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Effect of botanicals on shoot fly *Atherigona soccata* incidence in *kharif* sorghum

VA Padar, VU Sonalkar, SS Kale, PN Mane and RM Shinde

Abstract
In India, major sorghum growing states are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Rajasthan. The production of sorghum in these states is severely hampered due to various biotic and abiotic stresses. Among these, biotic stress particularly shoots fly infestation in sorghum is a major concern impacting the sorghum crop in the state. To manage the shoot fly infestation farmers adopts chemical insecticides either by seed treatment or foliar sprays. However, chemical pesticides have certain ill effects like environmental pollution, harmful to non-target pests, resurgence of minor pest etc. The plant derived oils or extracts had nontoxic effects and could be used for management of shoot fly in sorghum. Therefore, in the present study attempt has been made to evaluate the efficacy of some plant oils as seed treatments and sprays in kharif sorghum for shoot fly management. In present study, Seed treatment with Karanj oil @ 5 ml/ kg seed followed by neem oil @ 20 ml/l spray 7 DAE and seed treatment with neem oil @ 5 ml/kg seed, followed by neem oil @ 20 ml/l spray 7 DAE are effective against shoot fly oviposition. None of the treatment schedule does not affect egg count 14 and 21 days after emergence.

Keywords: botanicals, fly, *Atherigona soccata*, *kharif*

Introduction
In India, sorghum is grown on an area 4.96 million ha i.e. 2.50% of the total gross crop area (198 million ha) with annual production of 3.76 million tons with productivity 998 kg/ha (First advance estimate, crop production, GOI, 2019-20) [2]. Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Rajasthan are the major sorghum growing states.
In Maharashtra, sorghum is grown on an area of 2.17 million ha with a production 1.81 million tons and productivity of 1941 kg/ha (Agriculture Statistics report, GOI, 2018). As compare to the area, production is low in state due to various reasons like environmental conditions, scarcity of water, seed availability, fertilizers, damage due to insect-pests and diseases etc. Among these, insect pest is one of the major problems of lowering the productivity of sorghum crop in the state.
The farmers generally manage shoot fly in sorghum by using chemical insecticides either by seed treatment or foliar sprays (Sonalkar *et al*., 2018, Aghav *et al*., 2007) [1]. However, chemical pesticides have certain ill effects like environmental pollution, harmful to non-target pests, resurgence of minor pest etc. The plant derived oils or extracts had nontoxic effects and could be used for management of shoot fly in sorghum (Sable *et al*., 2010, Gautam *et al*., 2014, Joshi *et al*., 2016, Satisha *et al*., 2017) [7, 5, 6, 8]. Therefore, the present studies are planned to evaluate the efficacy of some plant oils as seed treatments and sprays in kharif sorghum for shoot fly management.

Material and Methods
The study of effect of botanicals on shoot fly incidence to work out the effective and economic treatment for management of shoot fly was carried out. The materials used and methods adopted during the course of investigation are as below.
Sorghum seed of the variety (CSV-34) was procured from sorghum research unit Dr. P.D.K.V, Akola. Agricultural implements, bullock pair, marker, rope, measuring tape, labels, pegs, sprayer, bucket, detergent powder, plant oils, insecticides, hot water, FYM and fertilizers, botanicals, insecticide etc. were used while conducting field experiment.

In this study following treatments were set for the experiment as below

Table 1: Treatment details

Treatment	Seed treatment	First spray (7 DAE)	Second spray (14 DAE)
T1	Neem oil @ 5 ml/kg seed	NSE @ 5%	-
T2	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	-
T3	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20ml/l	Karanj oil @ 20 ml/l
T4	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Neem oil @ 20 ml/l
T5	Karanj oil @ 5 ml/ kg seed	NSE @ 5%	Karanj oil @ 20 ml/l
T6	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	NSE @ 5%
T7	Neem oil @ 5 ml/kg seed	Neem oil @ 20 ml/l	Neem oil @ 20 ml/l
T8	Karanj oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Karanj oil @ 20 ml/l
T9	Neem oil @ 5 ml/kg seed	NSE @ 5%	NSE @ 5%
T10	Imidachloprid 48 FS @12 ml/kg seed	-	Quinalphos 25 EC @ 20 ml/ 10 l
T11	Untreated control	-	-

*DAE- Days after emergence

Results and Discussion

Management of sorghum shoot fly, *Atherigona soccata* through botanicals was carried out on the field of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during kharif 2019 to ascertain the effect of botanicals on shoot fly incidence and to work out the effective and economic treatment for management of shoot fly. Observations on number of shoot fly eggs and dead hearts were recorded at 7, 10, 14 and 21 and 10, 14, 21 and 28 days after emergence (DAE), respectively. Seedling vigour score were recorded on 12 DAE. The data thus obtained were subjected to statistical analysis. The experimental findings are discussed here with under different headings and subheadings in light of available literature.

