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Assessment of various management strategies implemented by farmers against *Spodoptera frugiperda* (J. E. Smith) in maize

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Abstract
Experiment on the effectiveness of various farming strategies were used to control *S. frugiperda* in maize during *Kharif* 2021 and *Rabi* 2022 at the Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment results showed that the standard check chlorantraniliprole 18.5% SC @ 0.4 ml/l recorded the lowest larval population (0.85 larvae/plant) and leaf damage score (2.57). Neem seed powder at 2 g/whorl was most effective and significantly superior to the rest of farmer practices, with the larval population of 0.91 larvae/plant. The next effective treatments were lime @ 5 g/whorl, soil @ 5 g/whorl and sand @ 5 g/whorl in reducing larval population and leaf damage infesting *S. frugiperda.* The highest grain yield (64.01 q/ha) was registered by chlorantraniliprole 18.5% SC followed by neem seed powder @ 2 g/whorl ((56.33 q/ha) and lime @ 5 g/whorl (47.40 q p/ha). The highest ICBR (1:3.66) was registered by chlorantraniliprole 18.5% SC followed by wood ash (1:1.85).

Keywords: Maize, *Spodoptera frugiperda*, larval population, leaf damage score

Introduction

The fall armyworm (FAW) (*Spodoptera frugiperda*), has most important insect pest for a many crop species, mostly maize (Luginbill, 1928) [10]. As an invasive species, FAW has expanded over Africa, the Near East, and Asia in recent years. Reports of FAW were recorded throughout continental West Africa in the early months of 2016 (Goergen, 2016) [8]. It rapidly expanded throughout sub-Saharan Africa in 2016, 2017 and by late 2018 (FAO, 2018) [6]. According to Ganiger *et al*. (2018) [7] it had been verified in Yemen and India by July 2018. By the beginning of 2019, five more Asian nations, including China, have confirmed it (FAO, 2018) [6]. Although FAW favors maize with frequently seen on rice, sorghum and cereals. It also occasionally significant with wide range of other crops, such as cotton and vegetables. Based on a review of the literature and further surveys conducted in Brazil, According to Montezano *et al*. (2018) [11], there are 353 species of host plants from 76 different plant families. The farmers used distinct cultural management techniques even though FAW has just recently been introduced to Africa. Smallholders, who operate in distinct environments from large-scale commercial farmers, make up the great majority of maize growers worldwide. The majority of small area farmers do not have access to risk-transfer mechanisms steady and overprices for their agriculture production or various subsidy, which significantly limits their access to expensive control treatments. In addition, the unchecked application of chemical pesticides in agriculture led to the contamination of water and soil, the emergence of insect pollinators resistant to pests, the emergence of natural enemies of insect pests and the degradation of farming communities. As reported by Chandola *et al.* (2011) [5], indigenous methods of controlling pests are affordable, efficient, and don't harm the ecosystem. Utilizing traditional knowledge in agriculture generally reduces the amount of agrochemical disruption of the ecosystem without sacrificing the ecosystems' natural services, supporting crop productivity, plant growth and defenses against pests. Locally farmers used a variety of management techniques that are not harmful to the environment or public health in different nations, areas, or locales. But the effective practices and lessons learned by these farmers were not consistently recorded and disseminated to farmers in many nations.

The purpose of this investigation is to summarize and choose the best indigenous knowledge and practices that may be shared with farmers and other farming stakeholders.

