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Impact of plant products on major insect pests of fodder sorghum under certified organic farming system

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Abstract
Pest management under organic farming is a challenging task, wherein, ecofriendly approaches against insect pest were accomplished through the use of appropriate strategies which promotes manipulation and alteration of agro-ecosystem. In this view, an experiment was laid out in Randomized Block Design with SSV-74, a sweet sorghum cum fodder variety (during *kharif* 2021-22 and 2022-23) at certified organic block (certified since 2006), Bio-Resource Farm, Institute of Organic Farming, University of Agricultural Sciences, Dharwad. The analysis of pooled data for two seasons revealed that, among various plant products evaluated the plots treated with NSKE @ 5% found superior with significantly lower incidence of shoot fly (1.44 eggs /plant and 8.92% dead hearts), and stem borer larvae (3.47 larvae /m row) as well as fall armyworm (1.20 larvae/plant) with considerably least damage severity. This was followed *Vitex negundo* @ 5%. However, all the organic plots documented relatively higher population of beneficial fauna in comparison with inorganic check.

Keywords: Fodder sorghum, certified organic farming system, *Atherigona soccata*, *Chilo partellus* and *Spodoptera frugiperda*

Introduction
Organic farming as a holistic production management system that encourages and improves health and biodiversity of agro-ecosystem. Pest management in organic farming is accomplished through the use of appropriate cropping techniques, biological control, and natural pesticides (primarily extracted from plant or animal origins), which promotes manipulation and alteration of agro-ecosystem. The main strategy to combat harmful pests is to build up a population of beneficial insects. Sorghum, *Sorghum bicolor* (L.) Moench [*Poaceae*], is the world's fifth most significant grain crop and a major food crop in Asia and Africa. Sorghum is grown on 5.7 million ha in India, with an output of 3 million tons (Somegowda *et al*., 2021) [10]. Sorghum is especially essential as a fodder crop (*kharif* crop) in the health and nutrition of cattle in India, which has one of the world's largest livestock populations (Sharda and Juyal, 2006) [9]. Furthermore, existing demand for meat and milk will increase to 14 million tons and 400 million tons, respectively, by 2050 (Earagariyanna *et al*., 2017) [5]. Forage crops will surely play a crucial role in feeding this vast cattle population to meet the growing demand for milk and its byproducts, Despite the fact that fodder sorghum accounts for 2.6 million ha of India's forage production land, the crop's production potential is not fully realized due to various constraints. Major contributors among them are insect infestations. Nevertheless, damage by insect pests at different phases of the plant's development can lower production, which has an influence on the poor income of farmers. As the insecticides are expensive and sorghum as fodder crop have a low economic value, pest management in these crops is currently understudied and rarely used. Hence, ecofriendly approaches for insect pest management in fodder sorghum are very much needed. Therefore, current investigation is planned in order to manage major insect pests of fodder sorghum under organic cultivation practices.

Material and Methods
Experiment was laid out in Randomized Block Design in three replications with a plot size of 4.20 × 3 m^2, leaving a gangway of 1m all around the plots. Plots were sown with SSV-74, a sweet sorghum cum fodder variety during *kharif* 2021-22 and 2022-23. Timely agronomic practices were carried out throughout the cropping season except for insect control. The required amount of fertilizer was supplied through the application of suitable organic source only based on the NPK requirement suggested under organic package of practice, UAS, Dharwad (Anon. 2020) [2]. To compare the results of each experiment a standard organic check

and an inorganic check (chemical check) were laid out separately at inorganic block, UAS, Dharwad in three replications. Plant samples (leaves or seeds) were collected and extracted by following standard protocols mentioned as below. For preparing neem seed kernel extract and pongamia extract, 50 g of dried and smashed neem/pongamia seeds were soaked overnight in 1 lit. of distilled water, squeezed through muslin cloth and diluted with distilled water to get 5 per cent concentration of the suspension. Similarly, for preparation of leaf extracts, fresh plant materials were collected and washed thoroughly (3-4 times) with tap water and finally with distilled water. Later, they were chopped into small pieces with a sharp knife. Five grams of chopped material were macerated in pestle and mortar and extracted with a small quantity of distilled water. The extracts were squeezed through muslin cloth and made up to 100 ml with distilled water. The filtrate was cold stored in clean reagent bottles for further use. The concentration of the suspension so prepared works out to be 5 per cent. The treatments were imposed 10-15 days after seedlings emergence and subsequent sprays were taken at 10 days' interval based on intensity of pest damage (need based spray).

