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STUDIES ON THE EFFECT OF COW URINE-BASED NEEM, NOCHI, AND ADHATODA LEAF EXTRACTS AGAINST PADDY STEM BORER, *SCIRPOHAGAINCERTULAS WALKER* IN ORGANIC RICE

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ABSTRACT

Studies on the bio-efficacy of cow-urine-based extracts of neem, nochi and adhatoda (NNA) leaves were conducted against paddy yellow stem borer (YSB), *Scirpophagaincertulas* Walk. in Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2023. Cow urine-based extracts of neem 10%, nochi 10%, and adhatoda 10%, NNA 5%, NNA 10%, NNA 15% were prepared and their efficacy were tested using NSKE 5% as standard check. The field experiment with 15% NNA leaf extract confirms the highest percent reduction over control (PROC) of 28.82 and 35.40, respectively for the dead hearts and white ears. The next effective treatment was NNA 10% application with a PROC of 25.08 and 30.84, respectively for dead hearts and white ears followed by NSKE 5% with a PROC of 23.57 and 28.05 for the first and second sprays, respectively. The NNA leaf extract @ 15 and 10 per cent have moderate impact on natural enemies like spiders and coccinellids and it indicates they are safer for beneficial arthropods. Due to eco-friendly nature of the neem, nochi and adhatoda leaf extracts, in future the cow-urine based NNA leaf extract may be incorporated as one of the plant protection inputs in the integrated management of stem borers under organic rice production system.

Key words: Organic rice, NNA leaf extracts, Efficacy for stem borer, Impact on natural enemies

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than 3.5 billion people in the world and predominantly grown in Asian countries (Birla *et al.*, 2017). Globally, rice is being cultivated around 166 million hectares with the production of 524 million tonnes per annum. Asia contributes nearly 90 per cent of the world's total rice production (Anon. 2023). India ranks first in area and second in production of rice at global level. Rice contributes more than 40 per cent of the India's total food grain production and requirement (Kumar *et al.*, 2020). Rice production is being achieved through intensive and extensive cultivation with high yielding high input response varieties. This resulted in increased insect pest damage and yield loss (Fahad *et al.*, 2019). Rice crop is infested by more than 20 major insect pests, among them the

yellow stem borer (*Scirpophagaincertulas* Walk.), a monophagous pest causing dead hearts and white ears, respectively during vegetative and reproductive stages, resulted in severe yield losses (Chatterjee and Mondal, 2014). The yield losses due to rice stem borers was up to 20% during early planted and 80% during late transplanted rice (Litsinger *et al.*, 2017).

A wider range of synthetic chemical pesticides are being used for the management of stem borers in rice crop. Continuous and indiscriminate use of these chemical pesticides resulted in the development of resistance and resurgence in addition to pesticide residues in food, feed, and fodder (Arora *et al.*, 2019). Organic method of rice cultivation with naturally available inputs is one of the ways to solve these problems. Among different non-chemical pest management inputs for rice stem borers, botanicals

play a vital role due to their cost-effective, biodegradable and environmentally friendly nature (Reddy and Chowdhary, 2021).

Around 2500 botanical plant species from 235 families have been identified with pesticidal properties around the globe. In which about 350 plant species have been identified with insecticidal properties and 800 with feeding deterrents and growth inhibiting properties (Yeswanth, 2021). Neem (*Azadirachta indica L.*) is considered a universal botanical for insect pest management in organic farming due to its wider range of properties like oviposition deterrent, antifeedant, repellent, insect growth regulation etc., against wide range of pests (Misra, 2014). Nochi (*Vitex negundo L.*) contains bio-active compounds like negundoside and vitexin with pesticidal and pest-repellent properties (Prasad, 2011). Adhatoda (*Adhatodavasisca N.*) contains potent compounds such as vasicine, vasicinone and adhatodin with pest repellent, deterrent and pesticidal properties (Nandre *et al.*, 2012). Considering the importance of neem, nochi and adhatoda in pest management a study was designed to determine their relative efficacy against paddy stem borers in organic rice production system.