Materials and Methods

In *Kharif* 2021 and *Rabi* 2022, the experiment was carried out on the Mahatma Phule Krishi Vidyapeeth (MPKV) maize improvement project farm in Rahuri. The field experiment was carried out with ten treatments and three replications, with plot size 4 x 3 m^2 and spacing of 75 x 25 cm^2. The cultivar Eco-parmeshwar (P-3302) was sown with all agronomical practices except plant protection measures. The treatments include: T_1: Wood ash @ 5 g/whorl, T_2: Soil @ 5 g/whorl, T_3: Sand @ 5 g/whorl, T_4: - Neem seed powder @ 2 g/whorl, T_5: Lime @ 5 g/whorl, T_6: Chilli extract spray 10% @ 10 ml/l, T_7: Chlorine water 0.03% @ 10 ml/whorl, T_8: Chlorantraniliprole - 18.5% SC @ 0.4 ml/l used as standard check, T_9: Detergent water spray @ 5 g/l and T_{10}: Untreated control. Source: woos ash, soil, sand, lime, chilli, chlorine water were procured from local market. Both chlorantraniliprole (18.5% SC) and neem seed powder were supplied by Liebigs Agro Chem Pvt. Ltd., Kolkata and FMC India Pvt. Ltd. of Bandra Kurla Complex (E), Mumbai, respectively. Two treatment applications were given on the experimental plot at intervals of 14 days. As soon as the fall armyworm incidence was observed, the first treatments were applied. Pre count observation on larval population and leaf damage score were recorded before application treatment while post count observations were recorded after application of treatments at five, ten and fourteen days after application (DAA) in each plot. According to Davis and Williams (1992) [15], the observations on leaf damage score were recorded on a grading range of 0 to 9. At harvesting grain yield was recorded in each plot and converted into q/ha for further statistical analysis. A randomised block design (RBD) was used to analyse the field experiment data. The designed ANNOVA was applied to the transformed data in order to compare the results among the treatments.

Results and Discussion

The data (Table 1) revealed that during *Kharif* 2021 and *Rabi* 2022, all treatments significantly reduced the incidence of larvae at 5, 10 and 14 days after two application of treatment; pretreatment counts varied from 1.62 to 1.87 and was statistically non-significant and showed chlorantraniliprole 18.5% SC is the best treatment which recorded larval population of 0.85 larvae per plant. Among the farmers practices the best treatment was neem seed powder @ 2 g/whorl which recorded larval population of 0.91 larvae per plant and lime @ 5 g/whorl (1.06 larvae/plant). This was followed by wood ash @ 5 g/whorl (1.13 larave/plant) and soil @ 5 g/whorl with larval population of 1.13 and 1.14 larvae, respectively. Whereas, untreated plots recorded the highest (2.11 larvae/plant) larval population in maize.

In respect of effect of different treatments on leaf damage score during *Kharif* 2021 and *Rabi* 2022 (Table 2) revealed that pretreatment counts varied from 4.87 to 5.62, and at five, ten and fourteen days after two application of treatments there was reduction in leaf damage score of 2.57 with chlorantraniliprole 18.5% SC. In all farmers practice, neem seed powder @ 2 g/whorl was best treatment in reducing leaf damage score i.e.3.27 followed by lime @ 5 g/whorl (4.25) and wood ash @ 5 g/whorl (4.30). The highest leaf damage score (6.56) recorded by untreated plots. In comparison to the untreated control, all treatments showed noticeably increased yields. According to present experiment (Table 3), chlorantraniliprole 18.5% SC @ 0.4 ml/l has registered the highest yield i.e. 64.01 q/ha. In all farmer's practices, neem seed powder registered highest yield (56.33 q/ha) followed by Lime @ 5 g/whorl (47.40 q p/ha). Furthermore, among all treatments, the treatment with chlorantraniliprole @ 0.4 ml/l produced the highest percentage increase in yield (50.84%). It was followed by neem seed powder demonstrated significant increase in yield (32.73%). The highest ICBR (1:3.66) was recorded by plot treated with chlorantraniliprole 18.5% SC @ 1.88 ml/kg. The maximum ICBR were recorded in the treatments *viz*., wood ash, chlorine water 0.03% and soil with 1:1.85, 1:1.52 and 1:1.24, respectively. Chlorantraniliprole 18.5% SC was significantly superior over the rest of treatment by reducing larval population and leaf damage score which affected in increase in grain yield followed by neem seed powder and lime (Fig.1).

