

KNOWLEDGE STATUS OF MAIZE FARMERS ON FALL ARMYWORM (*SPODOPTERA FRUGIPERDA*): PROSPECTS FOR SUSTAINABLE MANAGEMENT

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ABSTRACT

The Fall Armyworm (*Spodoptera frugiperda*) has high capacity of biological and ecological adaptation. Fall Armyworm (FAW) can survive on more than 80 plant species, including maize. An attempt made to know the knowledge and factors influencing knowledge of maize farmers on FAW incidence in Davanagere and Shivamogga district of Karnataka in India. The findings of the study revealed that, majority of the farmers in Davanagere district had medium (57.50 %) to high (23.75 %) level of knowledge. whereas knowledge of farmers in Shivamogga district, 43.75 percent had medium knowledge followed by high (28.75 %). When it comes to overall knowledge level of the farmers nearly half of the farmers had medium (44.33 %) level of knowledge and one third of the farmers (33.75 %) had high level of knowledge on FAW. Knowledge index reveal that, FAW activity in different seasons and time was known to 81.09 percent, followed by knowledge about the identification and biology of FAW (49.37%), damaging symptoms of FAW (48.48 %) and Infestation of FAW at different stages of crop growth (47.50 %). Fewer farmers know about Management of Fall Armyworm (24.08 %) Therefore universities should give recent information about knowledge of FAW and imparts skill amongst farmers through trainings and method demonstration. Also, State Agriculture Department should promote and start Farmers Field School (FFS) regarding FAW on Maize.

Keywords: knowledge, fall armyworm, maize growers, symptoms, damage, biology

INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crop in the world and it is called as “Queen of Cereal”. In India, Maize is one of the third most important food grain crops after rice and wheat and it is grown throughout the year in the country. In India, it occupies an area of 9.89 m ha with a production of 31.64 MT with average productivity of 31.99 q ha⁻¹. Karnataka holds the first rank in area and production among the Maize growing states in India, with 1.72 m ha and 5.36 MT respectively, with average productivity of 31.07q ha⁻¹. In the Indian context, not less than 15 million farmers are engaged in Maize cultivation and it generates employment for more than 650 million person-days at farming (www.fao.org). Importantly, Maize contributes more than 2.00 per cent to the total value of output from all agricultural crops (www.fao.org). Till recently, the crop was devoid of serious pests and economic expenditure on pesticide was very less (Sharanabasappa et al, 2021). However, the report of fall armyworm (FAW), *Spodoptera frugiperda* in 2018 had lot of

influence on the economic and social status of farmers, which needs to be studied.

In India the pest was reported in Karnataka during May, 2018 (Sharanabasappa et al, 2018) causing severe yield loss which accounts for 33.00 to 60.00 per cent (Balla et al., 2019 and Simiyu., 2019). Young larvae usually feed on leaves creating windows and moistened sawdust-like frass near the funnel and upper leaves. Older larvae stay in the funnel where they are protected from insecticide application and natural enemies, making it difficult to control (Canico., 2021). The incidence and intensity of incidence of FAW in Karnataka has increased since the year of report (Divya et al., 2021; Kalleshwaraswamy et al., 2023). Since then, it has been spread to several states in the country causing havoc to the Maize growing areas viz., Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Telangana, West Bengal, Arunachal Pradesh, Meghalaya, Manipur, Sikkim, Mizoram, Nagaland and Tripura (Firake et al., 2019). One of the

reasons for failure of successful management could be the lack of knowledge among the farmers on the life cycle and good agricultural practices. The productivity of the crop depends on the effective management practices followed by farmers. For effective deployment of control methods for a given pest, farmers should be able to diagnose the pest morphologically in field, incidence level and available best strategies for its management which do not have effect on non-target organisms. In cases of economically important and invasive insect pests such as FAW, it is crucial to know how familiar farmers are with the pest, what options they have to control it and identifying their constraints. Understanding these factors is critically important for setting a research agenda, designing extension strategies, and formulating research that meets farmers' demands (Mendesil et al. 2016 and Kumela et al. 2018). Hence, present knowledge analysis survey was conducted five years after the invasion of FAW (2022).

