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Evaluation of Novel Insecticides Alone and in Combination with Fungicides against Maize Fall Armyworm *Spodoptera frugiperda* (J.E. Smith)

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ABSTRACT: A field experiment was carried out at College farm, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad to study the efficacy of new generation insecticides and fungicides alone and in combination against maize fall armyworm *Spodoptera frugiperda* (J.E. Smith). Fourteen treatments were found significantly superior over control in reducing the infestation of fall armyworm, among all the treatments chlorantraniliprole 18.5% SC was most effective, recorded highest mean percent reduction (80.60%)of fall armyworm population over control followed by a combination of Chlorantraniliprole 18.5% SC+ (Azoxystrobin 18.2% +Difenoconazole 11.4% SC) (76.87%). The mean percent incidence of fall armyworm was less in Chlorantraniliprole 18.5% SC (8.04) followed by combination product Lambda Cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC (9.19) which indicates their efficacy. (Carbendazim 12% + Mancozeb 63% WP) recorded 49.77 highest percent incidence indicating least effective against fall army worm.

Keywords: Novel Insecticides, Fungicides, Fall armyworm, *Spodoptera frugiperda* (J.E. Smith) and Compatibility.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile crop having highest adaptability under varied agro-climatic conditions. Globally maize is known as queen of cereals because of its highest genetic yield potential among the cereals. It is cultivated on nearly 190 m ha in about 165 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 39% in the global grain production.

The world's total maize production was estimated at 1.05 million thousand tonnes in 2020. The United States of America is the largest producer of maize contributes nearly 36 per cent of the total production in the world. India produces 28.64 million tones of maize per year and stands seventh in position in maize production (DACNET, 2020).

In India maize is grown throughout the year, predominantly *kharif* crop with 85 per cent of the area under cultivation in the season. Maize is the third most important cereal crop in India after rice and wheat. It accounts for around 10 per cent of total food grain production in the country. In addition to staple food for human beings and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries. Maize is the second major cultivated crop in Telangana state with 2 million acres producing annually 2.9 million tonnes (Vyavasaya Panchangam, PJTSAU, 2019).

There are four major pests of maize prevalent in India *viz.,* spotted stem borer *Chilopartellus (Schinobi)*, pink stem borer *Sesamiainferens* (Walker), shoot fly *Atherigona* spp. and fall armyworm *S. frugiperda* (J.E. Smith). Among all the pests fall armyworm is causing serious damage to maize at all stages of its growth. In addition to the pests some of the diseases like charcoal rot, common rust, turcicum leaf blight occur simultaneously on maize. So, in order to reduce both pest and disease incidence farmers go for combination spray of both insecticide and fungicide which eventually leads to development of phytotoxicity, reduces the efficacy of one or the other pesticide. Therefore, there is a need to study the compatibility of insecticides and fungicides on maize.

The combinations may be physically incompatible, effect the bio efficacy, result in phytotoxic effects or aid in insecticide resistance development in pests (Peshney, 1990; Miller *et al.,* 2010). Injudicious use of pesticides in combinations without proper knowledge may reduce

the efficacy of the combinations in managing the pests and diseases (Kubendran *et al.,* 2009).

The occurrence of *S. frugiperda* was first reported from Karnataka in 2018. It is a polyphagous pest can feed on more than 80 species of crops including maize, sorghum, cotton, rice, millets, vegetable crops *etc*. (CABI, 2017). Damage is mostly done by mid to late larval instars. Young larvae feed on leaves leaving silvery transparent membrane, larvae feeding inside the whorls will make holes and faecal matter is seen inside the whorls, even silk, tassel and cobs are fed by the larvae. Yield reductions in maize due to feeding of fall armyworm have been reported as high as 34 per cent (Williams and Davis 1990).

MATERIAL AND METHODS

Experimentation on efficacy of new insecticides alone and in combination with fungicides against *S. frugiperda* was carried out in field conditions during *rabi* 2020-2021 at College Farm, Rajendranagar, Hyderabad located at an altitude of 630 m above mean sea level at 17°19′15″N latitude and 78°24′33″E longitude. Maize (DHM 121) was grown in natural conditions in an open field by following all the recommended agronomic practices.

The study includes a total of fourteen treatments *viz*., insecticides, fungicides and combinations. Four insecticides Lambda cyhalothrin + Chlorantraniliprole 15% ZC, Chlorantraniliprole 18.5% SC, Flubendiamide 39.35% SC, Azadirachtin 1500 ppm, two fungicide combinations (Azoxystrobin 18.2% + Difenoconazole 11.4% SC) and (Carbendazim 12% + Mancozeb 63% WP) (Table 1). Each treatment imposed at recommended dosage of insecticide or fungicide and replicated thrice following spray fluid @ 500 litres ha^{-1} with the help of a knapsack sprayer. Spraying was done at 15 and 30 days after sowing and an untreated control plot is also maintained in each replication as acheck. The pre-treatment count of *S. frugiperda* was recorded one day before treatment imposed and the data on fall armyworm damage was recorded during 0, 3, 7, 14 days after spraying. The per cent fall armyworm infestation was calculated using the formula given by Sisay *et al*. (2019).

Table 1: Mean efficacy of two sprayings in different pesticide combinations against fall armyworm, *S. frugiperda* during *rabi* 2020-2021.