Material and Methods

Preparation of extracts and treatments

Cow urine-based leaf extracts of neem, nochi and adhatoda were prepared in the laboratory, Nammazhvar Organic Farming Research Centre, Tamil Nadu Agricultural University, Coimbatore. One kilo gram of fresh leaves of neem / nochi / adhatoda was ground separately with each two litres of fresh cow urine and allowed for fermentation for 10 days with intermittent stirring. This is considered as stock solution and used at different concentrations for different treatments of the field study as detailed below.

- T₁ Neem leaf extract 10%
- T₂ Nochi leaf extract 10%
- T₃ Adhatoda leaf extract 10%
- T₄ Neem + Nochi + Adhatoda extract 5%
- T₅ Neem + Nochi + Adhatoda extract 10%
- T₆ Neem + Nochi + Adhatoda extract 15%
- T₇ Cow urine alone 10%
- T₈ Neem Seed Kernel Extract 5% (std. check)
- T₉ Untreated check (water spray)

Field studies

A field experiment was conducted at Wetland Paddy Fields located 11.002°N latitude and 76.923°E longitude

in Tamil Nadu Agricultural University, Coimbatore during the *Rabi* 2023. The field was laid out in Randomized Block Design (RBD) and replicated thrice with a plot size of 5m × 4m. Seeds of the rice variety CO 55 were sown in the nursery and transplanted in the main field under the system of rice intensification (SRI) with the recommended plant spacing of 25×25 cm. Before transplanting, the green manure *Sesbania aculeate* (Willd) was raised in the main field, incorporated at 50% flowering and 15 days before transplanting. Organic rice production package developed by TNAU was followed for supply of required nutrients to rice crop. Cow-urine based neem, nochi and adhatoda leaf extracts prepared was utilized for bio efficacy testing against stem borers. Based on the economic threshold level for stem borers in rice, the pre-treatment damage counts were taken in 10 randomly selected hills. Treatments were imposed at 40 and 75 DAT, the post-treatment count (vegetative stage) and white ear (reproductive stage) were taken at 1, 3, 5, 7, 10 and 15 DAS. The dead heart and white ear percent were computed by using the following formula:

$$\text{Dead heart Per cent} = \frac{\text{Number of dead hearts in 10 randomly selected hills}}{\text{Total number of tillers in 10 randomly selected hills}} \times 100$$

$$\text{White ear Per cent} = \frac{\text{Number of white ears in 10 randomly selected hills}}{\text{Total number of white ears in 10 randomly selected hills}} \times 100$$

Data were subjected to square root transformation using methods suggested by Gomez and Gomez (1985) with treatment variations tested for significance using mean standard error (SE) and critical difference (CD) at 5% level of significance.

Results and Discussion

Effect of NNA leaf extracts against rice yellow stem borer

The results on the bio-efficacy of different botanical treatments against rice stem borer dead heart damage at the vegetative stage of the rice crop is given in Table 1. The dead hearts in pre-treatment count ranged from 10.16 to 11.75 percent and non-significant with each other. The post-treatment damage present at 1DAS was also not significant. From 3 DAS onwards the dead hearts per cent were statistically significant. At 3 DAS, the dead heart damage levels ranged from 9.10 to 11.16 per cent, in which the application of NNA leaf extract at 15% was most effective with the lowest dead hearts (9.10%) followed by NNA leaf extract at 10 per cent (9.42 %) and NSKE 5 per cent (9.63%). At 5 DAS, the damage levels were in decreasing trend (7.81-11.86%) in all the treatments except untreated control and cow urine 10 per cent. At 7 DAS, the dead heart symptoms were further reduced and the lowest was in NNA leaf extract @ 15% (6.71%) application followed by NNA 10%

Table 1: Effect of treatments on stem borer dead heart symptoms in organic rice.

