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Evaluation of bio-pesticides, botanicals and plant extracts against brown plant hopper (*Nilaparvata lugens)* of rice

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Abstract
The field experiment was undertaken at Agriculture Research Station, Sakoli, Dist. Bhandara (MS) under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2018 to study the performance of herbal against brown plant hopper of paddy. This experiment incorporating eight treatments consisting of *Metarhizium anisopliae* ($1x10^8$ cfu/ml) @ 4 g /litre of water, neem oil @ 5 ml/litre of water, 5 % NSKE, 5 % bitter gourd leaf extract, 5 % custard apple leaf extract, 5 % garadi leaf extract, 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract and control. The results revealed that the treatment of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (2.42 nos./hill) was found significantly superior in reducing the population of brown plant hopper over other treatments and followed by 5 % garadi leaf extract (3.11 nos./hill), neem oil (3.23 nos./hill), *M. anisopliae* (3.62 nos./hill), 5 % custard apple leaf extract (3.69 nos./hill), 5 % bitter gourd leaf extract (3.76 nos./hill) and 5 % NSKE (3.97 nos./hill). However, the highest population of brown plant hopper was recorded in control (4.92 nos./hill). The maximum yield recorded in the treatment combination of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (39.33 q/ha).

Keywords: Rice, brown plant hopper, plant extract, bio-pesticides, efficacy

Introduction
Rice (*Oryza sativa* L.) is most important and extensively cultivated food crop, belonging to the family Gramineae is the staple food for one third world's population and occupies almost one fifth of the total land area covered under cereals. Most of the world's rice is cultivated and consumed in Asia, which constitutes more than half of the global population. In India rice cultivated on area 43.57 million hectares with an annual production 104.32 million tonnes and productivity about 2.98 tonnes/ha in 2017 (Anonymous, 2017). Total Indian output of rice was at all-time high of 166.5 MT (111.0 MT, milled basis). This level would stand 1.2 per cent above the final estimate for the 2016 season and some 2.3 million tonnes above previous FAO expectations, (Anonymous, 2018). Rice is a high energy or high calories food and of high biological value of the proteins. More than 100 species of insect have been recorded to infest the paddy crop but out of these 20 insect pests are of major economic significance. A few are widely distributed with great potential to create havoc the paddy crop *viz*., stem borer, gall midge, leaf folder, brown plant hopper, white blacked plant hopper and green leaf hopper. The brown plant hopper, *Nilaparvata lugens* (Stal.) belong to the order Homoptera, family Delphacidae with piercing and sucking mouth parts. The plant hoppers suck the plant sap from the phloem vessels through their proboscis, due to this plant starts wilting with outer most leaves drying first and then the entire plant dries up. Under severe cases field gives a burnt appearance in concentric circles known as "hopper burn". The yield losses caused by insect pest in rice have been reported to the tune of 25 per cent (Dhaliwal *et al*. 2010) [4]. The average yield loss in rice had been accounted for 20% loss in stem borer (Krishnaiah and Varma, 2015) [6]. Indiscriminate use of synthetic insecticides in crop protection programmes around the world resulted in disturbances of the environment, pest resurgences, pest resistance to pesticides and lethal effect to natural enemies in the agro-ecosystems in addition to direct toxicity to users. Therefore, it has now become necessary to search for the alternative means of pest control, which can minimize the use of synthetic pesticides. Botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides as they possess an array of properties including toxicity to the pest, repellency, antifeedance, insect growth regulatory activities against pests of agricultural importance.

Botanical pesticides have many advantages over synthetic pesticides like in general possess low mammalian toxicity thus constitute least or no health hazards and environmental pollution. There is practically no risk of developing pest resistance to these products, when used in natural forms, these causes less hazards to non-target organisms and pest resistance has not been reported except synthetic pyrethroids. No adverse effect on plant growth, seed viability and cooking quality of the grains and botanical pesticides are less expensive and easily available because of their natural occurrence in agro eco system. The botanicals are *M. anisopliae*, Neem oil, NSKE, leaf extract of bitter gourd, custard apple and garadi leaves were found effective for pest management in paddy crop. *M. anisopliae* found effective in reducing the brown plant hopper population and higher seed yield. NSKE show juvenile harmone mimic activity and inhibited larval development of *C. medanalis* (Schmuttere *et al*., 1983). Neem oil showed that the reduction of *N. virescene* and decreases the ability to transmit the tungro virus. (Saxena and khan, 1985) [7]. Custard apple leaf extract reduced the infestation of rice leaf folder and also checked tungro virues, (Narasimha and Mariappan, 1988). Bitter gourd exhibited oviposition deterrent activity against L. *trifolii* females, (Mekuria *et al*., 2005) and garadi leaves also reduce the infestation of insects (Somase, 2006) [11].

