Indian Journal of Entomology 85(4): 1061-1065 (2023) DoI. No.: 10.55446/IJE.2021.136

EVALUATION OF SOME ECOFRIENDLY IPM APPROACHES IN SORGHUM

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ABSTRACT

Some ecofriendly IPM modules were evaluated against insect pests of sorghum. These included: timely sowing (41st standard week-SW); seed treatment with imidacloprid 70WS @ 3 g/ kg seed; installing fishmeal trap @ 12/ ha up to 30 days after emergence (DAE); bund cropping with sorghum + bhendi; releasing egg parasitoid, *Trichogramma chilonis* at 35 DAE; spraying NSKE 5% at 60 DAE. These recorded minimum pest load with highest cost benefit ratio. This IPM package was compared to local common farmers' practice and the results proved that these approaches are superior.

Key words: Sorghum, *Atherigona soccata*, *Chilo partellus*, *Stenodiplosis sorghicola*, IPM modules, timely sowing, imidacloprid, NSKE, fishmeal trap, bund cropping, bhendi, *Trichogramma chilonis*

Sorghum (*Sorghum bicolor* L.) is an important cereal crop (FAO, 2018), and in Tamil Nadu, it is grown in drought-prone, marginal areas. In Tamil Nadu it is cultivated in an area of 3.85 lakh ha with a productivity of 1117 kg/ ha (AICSIP, 2021). The yield of sorghum is largely affected by biotic constraints and >150 insect species infest sorghum. Damage inflicted by these cause serious losses (Daware et al., 2012). In India, shoot fly and stem borer significantly reduce the yield, at times as high as 100% in grain and crop stand (Padmaja et al., 2010). In Tamil Nadu, shoot fly *Atherigona soccata* Rondani, stem borer *Chilo partellus* Swinhoe and grain midge *Stenodiplosis sorghicola* Coquillett are the regular pests in southern districts causing 2 to 48% damage (Anandhi and Sankarapandian, 2013; Anandhi et al., 2015). An array of sprayable and granular insecticides are recommended against these (Patil et al., 1992), but these have several limitations (Anandhi et al., 2017). Resource poor farmers find problem in chemical spraying due to increased cost of cultivation and possible phytotoxic effects (Sharma, 1993). Current recommendation of soil application with carbofuran 3G @ 30kg/ ha is very expensive (Shekharappa and Bhuti, 2007). Hence, improved IPM approaches are required. Habitat manipulation to enhance the activities of natural enemies aim at minimal or zero insecticide use (Gurr et al., 2004). Prior researches on ecological engineering model in cotton (Muthukrishnan et al., 2015), bhendi (Deepika, 2016) and rice (Chandrasekar, 2016) have demonstrated the use of these. The present study aims to assess the advantages of sorghum- based bund crop, along with other approaches as IPM modules in sorghum along with their validation under rainfed condition in southern region of Tamil Nadu.

MATERIALS AND METHODS

The experiment was conducted during 2017 and 2018 at the Agricultural Research Station, Kovilpatti, Tamil Nadu, with eight treatments replicated thrice in a randomized block design (RBD). The K-8 sorghum variety was used in plots of 24.3m^2 (5.4 x 4.5m) with spacing of 45 x 15 cm. The treatments included neem oil (NO) 3%, neem seed kernel extract (NSKE) 5%, *Vitex negundo* 10% leaf extract, *Ocimum sanctum* 10% leaf extract, *Aloe vera* 10% leaf extract, *Calotropis gigantea* 10% leaf extract, *Datura stramonium* 10% leaf extract and an untreated control. Botanicals such as leaves of *V. negundo*, *O. sanctum, A. vera, C. gigantea* and *D. stramonium* were collected and cut into small pieces. The cut leaves were mixed with water at 10% and boiled for 30-50 min and afterward allowed to cool for about 2 hr and was then filtered through muslin cloth (Shakti Khajuria et al., 2015). The extracts were sprayed on the crop on 25, 40 and 55 DAE (days after emergence). A total of 3 sprays at 15 days interval were given using knapsack sprayer @ 500 l spray fluid/ ha. Another experiment was conducted with seven treatments including an untreated check with three replications. Six bund crops viz., coriander, sesamum, cowpea, cluster bean, black gram and bhendi were selected. No chemical pesticides were applied throughout the crop season. The IPM modules consisted of five treatments including farmers practice with four replications were validated.

