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# Effect of Botanicals on Fall Armyworm and Predators in Sorghum Ecosystem

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## ABSTRACT

The present field experiment was conducted at Agricultural College Farm, Bapatla during *kharif* (June-November), 2019 to know the impact of botanicals against fall armyworm, *S. frugiperda* and their natural enemies (coccinellids, spiders and predatory bugs) in the sorghum ecosystem. Among the botanicals, the highest population reduction of FAW egg masses and larval population was recorded in NSKE @ 5% (71.43 and 60.87%, respectively), green chilli pod extract @ 5% (61.90 and 54.35%, respectively), neem leaf extract @ 5% (69.05 and 45.65%, respectively) and garlic bulb extract @ 5% (52.38 and 54.35%, respectively) treated plots. The botanicals that are used in the experiment were found safe from natural enemies. The maximum population of natural enemies *i.e.*, coccinellids, spiders and predatory bugs was recorded in pongamia leaf extract @ 5% (0.16, 0.22 and 0.10 plant$^{-1}$, respectively) whereas, the least was observed in emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ (0.02, 0.02 and 0.01 plant$^{-1}$ respectively) treated plots. The emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ presented an adverse effect on natural enemies whereas no or few natural enemies were observed compared to botanical extracts. Therefore, it is recommended that spraying of botanicals has to be done four times at weekly intervals to keep FAW populations below economic injury level until crop maturity and these treatments were also found safe to natural enemies of FAW.

**KEYWORDS:** Botanicals, fall armyworm, coccinellids, spiders, predatory bugs, sorghum

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## 1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is grown in tropical, subtropical and temperate regions of the world (Reddy and Patil, 2015). In India, it ranks third after wheat and rice in area and production. The major sorghum cultivating states in India are Maharashtra, Karnataka, Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh and Tamil Nadu. In India, the crop was cultivated over an area of 4.82 mha with an annual production of 4.77 mt and the productivity was 989 kg ha$^{-1}$ during 2019–20 (Anonymous, 2020). Sorghum grain contains nutritional components like carbohydrates (70–80%), proteins (11–13%), fats (2–5%), vitamins, minerals and salts (Varaprasad and Staggenborg, 2011). The productivity of sorghum in India (989 kg ha$^{-1}$) was low compared to world productivity (1408 kg ha$^{-1}$) due to abiotic and biotic factors. Over 150 species of pests and numerous natural enemies occupy the sorghum ecosystem in different agro-ecosystems in India (Sharma, 1993). Among them, shoot fly [*Atherigona soccata* (Rondani)], stem borer [*Chilo partellus* (Swinhoe)] and sorghum midge [*Contarinia sorghicola* (Coquillett)] have attained the major pest status in India and accounts to the yield loss of nearly 32 per cent in India. Fall armyworm (FAW) [*Spodptera frugiperda* (J.E. Smith)] is of serious concern due to its notorious and polyphagous behavior (Day et al., 2017, Sharanabasappa et al., 2018 and Swamy et al., 2018). The main reason for its fast spread might be its strong capacity to fly and disperse long distances annually during the summer months (Nagoshi et al., 2017, Prasanna et al., 2018). It is capable of feeding on more than 353 plant species belonging to 76 plant families and causing considerable economic losses in the members of Poaceae (106), Asteraceae (31), Fabaceae (31) Amaranthaceae (11) and Cucurbitaceae (9) (Montezano et al., 2018). The fall armyworm causes damage to all the crop growth stages of sorghum. The larvae make pin holes on leaves and feed across the whorl leading to irregular, elongated holes on leaves when they unfurl from the whorl which in turn elongated as lesions. The late instar larvae cause extensive defoliation, often leaving only the midribs and stalks of plants while feeding inside the whorl producing a large amount of sawdust-like fecal matter (Sharanabasappa et al., 2020 and Shylesha and Sravika, 2018). During the reproductive stage, the larvae continue to feed on the leaves and develop grains in the panicle of sorghum. The pest accounts for a 16% yield loss in sorghum (Abrahmas et al., 2017). In the present scenario, the problem caused by fall armyworm becomes a stumbling block in maize and sorghum production. The farmers are solely depending on insecticides and applying higher doses of pesticides repeatedly for its management in sorghum. The injudicious usage of insecticides affects the natural enemy population this may lead to the resurgence of target pests or non-target minor pests, increases the cost of cultivation, environmental pollution and development of resistance in insects. Insecticides like methomyl, chlorpyriphos, permethrin, cyperthrin, fenvalerate and methyl parathion were effective against FAW but due to the injudicious use of these insecticides, the pest has developed resistance against methomyl (223 folds), thiodicarb (124 folds), permethrin (48 folds), chlorpyriphos (47 folds) cypermethrin (6 folds) and fenvelarate (2 folds) (Rebeca et al., 2018). The application of insecticides in sorghum is uneconomical under subsistence farming and the indiscriminate use of pesticides on sorghum has created contamination of food chains through fodder (Koli and Bhardwaj, 2018). In this context, the usage of botanicals is one of the alternative methods for the suppression of pests and to reduce the cost of cultivation in sorghum. By keeping this view, the present study was undertaken to evaluate the impact of various botanicals on the population of fall armyworm and predators in the sorghum ecosystem.