Looking over the above mentioned facts, it is imperative to evaluate some useful plant products for management of pest of rice crop, so that quantity of insecticide used to control the major insect pests of paddy can be reduced. Hence, these useful practices could be utilized as the major components of an effective pest management strategy, against insect pests of paddy.

Materials and Methods

The field experiment was undertaken at Agriculture Research Station, Sakoli, Dist. Bhandara (MS) under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during kharif 2018 comprising eight treatments with three replications. The research work was carried on the seasonal incidence of major insect pests in one experimental plot of 500 m2. In the second experimental plot, the efficacies of different herbal products against major insect pests of paddy were studied. The field was prepared during summer by ploughing and harrowing. Well decomposed farm yard manure was added to the soil and thoroughly mixed by giving repeated harrowing. PKV HMT seeds were procured from ARS, Sakoli. Seed treated with 3 per cent brine solution was sown for raising seedling nursery on raised bed. 2-3 seedling of PKV HMT were transplanted per hill at the spacing of 20 x 15 cm in puddled soil. The recommended fertilizer dose for paddy crop was applied @ 100:50:50 kg NPK/ ha. Half dose of N (50 kg) and full dose of P2O5 (50 kg) and K2O (50 kg) was applied before transplanting and half dose of N (50 kg) was applied at 30 days after transplanting.

Methods

For recording seasonal incidence of major insect pests on paddy separate plot of 500 m2 area was sown and observations were recorded from nursery at 7 days interval till the harvest of crop. The observations of 30 hills were taken randomly. In the second experimental plot the efficacy of different herbal against major insect pests on paddy were studied.

Treatment details

Table 1

Tr. No.	Treatments
T1	*Metarrhizium anisopliae* (1x108 cfu/ml) (dose 4 gm/lit of water)
T2	5 % neem oil (dose 5ml/lit of water)
T3	5 % NSKE
T4	5 % bitter gourd (*Momrdica charantia*) leaf extract
T5	5 % custard apple *(Annona squamosa*) leaf extract
T6	5 % garadi (*Cleistanthus collinus*) leaf extract
T7	5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract
T8	Control (water spray)

Table 2: Information of herbal product used in the experiment

Sr. No.	Common Name	Formulation	Source of supply
1	*Metarrhizium anisopliae*	1×108 CFU/ml	Plant Pathology Section, College of Agriculture, Nagpur
2	Neem oil	5 %	Khadi Gram Udyog, Nagpur
3	NSKE	5 %	Prepared
4	Bitter gourd leaf extract	5 %	Prepared
5	Custard apple leaf extract	5 %	Prepared
6	Garadi leaf extract	5 %	Prepared
7	5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract	5 % each	Prepared

Preparation of botanical extracts

Preparation of bitter gourd leaf extract, custard apple leaf extract and garadi leaf extract

Freshly collected tender leaves (50 g/litre) were washed thoroughly under tap water. The washed leaves were rewashed with distilled water and drained out excess water and the excess moisture on leaves was removed by using muslin cloth which further allow to dry under shade. The leaves were completely dried without any trace of moisture. These dried leaves were taken and prepared into fine powder by means of mixture and kept for 16 hours in water. The crude extract slurry was prepared and the concentrated pure leaf extract thus obtained through a sterilized a Whatman no.1. Filter paper was used for spraying of required dose (Fiaz *et al.*, 2012).

Neem seed kernel extract preparation:

50 grams of shade dried neem seeds kernel were taken, crushed on one day before spraying and then soaked overnight in double the quantity of water. Later, on the day of spraying mixture was squeezed through the muslin cloth and the volume was made up to one liter and obtained 5 per cent solution 0.16 % of teepol (sticker) was mixed thoroughly in the extract at the time of spraying.

