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Research Article

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Evaluation of Neem Oil in Combination with Wetting Agent as Larvicide against *Spodoptera frugiperda* (Noctuidae: Lepidoptera)

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ABSTRACT

Background: Fall armyworm (FAW) *Spodoptera frugiperda* (Noctuidae: Lepidoptera) is native of America is now considered as invading pest in India. It causes damage to maize, wheat, rice, sugarcane, etc. The aim of this study was evaluation of neem oil in combination with wetting agent (SuperStiker) as larvicide against *Spodoptera frugiperda* (Noctuidae: Lepidoptera).
Methods: The present study was conducted to evaluate the larvicidal effect of neem oil (WA391: Nim Q) with combination of wetting agents (WA306: SuperStiker). Topical application of different combination of Neem Oil and SuperStiker along with control was given to selected days (2, 4, 6 and 12 days) larvae.
Results: The result revealed that the highest mortality percentage was recorded with the combination of 2 ml Neem oil + 5 ml of SuperStiker in all selected larvae after 24 hours of exposure.
Conclusion: Hence use of Nim Q and SuperStiker in combination was most effective for control FAW population. Therefore, this kind of study will motivate the use of more ecofriendly, less toxic control measuresto decrease the FAW population in agriculture field.

Key-words: Larvicidal, Mortality, Nim Q, *Spodoptera frugiperda*, SuperStiker

INTRODUCTION

Spodoptera frugiperda (Noctuidae: Lepidoptera) is native of tropical and subtropical region of America commonly known as fall armyworm [1,2]. It sprayed to African as invasive alien insect pest species from 2016 onward [3]. Sangomla *et al.* [4] reported that the FAW invaded Asia through Yemen and India, and then spread to Bangladesh, Myanmar, Nepal and China. The first record of the FAW attack is reported from Karnataka and further it sprayed to 20 states in India on Maize [5].

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Ganiger *et al*. [6] reported the occurrence of FAW in maize field of Karnataka. The FAW on the sugarcane reported from the belts of M/s Sakthi Sugars Ltd., Modakurichi, Erode district, and M/s E.I.D. Parry (India) Ltd., Pugalur, Karur district, Tamil Nadu, India in November 2018 [7]. Sisodiya *et al*. [8] reported FAW from sweet corn field in the Anklav village of Anand district Gujarat. Further Chormule *et al*. [9] reported FAW on sugarcane, maize, sorghum and sweet corn in different district of Maharashtra, India.

The presence of high host range i.e. 350 host plants, including maize, rice, sorghum, sugarcane and wheat; survival capacity under harsh conditions of hiding and migrating to different places and the ability of adult FAW female to travel long distance (around 100 km), which make FAW major concern agriculture pests [4]. To control this invasive pest, many synthetic insecticides have been widely used to slow its spread and minimize the damage.

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This injudicious and indiscriminate use of wide range insecticides has led to the development of resistance [10], so best alternative to these insecticides are the use of botanicals for control of fall armyworm. There are many plants which are having insecticidal properties and used traditionally by farmers [11-14]. Even many botanicals like *Myrciaria cauliflora*, *Argemone ochroleuca*, *Azadirachta indica*, etc. are showing the toxic effect against FAW [15-17]. Out of many botanicals, neem is considered for present study due to its easy availability for isolation of oil. Neem oil, extracted from the neem tree, *A. indica* (family: *Meliaceae*) seeds having phytochemicals [18]. The major constituent of neem is azadirachtin [19]. It acts as antifeedant, repellent, growth inhibitor or growth regulator [20]. The use of neem is safe for workers, with no handling risks, can be used throughout the entire crop production cycle, it is also low toxic to non-target organisms makes it as most favorites among researchers [21,22]. But only very small part of the total amount of pesticides applied for weed and pest control actually reaches the sites of action, due to larger proportion being lost *via* spray drift, off-target deposition, run-off and photo degradation [23]. So, the use of a wetting agent or surfactant will minimize the loss of pesticides. Hence the present study was conducted to evaluate the larvicidal effect of neem oil in combination of wetting agent on selected days of fall army worm larvae.