## 2. MATERIALS AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla during (June–November), 2019. The sorghum (CSH-16) was cultivated as per the standard agronomic recommendations. The field experiment was laid out in Randomised Block Design (RBD) consisting of eight treatments including control. The treatments *viz.*, NSKE @ 5%, neem leaf extract @ 5%, pongamia leaf extract @ 5%, green chili pod extract @ 5%, custard apple leaf extract @ 5%, garlic bulb extract @ 5%, emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ (Standard check) and untreated control, and they were replicated thrice.

### *2.1. Methodology for preparation of botanicals*

250 g of neem seed kernel powder, leaves (Neem, Pongamia, and Custard apple), chilli pods, and garlic bulbs were separately taken into a thin muslin cloth bag and soaked separately in five liters of water overnight after tying of open end of the bag. The soaked material was squeezed repeatedly and the final volume was adjusted to five litres. A pinch of detergent powder was added to the filtrate just before spraying (Mudigoudra and Shekharappa, 2009).

The first spraying was commenced from 10 DAS and further, it was repeated at 15 days of interval. Overall four sprays were undertaken for the management of fall armyworm in sorghum. The pre-treatment observation was taken 24 hours before the first spray. Sprayings were done using a high volume knapsack sprayer during morning hours. The population of fall armyworm (Egg masses and larvae) and natural enemies (coccinellid, spiders and predatory bugs) were recorded on 10 randomly selected plants at 10, 25, 40, and 55 DAS. The data pertaining to the population of fall

armyworm and natural enemies were subjected to square root transformation from respective treatments. The data were subjected to ANOVA and the mean comparisons were made by Least Significant Difference (LSD).

## 3. RESULTS AND DISCUSSION

### *3.1. Effect of various treatments on egg masses and larval population of fall armyworm*

#### *3.1.1. Egg masses*

The study on the efficacy of botanicals against fall armyworm in sorghum revealed that all the treatments were found to be significantly superior over untreated checks in the reduction of egg masses of fall armyworm. Among the botanicals, the highest reduction of fall armyworm egg masses was recorded in NSKE @ 5% (71.43%) followed by garlic bulb extract @ 5% (69.0 5%) whereas, the lowest was recorded in custard apple leaf extract @ 5 % (42.86%) and pongamia leaf extract @ 5% (28.57%) (Table 1).

#### *3.1.2. Larvae*

The data pertaining to the effect of different botanicals on the larval population of FAW in sorghum revealed that all the treatments were found significantly superior over untreated control. Among the botanicals, NSKE @ 5 % was found to be the most effective in the reduction of the larval population of FAW (60.87%) followed by garlic bulb extract @ 5% (54.35%) and green chilli pod extract @ 5% (54.35%). While the least population reduction over untreated control was observed in pongamia leaf extract @ 5% (30.48%) (Table 1).