OBJECTIVES

- (1) To assess the knowledge level of the farmer about fall army worm and its management in maize
- (2) Factors influencing knowledge level of farmers on Fall army worm in maize

METHODOLOGY

In the present study, Ex-post-facto research design was used. The two districts were selected for study, namely Davanagere and Shivamogga, the districts which have highest percentage area under Maize cultivation. Two taluks were selected from each district and total, eight villages from four taluks were selected and from each village, 20 respondents who grow maize from last five years were selected. Such farmers were selected by using simple random sampling techniques. The total sample size for the study was 160 farmers.

In the present study, knowledge was operationalized as the extent of information understood by the farmers about the FAW in Maize. Knowledge was (Parashuram, 2018). An interview schedule was developed to measure the knowledge level of respondents. A large number of items were enlisted under different criteria to assess the knowledge level of farmers about FAW. For this purpose, all possible knowledge items were developed from review of literature, discussion with experts, agricultural entomologists and progressive farmers. The questionnaire used was tested for validity and efficiency on 20 farmers in the research area before adapting the final questionnaire. Finally, most suitable eight main criteria were framed. The first criteria was named as identification and biology of FAW, which includes six items

and second criteria was coined as feeding habit of FAW had four items followed by damaging symptoms of FAW included seven items and infestation of FAW in different stages of crop growth framed with six items. Whereas, fifth was named as FAW activity in different time/seasons included four statements and sixth criteria coined as factors responsible for FAW infestation with three items. Management of FAW included 17 statements followed by five items included in impact of FAW was selected for the purpose and each was administered in a question form to the respondents. The answer to the question were quantified by giving "1" score to the correct answer and "0" to the incorrect one (can you quote the reference where this type of formula was used). The total knowledge score for each respondent was calculated by summing up the number of question under each criteria correctly answered by an individual respondents.

Based on the total score, knowledge index was calculated using the below formula

$$\text{Knowledge Index} = \frac{\text{Actual score}}{\text{Maximum score}} \times 100$$

Further, the respondents were grouped into three categories namely, 'low', 'medium' and 'high' level of knowledge using mean and standard deviation as a measure of check and are expressed as below. For each category, the criteria and values selected were (<- s) and < 36.40 for low, (\pm s) and 36.41 to 47.00 for medium and (>+ s) and > 47.00 for high.

RESULTS AND DISCUSSION

Karnataka being one of the major production centre of maize but is also home to several new pest reported especially armyworms (Sharanabasappa et al., 2018; Kalleshwaraswamy et al., 2023). Understanding the status of knowledge of farmers is crucial for intervention at various level for successful management of armyworms.

Overall knowledge level of farmers was varied among the two districts surveyed. Majority of the farmers in Davanagere district had medium level of knowledge (57.50 %) followed by high (23.75 %) and low (18.75 %) knowledge level on FAW. Whereas in Shivamogga district, nearly half of the farmers had medium knowledge (43.75 %) and nearly equal number of respondents had high (28.75 %) and low (27.50 %) knowledge about FAW. When it comes to overall knowledge level of the farmers about FAW in Maize, nearly half of the farmers had medium (44.33 %) level of knowledge and one third of the farmers (33.75 %) had high level of knowledge. However, low level of knowledge was observed in 21.82 per cent of the farmers. This might be due to fact that accessibility of source of information and present

information technology, education level of the farmers, extension participation and continuous cultivation of crop for longer period might have helped them to have medium to high level of knowledge on identification of FAW.