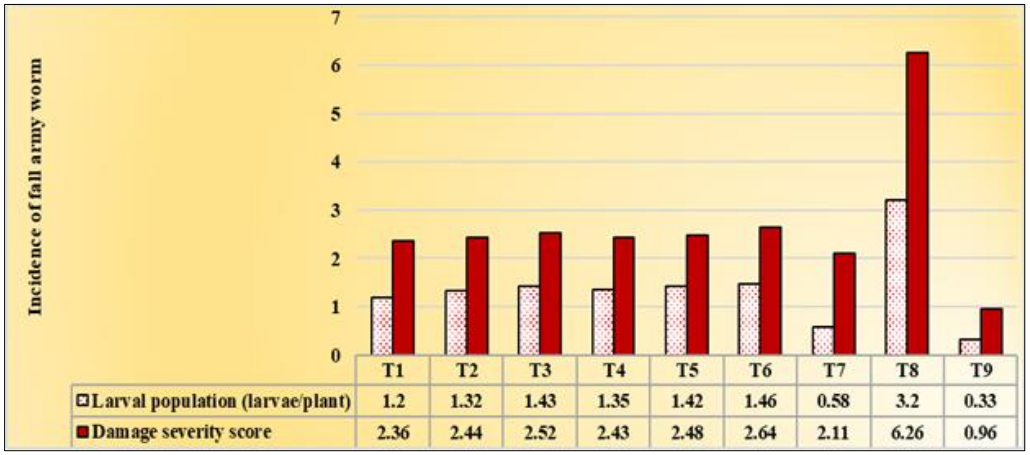
Further, observation on incidence of shoot fly, *Atherigona soccata* Rodani, stem borer, *Chilo partellus* (Swinhoe) and fall armyworm, *Spodoptera frugiperda* (J E Smith) as well as green fodder yield were recorded. The leaf damage severity was measured based on damage scale given by Davis and Williams (1992) [4]. Likewise, abundance of natural enemies was also documented.

Results and Discussion

In the current study, different plant products were evaluated against insect pests of fodder sorghum for two seasons **(***kharif* 2021-22 and 2022-23), and results of pooled data were presented hereunder. Among various plant products evaluated in fodder sorghum, plots treated with NSKE @ 5% recorded lower mean shoot fly egg count (1.44/plant) and lower per cent dead heart per plot of 8.92 per cent (Table 1). Similarly, number of stem borer larvae were considerably least (3.47 larvae/m row) under plots treated with NSKE @ 5%, with significantly least per cent dead hearts (7.72%) among all the plant products evaluated (Table 2). The larval count of fall armyworm statistically minimum under NSKE @ 5% treated plots with 1.20 larvae/plant as well as lower leaf damage score (Fig. 1). This was followed by *Vitex negundo* @ 5%, *Pongamia glabra* (leaf extract) @ 3% and *Pongamia glabra* (seed extract) @ 3%. In addition, the treatments such as *Adathoda vesica* @ 5% and *Vinca rosea* @ 5% found to be least effective with higher incidence of shoot fly, stem borer and fall armyworm damage but superior than UTC. The incidence and damage under inorganic check or recommended package of practice (RPP) was significantly lower among all the treatments.

