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# Evaluation of Botanicals against Grasshopper Infesting Rice

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## Abstract

A study was conducted to determine the comparative bio-efficacy of five botanicals viz., neemazal, cedar wood oil, lemon grass oil, eucalyptus oil and camphor oil each with three concentrations against grasshopper (Oxya nitidula) population on rice at MRCFC Khudwani Anantnag during Kharif 2018. The results revealed that the mean live population of O. nitidula per hill ranged from 3.50-4.53 before treatment and ranged from 1.96-2.17 after treatment of botanicals. The data on mean percent reduction of grasshopper, O. nitidula with botanicals revealed that all the treatments were significantly superior over control. Among the botanicals, neemazal, cedar wood oil, lemon grass oil, eucalyptus oil and camphor oil resulted 42.09 and 43.68%, 60.97 and 68.88%, 68.76 and 77.81%; 32.62 and 35.69%, 48.57and 58.92%, 57.79 and 68.62%; 34.65 and 37.30%, 54.41and 62.34%, 62.17and 70.43%; 39.15 and 42.62%, 54.60 and 63.87%, 65.24 and 76.75%; and 33.15 and 34.93%, 48.37 and 55.05%, 56.69 and 67.81% reduction of grasshopper, O. nitidula population at 1.0, 2.0 and 3.0 ml /L of water in comparison to check (0.00%) 7th and 15th DAT, respectively. The per cent grasshopper damaged leaves per hill ranged from 11.37-14.15% one day before treatment of botanicals and 1.25-5.89, 0.73-5.06 and 0.67-3.83%, 1.66-7.17, 1.35-6.14 and 1.37-4.53%, 1.47-6.88, 1.21-5.64 and 0.95-4.68%, 1.35-6.29, 1.18-4.91 and 0.78-4.43%, and 1.49-7.37, 1.41-6.40 and 1.29-5.47% in neemazal, cedar wood oil, lemon grass oil, eucalyptus oil and camphor oil treated plots at 1.0, 2.0 and 3.0 ml/L of water in comparison to check (3.00, 5.43, 8.37 and 9.28%), respectively. Application of test botanicals had an impact in increasing the grain yield of rice and brought about yield benefits between 43.20 to 655.56 kg/ha over control. The neemazal treatment produced highest grain yield of 6955.56 kg/ha at 3ml/L of water as against 6300.00 kg/ha in untreated control. The overall bio-efficacy of the botanicals evaluated was in the order of Neemazal > Eucalyptus oil > Lemon grass oil > Cedar wood oil > Camphor oil. Hence, botanicals, particularly neemazal, may be recommended for the management of grasshopper (O. nitidula) infesting rice in Kashmir.

**Keywords:** Botanicals; Grasshopper; Evaluation; Treatment; Grain Yield; Infesting

## Introduction

Rice (Oryza sativa L.) is an important cereal crop and source of calories for one-third of the world population. Rice being the staple food for more than 70 per cent of the population and the source of livelihood for 120 million rural households is the backbone of Indian agriculture. The rice is bestowed with a lot of pests and natural enemies' complex. The insect pests of rice infest the crop from seedling to maturity in overlapping generations and vary in nature of damage such as plant tissue borers, foliage feeders, sap suckers, etc. The average yield loss in rice have been accounted 30% by stem borers, while plant hoppers cause 20%, gall midge 15%, leaf hoppers 10% and other pests 25% [1]. Pest management in agriculture is a challenging task in the context of increasing agricultural productivity without upsetting the ecological balance and deteriorating the environment. Agrochemicals in agriculture of course are useful for protecting crops but these chemicals are posing enormous problems like environmental pollution, pesticide resistance, pest resurgence, toxicity hazards, secondary pest out breaks, residues in feeds, food, soil and water and destruction of biodiversity of natural enemies. With a view of these demerits, now-a-days more emphasis is being laid on IPM by using botanicals. Botanicals have long been touted as an attractive alternative to synthetic chemical insecticides for pest management [2]. Botanical pesticides are ecofriendly, economic, target specific and biodegradable. Their greatest strength is their specificity, as most of them are essentially non-toxic and non-pathogenic to animals and humans besides being ecofriendly. Considering the importance of ecofriendly approaches to manage pests, the experiment was designed to determine relative efficacy of different botanical extracts against grasshopper and its natural enemies.

## Material and Methods

The experiment was conducted at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST- K), Mountain Research Centre For Field Crops (MRCFC) Khudwani Anantnag and division of Entomology, Wadura Campus Sopore in Randomized Block Design (RBD), having 16 treatments consisting of five botanicals each with three concentrations along with untreated check were replicated thrice and each sub plot measured 5m x 3m in size [3]. Nursery of rice variety Jhelum was sown in the Ist of May and transplanting was done during Ist week of June at 20 x 15 cm hill spacing. The treatments were Neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, camphor oil, and untreated control each with three concentrations (Table 1).

Botanicals used in the research were obtained from International Rice Research Institute, Rajendranagar Hyderabad.