Among the botanicals, NSKE @ 5% followed by garlic bulb

Table 1 : Efficacy of botanicals against fall armyworm in sorghum during *kharif*, 2019

| Treatments | Pre-treatment count | | Mean number of fall armyworm egg masses and larval population plant$^{-1}$ | | | | | | Cumulative mean | | Percent reduction over control (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before spray (10 DAS) | | 25 DAS | | 40 DAS | | 55 DAS | | E | L | E | L |
| | E | L | E | L | E | L | E | L | | | | |
| $T_1$ | 0.13 (0.79) | 0.33 (0.91) | 0.10 (0.77)$^{a}$ | 0.27 (0.87)$^{b}$ | 0.07 (0.75)$^{a}$ | 0.20 (0.84)$^{ab}$ | 0.03 (0.73)$^{a}$ | 0.13 (0.79$^{ab}$ | 0.07 (0.75)$^{a}$ | 0.20 (0.84$^{ab}$ | 71.43 | 60.87 |
| $T_2$ | 0.10 (0.77) | 0.37 (0.93) | 0.10 (0.77)$^{a}$ | 0.33 (0.91)$^{bc}$ | 0.07 (0.75)$^{ab}$ | 0.27 (0.87)$^{b}$ | 0.05 (0.74)$^{a}$ | 0.23 (0.85)$^{bc}$ | 0.07 (0.76)$^{ab}$ | 0.28 (0.88)$^{bc}$ | 69.05 | 45.65 |
| $T_3$ | 0.13 (0.80) | 0.40 (0.95) | 0.13 (0.80)$^{a}$ | 0.43 (0.96)$^{bc}$ | 0.17 (0.82)$^{ab}$ | 0.33 (0.91)$^{bc}$ | 0.20 (0.83)$^{ab}$ | 0.30 (0.89)$^{c}$ | 0.17 (0.82)$^{b}$ | 0.36 (0.92)$^{c}$ | 28.57 | 30.43 |
| $T_4$ | 0.13 (0.79) | 0.37 (0.93) | 0.10 (0.77)$^{a}$ | 0.30 (0.89)$^{bc}$ | 0.10 (0.77)$^{ab}$ | 0.20 (0.84)ab | 0.07 (0.75)a | 0.20 (0.84)$^{bc}$ | 0.09 (0.77)$^{ab}$ | 0.23 (0.86)$^{bc}$ | 61.90 | 54.35 |
| $T_5$ | 0.10 (0.77) | 0.33 (0.91) | 0.10 (0.77)$^{a}$ | 0.30 (0.89)$^{bc}$ | 0.13 (0.77)$^{ab}$ | 0.27 (0.87)$^{b}$ | 0.17 (0.81)$^{a}$ | 0.27 (0.88)$^{bc}$ | 0.13 (0.79)$^{ab}$ | 0.28 (0.88)$^{bc}$ | 42.86 | 45.65 |
| $T_6$ | 0.13 (0.79) | 0.40 (0.95) | 0.13 (0.79)$^{a}$ | 0.27 (0.87)$^{b}$ | 0.10 (0.77)$^{ab}$ | 0.23 (0.85)$^{ab}$ | 0.10 (0.77)$^{a}$ | 0.20 (0.83)$^{bc}$ | 0.11 (0.78)$^{ab}$ | 0.23 (0.85)$^{bc}$ | 52.38 | 54.35 |
| $T_7$ | 0.10 (0.77) | 0.37 (0.93) | 0.05 (0.74)$^{a}$ | 0.10 (0.77)$^{a}$ | 0.03 (0.73)$^{a}$ | 0.07 (0.75)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.00 (0.71)$^{a}$ | 0.03 (0.73)$^{a}$ | 0.07 (0.76)$^{a}$ | 88.10 | 89.13 |
| $T_8$ | 0.13 (0.79) | 0.43 (0.97) | 0.20 (0.84)$^{b}$ | 0.47 (0.98)$^{c}$ | 0.23 (0.85)$^{b}$ | 0.50 (1.00)$^{c}$ | 0.27 (0.88)$^{b}$ | 0.57 (1.03)$^{d}$ | 0.23 (0.86)$^{b}$ | 0.51 (1.01)$^{d}$ | - | - |
| SEm± | 0.04 | 0.03 | 0.02 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.02 | 0.03 | - | - |
| CD ($p$≤0.05) | NS | NS | 0.07 | 0.09 | 0.09 | 0.11 | 0.10 | 0.16 | 0.05 | 0.07 | - | - |
| C.V. (%) | 9.07 | 5.49 | 4.90 | 6.32 | 6.61 | 7.05 | 7.49 | 10.64 | 4.01 | 5.61 | - | - |

