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Seasonal Incidence of Insect Pests and Natural Enemies in Foxtail Amaranthus and Spinach and Efficacy of Dimethoate Against Insect Pests Infesting Leafy Vegetables

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was made to study the efficacy of dimethoate against sucking and defoliator pest-infesting foxtail amaranths and spinach. The efficacy of dimethoate was evaluated at two doses, one at the recommented does of 200 g active ingredient (a.i.) ha-1 and other at double the recommended dose of 400 g a.i. ha-1 along with control and the other at double the recommended dose of 400 g a.i ha^{-1} along with control. The incidence of leaf webber (*Hymenia recurvalis*), ear-

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head bug (*Cletus pugnator*), Thrips (*Thrips tabaci*) and leaf *miner* (*Liriomyza trifoli*) were observed in foxtail amaranth. In spinach, leaf-eating caterpillars (*Spodoptera litura*), cutworm (*Agrotis ipsilon*) and Thrips (*Thrips tabaci*) were recorded. In spinach at the third leaf stage, nearly 9.20% leaf defoliation, 10.34% leaf damage and a mean thrips population of 3.48/five plants with a mean predator population of 0.32/ five plants were recorded. In the efficacy study, dimethoate was efficient in reducing the infestation of the leaf webber population with pre-mean count of 4.4± 0.87 in control and 1.2± 0.03 in X dose and 0.0± 0.0 in 2X dose after a day after treatment (DAT) in foxtail amaranths. In an efficacy study of dimethoate on thrips in spinach and foxtail amaranth, a complete reduction of thrips population was observed on 3 DAT at X dose and 2X dose with mean thrips population on control was 17.1± 2.12 in spinach and 8.5± 1.24 in foxtail amaranth 3 DAT. These findings indicate that dimethoate application has promising potential as a practical approach for managing insect pests in foxtail amaranth and spinach crops.

Keywords: Spinach; foxtail amaranths; dimethoate; efficacy; seasonal incidence.

1. INTRODUCTION

Vegetables play a vital role in the dietary requirements of humans and leafy vegetables reserve a unique spot in providing all the essential nutrients, vitamins and minerals [1]. The consumption of leafy vegetables was followed by ancestors and collection from wild sources was still a major practice in all parts of the world [2,3]. Leafy vegetables were eaten raw or cooked by many tribal and millions of rural communities as a traditional food [4]. Leafy vegetables are rich in antioxidants, flavonoids, beta-carotene and minerals like Zn, Na, Fe and Ca which serve as a wholesome meal apart from cereals and millets [5,6]. However, climate change has resulted in a shift in pest distribution and occurrence in all cultivated and arable crops especially vegetables, especially protected cultivation [7].

The recent incidence of chilli gall midge (Asphondylia capparis), solenopsis mealy bug (Phenacoccus solenopsis), Hadda beetle (Henosepilachna vigitioctopunctata) and plume moth (Sphenaeches caffer) in bottle gourd were reported in India on major vegetables [8,9,10]. The insect pest causes 30-40% yield loss in vegetables in India and also reduces the marketability and value of the produce [8,11].

Among the major pests infesting the vegetables, Lepidopteran insect pests viz. Helicoverpa armigera, Pieris brassicae, Leucinodes orbonalis, Phthorimaea operculella, Plutella xylostella, Spilosoma obliqua, Spodoptera litura and Hemipteran insect pest viz. Aphis gossypii, Bemisia tabaci, Brevicoryne brassicae, Myzus persica, Dysdercus cingulatus, Lipaphis erysimi and non-insect pests like spider mites, slugs and snails were predominantly attacking the vegetables in northern regions of India [12,13]. The major insect pests attacking spinach were leaf miners, Liriomyza spp.; green peach aphid, Myzus persicae; loopers worms, Trichoplusia ni; beet armyworm, Spodoptera exigua; whiteflies, Bemisia argentifolii; thrips, Frankliniella occidentalis and mites, Rhizoglyphus spp [14]. The impact of these insect pests on leafy vegetables not only reduces the yield but also reduces the marketability and quality of vegetables. These factors collectively highlight the need for effective pest management strategies to ensure the sustainable production of high-quality leafy vegetables.