A. Observations on insect pest, Oxya nitidula: Ten hills were selected at random in each subplot and the number of grasshoppers (O. nitidula) was counted in each hill one day before treatment (DBT)

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**Table 1:** List of botanicals used against grasshopper, *Oxya nitidula* Walker infesting rice *Oryza sativa* L.

| S. No. | Botanical name | Trade name | Formulation (ml / ha) | Dose (ml/ litre) |
|---|---|---|---|---|
| 1. | Neemazal | Neemarin | 1000 | 1.0 |
| | | | | 2.0 |
| | | | | 3.0 |
| 2. | Cedar wood oil | Cedar wood oil | 1000 | 1.0 |
| | | | | 2.0 |
| | | | | 3.0 |
| 3. | Lemon grass oil | Citronella grass oil | 1000 | 1.0 |
| | | | | 2.0 |
| | | | | 3.0 |
| 4. | Eucalyptus oil | Eucalyptus oil | 1000 | 1.0 |
| | | | | 2.0 |
| | | | | 3.0 |
| 5. | Camphor oil | Camphor oil | 1000 | 1.0 |
| | | | | 2.0 |
| | | | | 3.0 |
| 6. | Water spray (Untreated control) | Water spray (Untreated control) | 1000 | |

and at 1st, 3rd, 7th and 15th days after treatment (DAT) of botanicals. Data on grasshopper population was recorded during late evening hours when majority of them were found on rice hills than on bunds [4]. While making visual counts of grasshoppers, those flying away from intended spots of observations as a result of disturbance, were also taken into account. Mean number of grasshoppers was calculated to get number of grasshoppers per hill [5]. The per cent reduction of grasshoppers was calculated by using the following Abbot's (1925) formula:

$$\%\text{reduction} = \frac{\text{Pre-treatmentobservation} - \text{Posttreatmentobservation}}{\text{Pre-treatment observation}} \times 100$$

B. Observations on tiller damage: Ten hills were selected at random in each subplot and the number of total tillers and the tillers damaged by grasshoppers were counted in each hill [6]. The observations on tiller damage were recorded at 1st DBT and at 1st, 3rd, 7th and 15th days after treatment (DAT). The percentage grasshopper damaged tillers was calculated by using the following formula:

$$\text{Tiller damage (\%)} = \frac{\text{Number of damaged tillers per hill} \times 100}{\text{Total number of tillers per hill}}$$

C. Observations on leaf damage: Ten hills were selected at random in each subplot and the number of total leaves and the leaves damaged by grasshoppers were counted in each hill [7]. The observations on leaf damage were recorded at 1st DBT and at 1st, 3rd, 7th and 15th days after treatment (DAT). The percentage grasshopper damaged leaves was calculated by using the following formula:

$$\text{Leaf damage (\%)} = \frac{\text{Number of damaged leaves per hill} \times 100}{\text{Total number of leaves per hill}}$$

D. Recording of yield data: The crop was harvested and threshing of the crop was done manually when the grains were matured in all treatments and replications [8]. Threshing was done individually for each subplot. While threshing, care was taken to avoid mixing of the grains of different treatments and replications. Finally data on grain yield was recorded for each treatment and replication in kg/plot separately and then converted into Kg/ha [9]. Percentage increase (grain) and decrease (loss) in grain yield, treatment wise, over control (unprotected plot) was calculated by applying the mathematical formulae as per suggested by Khosla, 1997:

a) % Increase in yield = $\frac{Yt - Yc}{Yc} \times 100$

b) % Decrease in yield = $\frac{Yt - Yc}{Yc} \times 100$

Where, Yt = yield obtained from respective treatments and Yc = yield obtained from untreated check

E. Statistical analysis: The population of grasshoppers was transformed by square root transformation. The per cent reduction in grasshopper, and leaf damage was transformed into arc sine transformed values. The transformed data were then subjected to statistical analysis [10]. The yield per plot was subjected to statistical analysis directly.

## Results and Discussion

The data on mean number of grasshopper, O. nitidula population and their percent reduction over pre-treatment values at different treatments before 1st day and 1st, 3rd, 7th and 15th DAT is presented (Table 2), respectively.

The results revealed that the mean live grasshopper, O. nitidula population per hill ranged from 3.50-4.53 before treatment of botanicals and 3.10-1.42, 3.50-1.90, 3.27-1.62, 3.13-1.62, and 3.00-1.90 after treatment of botanicals, viz., neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, and camphor oil in comparison to control (3.70-5.27), respectively [11]. The data revealed that the pre-treatment populations of O. nitidula were not statistically significant denoting that the O. nitidula population was more or less uniformly distributed in the crop field. The data on mean live O. nitidula population varied from 2.10 to 3.70 hoppers/hill, 1.57 to 4.67 hoppers/hill, 1.17 to 4.83 hoppers/hill and 0.83 to 5.27 hoppers/hill after 1st, 3rd, 7th and 15th DAT of botanicals. The data on mean percent reduction of grasshopper, O. nitidula with botanicals revealed that all the treatments were significantly superior over control [12]. Amongst the botanicals, neemazal resulted 26.11, 38.15, 42.09 and 43.68%; 36.99, 51.59, 60.97 and 68.88%; 41.11, 56.20, 68.76 and 77.81% reduction of grasshopper, O. nitidula population at 1.0, 2.0 and 3.0 ml/L of water in comparison to check (8.92, 0.00, 0.00 and 0.00%) 1st, 3rd, 7th and 15th DAT, respectively. The overall bio-efficacy of the botanicals evaluated while pooling together all