Preparation of spray solution

The spray solution of desired concentration was freshly prepared before application. The required quantity of botanicals for each respective treatment was worked out and spray solution was prepared by mixing them in water with sticker in the all treatments except *M. anisopliae.*

The required quantity of herbal was thoroughly mixed with water as per the concentration of spray at the time of spraying and then the formulation was used for spraying.

Application of spray solution

Blanket application of all treatments except *M. anisopliae* was undertaken at 15 DAT, subsequently all treatments application was applied on 30, 50, 70 and 90 DAT. The knapsack sprayer was used for spraying operations. After every treatment, sprayer nozzles, pipes were washed twice thoroughly with clean water. Every care was taken to minimize drift and contamination of adjacent plot at the time of spraying. The spraying details are as under.

Table 3.

Sr. No.	Spray number	Spraying days After transplanting	Date of spraying
1	First	15 DAT	7.8.2018
2	Second	30 DAT	22.8.2018
3	Third	50 DAT	11.9.2018
4	Fourth	70 DAT	2.10.2018
5	Fifth	90 DAT	22.10.2019

Methods of recording observations

The observations were recorded as follows

1. For seasonal incidence

Thirty hills from seasonal incidence plot were taken for recording observations of seasonal incidence starting of major insect pests on paddy. A separate plot of 500 m2 area was sown and observations were recorded from nursery at weekly interval till the harvest of crop.

2. For efficacy of different herbal against major insect pests on paddy

Gall midge and stem borer infested silver shoot/ dead hearts count on 10 plants based on stratified random sampling were recorded at 15 days after each application (DAA) along with total tillers. The same method was followed for white ears by stem borer at the time of harvesting along with total productive tillers. The percent incidence of gall midge and stem borer was calculated as fallows.

$$\% \text{ Silver shoot} = \frac{\text{No. of silver shoot in 10 hills} \times 100}{\text{Total no. of tiller in 10 hills}}$$

$$\% \text{ Dead heart} = \frac{\text{No. of dead hearts in 10 hills} \times 100}{\text{Total no. of tiller in 10 hills}}$$

$$\% \text{ White earheads} = \frac{\text{No. of white earheads in 10 hills x 100}}{\text{Total no. of productive tillers in 10 hills}}$$

In case of hoppers populations, number a hopper one day before (1DB) and 3 days after each application (3DAA) on ten random hills were recorded and for leaf folder, the damaged leaves and total leaves from each 10 random hills were recorded on one day before (1DB) and 7 days after each application (7DAA). The per cent damage of leaf folder was calculated as

$$\% \text{ Damage leaf folder} = \frac{\text{No. of damaged leaves in 10 hills} \times 100}{\text{Total no. of leaves in 10 hills}}$$

Natural enemies *viz;* mirid bug, (brown mirid bug and green mirid bug) spider, coccinellid beetle were recorded at 10 days after each application.

Results and Discussions

The data thus obtained were statistically analysed after adopting appropriate transformations. The results obtained during the course of study are summarized below and presented in Table 3.

Second spraying

The treatment of *M. anisopliae* (0.43 nos./hill) was found significantly superior in reducing the population of brown plant hopper over untreated control (1.00 nos./hill) and at par with treatment neem oil (0.57 nos./hill) and 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (0.60 nos./hill). It was followed by 5 % custard apple leaf extract (0.70 nos./hill), 5 % NSKE (0.73 nos./hill), 5 % garadi leaf extract (0.73 nos./hill) and 5 % bitter gourd leaf extract (0.83 nos./hill).

Third spraying

Among the various treatments evaluated for management of brown plant hopper in paddy, 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (2.23 nos./hill) found significantly superior to other treatments and at par with 5 % garadi leaf extract (3.03 nos./hill). This was followed by treatment of neem oil (3.33 nos./hill), *M. anisopliae (*3.67 nos./hill), 5 % custard apple leaf extract (3.73 nos./hill), 5 % bitter gourd leaf extract (4.23 nos./hill) and 5 % NSKE (4.23 nos./hill). However, the highest population of brown plant hopper was recorded in control (5.37 nos./hill).