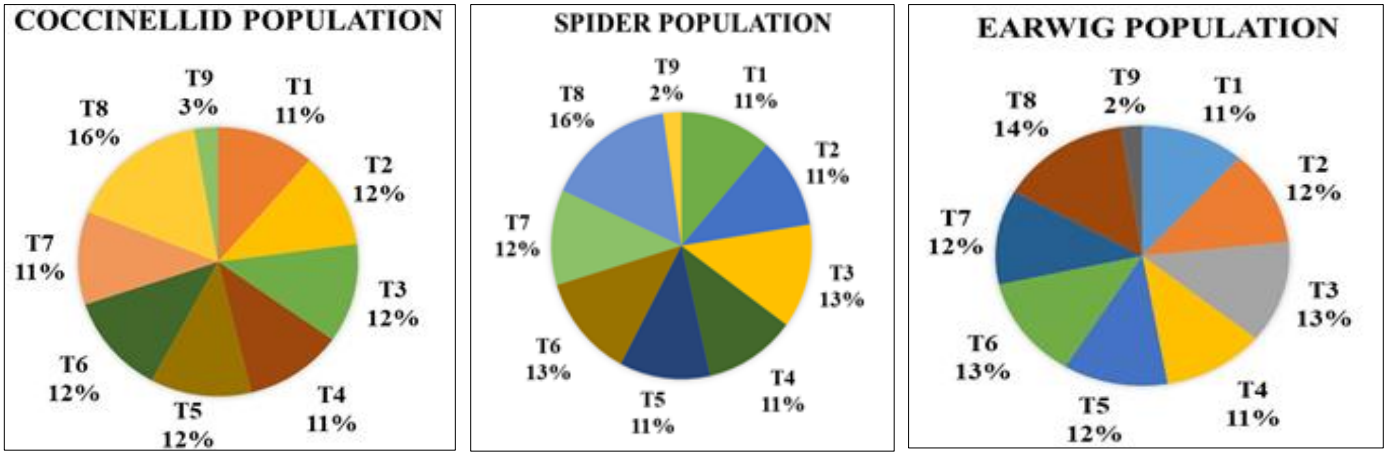
Likewise, observation on natural enemies (coccinellids, earwigs and spider population) (Fig. 2) reveled that, all the treatments with plant products including standard organic check registered significantly higher and on par natural enemy population which was ranged from 1.57-1.70 coccinellids/plant, 1.29-1.63 earwigs/plant and 1.51-1.66 spiders/plant at 60 DAS, this was non-significantly different with UTC. However, among all the treatments, RPP registered least number of coccinellids (0.20/plant), earwigs (0.12/plant) and spiders (0.20 /plant) at 60 DAS. Significantly maximum green fodder yield was documented by NSKE @ 5% with (17.41 t/ha) and higher B:C ratio of (1.47) among different plant products, followed by *Vitex negundo* @ 5% (14.26 t/ha) and *Pongamia glabra* (leaf extract) @ 3% (14.35 t/ha). Significantly lower yield was registered under UTC (8.16 t/ha).

Among different botanicals, neem based extract (NSKE) found very effective might be due to properties of neem in various forms helps in inhibiting growth and development of insect pests, which also hinders oviposition with reduced egg laying and adult emergence with reduction in insect survival. Neem also known to affect pest incidence and population density and show JH mimic, antifeedant, repellent and insecticidal activity against various group of insects which was documented in several reports (Karabhantanal *et al*., 2018) [6]. Wherein, botanicals like *Vitex negundo* and *Pongamia glabra* are also found affective after neem, which was due to their antifeedants, larvicidal and pupicidal activity which was confirmed by Rajput *et al.* (2018) [8]. Studies of Mudigoudra and Shekharappa (2009) reported that botanicals are safer to natural enemies. Similar results were also suggested by Bharathi (2005) [3] that botanicals such as aqueous extracts of neem, pogamia, vitex, adathoda and periwinkle (*Vinva rosea*) did not affect activity of natural enemies (coccinellids, predatory mites and spiders) much but recorded next best to untreated control under various agro ecosystems. Anandhi and Ambethgar (2022) [1] concluded that NSKE 5% registered significantly more grain yield (1869.55 kg/ ha) and cost benefit ratio (1:1.95) than other treatments.



T_1: NSKE (5%); T_2: *Vitex negundo* (5%); T_3: *Adathoda vesica* (5%); T_4: *Pongamia glabra* (leaf extract) (3%); T_5: *Pongamia glabra* (seed extract) (3%); T_6: *Vinca rosea* (5%); T_7: Standard organic check; T_8: Untreated check (UTC) and T_9: Inorganic check (RPP)

Fig 1: Effect of different plant products against incidence of *Spodoptera frugiperda* in fodder sorghum during 2021-22 and 2022-23 (Pooled data).



T1: NSKE (5%); T2: *Vitex negundo* (5%); T3: *Adathoda vesica* (5%); T4: *Pongamia glabra* (leaf extract) (3%); T5: *Pongamia glabra* (seed extract) (3%); T6: *Vinca rosea* (5%); T7: Standard organic check; T8: Untreated check (UTC) and T9: Inorganic check (RPP)

Fig 2: Effect of different plant products on natural enemy population in fodder sorghum during 2021-22 and 2022-23 (Pooled data).

