Chlorantraniliprole, Cartap hydrochloride, Triflumezopyrim recorded the highest grain yield of 49.65 q ha^{-1} with 31.91% increase over control followed by T1 - Neemazal, Eucaluptus oil and Cartap hydrochloride with 46.78 q ha^{-1} (24.28% IOC). The other treatment T2 Neemazal 1% EC, Neemoil, Triflumezopyrim 10% SC was recorded with grain yield of 44.35 q ha^{-1} with 14.40% increase over control, T3 - Neemazal 1% EC, Eucalyptus oil, Neem oil was observed with grain yield of 43.06 kg/ha with 14.40% increase over control. On the basis of reduction in incidence of rice gall midge, yellow stem borer, leaf folder, whorl maggot and result of yield of rice cultivation under investigation. It is concluded that the application of treatment T_1 (3.92% DL), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, proved most effective in control of rice gall midge, yellow stem borer, leaf folder and whorl maggot under field conditions.

Table 1: Details about the insecticidal treatments

Treatment	Treat no.	Insecticide	Dosage (ml L^{-1} or g m^2)
Botanicals + insecticides	T_1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}
		Eucalyptus oil (45 DAT)	2 ml L^{-1}
		Cartap hydrochloride 50% SC (65 DAT)	2 g m^{-2}
Botanicals + Insecticides	T_2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}
		Neemoil (45 DAT)	10 ml L^{-1}
		Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}
Botanicals + Insecticides	T_3	Neem Baan (Azadirachtin 10000 ppm) (25 DAT)	2 ml L^{-1}
		Karanj oil (45 DAT)	10 ml L^{-1}
		Fipronil 0.3 GR (65 DAT)	2.5 g m^{-2}
All Botanicals	T_4	Neemazal 1% EC (25 DAT)	2 ml L^{-1}
		Eucalyptus oil (45 DAT)	2 ml L^{-1}
		Neem oil (65 DAT)	10 ml L^{-1}
All insecticide	T_5	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}
		Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}
		Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}
Untreated control	T_6	Untreated control	

Table 2: Effect of the botanical insecticides against gall midge at different growth stages of rice crop

Treatments		Dosage	Damage caused by Gall midge (Silver shoots %)				ROC%
			30 DAT	50 DAT	70 DAT	Overall mean	
T_1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	35.03 (5.96)	15.56 (4.04)	8.59 (3.08)	19.73 (4.53)	40.74
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Cartap hydrochloride 50% SC (60 DAT)	2 g m^{-2}					
T_2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	35.73 (6.06)	17.18 (4.25)	10.33 (3.33)	21.08 (4.70)	36.69
	Neemoil (45 DAT)	10 ml L^{-1}					
	Triflumezopyrim 10% SC (60 DAT)	0.48 ml L^{-1}					
T_3	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	40.37 (6.43)	18.59 (4.31)	11.76 (3.56)	23.57 (4.94)	29.19
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Neem oil (60 DAT)	10 ml L^{-1}					
T_4	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}	23.42 (4.91)	7.62 (2.93)	4.39 (2.32)	11.81 (3.58)	64.52
	Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}					
	Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}					
T_5	Untreated control		53.54 (7.35)	28.42 (5.40)	17.91 (4.34)	33.29 (5.84)	0.00
	SE(m)±		0.32	0.35	0.18	0.21	
	C.D. at 5%		1.00	1.09	0.56	0.65	

*Figures in this parenthesis are square root transformed values($\sqrt{x + 0.5}$),
ROC= Reduction percent over control, DAT= Days after transplanting

Table 3: Effect of the botanical insecticides against stem borer at different growth stages of rice crop

Treatments		Dosage	Damage caused by stem borer				ROC%
			30 DAT	50 DAT	70 DAT	Overall mean	
T1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	2.51 (1.87)	2.93 (1.97)	3.18 (2.01)	2.87 (1.96)	63.09
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Cartap hydrochloride 50% SC (60 DAT)	2 g m^{-2}					
T2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	2.64 (1.90)	3.24 (2.03)	3.62 (2.14)	3.16 (2.03)	59.32
	Neemoil (45 DAT)	10 ml L^{-1}					
	Triflumezopyrim 10% SC (60 DAT)	0.48 ml L^{-1}					
T3	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	3.08 (2.01)	4.41 (2.32)	4.48 (2.33)	3.99 (2.23)	48.75
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Neem oil (60 DAT)	10 ml L^{-1}					
T4	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}	0.54 (1.22)	1.43 (1.55)	1.16 (1.47)	1.04 (1.43)	86.60
	Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}					
	Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}					
T5	Untreated control		7.38 (2.86)	8.69 (3.11)	7.26 (2.86)	7.78 (2.95)	0
	SE(m)±		0.15	0.11	0.12	0.09	
	C.D. at 5%		0.48	0.34	0.38	0.27	