Treatment	Mean dead heart per cent at vegetative phase of the crop								
	PT	1DAS	3DAS	5DAS	7DAS	10 DAS	15 DAS	Mean	PROC
T ₁	11.75(20.04)	10.08(18.51)	9.82(18.26)	9.74(18.18)	9.04(17.49)	10.27(18.69)	10.93(19.30)	9.98	17.67
T ₂	10.16(18.58)	10.46(18.86)	9.76(18.20)	9.50(17.95)	8.96(17.41)	10.08(18.51)	10.91(19.28)	9.95	17.96
T ₃	10.29(18.71)	10.13(18.55)	10.05(18.48)	9.85(18.29)	9.21(17.66)	10.41(18.82)	10.98(19.35)	10.11	16.64
T ₄	10.26(18.68)	10.20(18.62)	10.14(18.56)	10.03(18.46)	9.09(17.54)	11.45(19.77)	11.90(20.17)	10.47	13.64
T ₅	10.83(19.21)	10.24(18.66)	9.42(17.87)	8.17(16.6)	6.98(15.31)	9.17(17.62)	10.51(18.91)	9.08	25.08
T ₆	11.21(19.56)	10.03(18.46)	9.13(17.58)	7.81(16.22)	5.71(13.82)	8.67(17.12)	10.42(18.83)	8.63	28.82
T ₇	10.35(18.76)	10.28(18.70)	10.25(18.67)	10.56(18.96)	10.43(18.84)	11.93(20.20)	13.35(21.43)	11.13	8.15
T ₈	11.27(19.61)	10.35(18.76)	9.63(18.07)	8.21(16.65)	7.26(15.63)	9.43(17.88)	10.71(19.1)	9.27	23.57
T ₉	10.58(18.98)	10.82(19.2)	11.16(19.51)	11.86(20.14)	12.12(20.37)	12.42(20.63)	14.35(22.26)	12.12	0.00
<i>S Ed</i>	<i>NS</i>	<i>NS</i>	0.101	0.055	0.102	0.077	0.224	0.111	-
<i>CD</i> (<i>P=0.05</i>)	<i>NS</i>	<i>NS</i>	0.214	0.117	0.216	0.163	0.476	0.237	-

T₁ - Neem leaf extract 10%, T₂ - Nochi leaf extract 10%, T₃ - Adhatoda leaf extract 10%, T₄ - Neem + Nochi + Adhatoda leaf extract 5%, T₅ - Neem + Nochi + Adhatoda leaf extract 10%, T₆ - Neem + Nochi + Adhatoda leaf extract 15%, T₇ - Cow urine alone 10%, T₈ - Neem seed kernel extract 5% (standard check), T₉ - Control (untreated check) PT - Pre-treatment, DAT - Days after treatment, PROC - Percent reduction over control; *Figures in parentheses are Arcsine transformation values

(7.98%) and NSKE 5% (8.50%). After 10 DAS, the dead heart symptoms were slowly increased irrespective of treatments (8.67-12.42%). The results are in accordance with the findings of Dougoud *et al.*, (2019) against *Scirpophagaintertulas* in rice crop.

At 15 DAS, the dead heart damages due to rice stem borers was in the highest range of 10.91-14.34 per cent with the lowest in NNA 15% application (10.91%) and the highest in untreated control (14.36%). The mean dead heart per cent damage in the post treatment counts ranged from 8.87 to 12.12 per cent with the lowest in NNA leaf extract 15% (8.87) followed by NNA 10% (9.42) and NSKE 5% (9.77). The highest per cent reduction over control (PROC) of 26.79 was registered in NNA leaf extract applied at 15% followed by NNA leaf extract 10% (22.27) and NSKE 5% (19.40). This might be due to the ovicidal activity of cow urine-based neem, nochi and adhatoda leaves extracts (Ahad *et al.*, 2012), the synergistic effect of botanical combinations (Kumud Singh, 2018 and Amandeep *et al.*, 2021).