Table 1: Pooled data on effect of different plant products against shoot fly, *Atherigona soccata* infesting fodder sorghum during 2021-22 and 2022-23

Treatments	Number of eggs per plant				Per cent dead heart (%)			
	Pre count	14 DAE	21 DAE	Mean	14 DAE	21 DAE	28 DAE	Mean
T1: NSKE (5%)	1.79** (1.51)	1.61 (1.45)^{b}	1.26 (1.33)^{ab}	1.44	11.19*** (19.54)^{b}	9.93 (18.36)^{b}	5.65 (13.75)^{bc}	8.92
T2: *Vitex negundo* (5%)	1.82 (1.52)	1.70 (1.48)^{b}	1.42 (1.39)^{b}	1.56	11.23 (19.55)^{b}	9.97 (18.37)^{b}	5.85 (13.98)^{bc}	9.02
T3: *Adathoda vesica* (5%)	1.74 (1.50)	1.73 (1.49)^{b}	1.54 (1.42)^{b}	1.64	11.47 (19.78)^{b}	10.17 (18.56)^{b}	6.05 (14.24)^{b}	9.23
T4: *Pongamia glabra* (leaf extract) (3%)	1.81 (1.52)	1.69 (1.48)^{b}	1.43 (1.39)^{b}	1.56	11.31 (19.65)^{b}	10.01 (18.44)^{b}	5.86 (14.00)^{bc}	9.06
T5: *Pongamia glabra* (seed extract) (3%)	1.80 (1.51)	1.77 (1.51)^{b}	1.49 (1.41)^{b}	1.63	11.22 (19.56)^{b}	10.11 (18.52)^{b}	6.05 (14.18)^{b}	9.13
T6: *Vinca rosea* (5%)	1.77 (1.51)	1.79 (1.51)^{b}	1.56 (1.43)^{b}	1.68	11.69 (19.94)^{b}	10.28 (18.69)^{b}	5.89 (14.02)^{b}	9.29
T7: Standard organic check	1.81 (1.52)	1.77 (1.51)^{b}	1.57 (1.44)^{b}	1.67	8.62 (17.07)^{c}	6.61 (14.89)^{c}	2.26 (8.64)^{c}	5.83
T8: Untreated check (UTC)	1.76 (1.50)	3.14 (1.88)^{c}	4.31 (2.19)^{c}	3.73	13.00 (34.33)^{a}	22.71 (34.33)^{a}	29.50 (34.33)^{a}	21.73
T9: Inorganic check (RPP)	1.80 (1.52)	0.52 (1.01)^{a}	0.06 (0.75)^{a}	0.29	7.81 (16.20)^{c}	4.16 (11.44)^{d}	1.38 (6.75)^{d}	4.45
S. Em (±)	NS	0.10	0.10	-	1.22	1.22	0.91	-
C.V. (%)	7.06	8.45	8.25	-	7.23	7.86	7.52	-

DAE: Days after Emergence NS: Non significant Standard organic check: *Beauveria bassiana* (2g/lit.) RPP: Recommended Package of Practice *Significant @ 5% **Figures in parentheses are √x+0.5 transformed values ***Figures in parentheses are Arcsine transformed values Means denoted by same alphabet in vertical column do not differ significantly (P=0.05) by DMRT

Table 2: Pooled data on effect of different plant products against stem borer, *Chilo partellus* infesting fodder sorghum during 2021-22 and 2022-23