Table 1: Knowledge Index of farmers about fall armyworm in maize (n=160)

Sr. No.	Knowledge on different facets of FAW	Knowledge index (%)
1	Identification and biology of FAW	49.37
2	Feeding habit of FAW	46.87
3	Damaging symptoms of FAW	48.48
4	Infestation of FAW at different stages of crop growth	47.50
5	FAW activity in different seasons and time	81.09
6	Factors responsible for FAW incidence	39.58
7	Management of Fall Armyworm	24.08
8	Impact of FAW	42.70

The knowledge index of maize growing farmers revealed that, majority of the respondents had knowledge on FAW activity in different seasons and time (81.09 %). Knowledge about the identification and biology of FAW was known to the extent of 49.37 per cent followed by Damaging symptoms of FAW (48.48 %). Nearly half the

respondents had knowledge on infestation of FAW at different stages of crop growth (47.50 %) followed by information on feeding habit of FAW (46.87 %) and impact of FAW on crop yield (42.70 %). Factors responsible for FAW incidence (39.58 %) and management of Fall Armyworm (24.08 %) was known to a smaller number of people (Table 1) is one the important constraint identified.

Most farmers (89.37 %) had the knowledge on identifying the FAW and its larvae in maize (Table 2). More than half of the farmers were able to diagnose the FAW in whorls (61.25 %) and one third farmers had knowledge about identification of FAW at different stages (33.12 %). However, significantly few farmers had knowledge on life cycle (23.10 %) which is infact one of the major constraint identified from the study. It was astonishing to know that no one had knowledge about origin of FAW. This might be due to the fact that FAW causing damages in maize from last few seasons. It was identified that the mass media exposure and extension contact from the peers are very essential component to be incorporated in extension system to identify the pest. Due to lack of scientific knowledge sources, farmers could not able to know about life cycle of the pest (Patil and Gaikwad, 2021 and Canico *et al.* (2021). Farmers could able to identify the presence of wet fecal matter on leaves which helped them to differentiate FAW larvae from other lepidopteron pests.

Table 2. Knowledge of the farmers about different facets of Fall Armyworm in Maize (n=160)

Sr. No.	Practices	Frequency			
		Yes		No	
		f	%	f	%
I	Identification and Biology of FAW				
1	Origin of FAW	0	0	160	100.00
2	Identifying the FAW in Maize	143	89.37	17	10.63
3	Identification of FAW at different stages	53	33.12	107	66.88
4	Identification of FAW larvae in Maize	143	89.37	17	10.63
5	Life cycle of FAW	37	23.10	123	76.90
6	Finding of FAW in Maize whorl	98	61.25	62	38.75
II	Feeding habit of FAW				
1	Feeding on number of young plant leaves	128	80.00	32	20.00
2	Feeding on stem	46	28.75	114	71.25
3	Feeding on milky stage of grains	92	57.50	68	42.50
4	Feeding on matured cob	34	21.25	126	78.75
III	Damaging symptoms of FAW				
1	Causing whitish patches appearing as “scratches” on leaf surface	126	78.75	34	21.25
2	Ragged and elongated holes	106	66.25	54	33.75
3	Defoliation, skeletonization, on leaf and stem	76	47.50	84	52.50
4	Sickly appearance of leaves	37	23.12	123	76.88
5	Kills the growing point of the plant	99	61.12	61	38.88
6	Stunting, destruction of developing tassels and kernels	46	28.75	114	71.25
7	Damage on tassel and ears	53	33.12	107	66.88

IV Infestation of FAW at different stages of crop growth					
1	Emergence stage	60	40.00	100	60.00
2	1-3 rd leaf stage	113	70.62	47	29.38
3	7-10 th leaf stage	101	63.12	59	36.88
4	Tasselling stage	88	55.00	72	45.00
5	Silking stage	89	55.62	71	44.38
6	Physiological Maturity stage	5	3.12	155	96.87
V FAW activity in different seasons and time					
1	FAW was most active at early in the morning or evening	136	85.00	24	15.00
2	FAW infestation was more in late July or early August	144	90.00	16	10.00
3	Larval stage was actual damaging stage	141	88.12	19	11.88
4	FAW intensity was more in summer compared to <i>kharif</i> season	98	61.25	62	38.75
VI Factors responsible for FAW incidence					
1	Continuous mono cropping	147	91.85	13	8.15
2	Intercropping in Maize	24	15.00	136	85.00
3	Burying of dry matter in a field	19	11.87	141	88.12
VII Management of Fall Armyworm					
1	Integrated Pest Management Practices	3	1.87	157	98.13
2	Cultural method				
a	Deep ploughing before onset of monsoon	122	76.25	28	17.50
b	Application of suffocating materials such as wood ash, dry soil/sand in plant whorl	45	28.12	115	71.87