**Table 2:** Comparative bio-efficacy of botanicals against grasshopper (*Oxya nitidula*) infesting rice variety *Jhelum* at MRCFC Khudwani *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml) | Pre treatment count (1DBT) | *Mean live grasshopper population per hill | | | | Pooled mean | Overall mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Post treatment count (DAT) | | | | | |
| | | | | | 1st | 3rd | 7th | 15th | | |
| Neemazal | 1.0 | 1000 | 1 | 4.20 (2.05) | 3.10 (2.02) | 2.60 (1.90) | 2.43 (1.85) | 2.37 (1.83) | 2.62 (1.90) | 1.90 (1.69) |
| | | | 2 | 3.87 (1.96) | 2.43 (1.85) | 1.57 (1.60) | 1.50 (1.58) | 1.20 (1.48) | 1.67 (1.63) | |
| | | | 3 | 3.57 (1.89) | 2.10 (1.76) | 1.57 (1.60) | 1.17 (1.47) | 0.83 (1.35 | 1.42 (1.54) | |
| Cedar wood oil | 1.0 | 1000 | 1 | 4.30 (2.07) | 3.50 (2.12) | 3.00 (1.00) | 2.90 (1.97) | 2.77 (1.94) | 3.04 (1.76) | 2.29 (1.72) |
| | | | 2 | 3.50 (1.87) | 2.53 (1.88) | 2.03 (1.74) | 1.80 (1.67) | 1.43 (1.56) | 1.95 (1.71) | |
| | | | 3 | 4.03 (2.01) | 2.60 (1.90) | 2.03 (1.74) | 1.70 (1.64) | 1.27 (1.50) | 1.90 (1.69) | |
| Lemon grass oil | 1.0 | 1000 | 1 | 4.03 (2.00) | 3.27 (2.06) | 2.80 (1.95) | 2.63 (1.90) | 2.53 (1.88) | 2.81 (1.95) | 2.28 (1.80) |
| | | | 2 | 4.53 (2.13) | 3.23 (2.06) | 2.60 (1.90) | 2.07 (1.75) | 1.70 (1.64) | 2.40 (1.84) | |
| | | | 3 | 3.60 (1.89) | 2.30 (1.82) | 1.73 (1.65) | 1.37 (1.54) | 1.07 (1.44) | 1.62 (1.61) | |
| Eucalyptus oil | 1.0 | 1000 | 1 | 4.17 (2.04) | 3.13 (2.03) | 2.70 (1.92) | 2.53 (1.88) | 2.40 (1.84) | 2.69 (1.92) | 2.17 (1.77) |
| | | | 2 | 4.33 (2.08) | 2.97 (1.99) | 2.30 (1.81) | 1.97 (1.72) | 1.57 (1.60) | 2.20 (1.78) | |
| | | | 3 | 3.87 (1.97) | 2.43 (1.85) | 1.83 (1.68) | 1.33 (1.53) | 0.90 (1.38) | 1.62 (1.61) | |
| Camphor oil | 1.0 | 1000 | 1 | 3.50 (1.87) | 2.90 (1.97) | 2.57 (1.89) | 2.33 (1.82) | 2.33 (1.80) | 2.53 (1.87) | 2.25 (1.71) |
| | | | 2 | 4.00 (2.00) | 3.00 (1.00) | 2.40 (1.84) | 2.07 (1.75) | 1.80 (1.67) | 2.32 (1.56) | |
| | | | 3 | 3.93 (1.98) | 2.60 (1.90) | 2.03 (1.74) | 1.70 (1.64) | 1.27 (1.50) | 1.90 (1.69) | |
| Water | | | Check | 4.07 (2.01) | 3.70 (2.17) | 4.67 (2.38) | 4.83 (2.41) | 5.27 (2.50) | 4.62 (2.36) | 4.62 (2.36) |
| **C.D. (P=0.05)** | | | | **(NS)** | **(0.13)** | **(0.15)** | **(0.11)** | **(0.09)** | **(0.12)** | |

***** Each figure is mean of three replications and each replicate is mean of ten observations
Figures in parentheses are square root transformed values
DBT: Days before treatment; DAT: Days after treatment

concentrations was neemazal (51.03%), cedar wood oil (42.23%), lemon grass oil (44.33%), eucalyptus oil (47.57%) and camphor oil (40.61%). Thus the bio efficacy of the botanicals evaluated was in the order of Neemazal > Eucalyptus oil > Lemon grass oil > Cedar wood oil > Camphor oil (Table 3).