In second spraying, the pre-treatment stem borer damage per cent as white ear symptom was higher (10.91 to 12.14%) than the pre-treatment counts as dead heart (10.16 to 11.75) in first spray irrespective of the treatments, which were non-significant with each other (Table 2). In post treatment count at one day after spraying also the white ear symptom were non-significant with each other. At 3 and 5 DAS, there was slight decrease in white ear symptoms were observed and their respective values were 8.43-13.34 and 7.25-13.72 per cent. One week after spraying (7 DAS), the lowest white ear damages were observed in all the treatments except

untreated control. However, the lowest damage of 6.76% was registered in NNA leaf extract 15 per cent followed by NNA 10 per cent (7.65%) and NSKE 5 per cent (8.41%) when compared to the untreated control (13.93%). At 10 DAS, the damage levels were slightly increased in all the treatments when compared to the 7 DAS counts. At 15 DAS, the stem borer damages were moderately increased except control and cow urine alone at 10% application. In post treatment counts, the mean white ear damages ranged from 8.93 to 13.82 per cent with the lowest (8.93%) in NNA 15% and the highest (13.82%) in untreated control. The next best effective treatment was NNA 10% treatment (9.56%) and NSKE 5% as foliar spray (9.94%). These results are in agreement with the findings of Nishanthini and Kandibane (2022) and Richa *et al.*, (2017). The better efficacy of NNA leaf extract also might be due to the synergistic effect of neem, nochi and adhatoda leaves in the presence of cow urine which contains uric acid, carbonic acid, amino acids and enzymes (Dhama *et al.*, 2005)

The PROC for white ears at flowering stage of the rice was higher (6.03-35.40) irrespective of the treatments when compared to the same pest damage at vegetative stage as dead heart symptoms (8.15-28.82). In second spray, the highest PROC of 35.40 was observed in NNA 15% followed by NNA 10% (30.84) and NSKE 5% (28.05). Mihale *et al.*, (2009) also found the highest white ears reduction of 49.00% when cow urine-based extracts of neem, tobacco and eucalyptus leaves applied @ 7500 ml/ha. The PROC for individual extracts as neem, nochi and adhatoda leaves were lesser for white ears as that of their performances in first spray as dead hearts. It shows that the application of neem, nochi, and adhatoda leaf

Table 2: Effect of treatments on stem borer white ear symptoms in organic rice.

Treatment	Mean white ear per cent at reproductive phase of the crop								Mean	PROC
	PT	1DAS	3DAS	5DAS	7DAS	10 DAS	15 DAS			
T ₁	10.91 (19.28)	10.42 (18.83)	10.36 (18.77)	9.63 (18.07)	9.32 (17.77)	10.76 (19.14)	12.59 (20.78)	10.51	23.92	
T ₂	11.72 (20.01)	11.24 (19.58)	10.69 (19.08)	10.03 (18.46)	9.47 (17.92)	10.91 (19.28)	12.75 (20.92)	10.85	21.49	
T ₃	11.90 (20.17)	11.77 (20.06)	11.05 (19.41)	10.32 (18.73)	9.83 (18.27)	11.09 (19.45)	13.13 (21.24)	11.20	18.96	
T ₄	11.93 (20.2)	11.57 (19.88)	11.42 (19.75)	10.92 (19.29)	10.16 (18.58)	11.37 (19.70)	13.45 (21.51)	11.48	16.91	
T ₅	11.38 (19.71)	10.89 (19.26)	8.71 (17.16)	7.83 (16.24)	7.65 (16.05)	10.89 (19.26)	11.37 (19.70)	9.56	30.84	
T ₆	10.95 (19.32)	10.20 (18.62)	8.43 (16.87)	7.25 (15.62)	6.76 (15.07)	10.43 (18.84)	10.49 (18.89)	8.93	35.40	
T ₇	12.09 (20.34)	12.05 (20.31)	12.79 (20.95)	12.98 (21.11)	12.85 (21.00)	13.02 (21.15)	14.22 (22.15)	12.99	6.03	
T ₈	11.76 (20.05)	10.27 (18.69)	9.97 (18.40)	8.49 (16.94)	8.41 (16.85)	11.15 (19.50)	11.36 (19.69)	9.94	28.05	
T ₉	12.14 (20.39)	12.89 (21.04)	13.34 (21.42)	13.72 (21.74)	13.93 (21.91)	14.08 (22.03)	14.95 (22.74)	13.82	0.00	
<i>S Ed</i>	<i>NS</i>	<i>NS</i>	0.065	0.049	0.043	0.069	0.100	0.065	-	
<i>CD (P=0.05)</i>	<i>NS</i>	<i>NS</i>	0.139	0.104	0.091	0.146	0.212	0.138	-	

