Evaluation on Integrated Method of Fall Army Worm Pest Management in Maize Hybrid in Namakkal Districtof Tamil Nadu

Abstract

Maize (*Zea mays L.*) on farm trials were conducted by Krishi Vigyan Kendra, Namakkal to assess the management modules against Fall Army Worm in maize crop in terms of incidence of fall army worm damage percentage, pheromone catches, natural enemies occurrence, crop growth, yield attributes, grain yield, stalk yield and net return per hectare during Kharif 2019 in Namakkal district. The treatments T6 followedis summer ploughing,seed treatment with Fortezaduo (Cyantraniliprole +Thiamethoxam) @ 4ml/kg, Border crop with grain sorghum as trap crop (advance sowing) and legume intercrop (cowpea) to promote natural enemies (few rows at interval), Collection and destruction of egg masses, installation of sex pheromone trap @ 10 numbers per hectare, Azadirachtin 10000 ppm @ 1 per cent spray at 10 to 15 days after sowing; spraying of Emmamectin Benzoate 5SG @0.4g/ litre on 24 days after sowing and *Metarhizium anisophilae*($1x10^7$) @ 2 ml/ litre on 35 days after sowing and farmers practice on application of pesticides four to five times in crop period revealed thatmaize hybrid (NK 6240) recorded highest plant height of (105.7 and 194 cm) on 60 and 90 DAS, yield attributes *viz*., number of cobs per plant is 1.7; cob length is 14.4 cm; number of grain row/cob is 10.8; number of adult moth trapped in pheromone trap (1.3 number), natural enemies occurrence 3.2 number per m^2, and found to be non significant in plant height and growth attributes of Maize followed by Treatment T4 and T5, whereas higher grain yield of 64.25 quintal ha^{-1} and Stalk yield of 94.8 tonnes ha^{-1}, and first incidence of fall army worm larvae 17 days after sowing, lesser damage of fall army worm percentage (7.2%), were found to be significant as compared to farmers practice (Table 2 & 3). The lesser plant height of 89 cm, 171.3 cm, number of cob/ plant 1.3, cob length 11.4 cm, number of grain row/ con is 8.5, and 100 grain weight is 19.1 gm and grain yield of 56.6 quintal ha^{-1}, stalk yield of 61.5 quintal ha^{-1} and net return of Rs. 10550 /hand first incidence of FAW days after sowing on 11 days, and damage percentage of 11.4 % was recorded under farmers practice (Table 2 & 3). Treatment T6 plot recorded higher net return of Rs.21,575/ ha, respectively by cultivating maize hybrid (NK 6240) as against the T 7 with Net return of Rs. 10, 550/- with higher damage of cob (Table 2), respectively by cultivating Maize hybrid (NK 6240). Farmers were very satisfied withMaize hybrid (NK 6240), as crop find fewer incidences of fall army worm and higher return compared to other practices. Maize hybrid

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(NK 6240) followed under T6 recommended practices would be a better option for management of Fall Army Worm in kharif season in Namakkal district of Tamil Nadu. The aim of this study was to determine the effect of cultural practices, insecticide applicationat different plant growth stages between seedling emergence and flowering on yield loss caused by FAW in maize.

Keywords: Maize, Damage severity, Fall Army Worm, Pest incidence,IPM practices, insecticide applications, Pest management, Grain stalk yield, Net return.

Introduction

In India, miaze(*Zea mays* L.2n = 2x = 20) is third important crop after rice and wheat that provides food, feed and fodder and serves as a source of basic raw material for the number of industrial products, *viz*., starch, oil, protein, alcoholic beverages, food, sweeteners, cosmetics, bio-fuels etc. Thus, Maize has attained an important position in industrial crop because 83 percent of its products are used in starch and feed industries.Maize is being cultivated in an area of 8.69 million ha in India with the production and productivity of 21.81 million tonnes and 2509 kgha^{-1}, respectively. Major maize growing states are Tamil Nadu 1.60 lakh hectare (3.96 lakh acres), Maharashtra 1.21 lakh hectare (2.99 lakh acres), Bihar 0.86 lakh hectare (2.13 lakh acres), Telangana 0.82 lakh hectare (2.03 lakh acres), Gujarat 0.50 lakh hectare (1.24 lakh acres) and West Bengal 0.31 lakh hectare. In Tamil Nadu, Perambalur district stands first in Maize and Cotton cultivation in Tamil Nadu. Being a rainfed district, Perambalur district produces in an average of 4.0 lakh metric tons of food grains per year.