The details of the treatments are as follows- T_1- Insecticide module with only insecticide application (i. seed treatment with imidacloprid 70 WS @ 3 g/ kg seed; ii. spraying of carbaryl 50WP @ 1 kg/ ha at 28 DAE for shoot fly; iii. Dusting of carbaryl 10D @25 kg/ ha at 60 DAE for stem borer; iv. dusting of carbaryl 10D @25 kg/ ha at 90 DAE for midge), T_2- Ecofriendly module (i. bund cropping sorghum + bhendi; ii. installing fish meal trap up to 30 DAE; iii. releasing of egg parasitoid *Trichogramma chilonis* at 35 DAE for stem borer; iv. spraying of spinosad 45 % SC @ 75 g ai/ ha at 50 DAE for stem borer; v. spraying neem oil 3% at 60 DAE for midge), T_3- need based integrated module (i. spraying of spinosad 45% SC @ 75 g ai/ ha at 50 DAE for stem borer (stem borer-10% deadheart ETL crossed), ii. releasing of egg parasitoid *T. chilonis* at 35 DAE for stem borer; iii. spraying neem oil 3% at 60 DAE for midge- (ETL (5/ earhead) crossed), T_4- neem based module with application of only neem products (i. incorporation of neem cake 150 kg/ ha; ii. neem seed kernel extract (5%) at 28 DAE; iii. neem seed kernel extract (5%) at 45 DAE; iv. spraying of neem oil 3% at 60 DAE); and T_5- untreated check. Based on the above modules, the best treatments were assorted and compared with the farmers practice. To validate, large scale field experiments were conducted in farmer's field with two modules including a farmers practice as a control plot. The IPM modules imposed are as follows: T1- IPM Package (i. timely sowing (41st standard week); ii. seed treatment with imidacloprid 70 WS @ 3 g/ kg seed; iii. installing fishmeal trap @ 12/ ha up to 30 DAE; iv. bund cropping (sorghum + bhendi); v. releasing egg parasitoid *T. chilonis* at 35 DAE; vi. Spraying NSKE 5% at 60 DAE); and T2- farmers' practice compared as check. In case of farmers practice, broadcasting the seeds 15 kg/ ha without any plant protection.

The shoot fly deadheart at 28 days after emergence (%), stem borer deadhearts at 45 days after emergence (%), midge spikelet damage (%) panicle maturation stage were observed in each treatment following protocols of AICRIP, Sorghum, DSR, Hyderabad. The occurrence of predatory coccinellids (grubs and adults) and parasitoids (number/ plant) were recorded, and emergences rate of adult parasitoids were represented as % parasitism. In bund crop and IPM validation, cost benefit ratio was calculated considering additional cost (cost of insecticide and operational charge) and benefit (compared to untreated control) in the respective treatments. Data values in % were arc sine transformed prior to ANOVA and treatment means were compared by Least Significant Difference (LSD) (Gomez and Gomez, 1984). IPM Experiments were subjected to student's t- test.

RESULTS AND DISCUSSION

Effect of plant products against the major pests of sorghum study was consistent over two years and hence the pooled results are discussed. The deadhearts due to shoot fly and stem borer (%) at 28 and 45 DAE revealed that significantly less values in neem oil 3% (11.01 and 11.44%) and NSKE 5% treated plots (13.58 and 12.40%) as compared to control (50.96 and 41.50%). Maximum incidence of midge spikelet damage rating was of 9-grade in control, followed by *Aloe vera* 10% leaf extract (6-grade), and the least values were in neem oil 3% and NSKE 5% (3 and 3.33-grade). Significantly more grain yield was obtained with neem oil 3% (1907.67 kg/ ha) and NSKE 5% (1869.55 kg/ ha). Maximum cost benefit (C:B) ratio (1:1.95) was NSKE 5% followed by neem oil 3% treated plots (1:1.70) (Table 1). Prabakaran et al. (2019) observed maximum azadirachtin content in the neem tree populations growing in the southern part of India. Shrinivas and Mudigoudra Shekharappa (2009) and Sable (2009) reported that NSKE (5%) and neem oil (2%) spray in sorghum at 21DAT reduced deadhearts and gave maximum yield; similar results were observed with 3% neem oil (Gautam et al., 2014). The antifeedant properties of neem oil 3%, NSKE with shoot fly had been earlier reported (Zongo et al., 1993; Adane Tesfaye and Asmare Dejan, 2006). About the suitable bund crop, least deadhearts (%) due to shoot fly was observed in sorghum + bhendi (11.52%) and sorghum+ sesamum (13.92%); deadhearts due to stem borer was in sorghum + cowpea (6.11%) and sorghum + bhendi (10.20%); with incidence of midge, spikelet damage rating was the least with sorghum+ cowpea, sorghum+ sesamum and sorghum+ bhendi (2-3 grade).