Fourth spraying

Treatment of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (3.17 nos./hill) recorded significantly superior for reducing the number of brown plant hopper population over other treatments and control (6.70 nos./hill) and followed by 5 % garadi leaf extract (3.80 nos./hill), 5 % bitter gourd leaf extract (4.63 nos./hill), *M. anisopliae* (4.67 nos./hill), neem oil (4.93 nos./hill), 5 % custard apple leaf extract (5.03 nos./hill) and 5 % NSKE (5.23 nos./hill).

Fifth spraying

Population of brown plant hopper was significantly less in treatment with 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (3.67 nos./hill) as compared to other treatments and followed by treatment with neem oil (4.43 nos./hill), 5 % garadi leaf extract (4.87 nos./hill), 5% custard apple leaf extract (5.30 nos./hill), 5 % bitter gourd leaf extract (5.33 nos./hill), 5 % NSKE (5.67 nos./hill) and *M. anisopliae (*5.70 nos./hill). However, more population of brown plant hopper was recorded in control (6.60 nos./hill).

Pooled

Pooled analysis showed that the treatment of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (2.42 nos./hill) was found significantly superior in reducing the population of brown plant hopper over other

treatments and followed by 5 % garadi leaf extract (3.11 nos./hill), neem oil (3.23 nos./hill), *M. anisopliae* (3.62 nos./hill), 5 % custard apple leaf extract (3.69 nos./hill), 5 % bitter gourd leaf extract (3.76 nos./hill) and 5 % NSKE (3.97 nos./hill). However, highest population of brown plant hopper was recorded in control (4.92 nos./hill) (Table 17).

The results of present investigation are in accordance with Mariappan *et al.* (1982). They reported that *Annona squamosa* leaf extract showed insecticidal property against the brown plant hopper. Reddy *et al.* (2012) [9] found that custard apple leaf extract reduces the population of brown plant hopper. Somase (2006) [11] evaluated garadi leaves extract against major pests of soybean and recorded larval reduction of green semi looper after first spray of garadi leaves extract. Kumari *et al.* (2016) [7] reported that *Annona squamosa* and *Cleistanthus collinus* contain highest amount of the phytochemical and are most effective against mealy bug.

The comparative results were reported by Chiu *et al.* (1983) who showed that neem kernel powder suspension reduce honey dew secretion against the brown plant hopper. Similarly, Saxena *et al.* (1984) reported that NSKE showed potential against brown plant hopper. Senthil Nathan *et al.* (2007) [10] also reported that neem extract and azadirachtin effect on biology of brown plant hopper. Ramaraju and Sundarababu (1989) [2] reported that 1per cent neem oil reduce the emergence of brown plant hopper.

Metarhizium anisopliae is a naturally occurring fungus. Spores of *M. anisopliae* come in contact with cuticle of insect pests and germinate and grow directly through the spiracle in to the inner body of the host and drain the nutrients and infected hosts eventually die (Chinniah *et al.* 2016) [2]. The results of present studies are comparable with the findings of Rombach *et al.* (1986) [1], they tested *M. anisopliae* against brown plant hopper and observed mortality due to fungus infection ranged from 63 to 98 per cent 3 week after application. Aguda *et al.* (1987) reported that suppression of brown plant hopper population by *M. anisopliae* in rice. Gilliespie and Jimenez (1990) reported that *B. bassiana* and *M. anisopliae* were important pathogen of brown plant hopper. Thuy *et al.* (1994) [12] evaluated *M. anisopliae* which resulted in 42.2 per cent mortality of brown plant hopper at 10 days after treatment. Reddy *et al.* (2013) [8] found that *M. anisopliae* and *B. bassiana* was effective against brown plant hopper when increase in days after spray. Kiran and Veerana (2012) [5] stated that increases in dose of *M. anisopliae* from 2 kg/ha to 3 kg/ha decrease the brown plant hopper counts at 7 days after spraying.

Conclusion

The treatment of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract (2.42 nos./hill) was found significantly superior in reducing the population of brown plant hopper over other treatments and followed by 5 % garadi leaf extract (3.11 nos./hill), neem oil (3.23 nos./hill), *M. anisopliae* (3.62 nos./hill), 5 % custard apple leaf extract (3.69 nos./hill), 5 % bitter gourd leaf extract (3.76 nos./hill) and 5 % NSKE (3.97 nos./hill). However, the highest population of brown plant hopper was recorded in control (4.92 nos./ hill). On the basis of present investigation, it was concluded that the treatment of 5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract was found effective in management of brown plant hopper.