T₁ - Neem leaf extract 10%, T₂ - Nochi leaf extract 10%, T₃ - Adhatoda leaf extract 10%, T₄ - Neem + Nochi + Adhatoda leaf extract 5%, T₅ - Neem + Nochi + Adhatoda leaf extract 10%, T₆ - Neem + Nochi + Adhatoda leaf extract 15%, T₇ - Cow urine alone 10%, T₈ - Neem seed kernel extract 5% (standard check), T₉ - Control (untreated check) PT - Pre-treatment, DAT - Days after treatment, PROC - Percent reduction over control; *Figures in parentheses are Arcsine transformation values

extracts applied separately at 10% concentrations were least effective against stem borers in organic rice. Application of cow urine alone @ 10% was not effective against rice stem borers. The results are in accordance with the findings of Singh and Sarao (2022) and Ranjeeta *et al.*, (2014) stem borers in rice under field conditions.

Impact of NNA leaf extracts on natural enemies of stem borers in organic rice

Impact on spiders

In first spray, the pre-treatment population of spiders among the treatments were in the ranges from 1.51 to 1.96 per hill (Fig. 1). A minor decline in spider population was observed during one week after spraying and steady increase in their numbers were noticed during second week. The per cent impact over control (PIOC) of the treatments on spiders in the organic rice production system indicates that they were safer and the POIC was less than 30% irrespective of the treatments (16.88 to 27.08). Among them, the lowest PIOC of 16.88 was registered with spraying of 10% cow urine alone followed

by neem, nochi and adhatoda leaf extract 5% (17.14) and adhatoda leaf extract @ 10% spray (18.29) when compared to the control treatment and NSKE 5% (27.08). In second spray, the PIOC ranges were more (19.36-32.58) when compared to the PIOC in first spray. However, the PIOC was lesser (19.36) in cow urine sprayed at 10% followed by neem, nochi and adhatoda leaf extract 5% (19.43). The pooled mean PIOC was less (18.12) in neem, nochi and adhatoda leaf extract 15% application followed by neem, nochi and adhatoda leaf extract 5% spray (18.29) and nochi leaf extract 10% spray (22.46). Joseph *et al.*, (2010) who reported that neem oil and NSKE were safe to spiders in rice field. NSKE sprayed at 5% concentration showed the highest pooled PIOC of 29.83. Chen *et al.*, (2018) also found that the NSKE 5% had impact of 10-20% against spiders in rice ecosystem. Wakeli *et al.*, (2013) also reported that the neem products such as neem leaf extract (10%) and NSKE (5%) were found to be quite safe for the spiders. Vinothkumar (2014) found that application of