$T_1$: Neem seed kernel extract (NSKE) @ 5%; $T_2$: Neem leaf extract @ 5%; $T_3$: Pongamia leaf extract @ 5%; $T_4$: Green chilli pod extract @ 5%; $T_5$: Custard apple leaf extract @ 5%; $T_6$: Garlic bulb extract @ 5%; $T_7$: Emamectin benzoate 5 SG (Standard check)-0.04 % (@ 11 g a.i. ha$^{-1}$); $T_8$: Untreated control; Figures in parentheses are square root transformed values; E: Egg masses; L: Larval population; DAS: Days After Sowing; NS: Non significant; Numbers with same superscript are not statistically different

extract @5% was found most effective against FAW and it was safe for natural enemies. These results are in accordance with the findings of Mudigoudra and Shekharappa, (2009) recorded the lowest number of sorghum shoot fly eggs in NSKE @ 5% treated plots whereas, the highest population was recorded in plots treated with pongamia leaf extract @ 5%. Analogously, Sisay et al. (2019) reported that no live larvae of FAW were recorded in the *Azadirachta indica* treated plot in the second and third rounds of spraying.

*3.2. Biosafety of botanical pesticides against natural enemies of fall armyworm*

The natural enemies like coccinellids (*Cheilomenes sexmaculata* (Fab.), *Coccinella transversalis* (Fab.), *Brumoides suturalis* (Fab.) and *Cycloneda sanguinea* (L.)), spiders and predatory bugs *(Rhynocoris fuscipes* (Fab.), *Orius* sp. and *Eocanthecona furcellata* (Wolff)) were observed in the experimental field.

*3.3.1. Coccinellids*

The highest mean population of coccinellids was recorded in pongamia leaf extract @ 5% (0.16 coccinellids plant$^{-1}$) and it was significantly on par with custard apple leaf extract @ 5% (0.09 coccinellids plant$^{-1}$) and neem leaf extract @ 5% (0.09 coccinellids plant$^{-1}$). The next best treatments were green chilli pod extract @ 5%, garlic bulb extract @ 5% and NSKE @ 5% which were on par with each other. The minimum population was recorded in emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ (0.02 coccinellids plant$^{-1}$) (Table 2).

*3.2.2. Spiders*

The botanicals had shown significant effect on the population of spiders in the sorghum ecosystem. The highest number of spiders were noticed in untreated control (0.27 spiders plant$^{-1}$) and it was significantly on par with pongamia leaf extract @ 5% (0.22 spiders plant$^{-1}$) and custard apple leaf extract @ 5% (0.16 spiders plant$^{-1}$). The effectiveness of the remaining treatments was neem leaf extract @ 5% (0.10 spiders plant$^{-1}$), garlic bulb extract @ 5% (0.10 spiders plant$^{-1}$), green chilli pod extract @ 5% (0.08 spiders plant$^{-1}$), NSKE @ 5% (0.07 spiders plant$^{-1}$) and emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ (0.02 spiders plant$^{-1}$) (Table 2).

*3.2.3. Predatory bugs*

The maximum population of bugs was observed in the untreated control (0.13 predatory bugs plant$^{-1}$) and it was significantly on par with pongamia leaf extract @ 5% (0.10 predatory bugs plant$^{-1}$). Custard apple leaf extract @ 5% (0.06 predatory bugs plant$^{-1}$), neem leaf extract @ 5% (0.04

Table 1: Efficacy of botanicals against fall armyworm in sorghum during *kharif,* 2019