These results are in consistent with the findings of Mohan and Monoharan (1987) who reported population of O. nitidula in rice ranged from 0.01-13.50 hoppers/hill in India [13]. Muralirangan and Muralirangan (1990) reported that cause of rice to be preferred host was due to the changes in the structure of the mandibles and the pattern of the cuticular armature of the foregut in the insect. Chand and Muralirangan (2000) reported that reduced content of silica present in rice varieties made them more susceptible to O. nitidula which might be one of the reasons of this variety also to be preferred by the insect pest. The biological activity of these botanicals might be due to various compounds, including alkaloids, phenolics, saponins, flavonoids, etc. existing in the plants which jointly or independently contribute to the reduction of O. nitidula [14]. The reduction in population of O. nitidula by the botanicals recorded may be due to their different biological activities such as anti-feedant effects, inhibition of growth and development, disruption of metamorphosis, deterrence of oviposition, reduced survival, etc. Conclusively, the botanicals probably made sufficient coverage of plants and might have made the plants less favourable for the growth and reproduction of the insect pest as it was found that the pest fed less on the plants treated with the botanicals. Schmutterer (1990) suggested that botanicals, viz., azadirachtin modified the programme of insects by influencing hormonal system, especially that of the ecdysone, preventing both ecdysis and apolysis and can cause death before or during molting. Earlier studies by Chiu et al. (1983), Schmutterer (1990), Lee et al. (1991), Prakash and Rao (1997) and Stoll (2000) have reported botanicals to be highly effective against insect pests of rice including hoppers which is in congruence with the present findings. They have reported that when botanicals were sprayed at higher concentrations, most females of the grasshoppers did not emit signals and therefore, males could not locate them [15]. The efficacy of neemazal obtained during the present study is in agreement with the findings of Ramraju and Sundara Babu (1989) and Lee et al. (1991) who reported that treatments with neem resulted in the lowest survival rate of hoppers of rice. Mohan et al. (1991), Mohapatra (1992) and Mohapatra (1994) have also reported that neem pesticides could

**Table 3:** Per cent reduction of grasshopper (*Oxya nitidula*) with botanicals infesting rice variety *Jhelum* at MRCFC Khudwani during *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml) | Pre treatment count (1DBT) | *Mean per cent reduction of grasshopper over pre treatment | | | | Pooled mean | Overall mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Post treatment count (DAT) | | | | | |
| | | | | | 1st | 3rd | 7th | 15th | | |
| Neemazal | 1.0 | 1000 | 1 | 4.20 (2.05) | 26.11 (30.69) | 38.15 (38.13) | 42.09 (40.43) | 43.68 (40.43) | 37.51 (37.42) | 51.03 (44.67) |
| | | | 2 | 3.87 (1.96) | 36.99 (37.44) | 51.59 (45.89) | 60.97 (51.33) | 68.88 (51.33) | 54.61 (46.49) | |
| | | | 3 | 3.57 (1.89) | 41.11 (39.86) | 56.20 (48.54) | 68.76 (56.03) | 77.80 (56.03) | 60.97 (50.11) | |
| Cedar wood oil | 1.0 | 1000 | 1 | 4.30 (2.07) | 18.57 (25.50) | 30.29 (33.36) | 32.62 (34.80) | 35.69 (34.80) | 29.29 (32.11) | 42.23 (39.14) |
| | | | 2 | 3.50 (1.87) | 27.55 (31.65) | 42.19 (40.48) | 48.57 (44.16) | 58.92 (44.16) | 44.31 (40.11) | |
| | | | 3 | 4.03 (2.01) | 35.63 (36.62) | 50.33 (45.17) | 57.79 (49.46) | 68.62 (49.46) | 53.09 (45.18) | |
| Lemon grass oil | 1.0 | 1000 | 1 | 4.03 (2.00) | 18.93 (25.77) | 30.59 (33.55) | 34.65 (36.04) | 37.3 (36.04) | 30.37 (32.85) | 44.33 (40.64) |
| | | | 2 | 4.53 (2.13) | 28.61 (32.32) | 44.54 (41.85) | 54.41 (47.51) | 62.34 (47.51) | 47.47 (42.30) | |
| | | | 3 | 3.60 (1.89) | 36.05 (36.88 | 51.99 (46.12) | 62.17 (52.02) | 70.43 (52.02) | 55.16 (46.76) | |
| Eucalyptus oil | 1.0 | 1000 | 1 | 4.17 (2.04) | 24.85 (29.88) | 35.13 (36.33) | 39.15 (38.72) | 42.62 (38.72) | 35.44 (35.91) | 47.57 (42.35) |
| | | | 2 | 4.33 (2.08) | 31.55 (34.15) | 47.06 (43.30) | 54.60 (47.62) | 63.87 (47.62) | 49.27 (43.17) | |
| | | | 3 | 3.87 (1.97) | 37.26 (37.59) | 52.71 (46.54) | 65.24 (53.88) | 76.75 (53.88) | 57.99 (47.97) | |
| Camphor oil | 1.0 | 1000 | 1 | 3.50 (1.87) | 17.16 (24.44) | 26.70 (31.09) | 33.15 (35.12) | 34.93 (35.12) | 27.98 (31.44) | 40.61 (38.37) |
| | | | 2 | 4.00 (2.00) | 25.09 (30.01) | 39.94 (39.18) | 48.37 (44.05) | 55.05 (44.05) | 42.11 (39.32) | |
| | | | 3 | 3.93 (1.98) | 34.0 (35.65) | 48.43 (44.08) | 56.69 (48.83) | 67.81 (48.83) | 51.73 (44.35) | |
| Water | | | Check | 4.07 (2.01) | 8.92 (17.30) | 0.00 ( 0.00) | 0.00 (0.00) | 0.00 (0.00) | 2.23 (4.32) | 2.23 (4.32) |
| **C.D. (P=0.05)** | | | | **(NS)** | **(2.37)** | **(2.29)** | **(2.44)** | **(2.44)** | **(2.38)** | |