Larval parasitism on sorghum shoot fly, stem borer, midge and general predators such as coccinellids (*Menochilus sexmaculata*) and spiders were more with sorghum+ sesamum (28.0% and 14/ plot) and sorghum + bhendi (25.00 % and 15/ plot). Maximum grain yield was obtained from sorghum+ sesamum (2046.00 kg/ ha) followed by sorghum+ bhendi (1815.77 kg/ ha). Maximum C: B ratio (1: 2.25) was also obtained in sorghum+ bhendi followed by sorghum+ sesamum (1: 2.19) (Table 1). Karibasavaraja et al. (2005) reported that sorghum+ coriander, sorghum+ sesamum intercropping resulted in lowest number of deadhearts due to shoot fly. Sorghum+ bhendi best intercropping combination was reported by Degri and Richard (2014) and sorghum

+ groundnut, sorghum + pegionpea intercropping was suggested by Rana et al. (1998).

Validation of the IPM modules against major pests of sorghum revealed that the deadhearts due to shoot fly and stem borer at 28 and 45 DAE were significantly minimum in insecticide applied module (12.76%) followed by need based integrated module (14.97%) as compared to control (62.08%); similar was the trend in insecticide applied module (7.22) and ecofriendly module (7.30%) as compared to control (42.19%). The least incidence of midge spikelet/ damage rating was observed in need based integrated module and insecticide applied module (3-grade). Grain yield was maximum with insecticide module with only insecticide application (2396.25 kg/ ha) followed by need based integrated module consisting of insecticides, botanicals and natural enemies (2115.75 kg/ ha); however,

Table 1. Effect of plant products and bund cropping on *A. soccata, C. partellus* and *S. sorghicola* in sorghum (Pooled, 2017, 2018)

	Treatments	Deadheart (%)		*Stenodiplosis sorghicola*	Grain yield (kg/ ha)	C:B ratio
		Atherigona soccata at 28 DAE*	*Chilo partellus* at 45 DAE*	Panicle damage scale (1-9)		
T_1	Neem oil 3%	11.01 (19.05)**	11.44 (19.90)	3.00	1907.67	1: 1.70
T_2	Neem Seed Kernal Extract 5%	13.58 (21.31)	12.40 (21.37)	3.33	1869.55	1: 1.95
T_3	Notchi (*Vitex negundo*) 10% leaf extract	18.33 (23.97)	24.79 (27.57)	5.88	1511.55	1: 1.66
T_4	Tulsi (*Ocimum sanctum*) 10% leaf extract	19.47 (25.96)	19.48 (26.02)	5.44	1435.66	1: 1.54
T_5	Sothukathalai (*Aloe vera*)10% leaf extract	20.89 (27.15)	20.16 (27.25)	6.00	1241.22	1: 1.15
T_6	*Calotropis gigantea* 10% leaf extract	25.75 (30.44)	21.85 (29.20)	5.22	1482.44	1: 1.74
T_7	*Datura stramonium* 10% leaf extract	28.04 (31.91)	19.43 (29.34)	5.77	1363.77	1: 1.59
T8	Untreated control	50.96 (45.56)	41.50 (43.17)	9.00	790.55	1: 0.84
	SE	2.14	1.07	0.76	83.94	
	CD (p=0.05)	4.59	3.54	1.63	169.88	