The fall army worm (FAW), *Spodoptera frugiperda*, an invasive pest has become a threat to farmers and Indian Agriculture and first detected on the Indian subcontinent in May 2018 in Maize fields at the College of Agriculture,Shivamogga, Karnataka (6). Maize is the main staple food for more than 500 million people in SSA. It is mainly cultivated by small-scale farmers using low input production systems (2). Most farming systems in SSA are prone to major crop production constraints including biotic stressors (diseases and insect pests), abiotic stressors (drought stress and low soil fertility) and various socio-economic constraints such as inadequate extension services and poor access to credit opportunities. To overcome these constraints, the study was taken for assessing of fall army worm management in Maize crop. The fall armyworm (FAW) (*Spodoptera frugiperda*J.E.Smith (Lepidoptera: Noctuidae)) is a relatively new, polyphagous pest infest maize during all plant growth stages, with infestation during vegetative stages leading to serious leaf-feeding injury, while late

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infestation leads to ear damage **(4)**. Insecticide application has been the main method of FAW control in South America **(1).** The combination of FAW together with existing production constraints have threatened the stability and sustainability of food systems, livelihoods, ecosystems biodiversity, local, regional, and global trade in Sub-Saharan Africa (SSA) since its arrival in 2016, (3).

Materials and methods

The field trials were conducted in different farmers' fieldin an area of 0.6 ha atThattaiyengarpatty village, Pudhuchattiram block, Namakkal District during Kharif season 2019 - 20. Thattaiyengarpatty village is situated at 11.380 N latitude and 78.160 E longitude wit mean sea level of 142 MSL. The annual rainfall of Pudhuchattiram block was 509.3 mm with 57 rainy days. Of which, experimental season was September 2019 to December 2019, received average rainfall of 363.6 mm with 31 rainy days. Maximum monthly mean temperature was 31.6^{o}C and minimum was 21.8^{o}C. The experimental soil type was black in colour, sandy clay loam and sandy loam in texture and calcareous to non calcareous. The soil was neutral in soil reaction (7.84), non saline (0.052dS m^{-1}), low in organic carbon (0.52%), low in available nitrogen (212 kg ha^{-1}), medium in available phosphorus (16.42 kg ha^{-1}), and medium in available potassium (144 kg ha^{-1}). The plot size was 5 m x 4 m with plant spacing of 60 cm x 25 cm. sowingof maize hybrid was carried out under irrigated condition; Bore well and well is the main source of irrigation. Forty five percentage of the farmers used drip irrigation whereas 55 % of the farmers followed flood irrigation to irrigate maize crop.The germination percentage of seed was more than 94 per cent and required plant population was maintained with gap filling done within one week after sowing. Farm yard manure @ 12.5 ton ha^{-1} was applied to all the treatments. A fertilizer schedule of 135:62.5:50 kg of NPK ha^{-1} is recommended constant for all the treatments and apply quarter dose of N, full dose of P_2O_5 and K_2O as basally before sowing and remaining N top dressing after 20th and 45 days after sowing (DAS). Application of the pre-emergence herbicide, Atrazine 50WP @ 500 g ha^{-1} at 3days after sowing as spray on the soil surface followed by one hand weeding on 42 days after sowing. Treatment plot plant protection measures *viz.*, T1, Summer ploughing; Seed treatment with *Beauveria bassiana* @ 4 ml/ kg; *S. frugiperda pheromone traps* @ 10 no./ha.,;Azardiractin10000 ppm spray @ 2ml/ litre on 15 DAS, Second spray of Bt @ 2g/litre on 30 DAS and Mettarhiziumanisophilae spray ($1x10^{7}$) @ 2 ml/ litre on