*****Each figure is mean of three replications and each replicate is mean of ten observations
Figures in parentheses are arc sine transformed values
DBT: Days before treatment; DAT: Days after treatment

provide a satisfactory level of control against hoppers on rice [16].

The data on mean number of total tillers, grasshopper (O. nitidula) damaged tillers and their percent reduction over pre-treatment values at different treatments before 1st day and 1st, 3rd, 7th and 15th DAT is presented (Table 4). The results revealed that the mean total tillers and grasshopper (O. nitidula) damaged tillers per hill ranged from 11.37-12.80 and 0.00-0.00 before treatment of botanicals and, 11.37-12.80 and 0.00-0.00 after treatment of botanicals, viz., neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, and camphor oil in comparison to control (0.00-0.00). Thus data revealed that the grasshopper, O. nitidula did not damage the tillers of rice.

The data on mean number of total leaves, grasshopper (O. nitidula) damaged leaves and their percent damage over pre-treatment values at different treatments before 1st day and 1st, 3rd, 7th and 15th DAT is presented (Table 5 and Table 6) respectively. The results revealed that the mean total leaves and damaged leaves per hill ranged from 45.47-51.20 and 5.33-7.20 before treatment of botanicals, and 0.33-2.80, 0.63-3.60, 0.47-3.27, 0.40-3.07, and 0.67-3.60 after treatment of botanicals neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, and camphor oil in comparison to control (1.53-4.73), respectively. All the botanicals were found superior in reducing the damage of leaves due to grasshopper on rice as compared to control throughout the period of experimentation. The overall mean percent damaged leaves per hill by the grasshopper while pooling together all concentrations was neemazal (3.03%), cedar wood oil (3.96%), lemon grass oil (3.70%), eucalyptus oil (3.37%) and camphor oil (4.21%). Thus the bio efficacy of the botanicals evaluated was in the order of Neemazal > Eucalyptus oil > Lemon grass oil > Cedar wood oil > Camphor oil (Table 6). The percent grasshopper damaged leaves per hill ranging from 11.37-14.15% may be because of leaves being more tender as well as higher food assimilation as also documented by Delvi and Pandian (1972) in case of grasshopper, Poekilocerus pictus [17]. Our results are also in line with that of Thakur (1984) who reported 5-8% infestation of rice leaves by O. chiensis in Sikkim hills but contrary to that of Basilio et al. (1989) who reported that O. hyla intricata damaged more than 50% of the rice leaves in Malaysia.

The data presented (Table 7) revealed that the mean grain yield of

**Table 4:** Comparative bio-efficacy of botanicals against grasshopper (*Oxya nitidula*) infesting tillers of rice variety *Jhelum* at MRCFC Khudwani during *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml) | Pre treatment count (1DBT) | *Mean grasshopper damaged tillers per hill (DT/hill) Post treatment Count (DAT) | | | | Pooled mean | Overall mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1st | 3rd | 7th | 15th | | |
| Neemazal | 1.0 | 1000 | 1 | 11.90 (3.59) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| | | | 2 | 11.37 (3.51) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| | | | 3 | 12.37 (3.66) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| Cedar wood oil | 1.0 | 1000 | 1 | 12.53 (3.68) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| | | | 2 | 11.77 (3.57) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| | | | 3 | 12.57 (3.68) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| Lemon grass oil | 1.0 | 1000 | 1 | 11.90 (3.59) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| | | | 2 | 12.40 (3.66) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| | | | 3 | 12.43 (3.66) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| Eucalyptus oil | 1.0 | 1000 | 1 | 12.17 (3.63) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| | | | 2 | 12.73 (3.71) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| | | | 3 | 12.77 (3.71) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| Camphor oil | 1.0 | 1000 | 1 | 12.17 (3.63) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| | | | 2 | 12.37 (3.65) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| | | | 3 | 12.80 (3.71) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | |
| Water | | | Check | 12.73 (3.70) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| **C.D. (P=0.05)** | | | | **(NS)** | **(NS)** | **(NS)** | **(NS)** | **(NS)** | **(NS)** | |