Seedling vigour

Seedling vigour was varied in various treatments indirectly influencing the pest attack. The seedling vigour was expressed in the scale 1 to 5; least is the score more was the vigour and more was the score least vigorous was the seedling. The results on seedling vigour score (Table No. 2) indicates that the least seedling vigour score among botanicals was showed by treatments treatment schedule seed treatment withneem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and NSE @ 5% spray 14 DAE and treatment schedule seed treatment withneem oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE, NSE @ 5% spray 14 DAE with score 2.33 each indicating these lines are more vigorous. Apart from these treatment schedule seed treatment withneem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE, treatment schedule seed treatment withneem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE and treatment schedule seed treatment withneem oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE showed less seedling vigour score i.e. 2.67 each. The highest seedling vigour score i.e. 3.33 was showed by treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed, NSE @ 5% spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE and treatment schedule seed treatment withkaranj oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE each indicating least vigorous seedlings. Treatments *viz*., treatment schedule seed treatment withkaranj oil @ 5 ml/ kg seed and neem oil @ 20 ml/l spray 7 DAE and treatment schedule seed treatment withkaranj oil @ 5 ml/ kg seed, neem oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE were the next lines which had seedling vigour score 3.00 each.

Table 2: Plant population and seedling Vigour in various treatments

Treat-ment	Seed treatment	First spray (7 DAE)	Second spray (14 DAE)	Plant Population/Plot	Seedling Vigour (1-5)	
				OV	OV	TV*
T1	Neem oil @ 5 ml/kg seed	NSE @ 5%	-	121.00	2.67	1.63
T2	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	-	124.33	3.00	1.72
T3	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	Karanj oil @ 20 ml/l	122.67	3.00	1.72
T4	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Neem oil @ 20 ml/l	122.33	2.67	1.63
T5	Karanj oil @ 5 ml/ kg seed	NSE @ 5%	Karanj oil @ 20 ml/l	120.33	3.33	1.82
T6	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	NSE @ 5%	125.33	2.33	1.52
T7	Neem oil @ 5 ml/kg seed	Neem oil @ 20 ml/l	Neem oil @ 20 ml/l	121.33	2.67	1.63
T8	Karanj oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Karanj oil @ 20 ml/l	122.33	3.33	1.82
T9	Neem oil @ 5 ml/kg seed	NSE @ 5%	NSE @ 5%	126.00	2.33	1.52
T10	Imidachloprid 48 FS 12 ml/kg seed	-	Quinalphos 25 EC @ 20 ml/ 10 l	122.67	1.33	1.14
T11	Untreated control	-	-	121.67	3.67	1.91
	F test			NS		Sig
	SEM			2.21		0.12
	CD			6.51		0.35
	CV			3.12		12.36

OV: original vales, *TV square root transformed values.

Eggs 7 DAE

The egg count after 7 DAE in various treatment schedule was statistically non-significant (Table 2). However, the lowest eggs i.e. 7.00 were observed in treatment schedule seed treatment with neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE (T1), treatment schedule imidacloprid 48 FS @ 12 ml/kg seed (T10), and in treatment schedule seed treatment withkaranj oil @ 5 ml/ kg seed, NSE @ 5% spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T5). The treatment schedule seed treatment withneem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and NSE @ 5% spray 14 DAE (T6) and treatment schedule seed treatment with neem oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE (T7) expressed 7.33 eggs/10 plants. However, the maximum eggs per 10 plants was observed in untreated control (T11) which had 8.67 eggs/ 10 plants followed in treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed and neem oil @ 20 ml/l spray 7 DAE (T2) with 8.33 eggs/ 10 plants.

Eggs 10 DAE

In all treatment schedules, seed treatment, first spray 7 DAE and second spray 14 DAE were applied; the egg count 10 DAE was influence by seed treatment and first spray combinedly but not due to second spray.

The eggs laid by shoot fly 10 DAE in various treatment schedules were significant (Table 2). Significantly least eggs 6.33 /10 plants were in schedule seed treatment with karanj oil @ 5ml/ kg seed, neem oil @ 20 ml/l spray after 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T3) followed with 6.67 in treatment schedule seed treatment with neem oil @ 5 ml/kg seed, neem oil @ 20 ml/l and neem oil @ 20 ml/l (T7) and in treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed and neem oil @ 20 ml/l spray 7 DAE (T2) and these treatments had statistically eggs. However, the eggs in treatment schedule does not differ statistically in seed treatment neem oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE and NSE @ 5% spray 14 DAE (T9), karanj oil @ 5 ml/ kg seed, NSE @ 5% spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T5), neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE (T1) and imidacloprid 48 FS @ 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE (T10) which had 7.33, 7.33, 7.67 and 8.67 eggs /10 plants, respectively. Maximum oviposition i. e. 10.33 eggs/ 10 plants were noted in untreated control and eggs count in this was statistically equal with 9.67, 9.33, 9.33, 8.67 and 7.67 eggs/10 plants observed in treatment schedule neem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE (T4), neem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7DAE and NSE @ 5% 14 DAE (T6), karanj oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T8), imidacloprid 48 FS 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE and in seed treatment with neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE, respectively.