Experimental finding revealed that chlorantraniliprole @ 0.4 ml/l was best treatment over rest of the treatments against *S. frugiperda* is in conformity with several earlier workers Bajracharya *et al.* (2020) [3] reported that chlorantraniliprole 18.5% SC @ 0.4 ml/l was proved best treatment in all other treatments and recorded minimum leaf damage score. Ramesh and Tayde (2022) [12] concluded that chlorantraniliprole 18.5% SC (6.24%) was superior treatment in reducing larval population of *S. frugiperda* in maize. The results of Stevenson *et al.* (2017) [13], who reported that small-scale African farmers generally used neem leaves or seeds to manufacture botanical pesticides to control *S. frugiperda*, are similar with the observations of the current investigation regarding the efficiency of neem seed powder at 2 g/l. Adeye *et al.* (2018) [2] reported that applying 4.5 litres of neem oil per hectare reduced the frequency and intensity of insect pest which caused damage to the plants. The findings of this study corroborate Hruska's (2019) [9] who concluded that lime is an easily obtained substance that is widely used by smallholder farmers globally to control *S. frugiperda*. According to CABI (2017) [4], many smallholder farmers applied the sand combined with lime inside the whorl of maize for reducing the infestation of fall armyworm. The findings regarding wood ash's effectiveness are in line with Tambo *et al.* (2020) [14], who found that 17.7 per cent of farmers in five African countries used ash in the whorl of maize, with an efficacy of 48-77% as against to 92-97% for synthetic pesticides. Similarly, ash added to the whorls reduced yield losses in maize due by *S. frugiperda*, as reported by Abrahams *et al.* (2017) [1].

Table 1: Evaluation of farmer's practices on the larval population of *S. frugiperda* in maize (Pooled)

TN	Treatments	Dose/whorl or l	Number of larvae/plant							Pooled Mean
			Pre-count	First Application			Second Application			
				5 DAA	10 DAA	14 DAA	5 DAA	10 DAA	14 DAA	
T_1	Wood ash	5 g/whorl	1.78 (1.51)	1.20 (1.30)	1.17 (1.29)	1.37 (1.37)	0.95 (1.20)	0.90 (1.18)	1.27 (1.33)	1.14 (1.28)
T_2	Soil	5 g/whorl	1.63 (1.46)	1.12 (1.27)	1.07 (1.25)	1.33 (1.35)	1.00 (1.22)	1.00 (1.22)	1.27 (1.33)	1.13 (1.28)
T_3	Sand	5 g/whorl	1.82 (1.52)	1.18 (1.30)	1.12 (1.27)	1.37 (1.37)	1.07 (1.25)	1.05 (1.24)	1.32 (1.35)	1.18 (1.30)
T_4	Neem seed powder	2 g/whorl	1.82 (1.52)	0.83 (1.15)	0.82 (1.15)	0.88 (1.18)	0.63 (1.06)	0.60 (1.05)	0.65 (1.07)	0.91 (1.19)
T_5	Lime	5 g/whorl	1.62 (1.45)	1.08 (1.26)	1.05 (1.24)	1.27 (1.33)	0.92 (1.19)	0.83 (1.15)	1.20 (1.30)	1.06 (1.25)
T_6	Chilli extract spray 10%	10 ml/l	1.82 (1.52)	1.40 (1.38)	1.40 (1.38)	1.62 (1.45)	1.17 (1.29)	1.15 (1.28)	1.48 (1.41)	1.37 (1.37)
T_7	Chlorine water 0.03%	10 ml/whorl	1.78 (1.51)	1.25 (1.32)	1.22 (1.31)	1.47 (1.40)	1.15 (1.28)	1.10 (1.26)	1.37 (1.37)	1.26 (1.33)
T_8	Chlorantraniliprole 18.5% SC	0.4 ml/l	1.77 (1.51)	0.62 (1.06)	0.58 (1.04)	0.63 (1.06)	0.45 (0.97)	0.42 (0.96)	0.43 (0.96)	0.85 (1.16)
T_9	Detergent water spray	5 g/l	1.87 (1.54)	1.53 (1.43)	1.63 (1.46)	1.87 (1.54)	1.50 (1.41)	1.57 (1.44)	1.80 (1.52)	1.65 (1.47)
T_{10}	Untreated control	---	1.75 (1.50)	1.95 (1.56)	2.20 (1.64)	2.27 (1.66)	2.10 (1.61)	2.03 (1.59)	2.13 (1.62)	2.11 (1.62)
	SE(m) ±		0.04	0.02	0.02	0.02	0.02	0.02	0.03	0.01
	CD @ 5%		NS	0.06	0.05	0.05	0.06	0.06	0.08	0.04
	CV		4.17	5.65	4.02	4.06	5.57	6.85	7.54	4.78