***** Each figure is mean of three replications and each replicate is mean of ten observations
Figures in parentheses are mean per cent reduction in grass hopper infested tillers
DBT: Day before treatment; DAT: Day after treatment; TT: Total Tillers; DT: Damaged Tillers

**Table 5:** Comparative bio-efficacy of botanicals against grasshopper (*Oxya nitidula*) infesting leaves of rice variety *Jhelum* at MRCFC Khudwani during *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml) | Pre treatment Count (TL/hill) 1 DBT) | Pre treatment Count (DL/hill) 1 DBT | *Mean grasshopper damaged leaves per hill Days after treatment (DAT) | | | | Pooled mean | Over all mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1st | 3rd | 7th | 15th | | |
| Neemazal | 1.0 | 1000 | 1 | 47.60 (6.97) | 6.00 (2.64) | 0.60 (1.26) | 1.33 (1.53) | 2.43 (1.85) | 2.80 (1.95) | 1.79 (1.65) | 1.44 (1.54) |
| | | | 2 | 45.47 (6.82) | 5.33 (2.51) | 0.33 (1.15) | 0.97 (1.40) | 1.90 (1.70) | 2.30 (1.82) | 1.37 (1.52) | |
| | | | 3 | 49.47 (7.10) | 6.57 (2.75) | 0.33 (1.15) | 0.83 (1.35) | 1.53 (1.59) | 1.90 (1.70) | 1.15 (1.45) | |
| Cedar wood oil | 1.0 | 1000 | 1 | 50.13 (7.15) | 7.10 (2.84) | 0.83 (1.35) | 1.90 (1.70) | 3.10 (2.02) | 3.60 (2.14) | 2.36 (1.80) | 1.94 (1.69) |
| | | | 2 | 47.07 (6.93) | 5.60 (2.56) | 0.63 (1.28) | 1.43 (1.56) | 2.60 (1.90) | 2.90 (1.97) | 1.89 (1.68) | |
| | | | 3 | 50.27 (7.16) | 6.90 (2.81) | 0.63 (1.28) | 1.23 (1.49) | 2.17 (1.78) | 2.33 (1.82) | 1.59 (1.59) | |
| Lemon grass oil | 1.0 | 1000 | 1 | 47.60 (6.97) | 5.63 (2.57) | 0.70 (1.30) | 1.63 (1.62) | 2.83 (1.96) | 3.27 (2.06) | 2.11 (1.74) | 1.81 (1.65) |
| | | | 2 | 49.60 (7.11) | 6.77 (2.78) | 0.60 (1.26) | 1.53 (1.59) | 2.40 (1.84) | 2.80 (1.95) | 1.83 (1.66) | |
| | | | 3 | 49.73 (7.12) | 6.33 (2.71) | 0.47 (1.21) | 1.13 (1.46) | 2.10 (1.76) | 2.30 (1.82) | 1.50 (1.56) | |
| Eucalyptus oil | 1.0 | 1000 | 1 | 48.67 (7.05) | 5.97 (2.64) | 0.67 (1.29) | 1.40 (1.54) | 2.67 (1.91) | 3.07 (2.02) | 1.95 (1.69) | 1.69 (1.62) |
| | | | 2 | 50.93 (7.21) | 6.90 (2.81) | 0.60 (1.26) | 1.43 (1.56) | 2.27 (1.81) | 2.50 (1.87) | 1.70 (1.62 | |
| | | | 3 | 51.07 (7.21) | 6.87 (2.80) | 0.40 (1.18) | 1.00 (1.41) | 2.03 (1.74) | 2.27 (1.81) | 1.42 (1.54) | |
| Camphor oil | 1.0 | 1000 | 1 | 48.67 (7.04) | 6.07 (2.56) | 0.73 (1.32) | 1.83 (1.68) | 3.23 (2.05) | 3.60 (2.14) | 2.35 (1.80) | 2.10 (1.74) |
| | | | 2 | 49.47 (7.10) | 6.80 (2.79) | 0.70 (1.30) | 1.73 (1.65) | 2.83 (1.96) | 3.17 (2.04) | 2.11 (1.74) | |
| | | | 3 | 51.20 (7.22) | 7.20 (2.86) | 0.67 (1.29) | 1.47 (1.57) | 2.40 (1.84) | 2.80 (1.95) | 1.84 (1.66) | |
| Water | | | Check | 50.93 (7.21) | 5.80 (2.60) | 1.53 (1.59) | 2.77 (1.94) | 4.27 (2.29) | 4.73 (2.39) | 3.32 (2.05) | 3.32 (2.05) |
| **C.D. (P=0.05)** | | | | **(NS)** | **(0.21)** | **(0.09)** | **(0.12)** | **(0.14)** | **(0.15)** | **(0.12)** | |