Table 3: Effect of treatments schedules on oviposition by shoot fly 7 and 10 days after emergence in *kharif* sorghum

Treatment	Seed treatment	First spray (7 DAE)	Second spray (14 DAE)	Eggs 7 DAE (/10plants)		Eggs 10 DAE (/10plants)	
				OV	TV*	OV	TV*
T1	Neem oil @ 5 ml/kg seed	NSE @ 5%	-	7.00	2.64	7.67	2.76
T2	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	-	8.33	2.88	6.67	2.58
T3	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	Karanj oil @ 20 ml/l	8.00	2.82	6.33	2.50
T4	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Neem oil @ 20 ml/l	7.67	2.77	9.67	3.09
T5	Karanj oil @ 5 ml/ kg seed	NSE @ 5%	Karanj oil @ 20 ml/l	7.00	2.64	7.33	2.71
T6	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	NSE @ 5%	7.33	2.71	9.33	3.04
T7	Neem oil @ 5 ml/kg seed	Neem oil @ 20 ml/l	Neem oil @ 20 ml/l	7.33	2.70	6.67	2.57
T8	Karanj oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Karanj oil @ 20 ml/l	8.00	2.82	9.33	3.05
T9	Neem oil @ 5 ml/kg seed	NSE @ 5%	NSE @ 5%	7.67	2.76	7.33	2.70
T10	Imidachloprid 48 FS 12 ml/kg seed	-	Quinalphos 25 EC @ 20 ml/ 10 l	7.00	2.64	8.67	2.94
T11	Untreated control	-	-	8.67	2.93	10.33	3.21
	‘F´ test				NS		Sig.
	SE(m) ±				0.13		0.16
	CD at (5%)				0.38		0.46
	CV (%)				8.07		9.56

DAE: days after emergence, OV: original vales, *TV square root transformed values

Eggs 14 DAE

The egg count 14 DAE in various treatments schedule was statistically non-significant (Table 3). However, the lowest eggs 7.33 were laid treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed and neem oil @ 20 ml/l spray 7 DAE (T2) followed with 7.67 eggs/10 plants in treatment schedule neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE (T1), neem oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE and NSE @ 5% spray 14 DAE (T9), karanj oil @ 5 ml/ kg seed, neem oil @ 20 ml/lspray 7 DAE andkaranj oil @ 20 ml/l spray 14 DAE (T3) and in treatment schedule seed treatment with neem oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE (T7). The maximum number of eggs were observed in untreated control i. e. 10.67 eggs /10 plants followed in treatment schedule seed treatment neem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE (T4), karanj oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T8), neem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and NSE @ 5% spray 14 DAE (T6), karanj oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T5), imidacloprid 48 FS @ 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE (T10), which had 10.00, 9.67, 9.33, 8.67 and 8.67 eggs/10 plants respectively.

Eggs 21 DAE

The egg count 21 DAE in various treatments schedule was

does not differ statistically (Table 3). However, the lowest eggs were observed in treatment schedule imidacloprid 48 FS @ 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE (T10) followed with 5.67 in treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed and neem oil @ 20 ml/l spray 7 DAE (T2), 6.00 eggs in treatment schedule seed treatment with neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE (T1), treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed, NSE @ 5% spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T5), treatment schedule seed treatment with neem oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE NSE @ 5% spray 14 DAE (T9). However, the maximum eggs i.e. 8.00 were noted in untreated control followed with 7.33 in treatment schedule seed treatment with karanj oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T3), 7.00 eggs in treatment schedule seed treatment with neem oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and NSE @ 5% spray 14 DAE (T6), 6.67 eggs in treatment schedule seed treatment withneem oil @ 5 ml/kg seed, neem oil @ 20 ml/l and neem oil @ 20 ml/l (T7), 6.33 eggs in treatment schedule seed treatment with karanj oil @ 5 ml/ kg seed karanj oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE (T8) and in treatment schedule seed treatment with neem oil @ 5 ml/kg seed karanj oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE (T4).