Efficacy of bund cropping

	Treatments	Deadheart (%)		*Stenodiplosis sorghicola*	Natural enemies		Grain yield (kg/ha)	C:B ratio
		Atherigona soccata at 28 DAE*	*Chilo partellus* at 45 DAE*	Panicle Damage scale	% Parasitism (Midge)	Predators *** (No./ plot)		
T_1	Sorghum alone	56.32 (44.44)**	47.78 (42.43)	9.00	2.50 (1.56)	2.00 (1.56) **	952.00	1: 0.86
T_2	Sorghum+ coriander	17.14 (27.54)	17.88 (21.03)	4.00	8.00 (2.86)	8.00 (2.86)	1185.11	1: 2.01
T_3	Sorghum+ sesamum	13.92 (25.70)	11.83 (21.75)	2.33	28.00 (3.73)	14.00 (3.73)	2046.00	1: 2.19
T_4	Sorghum+ cowpea	24.0 (30.78)	6.11 (16.36)	3.00	21.00 (3.02)	9.00 (3.02)	1747.33	1: 1.72
T_5	Sorghum+ clusterbean	29.90 (33.06)	14.07 (67.07)	3.67	15.00 (3.17)	10.00 (3.17)	1575.77	1: 1.63
T_6	Sorghum+ blackgram	30.29 (33.68)	16.98 (24.29)	5.33	12.00 (2.30)	5.00 (2.30)	1176.33	1: 1.27
T_7	Sorghum+ bhendi	11.52 (24.12)	10.20 (22.13)	2.33	25.00 (3.85)	15.00 (3.85)	1815.77	1: 2.25
	SE	2.15	4.42	0.97	0.55	0.18	141.95	
	CD (0.05)	4.69	9.62	2.11	1.19	0.40	283.91	

(contd.)

(Table 1 contd.)

Efficacy of IPM modules (rabi 2018)						
Treatments		Deadheart (%)		*Stenodiplosis sorghicola*	Grain yield (kg/ ha)	C:B ratio
		Atherigona soccata at 28 DAE	*Chilo partellus* (%) at 45 DAE	Panicle Damage scale (1-9)		
T_1	Insecticide module with only insecticide application.	12.76 (20.90)[a]	7.22 (15.64)**[a]	3	2396.25	1: 1.11
T_2	Eco-friendly module	18.03 (25.10)[b]	7.30 (16.72)[a]	5	2173.75	1: 1.63
T_3	Need based integrated module consists of insecticides, botanicals and natural enemies	14.97 (22.74)[ab]	11.38 (19.55)[b]	3	2115.75	1: 1.08
T_4	Neem based module	23.13 (28.73)[c]	10.86 (18.63)[ab]	5	1932.5	1: 1.31
T_5	Untreated control	62.08 (52.01)[d]	42.19 (41.10)[c]	9	754.75	1: 0.78
	SE	1.24	1.79	1.41	58.93	
	CD (p = 0.05)	2.70	3.91	2.30	128.0	

*DAE=Days after emergence; **Figures in parentheses arc sine transformed value; ¤¤¤ Azadirachtin % in neem oil and NSKE 0.33 and 0.03 % by the test method IS 14300 (1995) - Neem Based EC containing azadirachtin (FAD 1: Pesticides and Pesticides Residue Analysis); ***Square root transformation value; *Sorghum grain equivalent yield (SGEY) kg/ha; Cost of inputs based on prevailing market prices; Means followed by different letters significantly different (p=0.05)

Table 2. Validation of IPM modules against *A.soccata, C. partellus* and *S. sorghicola* in sorghum (rabi 2018)

Treatments		Deadheart (%)		*Stenodiplosis sorghicola*	Grain yield (kg/ ha)	C:B Ratio	% Parasitism (Midge)	Predators No./ plot
		Atherigona soccata at 28 DAE*	*Chilo partellus* at 45 DAE*	Panicle Damage scale (1-9)				
T_1	IPM	13.02	7.61	2.58	2700.0	1:2.27	42.00	15.80
T_2	Farmers practices compared as check	45.97	36.67	8.08	810.00	1:0.84	6.8	2.0
	SED	0.54 11.73	0.57 3.59	0.57	59.70	-	10.16	5.43
	CD	4.14 11.23	2.41 11.55	1.31	127.80	-	21.0	11.00
	t value	8.81	7.66	12.70	3.46	-	3.46	2.48
	P value	-	-	-	-	-	-	0.02