*Each figure is mean of three replications and each replicate is mean of ten observations
Figures in parentheses are square root transformed values
DBT: Day before treatment; DAT: Day after treatment; TL: Total leaves; DL: Damaged leaves

**Table 6:** Per cent infestation of rice leaves infested with grasshopper (*Oxya nitidula*)after botanical treatments at MRCFC Khudwani during *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml) | Pre treatment Count (TL/hill) 1 DBT | Pre treatment Count (%DL/hill) 1 DBT | *Mean % grasshopper infested leaves (%DL/hill) Days after treatment (DAT) | | | | Pooled mean | Over all mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1st | 3rd | 7th | 15th | | |
| Neemazal | 1.0 | 1000 | 1 | 47.60 (6.97) | 12.60 (3.68) | 1.25 (6.40) | 2.80 (9.62) | 5.11 (13.05) | 5.89 (14.03) | 3.76 (10.78) | 3.03 (9.55) |
| | | | 2 | 45.47 (6.82) | 11.70 (3.56) | 0.73 (4.90) | 2.12 (8.37) | 4.17 (11.78) | 5.06 (12.98) | 3.02 (9.51) | |
| | | | 3 | 49.47 (7.10) | 13.26 (3.78) | 0.67 (4.69) | 1.68 (7.42) | 3.09 (10.10) | 3.83 (11.26) | 2.32 (8.37) | |
| Cedar wood oil | 1.0 | 1000 | 1 | 50.13 (7.15) | 14.15 (3.89) | 1.66 (7.40) | 3.79 (11.22) | 6.17 (14.36) | 7.17 (15.51) | 4.70 (12.12) | 3.96 (11.06) |
| | | | 2 | 47.07 (6.93) | 11.82 (3.58) | 1.35 (6.66) | 3.06 (10.05) | 5.51 (13.56) | 6.14 (14.33) | 4.01 (11.15) | |
| | | | 3 | 50.27 (7.16) | 13.71 (3.83) | 1.37 (6.38) | 2.45 (8.98) | 4.30 (11.96) | 4.53 (12.27) | 3.16 (9.90) | |
| Lemon grass oil | 1.0 | 1000 | 1 | 47.60 (6.97) | 11.81 (3.58) | 1.47 (6.91) | 3.43 (10.65) | 5.72 (13.77) | 6.88 (15.18) | 4.37 (11.63) | 3.70 (10.66) |
| | | | 2 | 49.60 (7.11) | 13.61 (3.82) | 1.21 (6.30) | 3.09 (10.11) | 4.83 (12.68) | 5.64 (13.73) | 3.69 (10.70) | |
| | | | 3 | 49.73 (7.12) | 12.71 (3.70) | 0.93 (5.52) | 2.28 (8.66) | 4.22 (11.84) | 4.68 (12.48) | 3.03 (9.62) | |
| Eucalyptus oil | 1.0 | 1000 | 1 | 48.67 (7.05) | 12.24 (3.64) | 1.35 (6.60) | 2.86 (9.64) | 5.47 (13.51) | 6.29 (14.52) | 3.99 (11.07) | 3.37 (10.19) |
| | | | 2 | 50.93 (7.21) | 13.55 (3.81) | 1.18 (6.21) | 2.83 (9.60) | 4.46 (12.71) | 4.91 (12.79) | 3.34 (10.33) | |
| | | | 3 | 51.07 (7.21) | 13.41 (3.79) | 0.78 (5.04) | 1.95 (8.01) | 3.98 (11.49) | 4.43 (12.13) | 2.78 (9.17) | |
| Camphor oil | 1.0 | 1000 | 1 | 48.67 (7.04) | 12.50 (3.67) | 1.49 (7.02) | 3.80 (11.20) | 6.61 (14.88) | 7.36 (15.72) | 4.81 (12.20) | 4.21 (11.42) |
| | | | 2 | 49.47 (7.10) | 13.72 (3.84) | 1.41 (6.81) | 3.50 (10.78) | 5.72 (13.83) | 6.40 (14.64) | 4.26 (11.51) | |
| | | | 3 | 51.20 (7.22) | 14.05 (3.88) | 1.29 (6.51) | 2.86 (9.73) | 4.68 (12.49) | 5.47 (13.51) | w3.57 (10.56) | |
| Water | | | Check | 50.93 (7.21) | 11.37 (3.51) | 3.00 (9.98) | 5.43 (13.46) | 8.37 (16.80) | 9.28 (17.72) | 6.52 (14.49) | 6.52 (14.49) |
| **C.D. (P=0.05)** | | | | **(NS)** | **(NS)** | **(1.02)** | **(1.26)** | **(1.20)** | **(1.15)** | **(1.16)** | |

*****Each figure is mean of three replications and each replicate is mean of ten observations

Figures in parentheses are arc sine transformed values

DBT: Day before treatment; DAT: Day after treatment; TL: Total leaves; DL: Damaged leaves

rice of 15 cm2 size plots was recorded as 10.12, 10.26, and 10.43 kg/ plot, 9.74, 9.79 and 9.98 kg/plot, 9.51, 9.66 and 9.84 kg/plot, 9.81, 9.87, 9.95 kg/plot, and 9.72, 9.75 and 9.81 kg/plot in neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, and camphor oil treated plots in comparison to control (9.45 kg/plot), respectively.