2. MATERIALS AND METHODS

2.1 Field Assay

A field experiment was laid out during October - November 2017 to study the dissipation study and efficacy study of dimethoate and to record the seasonal incidence of insect pests of foxtail amaranthus and spinach in Coimbatore, Tamil Nadu, India. Observation on insect pests and natural enemy populations was made at regular intervals and the insect specimens collected from foxtail amaranthus and spinach fields were identified in the biosystematics unit of Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

2.2 Efficacy Study

The efficacy of broad-spectrum insecticide, dimethoate Dimethoate was not recommended in green leafy vegetables but as Dimethoate was the most used insecticide in green vegetables in coimbatore region, dimethoate was used for the present study (Manivann et al. 2012) applied using a knapsack sprayer at the recommended dose of 200 g a.i. per ha and double the dose of 400 g a.i. ha^{-1} with three replicates. The second spray with the same recommended dose was applied 10 days after the first spray. The data on insect pests and natural enemy populations were recorded per five plants at regular intervals. Apart from the dissipation study of dimethoate in foxtail amaranth and spinach, an efficacy study was carried out to find the toxicity of dimethoate against insect pests of foxtail amaranth and spinach.

2.3 Statistical Analysis

The data collected during the study was recorded and mean data on pest and natural enemy populations in different treatments were analyzed along SAS software (SAS version 9.2, SAS Institute).

3. RESULTS AND DISCUSSION

The seasonal incidence of insect pest profile in foxtail amaranth is given in Table 1. In foxtail amaranths, the incidence of insect pests was negligible till 10 Days After Sowing (DAS) lay up to the third leaf stage. At the fifth leaf stage, nearly 6.28% leaf mining and 8.18% leaf damage were recorded with a mean predator population of 0.4/five plants observed. At eight leaf stage, 5.43% of defoliation, 1.36% of leaf-mining followed by mean sting bug (0.20), stem weevil (0.08) and thrips population (0.52) were recorded per five plants. At the tenth leaf stage, 11.15% of defoliation, and 1.12% leaf mining followed by mean stem weevil (1.50) and thrips population (1.20), predator (1.33) were recorded per five plants. Amaranthus stem weevil, Hypolixus truncatulus (Boheman), leaf webber, Hymenia recurvalis (Fabricius), leaf caterpillar, Erectmocera impactella (Walker) and ear-head bug, Cletus pugnator (Fabricius) was prevalent in the field. Damage by ash weevil, Myllocerus undecimpustulatus (Marshall), Thrips, Thrips tabaci Lindeman, grasshopper, Attractomorpha crenulata (Fabricius) and leaf miner Liriomyza trifoli (Burgess) were also observed in foxtail amaranth. A constant increase in coccinellid, spiders and rove beetle population were observed in unsprayed areas followed by a rise in insect pest populations in foxtail amaranths.

The perusal of data on seasonal incidence of insect pest profile in spinach was given in Table 2. At the third leaf stage, nearly 9.20% leaf defoliation, 10.34% leaf damage and mean thrips population of 3.48/five plants with a mean predator population of 0.32/five plants were recorded.