Treatments	Number of larvae per meter row length								Per cent dead heart (%)			
	Pre Count (28 DAE)	First spray			Second spray			Mean	14 DAE	21 DAE	28 DAE	Mean
		3 DAFS	7 DAFS	10 DAFS	3 DASS	7 DASS	10 DASS					
T1: NSKE (5%)	4.94** (2.33)	4.65 (2.27)^{bc}	3.93 (2.11)^{bc}	3.40 (1.96)^{bc}	3.06 (1.88)^{bc}	2.91 (1.85)^{c}	2.86 (1.83)^{b}	3.47	11.19*** (19.54)^{b}	9.93 (18.36)^{b}	5.65 (13.75)^{bc}	8.92
T2: *Vitex negundo* (5%)	4.97 (2.34)	4.90 (2.32)^{bc}	4.24 (2.18)^{bc}	3.82 (2.08)^{c}	3.27 (1.94)^{bc}	3.31 (1.95)^{c}	3.37 (1.96)^{b}	3.82	11.23 (19.55)^{b}	9.97 (18.37)^{b}	5.85 (13.98)^{bc}	9.02
T3: *Adathoda vesica* (5%)	4.95 (2.33)	5.14 (2.37)^{bc}	4.43 (2.22)^{c}	4.06 (2.13)^{c}	3.41 (1.97)^{bc}	3.66 (2.04)^{c}	3.63 (2.03)^{b}	4.06	11.47 (19.78)^{b}	10.17 (18.56)^{b}	6.05 (14.24)^{b}	9.23
T4: *Pongamia glabra* (leaf extract) (3%)	5.04 (2.35)	4.91 (2.32)^{bc}	4.32 (2.19)^{bc}	3.94 (2.11)^{c}	3.18 (1.91)^{bc}	3.33 (1.94)^{c}	3.06 (1.89)^{b}	3.79	11.31 (19.65)^{b}	10.01 (18.44)^{b}	5.86 (14.00)^{bc}	9.06
T5: *Pongamia glabra* (seed extract) (3%)	4.74 (2.29)	4.98 (2.34)^{bc}	4.44 (2.22)^{c}	3.99 (2.12)^{c}	2.97 (1.86)^{b}	3.52 (2.01)^{c}	3.13 (1.90)^{b}	3.84	11.22 (19.56)^{b}	10.11 (18.52)^{b}	6.05 (14.18)^{b}	9.13
T6: *Vinca rosea* (5%)	4.94 (2.33)	5.10 (2.36)^{bc}	4.48 (2.23)^{c}	4.11 (2.14)^{c}	4.09 (2.14)^{c}	3.96 (2.11)^{c}	3.82 (2.07)^{b}	4.26	11.69 (19.94)^{b}	10.28 (18.69)^{b}	5.89 (14.02)^{b}	9.29
T7: Standard organic check	4.88 (2.30)	3.80 (2.07)^{ab}	3.13 (1.88)^{ab}	2.21 (1.64)^{b}	1.18 (1.28)^{a}	0.96 (1.21)^{b}	0.28 (0.88)^{a}	1.93	8.62 (17.07)^{c}	6.61 (14.89)^{c}	2.26 (8.64)^{c}	5.83

T8: Untreated check (UTC)	5.09 (2.36)	5.66 (2.48)^{c}	6.62 (2.66)^{d}	7.03 (2.74)^{d}	7.49 (2.83)^{d}	7.90 (2.90)^{d}	8.22 (2.95)^{c}	7.15	13.00 (34.33)^{a}	22.71 (34.33)^{a}	29.50 (34.33)^{a}	21.73
T9: Inorganic check (RPP)	4.97 (2.34)	3.26 (1.91)^{a}	2.45 (1.72)^{a}	1.25 (1.32)^{a}	0.57 (1.03)^{a}	0.26 (0.87)^{a}	0.13 (0.79)^{a}	1.32	7.81 (16.20)^{c}	4.16 (11.44)^{d}	1.38 (6.75)^{d}	4.45
S. Em (±)	NS	0.13*	0.13	0.12	0.11	0.11	0.11	-	1.22	1.22	0.91	-
C.V. (%)	7.37	7.09	7.39	7.29	7.27	7.18	7.25	-	7.23	7.86	7.52	-

DAE: Days after Emergence DAFS: Days after first spray DASS: Days after second spray NS: Non significant Standard organic check: *Beauveria bassiana* (2g/lit.) RPP: Recommended Package of Practice *Significant @ 5% **Figures in parentheses are √x+0.5 transformed values ***Figures in parentheses are Arcsine transformed values Means denoted by same alphabet in vertical column do not differ significantly (P=0.05) by DMRT

Conclusion

The use of plant products with diverse mode of action not only improves herbivore management but also lowers the cost of plant protection which will intern benefit small and marginal farmers with improved plant and soil health. The present research, special emphasis was placed on hundred per cent organic production system which promotes livestock health- safety through pesticide-free organic pest management in fodder production. In addition, it supports conservation agriculture, notably the biocontrol agents (natural enemies) which accelerates the insect pest management.

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