Table 4: Effect of treatments schedules on oviposition by shoot fly 14 and 21 days after emergence in *kharif* sorghum

Treatment	Seed treatment	First spray (7 DAE)	Second spray (14 DAE)	Eggs 14 DAE(/10plants)		Eggs 21 DAE (/10plants)	
				OV	TV*	OV	TV*
T1	Neem oil @ 5 ml/kg seed	NSE @ 5%	-	7.67	2.76	6.00	2.43
T2	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	-	7.33	2.70	5.67	2.37
T3	Karanj oil @ 5 ml/ kg seed	Neem oil @ 20 ml/l	Karanj oil @ 20 ml/l	7.67	2.77	7.33	2.70
T4	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Neem oil @ 20 ml/l	10.00	3.13	6.33	2.50
T5	Karanj oil @ 5 ml/ kg seed	NSE @ 5%	Karanj oil @ 20 ml/l	8.67	2.94	6.00	2.44
T6	Neem oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	NSE @ 5%	9.33	3.04	7.00	2.61
T7	Neem oil @ 5 ml/kg seed	Neem oil @ 20 ml/l	Neem oil @ 20 ml/l	7.67	2.77	6.67	2.56
T8	Karanj oil @ 5 ml/kg seed	Karanj oil @ 20 ml/l	Karanj oil @ 20 ml/l	9.67	3.10	6.33	2.51
T9	Neem oil @ 5 ml/kg seed	NSE @ 5%	NSE @ 5%	7.67	2.76	6.00	2.44
T10	Imidachloprid 48 FS 12 ml/kg seed	-	Quinalphos 25 EC @ 20 ml/ 10 l	8.67	2.93	5.00	2.23
T11	Untreated control	-	-	10.67	3.26	8.00	2.81
	'F' test				NS		NS
	SE(m) ±				0.19		0.18
	CD at (5%)				0.55		0.52
	CV (%)				11.02		12.23

DAE: days after emergence, OV: original vales, *TV square root transformed values

In present study, 7 DAE non-significant data on egg count indicates that the seed treatments either of neem oil, karanj oil or imidacloprid had no influence on oviposition. The eggs count was significantly affected 10 DAE, it might be due to the 7 DAE spray of plant oil and extract. The oviposition data 14 and 21 was also non-significant, this indicates that 7 DAE spray (first) had no impact on 14 DAE egg count and 14 DAE spray (second) not influencing egg number 21 DAE indicating plant oils and extract are not long lasting. This has been proven by various researchers earlier (Caboni *et al*. 2006; Estefania *et al*. 2016) [3, 4]. Joshi *et al.* (2016) [6] conducted the experiment to study Management of sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) through botanicals and maximum oviposition was recorded in the untreated check, while the minimum was recorded in neem oil 2% and karanj oil 2%.

Conclusions

Seed treatment with Karanj oil @ 5 ml/ kg seed followed by Neem oil @ 20 ml/l spray 7 DAE and seed treatment with Neem oil @ 5 ml/kg seed, followed by Neem oil @ 20 ml/l spray 7 DAE are effective against shoot fly oviposition 14 days after emergence.

Any of the seed treatments studied *viz*., seed treatment with neem oil @ 5 ml/kg seed, seed treatment with karanj oil @ 5 ml/ kg seed and seed treatment with imidacloprid 48 FS 12 ml/kg seed are not effective against shoot fly oviposition 7 days after emergence. None of the treatment schedule does not affect egg count 14 and 21 days after emergence.

The treatment schedule seed treatment with neem oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE performed better for increasing grain yield presiding to chemical treatment schedule of seed treatment with imidacloprid 48 FS @ 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE. Seed treatment with neem oil @ 5 ml/kg seed, neem oil @ 20 ml/l spray 7 DAE and neem oil @ 20 ml/l spray 14 DAE and seed treatment with karanj oil @ 5 ml/kg seed, karanj oil @ 20 ml/l spray 7 DAE and karanj oil @ 20 ml/l spray 14 DAE were the treatment schedules next to chemical treatment schedule of seed treatment with imidacloprid 48 FS @ 12 ml/kg seed followed by quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE expressed better results of fodder yield.

The chemical treatment schedule seed treatment with imidacloprid 48 FS @ 12 ml/kg seed and quinalphos 25 EC @ 20 ml/ 10 l spray 14 DAE emerged best in respects with highest incremental cost benefit (ICBR). Of the plant oils and extract based schedules *viz*., treatment schedule seed treatment with neem oil @ 5 ml/kg seed and NSE @ 5% spray 7 DAE and treatment schedule seed treatment with neem oil @ 5 ml/kg seed, NSE @ 5% spray 7 DAE NSE @ 5% spray 14 DAE are partially economical while the others are not economical.

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