Application of test botanicals had an impact in increasing the grain yield of rice and brought about yield benefits between 43.20 to 655.56 kg/ha over control. The yield potential of the crop variety and the bio-efficacy of the botanicals against the pest that influences the pest activity and ultimate effect on grain yield of rice immensely contributed the increase in grain yield [18]. The differences in yield between treated and untreated check in the present study is probably due to reduction in leaf and grain damage by the botanicals in treated plots and also largely due to protection of rice leaves, mainly boot leaf, by the botanicals which in turn led to improvement in yield as compared to untreated check. Among botanicals, viz., neemazal, cedar wood oil, lemon grass oil, eucalyptus oil, and camphor oil, evaluated under field conditions for management of grasshoppers on rice, neemazal @ 3ml/L gave higher yield (6955.56 kg/ha) as against 6300.00 kg/ha in untreated control (Table 7). Present findings regarding higher yield in rice is also supported by the findings of Kumar and Rangasamy (1986), Mukherji and Mandal (1973) and that of Venkat Reddy et al. (2012) who reported higher grain yield in rice when NSKE @ 7.5% was sprayed.

## Conclusion

The present field investigation was to develop an ecofriendly management of insect pests of rice under irrigated conditions with the help of botanicals, viz., neemazal, eucalyptus oil, camphor oil, lemongrass oil and cedar wood oil at different concentrations. The effect of botanicals on grasshopper, O. nitidula revealed that all the treatments were superior to the control for the reduction in grasshopper, O. nitidula population in rice. Hence, botanicals can be used in reduction of grasshopper, O. nitidula in rice without causing adverse effects on natural enemies and environment in Kashmir.

**Table 7:** Comparative bio-efficacy of botanicals on grain yield of rice variety *Jhelum* infested with grasshopper (*Oxya nitidula*) at MRCFC Khudwani during *Kharif* 2018.

| Botanical | a.i in formulation | Rate of formulation (ml/ha) | Conc. (ml/l) | Phyto-toxicity Observed | Grain yield/plot (kg/15 $m^2$) | Grain yield (Kg/ha) | Increase over control (Kg/ha) | % Increase over control (Kg/ha) | Pooled mean of increase over control (Kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| Neemazal | 1.0 | 1000 | 1 | Nil | 10.12 (3.33) | 6744.45 (82.10) | 444.45 | 7.05 | 547.41 |
| | | | 2 | Nil | 10.26 (3.35) | 6842.22 (82.70) | 542.22 | 8.61 | |
| | | | 3 | Nil | 10.43 ( 3.38) | 6955.56 (83.37) | 655.56 | 10.40 | |
| Cedar wood oil | 1.0 | 1000 | 1 | Nil | 9.74 (3.28) | 6439.99 (80.58) | 139.99 | 2.22 | 229.62 |
| | | | 2 | Nil | 9.79 (3.28) | 6493.32 (80.79) | 193.32 | 3.06 | |
| | | | 3 | Nil | 9.98 (3.31) | 6655.53 (81.57) | 355.53 | 5.64 | |
| Lemon grass oil | 1.0 | 1000 | 1 | Nil | 9.51 (3.24) | 6343.20 (79.64) | 43.20 | 0.68 | 176.99 |
| | | | 2 | Nil | 9.66 (3.26) | 6530.00 (80.24) | 230.00 | 3.65 | |
| | | | 3 | Nil | 9.84 (3.29) | 6557.77 (80.97) | 257.78 | 4.10 | |
| Eucalyptus oil | 1.0 | 1000 | 1 | Nil | 9.81 ( 3.29) | 6543.33 (80.85) | 243.33 | 3.86 | |
| | | | 2 | Nil | 9.87 (3.30) | 6582.20 (81.12) | 282.20 | 4.48 | 287.36 |
| | | | 3 | Nil | 9.95 (3.31) | 6636.56 (81.46) | 336.56 | 5.34 | |
| Camphor oil | 1.0 | 1000 | 1 | Nil | 9.72 (3.27) | 6483.10 (80.52) | 183.10 | 2.91 | 208.81 |
| | | | 2 | Nil | 9.75 (3.28) | 6499.97 (80.62) | 199.97 | 3.17 | |
| | | | 3 | Nil | 9.81 (3.29) | 6543.35 (80.89) | 243.35 | 3.86 | |
| Water | | | Check | Nil | 9.45 (3.23) | 6300.00 (79.38) | 0.00 | | |
| **C.D. (P=0.05)** | | | | **(NS)** | **(NS)** | **(NS)** | **(NS)** | **(NS)** | **(NS)** |

*****Each figure is mean of three replications
Figures in parentheses are subjected to square root transformed values

## Acknowledgement

None

## Conflict of Interest

None

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