Table 4: Effect of different bio-pesticide, botanicals and herbal extracts on population of brown plant hoppers on paddy

Tr. No.	Treatments	Brown plant hoppers (no./hill)											
		1st Spraying		2nd Spraying		3rd Spraying		4th Spraying		5th Spraying		Pooled	
		BT	AT	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
		14 DAT	18 DAT	29 DAT	33 DAT	49 DAT	53 DAT	69 DAT	73 DAT	89 DAT	93 DAT		
T_1	*Metarhizium anisopliae* ($1x10^8$ cfu/ml) @ 4 g /litre of water	0.00 (0.00)	0.00 (0.00)	0.10a (0.32)	0.43a (0.66)	0.20a (0.45)	3.67b (1.91)	4.30 (2.07)	4.67c (2.16)	4.40 (2.10)	5.70b (2.39)	2.25 (1.50)	3.62c (1.90)
T_2	Neem oil @ 5 ml/litre of water	0.00 (0.00)	0.00 (0.00)	0.17a (0.41)	0.57a (0.75)	1.27b (1.13)	3.33b (1.83)	3.13 (1.77)	4.93c (2.22)	3.80 (1.95)	4.43b (2.18)	2.09 (1.45)	3.32b (1.82)
T_3	5 % NSKE	0.00 (0.00)	0.00 (0.00)	0.23b (0.48)	0.73b (0.86)	1.20b (1.10)	4.23b (2.06)	3.47 (1.86)	5.23c (2.29)	3.77 (1.94)	5.67b (2.38)	2.17 (2.00)	3.97c (1.99)
T_4	5 % bitter gourd (*Momrdica charantia*) leaf extract	0.00 (0.00)	0.00 (0.00)	0.13a (0.37)	0.83b (0.91)	1.20b (1.10)	4.23b (2.06)	3.20 (1.79)	4.63c (2.15)	3.47 (1.86)	5.33b (2.31)	2.00 (1.41)	3.76c (1.94)
T_5	5 % custard apple *(Annona squamosa*) leaf extract	0.00 (0.00)	0.00 (0.00)	0.20a (0.45)	0.70b (0.84)	1.53b (1.24)	3.73b (1.93)	5.13 (2.27)	5.03c (2.24)	3.53 (1.88)	5.30b (2.30)	2.60 (1.61)	3.69c (1.92)
T_6	5 % garadi (*Cleistanthus collinus*) leaf extract	0.00 (0.00)	0.00 (0.00)	0.17a (0.41)	0.73b (0.86)	1.57b (1.25)	3.03a (1.74)	5.00 (2.24)	3.80b (1.95)	3.83 (1.96)	4.87b (2.21)	2.64 (1.63)	3.11b (1.76)
T_7	5 % bitter gourd leaf extract + 5 % garadi leaf extract + 5 % custard apple leaf extract	0.00 (0.00)	0.00 (0.00)	0.17a (0.41)	0.60a (0.77)	1.63b (1.28)	2.23a (1.49)	4.37 (2.09)	3.17a (1.78)	3.33 (1.83)	3.67a (1.91)	2.38 (1.54)	2.42a (1.55)
T_8	Control (water spray)	0.00 (0.00)	0.00 (0.00)	0.43b (0.66)	1.00c (1.00)	2.23c (1.49)	5.37c (2.32)	3.57 (1.89)	6.70d (2.59)	3.87 (1.97)	6.60c (2.57)	2.53 (1.59)	4.92d (2.22)
	'f' test	NS	NS	Sig	Sig	Sig	Sig	NS	Sig	NS	Sig	NS	Sig
	SE (±M)	-	-	0.05	0.04	0.12	0.10	-	0.05	-	0.07	-	0.04
	CD at 5%	-	-	0.14	0.13	0.37	0.30	-	0.16	-	0.21	-	0.13
	CV (%)	-	-	18.15	8.62	19.10	9.09	-	4.37	-	5.36	-	3.93

BT- one day before treatment, AT-3days after treatment Sig – Significant, NS- Non-Significant

**Figures in parentheses are corresponding values of square root (n) transformation, n= Brown plant hoppers (no./hill)

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