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45DAS.T2, Summer ploughing; *S. frugiperda pheromone traps* @ 10 no./ha.; Azardiractin 10000 ppm @ 2ml/ litre on 15 DAS andMettarhiziumanisophilae spray ($1x10^7$) @ 2 ml/ litre on 30 DAS; T3, Summer ploughing; Border crop with grain sorghum + intercrop with cowpea (few rows); Azardiractin 10000 ppm @ 2ml/ litre on 15 DAS; Insecticide spray of Emmamectin benzoate 5SG @0.4g/ litre on 30 DAS and Mettarhiziumanisophilae spray ($1x10^7$) @ 2 ml/ litre on 45 DAS; T4, Spraying of insecticide – after noticing the FAW incidence farmers practice of spraying Emmamectin Benzoate 5SG @ 0.6 g/ litre on 15 DAS; Spinosad 480 SC @ 0.6 ml/ litre on 30 DAS; Chlorantraniliprole @ 1ml/ litre and Delicate @ 2 ml / litre on 45 DAS; T5, Summer ploughing; Seed treatment with Fortenza duo (Cyantraniliprole + Thiamethoxam) @ 4 ml/ kg; Emmamectin Benzoate 5SG @ 0.6 g/ litre on 15 DAS; Spinosad 480 SC @ 0.6 ml/ litre on 30 DAS and Chlorantraniliprole @ 1ml/ litre on 45 DAS; T6, Summer ploughing, Seed treatment with Fortenza duo (Cyantraniliprole + Thiamethoxam) @ 4 ml/ kg; Collection and destruction of egg masses; *S. frugiperda pheromone traps* @ 10 no./ha.; Border crop with grain sorghum as a trap crop (advance sowing) + intercrop with cowpea (few rows) to promote natural enemies; Azardiractin10000 ppm @ 2ml/ litre on 15 DAS; First insecticide sprays -Emmamectin benzoate 5SG @ 0.4g/litre on 25 DAS; Mettarhiziumanisophilae spray ($1x10^7$) @ 2 ml/ litre on 35 DAS; Second insecticide spray -Chlorantraniliprole 18.5 SC @ 0.3 ml/ litre on 45 DAS; and T7, Summer ploughing; Blue bendamide @ 1.5 ml/ litre on 20 DAS; Lambda cyclothrine @ 3 ml / litre on 40 DAS (Table 1).Spraying of insecticide was done by using Battery operated hand sprayer on the growth of terminal shots of every plant. Sex pheromone trap was placed randomly in different places of maize field with *Spodoptera frugiperda* lure placed above the plant height on 5 DAS and lure replaced on 60 DAS.The data on first incidence of Fall Army Worm larvae (Days after sowing), damage percentage, number of adult moth captured in pheromone trap, Natural enemies occurrence, growth attributes, yield attributes, Plot were harvested to calculate the yield of Grain and stalk yield and expressed in quintal per hectare, Gross return in Rs./ ha; Net return Rs./ ha and Benefit Cost ratio were recorded.

Results and Discussions

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The discussion should not repeat the results, but provide detailed interpretation of data

The field trials revealed that maize hybrid (NK 6240)in the treatment (T6)Summer ploughing, Seed treatment with Fortenza duo (Cyantraniliprole + Thiamethoxam) @ 4 ml/ kg; Collection and destruction of egg masses; *S. frugiperda pheromone traps* @ 10 no./ha.; Border crop with grain sorghum as a trap crop (advance sowing) + intercrop with cowpea (few rows) to promote natural enemies; Azardiractin- 10000 ppm @ 2ml/ litre on 15 DAS; First insecticide sprays -Emmamectin benzoate 5SG @ 0.4g/litre on 25 DAS; Mettarhiziumanisophilae spray ($1x10^7$) @ 2 ml/ litre on 35 DAS; Second insecticide spray - Chlorantriliniprole 18.5 SC @ 0.3 ml/ lit. on 45 DASrecorded highest plant height of (105.7 and 194 cm) on60 and 90 DAS, yield attributes *viz*., number of cobs per plant is 1.7; cob length is 14.4 cm; number of grain row/cob is 10.8; number of adult moth trapped in pheromone trap (1.3 number), natural enemies occurrence 3.2 number per m^2, and found to be non significant in plant height and growth attributes of Maize followed by Treatment T4 and T5, whereas higher grain yield of 64.25 quintal ha^{-1} and Stalk yield of 94.8 tonnes ha^{-1}, and first incidence of fall army worm larvae 17 days after sowing, lesser damage of fall army worm percentage (7.2%), were found to be significant as compared to farmers practice (Table 2 & 3). The lesser plant height of 89 cm, 171.3 cm, number of cob/ plant 1.3, cob length 11.4 cm, number of grain row/ con is 8.5, and 100 grain weight is 19.1 gm and grain yield of 56.6 quintal ha^{-1}, stalk yield of 61.5 quintal ha^{-1} and net return of Rs. 10550 /hand first incidence of FAW days after sowing on 11 days, and damage percentage of 11.4 % was recorded under farmers practice (Table 2 & 3). Treatment T6 plot recorded higher net return of Rs.21,575/ ha, respectively by cultivating maize hybrid (NK 6240) as against to farmers practice Rs. 10, 550/- with higher damage of cob (Table 2). Farmers were very satisfied withMaize hybrid (NK 6240), as crop find fewer incidences of fall army worm, increase in grain and stalk yield and higher return compared to farmers' practices might be due to increase in growth and yield attribute of maize due to integration of organic and inorganic fertilizer application, integrated pest and disease management practices. The result of the present study is in comparable with those of investigation (5). The marketing rate of selling maize grain during November –December was not much higher, though the farmers got less net return.