At fifth leaf stage, 11.03% of defoliation, and 4.14% of leaf-mining followed by a mean thrips population (6.72) was recorded per five plants. At eight leaf stage, 16.10 % defoliation, 2.93% leaf-mining followed by mean thrips population (8.2) and predator (1.38) were recorded per five plants. Severe damage by leaf-eating caterpillars, Spodoptera litura (Fabricius), cutworms, Agrotis ipsilon (Hufnagel) and Thrips, Thrips tabaci Lindeman were recorded in spinach. Leaf webber, H. recurvalis, leaf miner, L. trifoli, and tortoise beetle, Aspidomorpha exilis (Boheman) infestation were also observed feeding on spinach. Simko et al. [14] also reported that Spodoptera littoralis was the major pest attacking spinach in Italy while in our study S. litura was recorded as a minor pest while L. trifoli and Thrips tabaci were the predominant. Mou et al. [15] reported in their study that leafminer, Liriomyza spp. was the major pest of spinach in the USA and Kirisik et al. [16] stated that mite Tyrophagus neiswanderi was the major pest of spinach under greenhouse conditions.

The perusal of results of the efficacy study of dimethoate on amaranths leaf webber in foxtail amaranths was given in Table 3. The results revealed that dimethoate was efficient in reducing the infestation of the leaf webber population in both X and 2X doses. Before the first spray, the pre-mean leaf webber population was 3.1± 0.12 in control and 4.3±0.32 in x dose and 3.5± 0.41 in 2X dose plots. The mean leaf webber population was 4.4± 0.87 in control, 1.2± 0.03 in X dose and 0.0± 0.0 in 2X dimethoate after 1 DAT. The subsequent increase in population was recorded in control from 7.6± 0.92 on 3 DAT to 8.3± 0.45 on 5 DAT. Further incidence of leaf webber population was recorded 10 DAT and a second spray was applied with same recommended dose of X and 2X with control. Before the second spray, the pre-mean leaf webber population was 2.6± 0.39 in control, 1.1± 0.19 in x dose and 1.8± 0.22 in 2X dose plots. The mean leaf webber population was 3.2± 0.09 in control and 0.0± 0.0 in both X dose and 2X dose of dimethoate after 1 DAT. The subsequent increase in population was recorded in control from 3.6± 0.18 on 3 DAT to 4.0± 0.87 on 5 DAT, while the complete reduction in population was observed in treatments.

Table 1. Seasonal incidence of pest in foxtail amaranthus in first season 2017-18

DAS	No. of leaves*	No of leaves defoliated*	Percent leaf defoliated **	No of leaves mined	Percent leaf mined **	No of leaves webbed 8	No. of stem with galls*	Ear-head bug*	Leaf webber*	Stem weevil*	Thrips*	Predators *	Parasitoids *	Inference
10	2.84± 0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	No pest incidence in 2-3 leaf stage
15	6.36± 0.25	0.52± 0.20	8.18	0.40± 0.09	6.29	0.00	0.00	0.00	0.00	0.00	0.00	0.04± 0.04	0.00	at 5-8 leaf stage leaf miner and defoliator were recorded
20	8.84± 0.26	0.48± 0.17	5.43	0.12± 0.06	1.36	0.00	0.00	0.20± 0.08	0.00	0.08± 0.05	0.52± 0.13	0.24± 0.08	0.00	Increase in coccinellid, spiders and rove beetle population was observed
25	10.76± 0.32	2.14± 0.18	11.15	1.00± 0.00	1.12	0.00	1.00± 0.00	0.00	0.00	1.50± 0.1	1.20± 0.08	1.33± 0.09	0.00	

*Mean number of individuals observed in 5 plants
** Percent leaf defoliated/leaf mined
DAS- Days After Sowing

Table 2. Seasonal incidence of pest in spinach in 2017-18

DAS	No. of leaves *	No of leaves defoliated*	Percent leaf defoliated **	No. of leaves mined	Percent leaf mined **	No of leaves webbed 8	No. of stem with galls*	Ear-head bug*	Leaf webber*	Stem weevil*	Thrips*	Predators *	Parasitoids *	Inference
10	2.44± 0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	No pest incidence in 2-3 leaf stage
15	3.48± 0.10	0.32± 0.14	9.20	0.36± 0.10	10.34	0.00	0.00	0.00	0.00	0.00	3.48± 0.07	0.32± 0.04	0.00	at 2.4 leaf stage leaf miner and defoliator were recorded
20	5.8± 0.17	0.64± 0.18	11.03	0.24± 0.09	4.14	0.00	0.00	0.00	0.00	0.00	0.72± 0.12	0.32± 0.09	0.00	Increase in the natural enemy population was observed
25	8.2± 0.16	1.38± 0.24	16.10	0.32± 0.08	2.93	0.00	0.00	0.00	0.00	0.00	8.2± 0.12	1.38± 0.11	0.00	