*Figures in this parenthesis are square root transformed values($\sqrt{x + 0.5}$),
ROC= Reduction percent over control, DAT= Days after transplanting

Table 4: Effect of the botanical insecticides against leaf folder at different growth stages of rice crop

Treatments		Dosage	Damage caused by leaf folder				ROC%
			30 DAT	50 DAT	70 DAT	Overall mean	
T_1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	2.96 (1.97)	3.41 (2.09)	2.87 (1.97)	3.08 (2.02)	54.29
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Cartap hydrochloride 50% SC (60 DAT)	2 g m^{-2}					
T_2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	2.53 (1.87)	3.98 (2.22)	3.17 (2.04)	3.22 (2.05)	52.16
	Neemoil (45 DAT)	10 ml L^{-1}					
	Triflumezopyrim 10% SC (60 DAT)	0.48 ml L^{-1}					
T_3	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	3.46 (2.11)	4.99 (2.43)	3.42 (2.09)	3.96 (2.22)	41.27
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Neem oil (60 DAT)	10 ml L^{-1}					
T_4	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}	0.54 (1.24)	1.41 (1.55)	1.47 (1.57)	1.14 (1.46)	83.08
	Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}					
	Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}					
T_5	Untreated control		5.45 (2.54)	8.43 (3.06)	6.34 (2.70)	6.74 (2.78)	0
	SE(m)±		0.10	0.15	0.10	0.07	
	C.D. at 5%		0.32	0.46	0.30	0.22	

*Figures in this parenthesis are square root transformed values($\sqrt{x+0.5}$),
ROC= Reduction percent over control, DAT= Days after transplanting

Table 5: Effect of the botanical insecticides against whorl maggot at different growth stages of rice crop

Treatments		Dosage	Damage caused by whorl maggot				ROC%
			30 DAT	50 DAT	70 DAT	Overall mean	
T1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	4.97 (2.44)	4.15 (2.27)	2.65 (1.90)	3.92 (2.22)	56.44
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Cartap hydrochloride 50% SC (60 DAT)	2 g m^{-2}					
T2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	6.07 (2.65)	4.61 (2.36)	3.37 (2.08)	4.68 (2.38)	47.99
	Neemoil (45 DAT)	10 ml L^{-1}					
	Triflumezopyrim 10% SC (60 DAT)	0.48 ml L^{-1}					
T3	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	8.12 (3.01)	5.11 (2.45)	4.12 (2.26)	5.78 (2.60)	35.81
	Eucalyptus oil (45 DAT)	2 ml L^{-1}					
	Neem oil (60 DAT)	10 ml L^{-1}					
T4	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}	2.96 (1.97)	2.49 (1.86)	1.41 (1.55)	2.29 (1.81)	74.61
	Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}					
	Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}					
T5	Untreated control		9.18 (3.18)	9.90 (3.30)	7.94 (2.99)	9.01 (3.16)	0
	SE(m)±		0.11	0.10	0.08	0.05	
	C.D. at 5%		0.33	0.31	0.25	0.15	

*Figures in this parenthesis are square root transformed values($\sqrt{x+0.5}$),
ROC= Reduction percent over control, DAT= Days after transplanting

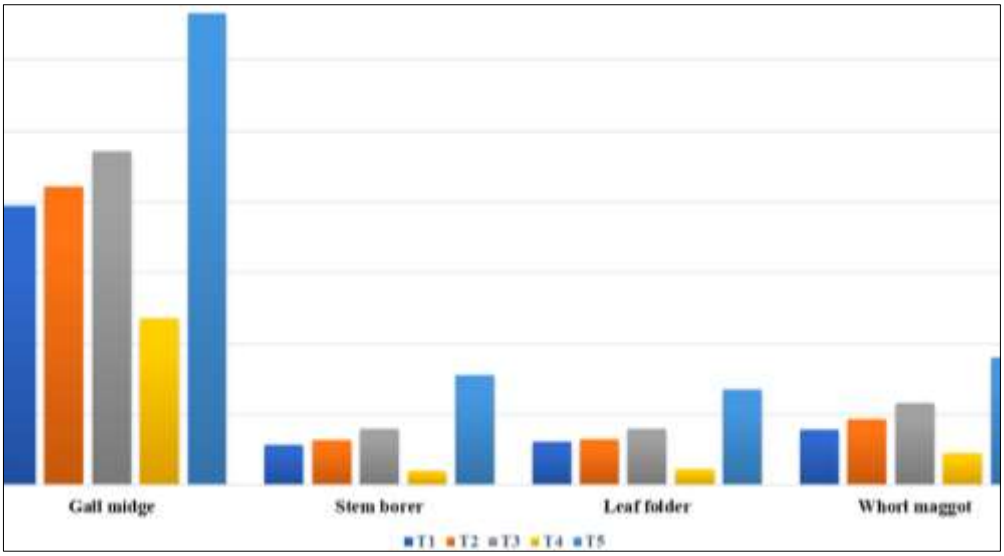

Fig 1: Effect of the botanical insecticides against major insect pests of rice crop during *Kharif* 2021