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The probable reason for lesser incidence of Fall Army Worm in maize on treatment T6 was due to seed treatment with Fortenza duo, followed by raising border crop with grain sorghum and cow pea inter crop, installation of *Spodoptera frugiperda* trap, need based application of pesticide, neem oil, bio–pesticide in time effectively controlled the pest and resulted in higher seed weight, grain yield influenced by genotype, environmental and management factor (6). The impact on FAW on farmers' income is compounded by the high

cost of essential agricultural inputs, fertilizers, pesticides and its application expenses which reflected in less net return and benefit cost ratio.

Conclusion

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Reference

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1. All, J. N.; Javid, A and Guillebeau, P. Control of fall armyworm with insecticide in North Georgia Sweet corn. Fla. Entomol. 1986, 69, 598 -602. (CrossRef)
2. Diiro, G.M.; Seymour, G.; Kassie, M.; Muricho, G. and Murithi, B.W. 2018. Women's empowerment in agriculture and productivity: Evidence from rural maize farmer households in western Kenya. PLoS ONE 2018, 13, e0197995. [Cross Ref].
3. FAO. Integrated Management of the Fall Army Worm on Maize: A Guide for Farmer Field Schools in Africa. Food and Agriculture Organization of United Nations. 2018. Available online: http://www.fao.org/publications/card/en/c/I8665EN/ (accessed on 23 January 2019).
4. Harrison, F.P. The development of an economic injury level for low populations off all armyworm (Leepidoptera: Noctuidae) in grain corn. *Fla. Entomol*. 1986, 67, 335-339. (CrossRef)
5. Kumar Rakesh, Kumavat Narendra, Kumar Sudhir, Singh Amitesh kumar and Bohra J.S. (2017). Effect of NPK and Zn fertilization on growth and yield quality of Baby Corn- A Review. *International Journal of Current Microbiology and Applied Sciences* 6(3):1422-1428.
6. Mooventhan, P.; Murali Baskaran, R. K.; Sridhar, J.; Pankaj Kaushal and Jagdish Kumar. 2019. Integrated management of Fall Army Worm in Maize. ICAR- National Institute of Biotic Stress management. Technical bulletin, 2019, 1-24.

Table 1. Packages and practices followed for control of Fall Army Worm in Maize crop