*Mean number of individuals observed in 5 plants
** Percent leaf defoliated/leaf mined
DAS- Days After Sowing

Table 3. Efficacy of dimethoate against leaf webber, Hymenia recurvalis in foxtail amaranthus during 2017-18

Treatment	Chemical Name	Dose a.i./ha	Pre-Treatment count	Mean population after 1st spray*			Pre-treatment count for second spray	Mean population after 2st spray*		
				1 DAT	3 DAT	5 DAT		1 DAT	3 DAT	5 DAT
T1	Control	-	3.1± 0.12	4.4± 0.87	7.60.92	8.3±0.45	2.6±0.39	3.2± 0.09	3.6± 0.18	4.0±0.87
T2	Dimethoate X dose	200	4.3±0.32	1.2±0.03	0.0±0.0	0.0±0.0	1.1± 0.19	0.0± 0.0	0.0± 0.0	0.0± 0.0
T3	Dimethoate 2X dose	400	3.5± 0.41	0.0±0.0	0.0±0.0	0.0±0.0	1.8± 0.22	0.0± 0.0	0.0± 0.0	0.0± 0.0

**Mean number of leaf webbers observed in 5 plants*
DAT- Days After Treatment

Table 4. Efficacy of dimethoate against thrips in foxtail amaranths during 2017-18

Treatment	Chemical Name	Dose a.i./ha	Pre-Treatment count	Mean population after 1st spray*			Pre-treatment count for second spray	Mean population after 2st spray*		
				1 DAT	3 DAT	5 DAT		1 DAT	3 DAT	5 DAT
T1	Control	-	5.4± 0.82	4.2±1.12	8.5±1.24	11.3±2.28	8.8±1.24	12.3±2.34	15.7±3.49	19.8±3.14
T2	Dimethoate X dose	200	4.8± 0.74	2.6± 0.93	0.0 ± 0.0	0.0 ± 0.0	4.4±0.92	2.5± 0.92	0.0 ± 0.0	0.0 ± 0.0
T3	Dimethoate 2X dose	400	6.1± 1.02	1.3± 0.09	0.0 ± 0.0	0.0 ± m 0.0	4.9± 0.86	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

**Mean number of thrips observed in three leaves per plant*
DAT- Days After Treatment

Table 5. Efficacy of dimethoate against thrips in spinach during 2017-18

Treatment	Chemical Name	Dose a.i./ha	Pre-Treatment count	Mean population after 1st spray*			Pre-treatment count for second spray	Mean population after 2st spray*		
				1 DAT	3 DAT	5 DAT		1 DAT	3 DAT	5 DAT
T1	Control	-	6.6± 0.17	8.5± 0.34	24.1± 3.14	27.4± 5.67	9.6±2.34	13.2± 3.10	17.1± 2.12	22.5± 3.37
T2	Dimethoate X dose	200	5.4± 0.41	2.3±0.09	0.0 ± 0.0	0.0 ± 0.0	6.0± 1.78	2.4± 0.14	0.0 ± 0.0	0.0 ± 0.0
T3	Dimethoate 2X dose	400	7.9± 0.57	1.7±0.17	0.0 ± 0.0	0.0 ± 0.0	5.3± 1.90	1.3± 0.10	0.0 ± 0.0	0.0 ± 0.0