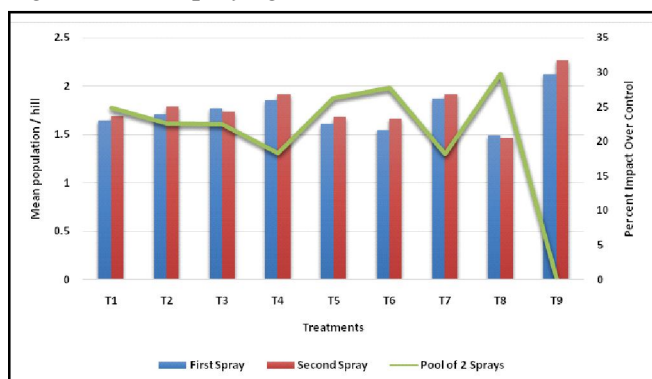


Fig. 1: Impact of NNA leaf extracts on spiders in organic rice.

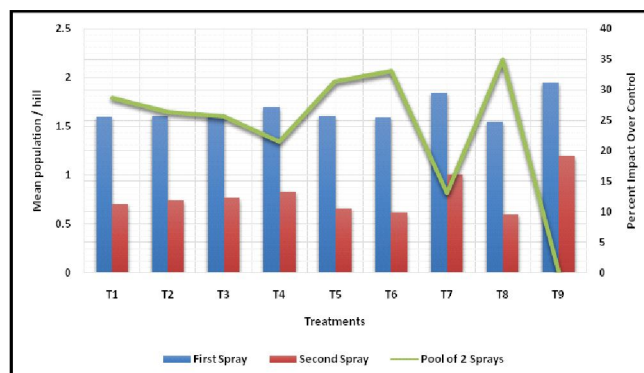


Fig. 2: Impact of NNA leaf extracts on coccinellid beetles in organic rice.

Eupatorium adinophorum 5%, neem oil 3% and NSKE 5% registered less than 12 per cent reduction in spider population over untreated control under rice ecosystem.

Impact on coccinellid beetles

The mean population of coccinellid beetles in the first spray ranged from 1.55 to 1.95 nos./hill (Fig. 2). The beetle numbers at 7 and 15 DAS were in the range between 1.43 - 1.86 and 1.67 - 2.16, respectively. The lowest PIOC of 10.75 was recorded in spraying of cow urine alone @ 10% followed by neem, nochi and adhatoda leaf extract @ 5% as foliar spray (12.33). The highest PIOC of 20.46 was registered in NSKE 5% application. In second spray, the coccinellid beetle population was lesser when compared to first spray irrespective of the treatments and the mean population ranges from 0.60 to 1.20 nos./hill. The PIOC of the second spray was higher than the first spray which ranges from 15.34 to 49.51. The overall pooled mean of coccinellid beetles ranged from 1.08 to 1.57 nos. / hill, with the overall pooled PIOC was 13.05 - 34.99. The results showed that application of NNA 15%, NNA 10% and NSKE 5% had moderate effect and were safer to the coccinellid beetles. Rosaiah (2001) recorded that coccinellids were most predominant and there was no significant difference between population when sprayed with botanicals on rice crop. Saini *et al.*, (2013) observed maximum counts of coccinellid beetles with *Jatropha* leaf extract 10% enriched with fermented cow urine. Verma *et al.*, (2021) found that NSKE showed an impact on natural enemies with a reduction of 25-35 per cent in rice production system. The results are corroborated with the findings of Nishanthini and Kandibane (2022).

Conclusion

The study concluded that, the application of cow urine-based extracts of neem, nochi and adhatoda leaves @ 15% were moderately effective in controlling stem borer, *Scirpophagaintertulas* during both vegetative and reproductive phases of the rice crop. Foliar spraying of neem, nochi and adhatoda leaf extract @ 10% also showed its moderate effect and it was on par with standard check treatment (NSKE 5%). A gradual increase in the efficacy of neem, nochi and adhatoda leaf extracts across two consecutive sprays were observed which resulted in detrimental effect of NNA extract on growth and development of stem borers in addition to ovicidal property due to presence of multiple bio-active compounds. In future, cow urine-based NNA formulation will be developed with the locally available neem, nochi and adhatoda leaves that may be one of the best alternatives for NSKE (standard check) and the same may be recommended for borer pest management not only in

rice but in other crops grown organically.