MATERIALS AND METHODS

The present study was conducted in Entomology laboratory, Warkem Biotech Pvt. Ltd., Mumbai, India duration of 2018 to 2019.

Mass rearing of fall army worm- The collected pupae from the unsprayed maize field in Entomology laboratory, Warkem Biotech Pvt. Ltd. Mumbai. These collected pupae were kept in a container for molting into adults. The newly molted adults (male and female) were kept in the container (30 cm x 30cm x 50 cm) having freshly cut leaves of maize and 20% honey dipped cotton in petri-plate for mating. The gravid females were laid egg patches on freshly cut leaves of maize. These larvae hatched and to avoid cannibalism, newly hatched larvae were separated and kept in individual vials. The further rearing and breeding was done at 24±1°C, 70% RH, and 14 L: 10 D photoperiod. The proper, timely cleaning and food was provided at regular interval. Further 2, 4, 6 and 12 days old larvae stages were collected for conducting larvicidal study. Finally, the five replications were kept (20 larvae for each different stage).

Treatments- Two hours pre-starve selected days fall army worm larvae were exposed to following treatment along with the control. Topical application was used for recording the efficiency of product at 24°C±2°C and RH 70-75 % (14 L: 10 D photoperiod) along with control. Total five replicates were kept for all treatment (Table 1).

Table 1: Details of different treatment used in the experiment

Different Treatment	Treatment Details
T1	1 ml SuperStiker + 0.5 ml Nim-Q
T2	2 ml SuperStiker + 0.5 ml Nim-Q
T3	3 ml SuperStiker + 0.5 ml Nim-Q
T4	4 ml SuperStiker + 0.5 ml Nim-Q
T5	5 ml SuperStiker + 0.5 ml Nim-Q
T6	0.5 ml Nim-Q
T7	1 ml SuperStiker + 1.0 ml Nim-Q
T8	2 ml SuperStiker + 1.0 ml Nim-Q
T9	3 ml SuperStiker + 1.0 ml Nim-Q
T10	4 ml SuperStiker + 1.0 ml Nim-Q
T11	5 ml SuperStiker + 1.0 ml Nim-Q
T12	1.0 ml Nim-Q
T13	1 ml SuperStiker + 1.5 ml Nim-Q
T14	2 ml SuperStiker + 1.5 ml Nim-Q
T15	3 ml SuperStiker + 1.5 ml Nim-Q
T16	4 ml SuperStiker + 1.5 ml Nim-Q
T17	5 ml SuperStiker + 1.5 ml Nim-Q
T18	1.5 ml Nim-Q
T19	1 ml SuperStiker + 2.0 ml Nim-Q
T20	2 ml SuperStiker + 2.0 ml Nim-Q
T21	3 ml SuperStiker + 2.0 ml Nim-Q
T22	4 ml SuperStiker + 2.0 ml Nim-Q
T23	5 ml SuperStiker + 2.0 ml Nim-Q
T24	2.0 ml Nim-Q
Control	Water Spray

Statistical Analysis- After 24 h of the exposure period, the number of dead larvae was recorded from each replicates at all the dosage and the percentage of larval mortality was calculated using the Abbott's formula [24].

$$\text{Mortality (\%)} = \frac{(X-Y)}{X} \times 100$$

X= Percentage survival in control, Y= Percentage survival in treated sample

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RESULTS

The present investigation revealed that the maximum i.e. 100% mortality was recorded when two days old larvae of the fall army worm exposed to 1.5 and 2.0 ml of neem oil (Nim Q) in combination with all five different dosages of SuperStiker (1.0, 2.0, 3.0, 4.0 and 5.0 ml). With 1.0 ml of Nim Q the absolute mortality was observed with 2.0, 3.0, 4.0 and 5.0 ml of SuperStiker, whereas the minimum mortality (71%) was recorded when larvae get exposed to 0.5 ml neem oil and 1.0 ml SuperStiker. The result also revealed that Nim Q without SuperStiker was shows low mortality percentage compared to all selected dosage of Nim Q and SuperStiker combination (Table 2).