Figures in parenthesis are $\sqrt{x + 0.05}$ transformed values, NS: Non- significant, DAS: Days after application

Table 2: Evaluation of farmer's practices against leaf damage score by *S. frugiperda* in maize (Pooled)

TN	Treatments	Dose/whorl or l	Leaf damage score							Mean
			Pre-count	First Application			Second Application			
				5 DAA	10 DAA	14 DAA	5 DAA	10 DAA	14 DAA	
T_1	Wood ash	5 g/whorl	4.87	4.77	4.15	4.45	4.30	3.63	4.48	4.30
T_2	Soil	5 g/whorl	5.25	5.05	4.23	4.62	4.52	3.75	4.62	4.46
T_3	Sand	5 g/whorl	5.17	5.10	4.28	4.72	4.58	3.85	4.77	4.55
T_4	Neem seed powder	2 g/whorl	4.83	4.00	3.35	3.50	3.02	2.45	3.32	3.27
T_5	Lime	5 g/whorl	4.90	4.58	4.05	4.37	4.57	3.55	4.37	4.25
T_6	Chilli extract spray 10%	10 ml/l	5.57	5.57	4.70	5.27	5.18	4.75	4.98	5.08
T_7	Chlorine water 0.03%	10 ml/whorl	5.62	5.65	4.60	5.22	5.08	4.22	5.02	4.96
T_8	Chlorantraniliprole 18.5% SC	0.4 ml/l	5.07	3.70	2.63	2.70	2.42	1.78	2.17	2.57
T_9	Detergent water spray	5 g/l	5.10	5.03	4.82	5.23	5.12	4.90	5.50	5.10
T_{10}	Untreated control	-	5.13	5.93	6.28	6.58	6.88	6.83	6.82	6.56
	SE(m) ±		0.29	0.26	0.23	0.24	0.22	0.24	0.25	0.11
	CD @ 5%		NS	0.78	0.67	0.71	0.65	0.72	0.75	0.33
	CV		9.90	9.20	9.13	8.85	8.30	10.52	9.52	6.22

NS: Non-significant, DAA= Days after application

Table 3: Effect of farmer practices against *S. frugiperda* on grain yield on maize.

Treatments		Dose g or ml/l	Yield (q/ha)			Increase in yield over control (%)	ICBR
			Kharif (2021)	*Rabi* (2022)	Average of two seasons		
T_1	Wood ash	5 g/whorl	42.60	49.56	46.08	8.57	1:1.85
T_2	Soil	5 g/whorl	41.98	48.62	45.30	6.73	1:1.24
T_3	Sand	5 g/whorl	41.86	48.51	45.18	6.46	1:0.38
T_4	Neem seed powder	2 g/whorl	52.82	59.84	56.33	32.73	1:0.85
T_5	Lime	5 g/whorl	43.76	51.04	47.40	11.69	1:0.51
T_6	Chilli extract spray 10%	10 ml/l	41.40	48.30	44.85	5.68	1:0.07
T_7	Chlorine water 0.03%	10 ml/whorl	41.44	48.36	44.90	5.80	1:1.52
T_8	Chlorantraniliprole18.5% SC	0.4 ml/l	60.51	67.52	64.01	50.84	1:3.66
T_9	Detergent water spray	5 g/l	40.65	47.22	43.94	3.53	1:0.83
T_{10}	Untreated control	-	39.05	45.83	42.44	--	
SE(m) ±					0.32	0.34	
CD @ 5%					0.95	1.02	
CV (%)					12.44	11.56	