| Treatments | Pre-treatment count | | | Mean number of natural enemies population plant$^{-1}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Before spray (10 DAS) | | | 25 DAS | | | 40 DAS | | |
| | C | S | P | C | S | P | C | S | P |
| $T_1$ | 0.10 (0.77) | 0.13 (0.79) | 0.03 (0.73) | 0.07 (0.75) | 0.10 (0.77)$^{ab}$ | 0.03 (0.73) | 0.03 (0.73)$^{bc}$ | 0.07 (0.75)$^{c}$ | 0.00 (0.71)$^{c}$ |
| $T_2$ | 0.13 (0.79) | 0.17 (0.81) | 0.10 (0.77) | 0.10 (0.77) | 0.13 (0.80)$^{ab}$ | 0.07 (0.75) | 0.10 (0.77)$^{bc}$ | 0.10 (0.77)$^{bc}$ | 0.03 (0.73)$^{bc}$ |
| $T_3$ | 0.10 (0.77) | 0.17 (0.82) | 0.10 (0.77) | 0.17 (0.82) | 0.20 (0.84)$^{ab}$ | 0.07 (0.75) | 0.13 (0.79)$^{ab}$ | 0.23 (0.86)$^{ab}$ | 0.10 (0.77)$^{ab}$ |
| $T_4$ | 0.13 (0.80) | 0.10 (0.77) | 0.07 (0.75) | 0.10 (0.77) | 0.10 (0.77)$^{ab}$ | 0.03 (0.73) | 0.07 (0.75)$^{bc}$ | 0.07 (0.75)$^{c}$ | 0.03 (0.73)$^{bc}$ |
| $T_5$ | 0.13 (0.80) | 0.13 (0.80) | 0.00 (0.71) | 0.10 (0.77) | 0.17 (0.82)$^{ab}$ | 0.07 (0.75) | 0.10 (0.77)$^{bc}$ | 0.13 (0.80)$^{abc}$ | 0.07 (0.75)$^{abc}$ |
| $T_6$ | 0.10 (0.77) | 0.13 (0.77) | 0.07 (0.75) | 0.07 (0.75) | 0.13 (0.80)$^{ab}$ | 0.03 (0.73) | 0.07 (0.75)$^{bc}$ | 0.10 (0.77)$^{bc}$ | 0.03 (0.73)$^{bc}$ |
| $T_7$ | 0.10 (0.77) | 0.10 (0.77) | 0.03 (0.73) | 0.07 (0.75) | 0.07 (0.75)$^{b}$ | 0.00 (0.71) | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{c}$ |
| $T_8$ | 0.13 (0.79) | 0.17 (0.81) | 0.07 (0.75) | 0.17 (0.82) | 0.23 (0.86)$^{a}$ | 0.10 (0.77) | 0.23 (0.86)$^{a}$ | 0.27 (0.87)$^{a}$ | 0.13 (0.80)$^{a}$ |
| SEm± | 0.03 | 0.04 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.02 |
| CD ($p$≤0.05) | NS | NS | NS | NS | 0.09 | NS | 0.07 | 0.09 | 0.05 |
| C.V. (%) | 6.52 | 8.41 | 6.92 | 5.11 | 6.37 | 3.65 | 4.96 | 6.62 | 4.22 |

Table 2: Continue...

| Treatments | Mean number of natural enemies population plant$^{-1}$ | | | Cumulative mean | | |
|---|---|---|---|---|---|---|
| | 55 DAS | | | C | S | P |
| | C | S | P | | | |
| $T_1$ | 0.00 (0.71)$^{c}$ | 0.03 (0.73)$^{bc}$ | 0.00 (0.71)$^{b}$ | 0.03 (0.73)$^{cd}$ | 0.07 (0.75)$^{bc}$ | 0.01 (0.71)$^{d}$ |
| $T_2$ | 0.07 (0.75)$^{bc}$ | 0.07 (0.75)$^{bc}$ | 0.03 (0.73)$^{b}$ | 0.09 (0.77)$^{ab}$ | 0.10 (0.77)$^{bc}$ | 0.04 (0.74)$^{bc}$ |
| $T_3$ | 0.17 (0.82)$^{ab}$ | 0.23 (0.86)$^{a}$ | 0.13 (0.80)$^{a}$ | 0.16 (0.81)$^{ab}$ | 0.22 (0.85)$^{a}$ | 0.10 (0.77)$^{ab}$ |
| $T_4$ | 0.03 (0.73)$^{c}$ | 0.07 (0.75)$^{bc}$ | 0.00 (0.71)$^{b}$ | 0.07 (0.75)$^{cd}$ | 0.08 (0.76)$^{bc}$ | 0.02 (0.72)$^{cd}$ |
| $T_5$ | 0.07 (0.75)$^{bc}$ | 0.17 (0.82)$^{ab}$ | 0.03 (0.73)$^{b}$ | 0.09 (0.77)$^{bc}$ | 0.16 (0.81)$^{ab}$ | 0.06 (0.75)$^{b}$ |
| $T_6$ | 0.03 (0.73)$^{c}$ | 0.07 (0.75)$^{bc}$ | 0.00 (0.71)$^{b}$ | 0.06 (0.75)$^{cd}$ | 0.10 (0.77)$^{bc}$ | 0.02 (0.72)$^{cd}$ |
| $T_7$ | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{c}$ | 0.00 (0.71)$^{b}$ | 0.02 (0.72)$^{d}$ | 0.02 (0.72)$^{c}$ | 0.01 (0.71)$^{d}$ |
| $T_8$ | 0.27 (0.87)$^{a}$ | 0.30 (0.89)$^{a}$ | 0.17 (0.82)$^{a}$ | 0.22 (0.85)$^{a}$ | 0.27 (0.87)$^{a}$ | 0.13 (0.80)$^{a}$ |
| SEm± | 0.02 | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 |
| CD ($p$≤0.05) | 0.07 | 0.09 | 0.05 | 0.04 | 0.06 | 0.03 |
| C.V. (%) | 5.06 | 6.94 | 3.60 | 3.02 | 4.63 | 1.96 |