Table 6: Yield analysis of different treatments

Treatments		Dosage	Yield	
			Q/ha	% IOC
T_1	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	46.78	24.28
	Eucalyptus oil (45 DAT)	2 ml L^{-1}		
	Cartap hydrochloride 50% SC (60 DAT)	2 g m^{-2}		
T_2	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	44.35	17.83
	Neemoil (45 DAT)	10 ml L^{-1}		
	Triflumezopyrim 10% SC (60 DAT)	0.48 ml L^{-1}		
T_3	Neemazal 1% EC (25 DAT)	2 ml L^{-1}	43.06	14.40
	Eucalyptus oil (45 DAT)	2 ml L^{-1}		
	Neem oil (60 DAT)	10 ml L^{-1}		
T_4	Chlorantraniliprole 0.4G (25 DAT)	1.0 g m^{-2}	49.65	31.91
	Cartap hydrochloride 50% SC (45 DAT)	2 g m^{-2}		
	Triflumezopyrim 10% SC (65 DAT)	0.48 ml L^{-1}		
T_5	Untreated control		37.64	0
	SE(m))±		1.03	
	C.D. at 5%		3.22	

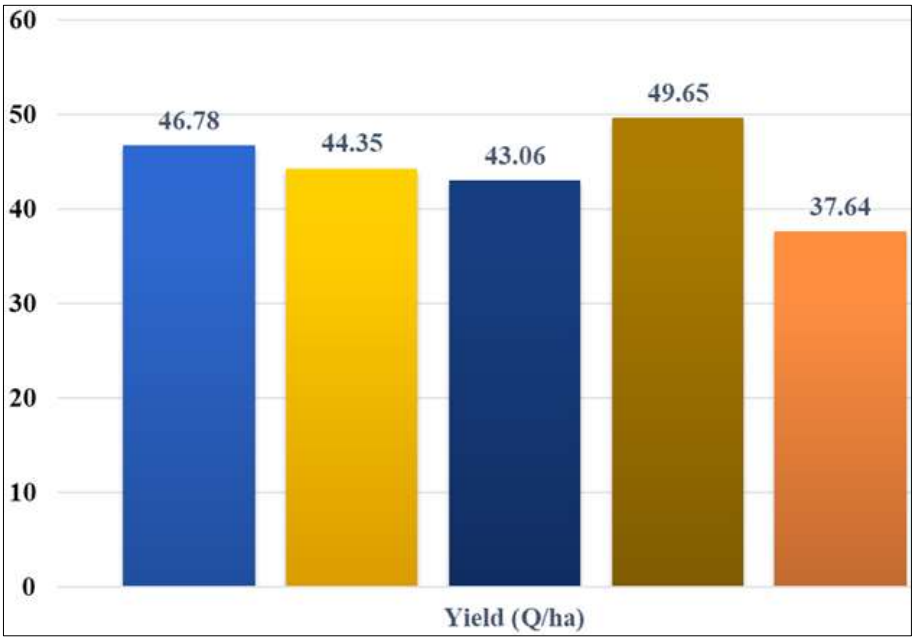

Fig 2: Yield recorded on different treatments

Conclusion

In the evaluation of botanical insecticides, Among the treatments, significantly superior results were recorded in check treatment T_4 (containing combination of Chlorantraniliprole 0.4G, Cartap hydrochloride 50% SC and Triflumezopyrim 10% SC) for all major insect pests with 64.52% ROC, 86.60% ROC, 83.08% ROC and 74.61% ROC in gall midge, stem borer, leaf folder and whorl maggot respectively.

Among the treatments, T_1 (combination of Neemazal 1% EC, Eucalyptus oil and Cartap hydrochloride 50% SC) performed best (40.74% ROC) against gall midge and against stem borer, T_1 (combination of Neemazal 1% EC, Eucalyptus oil and Cartap hydrochloride 50% SC) performed best (63.09% ROC).