T 1	➢ Summer ploughing ➢ Seed treatment with *Beauveria bassiana*@ 4 g/ kg. ➢ *S. frugiperda pheromone traps* @ 10 no./ha., ➢ Azardiractin10000 ppm spray @ 2ml/ litre on 15 DAS, ➢ Second spray of Bt @2g/litre on 30DAS, ➢ Mettarhiziumanisophilae spray ($1x10^7$) @2 ml/ litre on45DAS.
T 2	➢ Summer ploughing ➢ *S. frugiperda pheromone traps* @ 4 no./ acre. ➢ Azardiractin10000 ppm @ 2ml/ litreon 15 DAS, ➢ *Mettarhiziumanisophilae* spray ($1x10^7$) @2 ml/ litre on 30 DAS,
T 3	➢ Summer ploughing ➢ Border crop with grain sorghum+ intercrop with cowpea (few rows). ➢ Azardiractin10000 ppm @ 2ml/ litre on 15 DAS, ➢ First Insecticide spray of Emmamectin benzoate5SG @0.4g/ litre on 30 DAS, ➢ *Mettarhiziumanisophilae* spray ($1x10^7$) @2 ml/ litreon 45 DAS.
T 4	Spraying of insecticide – after noticing the FAW incidence ➢ Emmamectin Benzoate 5SG @ 0.6 g/ litre on 15 DAS, ➢ Spinosad 480 SC @ 0.6 ml/ litre on 30 DAS, ➢ Chlorantraniliprole @ 1ml/ litre and Delicate @ 2 ml / litre on 45 DAS,
T 5	➢ Summer ploughing, ➢ Seed treatment with Fortenza duo (Cyantraniliprole + Thiamethoxam) @ 4 ml/ kg, ➢ Emmamectin Benzoate 5SG @ 0.6 g/ litre on 15 DAS, ➢ Spinosad 480 SC @ 0.6 ml/ litre on 30DAS, ➢ Chlorantraniliprole @ 1ml/ litreon 45DAS.
T 6	➢ Summer ploughing ➢ Seed treatment with Fortenza duo (Cyantraniliprole + Thiamethoxam) @ 4 ml/ kg. ➢ Collection and destruction of egg masses, ➢ *S. frugiperda pheromone traps* @ 10 no./ha.,

	➢ Border crop with grain sorghum+ intercrop with cowpea (few rows), Azardiractin10000 ppm @ 2ml/ litre on 15 DAS, ➢ First insecticide sprays -Emmamectin benzoate 5SG @0.4g/ litre on 25 DAS, ➢ *Mettarhiziumanisophilae* spray ($1x10^7$) @2 ml/ litre on 35 DAS, ➢ Second insecticide sprays -Chlorantraniliprole 18.5 SC @0.3 ml/ litreon 48 DAS.
T 7	➢ Summer ploughing ➢ Blue bendamide@ 1.5 ml/ litre on 20 DAS, ➢ Lamdacyclothrine @ 3 ml / litre on 40 DAS.

Table2 Effect of IPM on Fall Army Worm incidenceand management on growth and yield of Maize crop

Treatments	Plant height on 60 DAS (cm)	Plant height on. 90 DAS (cm)	No. of cob/plant. (No.)	Cob length (cm)	No. of grain row/ cob (No.)	100 grain weight (g.)	Grain yield (Q./ha).	Stalk yield (Q/.ha.)	Net return (Rs.)
T1	93.0	180.3	1.3	12.5	8.7	19.5	58.5	75.5	17117
T2	91.0	179.7	1.3	12.3	8.6	19.3	57.5	72.5	16975
T3	98.7	184.0	1.3	12.9	8.9	20.3	58.7	82.0	19403
T4	101.0	188.0	1.7	13.4	10.5	21.5	59.0	86.0	21492
T5	99.7	187.7	1.7	13.2	9.9	20.5	58.9	82.5	20583
T6	105.7	194.0	1.7	14.4	10.8	21.7	65.4	94.8	21575
T7	89.0	171.3	1.3	11.4	8.5	19.1	56.6	61.5	10550
Total	678.0	1285.0	10.3	90.1	65.8	141.9	414.6	554.8	127695
Mean	96.9	183.6	1.5	12.9	9.4	20.3	59.2	79.3	18242
S Ed	5.92	5.99	0.50	0.99	0.84	1.39	2.1	5.8	1183
C.D.	12.91	13.06	1.59	2.17	1.82	3.03	4.5	12.7	2578
F test	NS	NS	NS	NS	NS	NS	*	*	*

Table3 Effect of IPM on Fall Army Worm incidence and its management in Maize crop

Treatments	First incidence of FAW days after sowing (No.)	Damage percentage (%)	Natural Enemies occurrence (no/ sq.m)	No. of adult moth trapped
T1	14	9.97	2.8	1.4
T2	13	10.9	2.7	2.3
T3	14	9.50	3.0	-
T4	15	8.80	3.0	-
T5	15	9.20	3.0	-
T6	17	7.20	3.2	1.3
T7	11	11.4	2.6	-
Total	99	66.97	20.4	-
Mean	14	9.57	2.9	-
S Ed	1	0.77	0.3	-
C.D.	2	1.67	0.6	-
F test	*	*	NS	-