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Author Contribution

B Anilkumar conducted the original experiment under the guidance of Dr. K. Ganesan and wrote the original manuscript & did the data analysis. MS, SV and VM was helped for preparation of extracts, conducting pot culture experiment and field experiment. KG, RP S, MM, SVS were involved in the correction and supervised the process. All authors read and prepared the final manuscript.

Conflict of Interest : The authors declare that there is no conflict of interest

References

- Ahad, I., Shaw S.S., Gupta R. and Deole S. (2012). Effect of bioactive green leaf extracts on egg hatching and ovipositional behavior of yellow stem borer. *Asian Agri-History*. **16(1)**, 23-26.
- Amandeep Singh, G., Ram M. and Batham P. (2021). Effects of indigenous plant extracts with cow urine on incidence of stem borer, *Scirpophagaintertulas* (Walker) in paddy (*Oryza sativa* L.). *Crop Research*. **56(6)**, 341-345.
- Arora, S., Sehgal M., Srivastava D.S., Arora S. and Sarkar S.K. (2019). Rice pest management with reduced risk pesticides in India. *Environmental Monitoring and Assessment*. **191(4)**, 241-242.
- Birla, D.S., Malik K., Sainger M., Chaudhary D., Jaiwal R. and Jaiwal P.K. (2017). Progress and challenges in improving the nutritional quality of rice (*Oryza sativa* L.). *Critical Reviews in Food Science and Nutrition*. **57(11)**, 2455-2481.
- Chen, Jun., Wu Hualing., Ping Xiating., Li Jie., Chen Cen., Ren Hong., Gu Yuchao., Qiao Hongxiang., Shang Yunlong., Wang and Jianfang (2018). Neem leaf extract as well as preparation process and application. *Annals of Plant Protection Sciences*. **9(4)**, 101-103.
- Choudhary, R., Chandrakar G., Bhardwaj J.R., Khan H.H. and Sahu R. (2017). Assessment of the efficacy of neem-based insecticides for the management of yellow stem borer, *Scirpophagaintertulas* Walk. in paddy field. *Journal of Pharmacognosy and Phytochemistry*. **6(5)**, 1446-1449.
- Devi, M.R., Singh K.I., Ray D.C. and Yumnam S. (2014). Field efficacy of botanical insecticides against yellow rice stem borer, *Scirpophagaintertulas* Walker and their toxic effect on predatory spider in Kharif rice crop in Manipur. *Egyptian Journal of Biological Pest Control*. **11**, 25-30.