Maximum 100% mortality were recorded in 4-day old larvae of the fall army worm, when larvae get exposed to 2.0 ml neem oil (Nim Q) in combination of 2.0, 3.0, 4.0, and 5.0 ml SuperStiker. When larvae exposed to 1.5 ml of neem oil in combination of 3.0, 4.0, and 5.0 ml SuperStiker the absolute mortality was recorded, whereas with 1.0 ml neem oil the 100% mortality was recorded in combination of 4.0 and 5.0 ml of SuperStiker. The minimum mortality of second instar of the fall army worm was recorded as 68 % in combination of 0.5 ml neem oil and 1.0 ml SuperStiker. The result also revealed that Nim Q without SuperStiker was showing low mortality percentage compared to all selected dosage of Nim Q and SuperStiker combination (Table 2).

In 6-day old larvae the maximum i.e. 100% mortality was recorded in 1.5 ml and 2 ml neem oil with a combination of 3, 4, and 5 ml SuperStiker. When larvae exposed to 1.0 ml neem oil the absolute mortality was recorded in 4 and 5 ml of SuperStiker, whereas the minimum mortality was recorded at 60% in combination of 0.5 ml neem oil and 1.0 ml SuperStiker. The result also revealed that Nim Q without SuperStiker was showing low mortality percentage compared to all selected dosage of Nim Q and SuperStiker combination (Table 2).

When 12-day old larva stage exposed to Nim Q dosage (1.5 ml and 2 ml) in combination with 5 ml of SuperStiker causes maximum 96 % mortality after 24 hours of exposure of 12-day old larvae. The minimum mortality was recorded as 37 % with 0.5 ml Nim Q and 1.0 ml SuperStiker in 12-day old larvae when compared to control. The result also revealed that Nim Q without SuperStiker was showing low mortality percentage compared to all selected dosage of Nim Q and SuperStiker combination (Table 2).

Table 2: Mean percentage (±SEM) of cumulative Mortality of selected days FAW larvae at 24 h after application of different treatment in a laboratory test

Treatment Details per litre of water	Selected days, larval stages use for treatments			
	2 days	4 days	6 days	12 days
T1	71.0±1.00	75.0±1.58	62.0±1.22	37.0±2.54
T2	77.0±1.22	80.0±2.73	70.0±2.73	46.0±2.44
T3	88.0±2.54	91.0±1.8	78.0±1.22	58.0±1.22
T4	93.0±1.2	93.0±1.22	84.0±1.87	70.0±1.58
T5	96.0±1.87	95.0±1.58	93.0±1.22	75.0±1.58
T6	45.0±2.24	41.0±1.0	36.0±1.0	26.0±1.0
T7	90.0±1.58	90.0±2.24	79.0±1.87	45.0±2.73
T8	100	94.0±1.0	78.0±1.22	57.0±1.22
T9	100	97.0±1.22	89.0±1.87	67.0±1.22
T10	100	100	96.0±1.87	76.0 ±1.87
T11	100	100	100	82.0±1.26

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T12	59.0±1.87	52.0±1.22	49.0±1.87	33.0±1.22
T13	100	94.0±1.0	87.0±1.22	52.0±1.22
T14	100	99.0±1.0	91.0±1.87	65.0±1.58
T15	100	100	95.0±1.22	72.0±1.22
T16	100	100	98.0±2.0	82.0±1.22
T17	100	100	100	90.0±1.58
T18	68.0±1.87	60.0±1.58	58.0±2.0	45.0±1.58
T19	100	98.0±1.22	93.0±1.22	64.0±1.0
T20	100	100	95.0±2.23	72.0±1.22
T21	100	100	100	80.0±1.58
T22	100	100	100	92.0±1.22
T23	100	100	100	96.0±1.87
T24	73±1.22	68.0±1.22	60.0±1.58	52.0±1.22
Control	0	0	0	0