Considering the feeding habit of FAW majority of the respondents had knowledge about feeding on young leaves (80.00 %) followed by feeding on milky stage of grains (57.50 %). This might be due to the fact that farmers used to have a close monitoring of the crop at early stage till it attains the economic yield and visible symptoms on leaves surface and also exposure to mass medias like TV, newspaper and print media helped them to have a knowledge on feeding habit. In Africa, it has been demonstrated that the farmers had a higher knowledge of identifying the damage symptoms probably due to extension functionaries (Abro *et al.* 2021). It appears that large media coverage given to this invasive pest is the reason for this. The farmers had regular extension contact which helped them to take up effective management practices. Majority of the farmers had knowledge on symptoms like occurrence of whitish patches appearing as “scratches” on leaf surface (78.75 %) followed by 66.25 per cent of farmer had knowledge on ragged and elongated holes and 61.12 per cent of the farmers had knowledge about larvae feeds on the growing point of the plant. Less than half of the farmers had knowledge on defoliation and skeletonization on leaf and stem (47.50 %) and 33.12 per cent of farmers had knowledge about damage on tassel and ears. Whereas, 28.75 per cent of farmers had knowledge about stunting, destruction of developing tassels and kernels followed by leaves leading

to sickly appearance (23.12 %). Symptoms were prominently visible for the farmers due to exposure to different media of information like mass media, extension contact, literatures and personal exposures to same situation had given them a experience to have more knowledge on all the symptoms like it was reported in Africa (Houngbo *et al.* (2020).

Knowledge status of FAW infestation at different stages of plant growth indicate that nearly three fourth of farmers had knowledge about FAW attack in 1 to 3rd leaf stage (70.62 %) followed by more than half of the farmers had knowledge about infestation of FAW at 7 to 10th leaf stage (63.12 %). Nearly equal number of farmers had knowledge about infestation at tasselling (55.00 %) and Silking stage (55.62 %). Only five farmers (3.12 %) had knowledge about FAW attack at physiological maturity stages. Severity of FAW attack could be observed at the early stages FAW feeds voraciously on leaves resulted in stunted growth of plant and leafless appearance made easy to identify. Studies indicated that the farmers were more concerned about the establishment of the crop during early stage of crop growth.

Result pertaining to FAW activity in different seasons and time shows that large majority of the farmers had knowledge about, FAW infestation was more in late July or

early August (90.00 %) followed by 88.12 per cent of farmers had knowledge about larval stage was actual damaging stage. About 61.25 per cent of farmers opined that FAW incidence was intense during summer season compared to *kharif* season. Farmers were visiting their fields more often during morning and evening time. They used to follow scouting and monitoring of field, this made them to observe the larvae during that time as FAW was more active in morning and evening hours that helped to diagnose the FAW incidence.

When we look at the knowledge status on factors responsible for FAW infestation, most of the farmers had knowledge that continuous mono-cropping leads to more infestation of FAW (91.85 %). Whereas, 15.00 per cent of farmers had knowledge about intercropping in Maize which reduce the infestation and by burying dry matter in field will increase FAW infestation in Maize was known to 11.87 per cent of respondents. This might be due to the fact that mono cropping leads to continuous spatial availability of host plant for the pest as farmers were experiencing it from last few

seasons for the same crop.

Knowledge on management is crucial for both sustainability and livelihood. Negligible numbers of farmers had knowledge about integrated pest management practices (3.00 %) which is the one area which needs to be looked into by policy makers and scientists. Three fourth of farmers had knowledge on deep ploughing before onset of monsoon (76.25 %) followed by optimum spacing (58.75 %) and proper fertilizer application (30.00 %). Equal number of farmers had knowledge on early sowing (29.37 %) and application of suffocating materials such as wood ash, dry soil/sand in plant whorl (28.12 %). Only a few farmers were practiced spreading of neem cake @ 208.00 kg ha⁻¹(5.65 %). Maize is a traditional crop to these farmers, but the data indicates there was lack of knowledge on integrated pest management that could be due to its recent introduction. Hence there is a need of extension education through various media that could improve the knowledge status of the farmers.