- Dhama, K., Rathore R., Chauhan R.S. and Tomar S. (2005). Panchagavya: An over view. *International Journal of Cow Science*. **1**, 1-15.
- Dougoud, J., Toepfer S., Bateman M. and Jenner W.H. (2019). Efficacy of homemade botanical insecticides based on traditional knowledge. *Agronomy for sustainable development*. **39(4)**, 37.
- El-Wakeil, N., Gaafar N., Sallam A. and Volkmar C. (2013). Side effects of insecticides on natural enemies and possibility of their integration in plant protection strategies. Agricultural and biological sciences insecticides - development of safer and more effective technologies. Intech, Rijeka, *Croatia*. **30**, 1-54.
- Fahad, S., Adnan M., Noor M., Arif M., Alam M., Khan I.A. and Wang D. (2019). Major constraints for global rice production. In *Advances in rice research for abiotic stress tolerance*. 1-22.
- Freeman, G.H., Gomez K.A. and Gomez A.A. (1985). Statistical procedures for agricultural research. *Biometrics*. **41(1)**, 342.
- Joseph, R.A., Premila K.S., Nisha V.G., Rajendran S. and Mohan S.S. (2010). Safety of neem products to tetragnathid spiders in rice ecosystem. *Journal of Biopesticides*. **3**, 88.
- Karr, K.A., Fujita R., Carcamo R., Epstein L., Foley J.R., Fraire-Cervantes J.A. and Kritzer J.P. (2017). Integrating science-based co-management, partnerships, participatory processes and stewardship incentives to improve the performance of small-scale fisheries. *Frontiers in Marine Science*. **4**, 345.
- Kumar, K., Tirath R., Kumar H., Pawar J., Pal Munendra and Verma Sandeep (2021). Marketable, Marketed and Marketing cost of rice and wheat in ballia district of Uttar Pradesh, India. *Asian Journal of Science and Technology*. **12(12)**, 12015-12019.
- Mihale, M.J., Deng A.L., Selemani H.O., Kamatenesi M.M., Kidukuli A.W. and Ogenjo J.O. (2009). Use of indigenous knowledge in the management of field and storage pests around Lake Victoria basin in Tanzania. *African Journal of Environmental Science and Technology*. **3(9)**, 251-59.
- Misra, H.P. (2014). Role of botanicals, biopesticides and bioagents in integrated pest management. *CAB Digital Library*. 62-67.
- Mondal, M., Nag D., Koley H., Saha D.R. and Chatterjee N.S. (2014). The *Vibrio cholerae* extracellular chitinase ChiA2 is important for survival and pathogenesis in the host intestine. *PLoS One*. **9(9)**, 103-119.
- Nandre, B.N., Bakliwal S.R., Rane B.R. and Pawar S.P. (2012). A review on *Adhatodavastica*. *Pharma Science Monitor*. **3(4)**, 112-117.
- Nishanthini, K. and Kandibane M. (2022). Efficacy of Botanical Extracts Against Rice Stem Borer *ScirpophagaIncertulas* (Walker). *Indian Journal of Entomology*. **12**, 363-367.
- Prasad, T.V. (2011). Objective Entomology. New Vishal Publication, New Delhi, India. 277.
- Reddy, D.S. and Chowdary N.M. (2021). Botanical biopesticide combination concept a viable option for pest management in organic farming. *Egyptian Journal of Biological Pest Control*. **31(1)**, 1-10.
- Rosaiah, B. (2001). Evaluation of different botanicals against the pest complex of brinjal. *Pestology*. **25(4)**, 14-16.
- Saini, T.M., Patel G.M. and Jat M.K. (2013). Effect of the farmers plant protection practices on natural enemies of insect pests in cotton. *Bioinfolet-A Quarterly Journal of Life Sciences*. **10(1)**, 225-226.
- Senthil Nathan, S. (2011). Biology, behavioral and population dynamics of the rice leaf folder complex: Dynamics of Insect Behavior. *Scientific Publishers*. **10(5)**, 156-167.
- Singh, K. (2018). Comparative Efficacy of botanicals against yellow Stem Borers (*Scirpophagaincertulas*, Walker) and leaf folder (*Cnaphalocrocismedinalis*) of rice in Eastern Uttar Pradesh. *Journal of Pharmacognosy and Phytochemistry*. **7(15)**, 474-478.
- Singh, S. and Sarao P.S. (2023). Field evaluation of biopesticides against rice insect pests under organic farming. *Indian Journal of Entomology*. **13**, 1030-1034.
- Vejjuyeswanth (2021). Prospects of plant extracts in progressive agriculture: A review. *International Journal of Creative Research Thoughts*. **9**, 2320-2882.
- Verma, S., Singh S.K., Pradhan S.S. and Singh A. (2021). A review on response of neem seed and leaf extract on crop protection and production. *International Journal of Plant and Soil Science*. **33(6)**, 22-27.
- Vinothkumar, B. (2014). Impact of insecticides and botanicals on leaf folder and stem borer in the mid-hill rainfed rice agroecosystem. *Indian Journal of Plant Protection*. **42(4)**, 317-323.