**** Treatment details are given in above Table 1**

DISCUSSION

The effectiveness of neem plant extracts against different insect pests was reported by Kunbhar *et al.* [25]. Neem having rapid degradation in the environment and minimal effects of biological control agents, which make neem as excellent tree [26]. In the present study, the increase in mortality was recorded with an increase the dosage of neem oil. Similarly, Mordue (Luntz) and Blackwell [27] also reported the increase in mortality related to increased the neem oil concentrations by to the effects of azadirachtin depend on both dose and exposure time. Jarvis *et al.* [28] and Simmonds *et al*. [29] also reported the insecticidal effect of neem on *S. frugiperda*, *S. littoralis* and *Helicoverpa armigera*. Viana and Prates [30] also reported the toxic effect of aqueous neem leaf extractagainst *S. frugiperda* caterpillars, which causedthe mortality of *S. frugiperda* caterpillars. Isman *et al.* [31] also reported that *Azadirachta indica* control *S. frugiperda*, *H.virescens*, *S.litura* and *Plutella xylostella*. Maredia *et al.* [32] also reported the potential effect of *A. indica* against *Heliocoverpa zea*, *S. frugiperda*, *Diatraea saccharalis*, *D. grandiosella*, *Sitophilus zeamais* and *Prostephanus truncatus.* Similarly, Tavares *et al.* [1] also reported the mortality of 4 or 6 days old *S. frugiperda* caterpillars to using neem oil.

Roel *et al*. [33] recorded 100% mortality at 4,000 ppm on immature stage of *S. frugiperda* by *A. indica* oil. Similarly, Lima *et al.* [34]; de Campos and Boica-Junior [35] reported 83% mortality of FAW larvae by using neem oil. Silva *et al.* [17] reported the toxic effect of aqueous neem leaf extracts against *S. frugiperda*. Duarte *et al.* [36] reported effectiveness of neem oil against larva and adult of the *S. frugiperda* by the decreased the fecundity and longevity. Similarly, Sisay *et al.* [37] also reported the high percentage larval mortality (>95%) in 72 h after exposure of *A. indica*, *Schinnus molle*, and *Phytolacca dodecandra*. When neem oil used along with wetting agent increased the mortality rate in less time. Butler and Henneberry [38] used oils with surfactants or other adjuvants as emulsifiers which leads to increase spreading and reported very effective against whiteflies and other pests. Even Schonherr *et al.* [39] also reported that when any agrochemical used along with wetting agent or surfactant leads to softening of crystalline waxes in cuticle and thus increased the mobility of the agrochemicals across the skin which leads to fast mortality.

CONCLUSIONS

The present laboratory studies revealed that the combination of neem oil (WA391: Nim Q) along with

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wetting agent (WA306: SuperStiker) are very effective in controlling the population of 2, 4, 6 and 12 days old larvae of FAW under laboratory condition. At 2 ml Nim Q and 5 ml of SuperStiker was showing maximum mortality for all selected larval stages after 24 hours. Therefore, current study motivates to use neem oil in combination of wetting agent against fall army worm under field condition.

This kind of study will decrease the indigenous use of pesticides and its adverse effects on environments and non-target living organism. Its can open the channel to use ecofriendly control measure by integrating it in integrated pest management (IPM) practices.

CONTRIBUTION OF AUTHORS

Research concept- Dr. Anita Singh
Research design- Dr. Anita Singh
Supervision- Dr. Rajas Warke, Dr. Kavita Khadke
Materials- Ms. Pallavi Waykole
Data collection- Dr. Anita Singh
Data analysis and Interpretation- Dr. Anita Singh
Literature search- Dr. Anita Singh
Writing article- Dr. Anita Singh
Critical review- Dr. Anita Singh
Article editing- Dr. Anita Singh
Final approval- Dr. Rajas Warke, Dr. Kavita Khadke

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