Table 3. Knowledge of the farmers about different facets of Fall Armyworm in Maize

(n=160)

Sr. No.	Practices	Frequency			
		Yes		No	
		f	%	f	%
1	Early sowing	46	29.37	114	28.75
2	Proper nutrient management	48	30.00	112	70.00
3	Optimum spacing	94	58.75	66	41.25
4	Spreading of neem cake @ 208 kg acre ⁻¹ before sowing	9	5.65	151	94.37
B	Mechanical method				
1	Use of Pheromone traps (15traps acre ⁻¹)	2	1.25	158	98.75
2	Hand picking of larvae and squashing of egg	48	30.00	112	70.00
3	Growing of trap crop	0	0	160	100.00
4	Install of bird perches lead to larval control	0	0	160	100.00
C	Chemical method				
1	Emamectin benzoate 5 SG @ 125 g acre ⁻¹	140	87.50	20	12.50
2	Spinetoram 11.7 % SC @ 100 ml acre ⁻¹ interval.	38	23.75	122	76.25
3	Spinosad 45 % SC @ 100 ml acre ⁻¹	17	10.62	143	89.37
4	Chlontraniliprole 18.50 % SC 60 ml acre ⁻¹	21	13.12	139	86.87
D	Bio control agents	3	1.87	157	98.13
E	Scouting and monitoring	19	11.87	141	88.13
F	Impact of FAW				
1	Yield loss	160	100.00	0	0.00
2	Quality deterioration	46	28.75	114	71.25
3	Changes in grain Colour	66	41.25	94	6.00
4	Reduced shelf life	62	38.75	98	2.00
5	Could not use as seed material	8	5.00	152	95.00

Only fewer farmers had knowledge on mechanical means of controlling FAW such as hand picking of larvae

and squashing eggs (30.00 %) and only two farmers had knowledge on use of pheromone traps (1.25 %). None of them had knowledge on growing trap crop in maize in general and install bird parches to control pests in maize field. The studies ascertain that there is a need for technological intervention and also possible utilization of these techniques in FAW managemme

Although insecticidal spray is recommended as last resort for any insecticide management, it appears that this is the primary and extensively used method in pest management. Same is the case in FAW management in maize. Majority of farmers had knowledge on use of emamectin benzoate 5 SG @ 125 g acre⁻¹ (87.50 %) followed by use of spinetoram 11.70 per cent SC @ 100 ml acre⁻¹ (23.75 %). Whereas, 13.12 per cent of farmers had knowledge on use of chlontraniliprole 18.50 per cent SC 60 ml acre⁻¹ and only 10.62 per cent of farmers had knowledge about use of spinosod 45.00 per cent SC @ 100 ml acre⁻¹. From that study it appears that the small and marginal farmers purchase emamectin benzoate which costing low compared to all other chemicals as reported previously (Houngbo *et al.*, 2020; Kansiiime *et al.* 2019 and Yigezu and Wakgari, 2020). Only 1.87 per cent of the farmers had knowledge on bio control agents which needs to be improved and also bio control agents should be made available for the farmers. The majority of the farmers informed that they have very limited knowledge of other control strategies or any ready to use products available for efficient management (Bellagi *et al.* 2022).

But it is astonishing to note that cent per cent of farmers had knowledge on yield loss followed by 41.25 per cent of farmers had knowledge about the colour change in grains after FAW infestation (Table 2). Whereas, nearly one third of farmers had knowledge on reduced shelf life (38.75 %) followed by deterioration in quality (28.75 %). Only eight farmers had knowledge about the grain should not be used as seed material. However, the relationship between actual incidence and yield loss was appreciated by only 5.00 per cent of farmers. Quality deterioration was experienced due to larval damage on tender cobs but its relationship with the storage and marketing has not been understood (Swami *et al.* 2024).