*DAE=Days after emergence; IPM includes: Timely sowing (41st standard week); Seed treatment with imidacloprid 70 WS @ 3 g/kg seed; Installing fishmeal trap @ 12/ha upto 30 DAE; Bund cropping sorghum + bhendi; Releasing egg parasitoid, *T. chilonis* at 35 DAE; Spraying NSKE 5% at 60 DAE

the maximum C: B ratio (1:1.63) was obtained in ecofriendly module followed by neem based module (1:1.31) (Table 2). The best performing ecofriendly IPM module was reframed as modified IPM module and was conducted in large scale. The results revealed that deadhearts due to shoot fly and stem borer at 28 and 45 DAE get significantly reduced in IPM module (13.02 and 7.61%) as compared to control (45.97 and 36.67%); also lease incidence of midge/ spikelet damage rating was in the integrated module (2.58 grade). Yield was significantly more from IPM module (2700 kg/ ha) with maximum C: B ratio (1:2.27). A fine tuning of advocated sorghum-IPM has proven to maximize the yield generation (Table 2).

Daware and Ambilwade (2014) and Karabhantanal et al, 2018 identified IPM module with different components for management of sorghum pests in India. In the present study, the IPM module validated in large scale including timely sowing (41st standard week), seed treatment with imidacloprid 70 WS @ 3 g/ kg seed, installing fishmeal trap @ 12/ ha upto 30 DAE; bund cropping (sorghum + bhendi), releasing egg parasitoid, *T. chilonis* at 35 DAE; followed by spraying

NSKE 5% at 60 DAE was found economically prudent to suppress major pests incidence and increased the production. Hence, this module can be recommended as part of an integrated pest control system, since the module recorded minimum pests infestation and increased population of free living natural enemies with highest cost benefit ratio of (1: 2.27) in large scale demonstrations against major pests of sorghum.

REFERENCES

AICSIP (All India Coordinated Sorghum Improvement Project) 2021. Progress reports of the All India Coordinated Sorghum Improvement Project, New Delhi, India: Indian Council of Agricultural Research.

Adane Tesfaye, Asmare Dejan. 2006. Evaluation of Neem (*Azadirachta indica*) derivatives for management of sorghum stem borers (*Busseola fusca*) and *Chilo partellus*. Ethiopian Journal of science and Technology 3(2): 69-80.

Anandhi P, Sankarapandian R. 2013. IPM module for sorghum pest management. Patil J V, Chapke R R, Mishra J S, Umakanth A V, Hariprasanna K (eds.) Sorghum cultivation-a compendium of improved technologies, Volume I: Directorate of Sorghum Research, Hyderabad, India. 105 pp.

Anandhi P, Bagwat V R, Elamathi S, Gailce Leo Justin C, Jawahar D. 2015 . Evaluation of Indian popular varieties and validation of Integrated Pest Management strategies against major pests of sorghum. Proceedings of National Academic Sciences of India Section B Biological Sciences 87(1): 261-266.

Anandhi P, Elamathi S, Arthi Rani B. 2017. Population dynamics and bio-intensive management of sorghum midge, *Contarinia sorghicola* (Coquillett) in sorghum under southern Tamil Nadu. International Journal of Plant Protection 10(1): 157-166.

Chandrasekar K. 2016. Developing ecological engineering cropping methods for enhancing entomophages and increasing pest suppression in rice ecosystem. Ph. D. Thesis, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Daware D G, Bhagwat V R, Ambilwade P P, Kamble R J. 2012. Evaluation of integrated pest management components for the control of sorghum shoot pests in rabi season. Indian Journal of Entomology 74(1): 58-61.

Daware D G, Ambil Wade P P. 2014. Comparative study between IPM module and non IPM (farmer's practice) for the control of sorghum shoot pests in kharif season. Journal of Entomological Research 38(1): 17-21.

Deepika A. 2016. Developing ecological engineering methods and enhancing endomophages and increasing pest suppression on okra. M Sc (Ag). Thesis, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.