$T_1$: Neem seed kernel extract (NSKE) @ 5%; $T_2$: Neem leaf extract @ 5%; $T_3$: Pongamia leaf extract @ 5%; $T_4$: Green chilli pod extract @ 5%; $T_5$: Custard apple leaf extract @ 5%; $T_6$: Garlic bulb extract @ 5%; $T_7$: Emamectin benzoate 5 SG (Standard check)-0.04 % (@ 11 g a.i. ha$^{-1}$); $T_8$: Untreated control; Figures in parentheses are square root transformed values; E: Egg masses; L: Larval population; DAS: Days After Sowing; NS: Non significant; Numbers with same superscript are not statistically different

predatory bugs plant$^{-1}$), green chilli pod extract @ 5% (0.02 predatory bugs plant$^{-1}$) and garlic bulb extract @ 5% (0.02 predatory bugs plant$^{-1}$) which were significantly on par with each other. The other two treatments *i.e.,* NSKE @ 5% (0.01 predatory bugs plant$^{-1}$), and emamectin benzoate 5 SG @ 11 g a.i. ha$^{-1}$ (0.01 predatory bugs plant$^{-1}$) were on par with each other (Table 2).

This study revealed that the tested treatments were highly effective against *S. frugiperda.* The standard check emamectin benzoate 5 SG @ 0.04% found the best insecticide to reduce egg masses and larval population of FAW in sorghum but, it was not safe for natural enemies. The above finding was found similar to the Islam and Das (2017) reported that emamectin benzoate 5 SG @ 0.004% showed 15.66%, 15.66% and 11.99% mortality of coccinellids, lynx spider and wolf spider in brinjal ecosystem. Singh et al., 2016 reported that lynx and wolf spiders were susceptible to the avermectin pesticides (abamectin and emamectin benzoate). All the botanicals tested against fall armyworm were safe to natural enemies but the enhanced activity of natural enemies was observed in pongamia leaf extract @ 5% treated plot due to the availability of the highest prey population. These results are in accordance with the findings of Baidoo and Mochiah (2016) who reported that the population of coccinellids was significantly more in garlic and pepper sprayed plots compared to insecticide sprayed plots in cabbage. Mandal (2018) tested the eco-friendly products against major lepidopteran pests in soybean and reported that the population of predatory bugs was more in garlic+ chilli @ 8.75 kg ha$^{-1}$ (0.69 predatory bugs plant$^{-1}$) and NSKE @ 5% (0.50 predatory bugs plant$^{-1}$) treated plots. Balikai and Lingappa (2004) stated that the leaf extract of pongamia @ 5% was safe for syrphids, and coccinellids in the sorghum ecosystem.

## 4. CONCLUSION

Among the botanicals, NSKE @ 5% were significantly effective in reducing the egg masses and larval population of FAW and it was safe to natural enemies. Deleterious effects of treatments were not observed on predators in sorghum throughout the season *i.e.,* coccinellids, spiders and predatory bugs.

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