As of now in India, many relevant and ecofriendly Integrated Pest management methods have been tested and suggested by the institutes and universities for the management of fall armyworm. These includes deep ploughing, eggs mass squashing, entomopathogenic fungus such as *Metarrhium anisopliae* and *Beauveria bassiana*, entomopathogenic nematodes (EPNs) such as *Steinernema carpocapsae* and *Heterorhabditis indica* and use of insecticides (Sharanabasappa *et al.*2021; Prasanna *et al.*

2018b; Ratnakala *et al.*2023; Kalleshwaraswamy *et al.*, 2023).

Farmers can search for the eggs and identify them through visual monitoring with adequate training, so as to prevent the caterpillars from damaging the crops. Synchronous planting needs to be followed to avoid population build up with staggered planting dates. During kharif season where the activity of the pest is known to be high, Information on sowing should be spread among the farmers to take sowing. This requires coordinated efforts from policy makers, line departments and extension agencies for making seeds and fertilizers available so that farmers can take up sowing as soon as the monsoon season starts. Any constraint or non-availability of materials during this period will only increase the damage which the farmers has to bear on insecticides cost with no other options left with once the field incidence becomes very high. Delivery of EPN or insecticides through sand or soil applied to whorl found promising than spray reducing insecticide usage and effect of natural enemies could be lower (Divya *et al.* 2022; Kalleshwaraswamy *et al.*, 2022; Meghana *et al.*, 2023).

Association between personal, psychological, communication and economic characteristics with knowledge of farmers about Fall Armyworm

Table 4. Association between personal, psychological, communication and economic characteristics with knowledge of farmers about Fall Armyworm

Sr. No.	Characteristics	P value
X ₁	Age X	31.25 *
X ₂	Education	24.43 **
X ₃	Family size	3.35 NS
X ₄	Farming experience	19.39 **
X ₅	Cropping pattern	4.08 NS
X ₆	Land holding	6.09 NS
X ₇	Extension participation	22.11 **
X ₈	Market orientation	1.55 NS
X ₉	Risk orientation	15.28 **
X ₁₀	Innovativeness	23.40 **
X ₁₁	Informal sources	20.09 **
X ₁₂	Formal sources	14.79 *
X ₁₃	Mass media	4.23 NS
X ₁₄	Overall sources of information	16.12 *
X ₁₅	Source of capital	2.38 NS

* Significant at 0.05 per cent level of probability

** Significant at 0.01 per cent level of probability

NS non-significant

It was observed from Table 5 that, the personal

characteristics of the respondents such as age, education, farming experience were found to be significantly associated with knowledge level of the farmers and family size, cropping pattern and land holding were non-significantly associated with knowledge level. When we had looked over psychological characteristics of the farmers, it was observed that extension participation, innovativeness and risk orientation was found to be significantly associated at 1.00 per cent level of significance. In case of market orientation association was non-significant. Communication characteristics like source of information was significantly associated with level of knowledge and informal source of information was highly significantly associated with knowledge level whereas, formal sources were significantly associated with knowledge level followed by mass media and Source of capital had non-significant association with knowledge level of farmers about FAW. Majority of the farmers they don't trust mass media because absence of face-to-face contact and most of farmers sell their produce in village. They were not aware of different marketing strategies so they had non-significant association with knowledge level of the farmers. This finding is supported by the findings of Kalasariya et al. (2022), Gamit and Vinaya (2022).

CONCLUSION

The study concluded that the majority of the farmers had medium level of knowledge on various aspects of FAW in Maize. Characteristics of the farmers like extension participation, innovativeness and risk orientation, farming experience and access to informal sources of information had significantly associated at 1.00 per cent level of significance.

POLICY IMPLICATION

Extension efforts such as training, field visits by scientists, campaigns on management aspects of FAW should be taken up by the concerned authorities. There is a need to impart skill among the farmers through trainings on pheromone traps, trap cropping, mechanical control strategies and use of chemicals. There is a need of technological intervention for alternate techniques available for eco-friendly management. Use of Demonstrations and good quality publications like leaflets, folders, bulletins should be provided at gross root level. In addition to this State Agriculture Department should promote and start Farmers Field School (FFS) regarding FAW management in Maize.

CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

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