Degri M, Richard I B. 2014. Impact of intercropping sorghum and okra on the incidence of flea beetles of okra *Podagrica* spp. in Dalwa, Maiduguri Semi-Arid Zone of Nigeria. International Letters of Natural Sciences 9: 51-58.

FAO. 2018. Sorghum in the 21st century- Food, feed and fuel in a rapidly changing world. Save food: Global initiative on food loss and waste reduction, community of practice on food loss reduction. 9.4.2018 to 12.4.2018.

Gautam N, Mansuri M A, Singh K, Swaminathan R. 2014. Bio-efficacy of different botanicals against shoot-feeding insect pests of sorghum. Indian Journal of Applied Entomology 28(1): 30-34.

Gomez K A, Gomez A A. 1984. Statistical procedures for agricultural research (eds.), John Wiley and Sons, New York. pp.7-20.

Gurr G M, Wratten S D, Altieri M A. 2004. Ecological engineering: Advances in habitat manipulation for arthropods. Collingwood (Australia). CSIRO Publishing. 232pp.

Karabhantanal S S, Shyam Prasad, G, Biradsr, A P and Boranayaka 2018. Evaluation of Integrated Pest Management components in the management of insect pests in rabi Sorghum. Journal of Experimental Zoology, India 21 (2), 1245-1249.

Karibasavaraja L R, Balikai R A, Deshpande V P. 2005. Thiamethoxam 70 WS, A new promising seed dress for the suppression of sorghum shoot fly. Annals of Plant Protection Sciences 13: 85-87.

Muthukrishnan N, Ananthraj B, Jayaraj J. 2015. Developing polyculture based Ecological engineering methods in cotton for enhancing predators for the management of whiteflies. Proceedings. International conference on innovative insect management approaches for sustainable agroecosystem, Tamil Nadu Agricultural University, AC&RI, Madurai. pp. 138-141.

Padmaja P G, Madhusudhana R, Seetharama N. 2010. Sorghum shoot fly. Directorate of Sorghum Research, Hyderabad-30, India. 82pp.

Patil B V, Bheemanna M, Somasekhar Hiremath S C. 1992. Effect of seed soaking of insecticides on sorghum shoot fly, *Atherigona soccata* Rondani. Indian Journal of Entomology 54: 424-427.

Prabakaran P, Kumaran K, Baburaj L K, Balaji S, Mageshram S, Balakumar C, Radhakrishnan, R. 2019. Variability Studies on Seed Parameters, Oil and Azadirachtin Content of Neem (*Azadirachta indica A.Juss*.) in Tamil Nadu and Karnataka. International Journal of Current Microbiology and Applied Sciences 8(5): 339-346.

Rana S S, Sharma J J, Manuja S S. 1998. Evaluation of promising herbicide mixtures for weed control in maize. New Agriculturist 9 (1&2): 1-5.

Sable V A. 2009. Non-chemical approaches for the management of shootfly *Atherigona soccata* (Rondani) in kharif sorghum. M Sc (Ag) Thesis, University of Agricultural Sciences, Dharwad.

Sharma H C. 1993. Host-plant resistance to insects in sorghum and its role in integrated pest management. Crop Protection 12(1): 11-34.

Shakti Khajuria, Rai A K, Lata Kanak, Kumar Raj, Jadav J K. 2015. Evaluation of integrated pest management (IPM) module against sucking pests of black gram under semi arid conditions. Insect Environment 20(4): 126-132.

Shekharappa S, Bhuti G. 2007. Integrated Management of Sorghum Shootfly, *Atherigona soccata* Rondani. Karnataka Journal of Agricultural Sciences 20(3): 535-536.

Shrinivas, Mudigoudra Shekharappa. 2009. Evaluation of plant products against sorghum shootfly, *Atherigona soccata* Rondani. The Journal of Plant Protection Sciences 1(1): 66-68.

Zongo J O, Vincent C, Stewart R K. 1993. Effects of intercropping sorghum-cowpea on natural enemies of the sorghum shootfly, *Atherigona soccata* Rondani (Diptera: Muscidae) in Burkina Faso. Biological Agriculture and Horticulture 9: 201-213.

(Manuscript Received: May, 2021; Revised: September, 2021;
Accepted: September, 2021; Online Published: January, 2022)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e21119