**Mean number of thrips observed in three leaves per plant*
DAT- Days After Treatment

The perusal of results of the efficacy study of dimethoate on thrips in foxtail amaranths was given in Table 4. The results revealed that dimethoate was efficient in reducing the infestation of the thrips population in both X and 2X doses. The Before first spray, the pre-mean thrips population was 5.4± 0.82 in control, 4.8± 0.74 in X dose and 6.1± 1.02 in 2X dose plots. The mean thrips population was 4.2± 1.12 in control, 2.6± 0.93 in X dose and 1.3± 0.09 in 2X dose of dimethoate after 1 DAT. The subsequent increase in thrips population was recorded in control from 8.5± 1.24 on 3 DAT to 11.3± 2.28 on 5 DAT. Further incidence of thrips population was recorded 10 DAT and a second spray was applied with same recommended dose of X and 2X with control. Before the second spray, the pre-mean thrips population was 8.8± 1.24 in control and 4.4± 0.92 in x dose and 4.9± 0.86 in 2X dose plots. The mean thrips population was 12.3± 2.34 in control and 2.5± 0.92 in both X dose and 0.0 ± 0.0 in 2X dose of dimethoate after 1 DAT. The subsequent increase in population was recorded in control from 15.7± 3.49 on 3 DAT to 19.8± 3.14 on 5 DAT, while the complete reduction in thrips population was observed in treatments.

The perusal of results of the efficacy study of dimethoate on thrips in spinach was given in Table 5. The results revealed that dimethoate was efficient in reducing the infestation of the thrips population in both X and 2X doses. Before the first spray, the pre-mean thrips population was 6.6± 0.17 in control, 5.4± 0.41 in X dose and 7.9± 0.57 in 2X dose plots. The mean thrips population was 8.5± 0.34 in control, 2.3± 0.09 in X dose and 1.7± 0.17 in 2X dimethoate after 1 DAT. The subsequent increase in thrips population was recorded in control from 24.1± 3.14 on 3 DAT to 27.4± 5.67 on 5 DAT. Further incidence of thrips population was recorded 10 DAT and second spray was applied with same recommended dose of X and 2X with control.

Before the second spray, the pre-mean thrips population was 9.6± 2.34 in control, 6.0± 1.78 in x dose and 5.3± 1.90 in 2X dose plots. The mean thrips population was 13.2± 3.10 in control and 2.4± 0.14 in both X dose and 1.3± 0.10 in 2X dose of dimethoate after 1 DAT. The subsequent increase in population was recorded in control from 17.1± 2.12 on 3 DAT to 22.5± 3.37 on 5 DAT, while the complete reduction in thrips population was observed in treatments. Kachot et al. [17] also reported in their study that dimethoate in combination with Beauveria bassiana 1.15% WP resulted in 95% reduction in thrips population in onion, at 5 DAT. The present study was the continuation of the previous study by Gopalakrishnan et al. [18] on the dissipation pattern of dimethoate in foxtail amaranths and spinach and during study the efficacy of dimethoate on different sucking and defoliator pests were evaluated and it was found effective in managing the insect pest infesting leafy vegetables.

4. CONCLUSION

The efficacy study of dimethoate against sucking and defoliator-infesting foxtail amaranths and spinach revealed that the recommended dose (200 g a.i ha^{-1}) was effective in controlling the pest incidence level. Based on our study, we conclude that the incidence of sucking and defoliator pests were controlled at the recommended dose of 200 g a.i ha^{-1} and the dissipation pattern data (data not shown) showed that the safe waiting period of dimethoate was 3.99 days in foxtail amaranths and 7.02 day in spinach. The change in food habits and reliance of diet on fresh leafy vegetables in recent times insist to carry out more research on pest efficacy and residue-related studies in green leafy vegetables. Hence, pest management in leafy vegetables needs integration of biological and chemical control measures to curb the off-target effect of pesticides and pesticide residue issues in food stuffs.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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