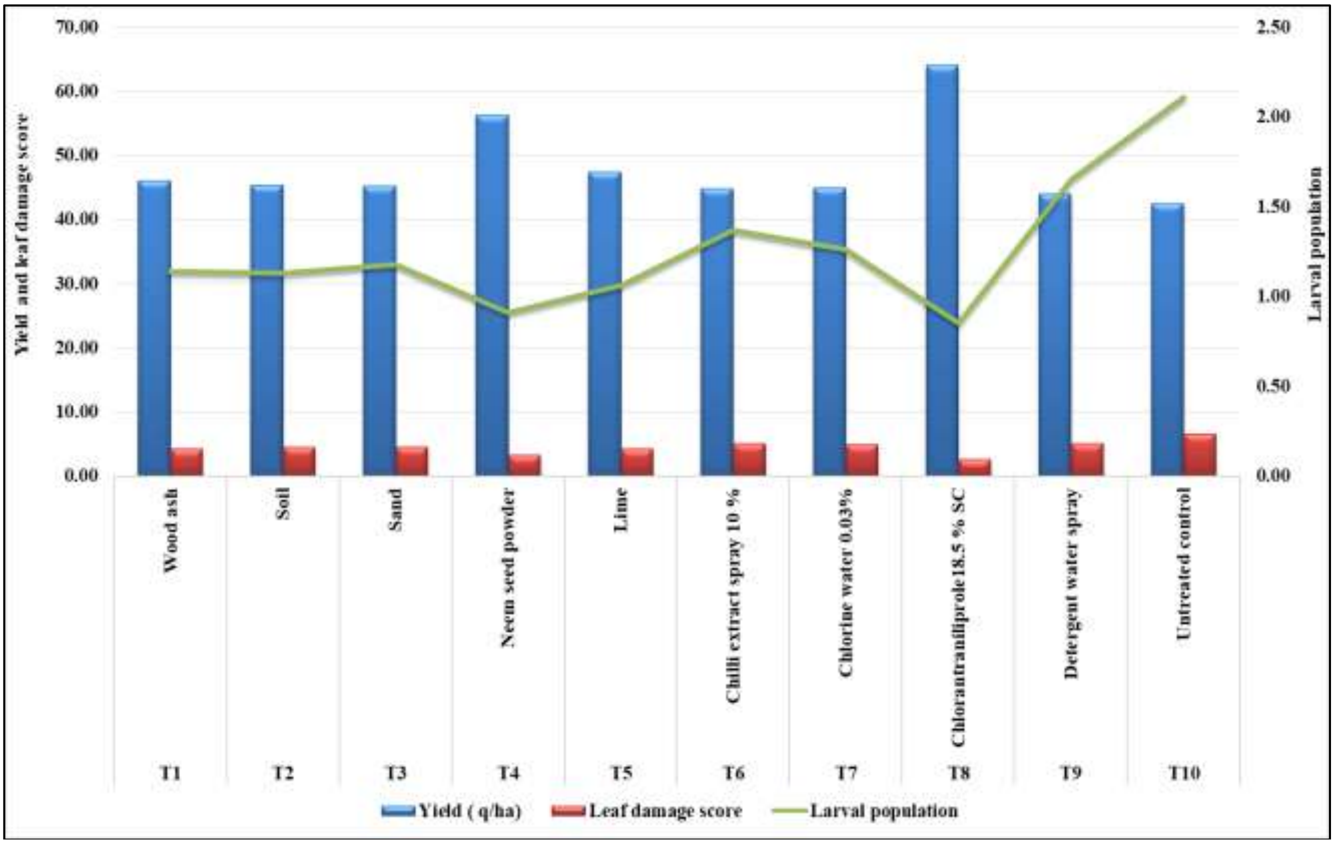

Fig 1: Impact of different farmers practices on yield, larval population and leaf damage score in maize

Conclusion

According to the results of experiment, insecticide chlorantriniliprole 18.5% SC (Standard check) was proved the best treatment in reducing the larval population and leaf damage caused by *S. frugiperda*. In all the farmer's practices, neem seed powder @ 2 g/whorl, lime @ 5 g/whorl and wood ash @ 5 g/whorl were found effective for the control of *S. frugiperda*. Small-scale farmers can utilize these farming practices to manage fall armyworms in an environmentally sustainable manner.

Authorship Contribution

Pagire K S and Patil C S conceptualized and designed the study, Pagire K S conducted the study, analysed the data and authored the report under the supervision of Firake D M, Chaudhari C S, Navale A M and Dhonde S R

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Conflict of Interest: No conflict of interest exist.

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