For leaf folder, T_1 (combination of Neemazal 1% EC, Eucalyptus oil and Cartap hydrochloride 50% SC) was found to be superior (54.29% ROC. Against whorl maggot, T_1 (combination of Neemazal 1% EC, Eucalyptus oil and Cartap hydrochloride 50% SC) performed best (56.44% ROC.

The yield analysis concluded that the application of treatment T_1 (3.92% DL), which was combination of Neemazal 1% EC @ 2 ml L^{-1}, Eucalyptus oil @ 2 ml L^{-1} and Cartap hydrochloride 50% SC @ 2 g L^{-1} applied at 25, 45 and 65 DAT respectively, proved most effective in control of rice gall midge, yellow stem borer, leaf folder and whorl maggot under field conditions.

Acknowledgements

The authors are highly thankful to ICAR-IIRR (Indian Institute of Rice Research), Rajendranagar, Hyderabad and IGKV, Raipur for financial assistance. The authors duly acknowledge all the institutes for technical and financial support for research.

The experiment was conducted in a randomized block design with 4 replications. The experiment consists of 6 different treatments.

References

1. Bhojane SN, Desai VS, Wade PS, Jalgaonkar VN, Wankhede SM, Desai SD, *et al*. Management of major pests infesting rice (*Oryza sativa* L.) using botanicals. Journal of Entomology and Zoology Studies. 2020;8(4):1962-1964.
2. Dhaliwal GS, Multani JS, Singh S, Kaur G, Dilawari VK, Singh J, *et al*. Field evaluation of azadirachtin-rich neem

formulations against *Cnaphalocrocis Medinalis* (Guenee) and *Scirpophaga incertulas* (Walker) on rice. Pesticide Research Journal. 2002;14(1):69-76.
3. Draper NR, Smith H. Applied regression analysis, Third edition, John Wiley & Sons Inc; c1998. p. 17-50.
4. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd addition. An International Rice Research Institute Book, A Wiley-Inter science Publication, New York. 1984;3(1):304-308.
5. Hannig GT, Ziegler M, Marçon PG. Feeding cessation effects of chlorantraniliprole, a new anthranilic diamide insecticide, in comparison with several insecticides in distinct chemical classes and mode-of-action groups. Pest Management Science. 2009;65:969-974.
6. Islam MS, Das S, Islam KS, Rahman A, Huda MN, Dash, PK, *et al*. Evaluation of different insecticides and botanical extracts against yellow stem borer (*Scirpophaga incertulas*) in rice field. International Journal of Biosciences. 2013;3(10):117-125.
7. Karthikeyan K, Swathy PS. IPM approach against major pests of paddy. Journal of Entomological Research. 2020;44(2):233-237.
8. Karthikeyan K, Sosamma J, Pathummal B, Purushothaman SM. Evaluation of different integrated pest management modules for the management of major pests of rice (*Oryza sativa*). Indian Journal of Agricultural Sciences. 2010;80(1):59-62.
9. Khan M, Saljokqi AR, Latif A, Abdullah K. Evaluation of some rice varieties against stem borer (*Tryporyza incertulus*). Asian Journal of Plant Sciences. 2003;2(6):498-500.
10. Khater HM. Prospects of Botanical Biopesticides in Insect pest Management. Pharmecologica. 2012;3(12):641-656.
11. Lai R. Field evaluation of some biopesticide for management of rice leaf folder, *Cnaphalocrocis medinalis* (G) in Haryana. Pest. Res. J. 2001;13:62-65.
12. Lal OP. Recent Advances in Entomology, (Ed). APC Publications Pvt. Ltd. New Delhi; c1996. p. 392.
13. Marchesini E, Mori N, Pasini M, Bassi A. Selectivity of rynaxpyr towards beneficial arthropods in different agrosystems. Giornate-Fitopatologiche, Cervia, Italy. 2008, 71-76.
14. Mathur KC, Reddy PR, Rajamali S, Moorthy BTS. Integrated pest management of rice to improve productivity and sustainability. Oryza. 1999;36(3):195-207.
15. Mohapatra LN. Field evaluation of ITKs against insect pests of rice. Indian Journal of Traditional Knowledge. 2018;17(2):360-364.
16. Pasalu IC, Krishnaiah NV, Katti G, Varma NRG. IPM in rice. IPM Mitr. 2002, 45-55.
17. Sudhakar TR. Evaluation of neem products in rice insect pest control. Indian Journal of Plant Protection. 2000;28(1):48-50.
18. Sen T, Rodriguez BL, Chen L, Corte CM, Morikawa N, Fujimoto J, *et al*. Targeting DNA damage response promotes antitumor immunity through STING-mediated T-cell activation in small cell lung cancer. Cancer discovery. 2019 May 1;9(5):646-661.