Treatments	Mean per cent reduction in fall armyworm population over control			Overall Mean
	3 DAS	7 DAS	14 DAS	
Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC	87.20 (69.16)	79.04 (62.79)	59.41 (50.43)	75.27 (60.71)
Chlorantraniliprole 18.5% SC	90.10 (71.85)	83.51 (66.01)	68.20 (55.68)	80.60 (64.43)
Flubendiamide 39.35% SC	80.51 (63.85)	74.47 (59.63)	59.48 (50.45)	71.48 (57.94)
Azadirachtin 1500 ppm	74.96 (59.97)	68.45 (55.85)	43.44 (41.21)	62.28 (52.32)
(Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC) + (Azoxystrobin 18.2% +Difenoconazole 11.4% SC)	83.47 (66.09)	76.04 (60.69)	51.33 (47.49)	70.28 (57.46)
Chlorantraniliprole 18.5% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	87.83 (69.74)	80.96 (64.18)	61.84 (51.84)	76.87 (61.82)
Flubendiamide 39.35% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	77.58 (61.73)	72.13 (58.12)	52.16 (46.22)	67.29 (55.35)
Azadirachtin 1500 ppm + (Azoxystrobin18.2% +Difenoconazole 11.4% SC)	67.87 (55.46)	64.82 (53.61)	44.35 (41.73)	59.01 (50.26)
(Lambda cyhalothrin 4.6%+ Chlorantraniliprole 9.3% ZC)+ (Carbendazim 12% +Mancozeb 63% WP)	77.59 (61.72)	73.67 (59.10)	55.31 (48.04)	68.85 (56.28)
Chlorantraniliprole 18.5% SC + (Carbendazim 12% + Mancozeb 63% WP)	85.86 (67.96)	76.86 (61.22)	64.57 (53.46)	75.76 (60.85)
Flubendiamide 39.35% SC + (Carbendazim 12%+ Mancozeb 63% WP)	73.24 (58.84)	65.60 (54.07)	41.19 (39.89)	60.01 (50.93)
Azadirachtin 1500 ppm + (Carbendazim 12% + Mancozeb 63% WP)	67.04 (54.94)	60.02 (50.76)	37.67 (37.84)	54.91 (47.84)
(Azoxystrobin 18.2% + Difenoconazole11.4% SC)	49.37 (44.62)	41.01 (39.72)	12.50 (20.66)	34.29 (35.04)
(Carbendazim 12% + Mancozeb 63% WP)	39.75 (39.04)	34.13 (35.68)	2.77 (9.53)	25.55 (28.12)
Untreated control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C.D.	3.59	3.04	3.39	5.91
SEM	1.23	1.04	1.16	2.03
F test	S	S	S	S
C.V%	3.79	3.48	5.09	7.14

Figures in parenthesis are angular transformed values; S = Significant DAS= Days After Spraying

$$\% \text{ FAW infestation} = \frac{\text{No. of FAW infested plants}}{\text{Total no. of plants observed}} \times 100$$

Mean per cent efficacy of pesticide combination over control of *S. inferens* was calculated by using the following formula

Mean per cent efficacy over control= C-T/C × 100

C = per cent incidence or severity in control

T = per cent incidence or severity in treatment

Per cent population reduction over control was calculated by using the following formula

$$\%\ population\ reduction\ = [1-[\frac{post\ treatment\ population\ in\ treatment}{pre\ treatment\ population\ in\ treatment}\times\frac{\text{Pre treatment population in control}]}{post\ treatment\ population\ in\ control}\times 100$$

The mean data recorded during the experiment was statistically analysed in RBD as per Gomez and Gomez (1984). Per cent incidence or infestation was subjected to square root transformation and per cent population reduction over control was subjected to angular transformation.

RESULTS AND DISCUSSION

The results of the present study r*abi* 2020-21are presented in Table 1 revealed that the mean percent incidence of *S. frugiperda* ranged from 8.04 (chlorantraniliprole 18.5% SC) to 79.62 (untreated Control). Among the different treatments Chlorantraniliprole 18.5% SC recorded less incidence of fall armyworm (8.04) with minimum damage recorded by fall army worm followed by (Lambdacyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC) (9.19), Chlorantraniliprole 18.5% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC) (9.71), (Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC)+(Azoxystrobin 18.2% +Difenoconazole 11.4% SC) (11.86), Flubendiamide 39.35% SC (12.01), Chlorantraniliprole 18.5% SC + (Carbendazim 12% + Mancozeb 63% WP) (12.43), Azadirachtin 1500ppm (14.86), Flubendiamide 39.35% SC+ (Azoxystrobin 18.2% + Difenoconazole11.4% SC) (15.93), (Lambdacyhalothrin 4.6% + Chlorantraniliprole 9.3%ZC) + (Carbendazim 12% + Mancozeb 63%WP) (17.00), Azadirachtin 1500 ppm + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC) (18.52), Flubendiamide 39.35% SC + (Carbendazim 12% + Mancozeb 63% WP) (20.52), Azadirachtin 1500 ppm + (Carbendazim 12% + Mancozeb 63% WP) (27.10), (Azoxystrobin 18.2% + Difenoconazole 11.4%SC) (40.80), (Carbendazim 12% + Mancozeb 63%WP) (49.77) in the increasing order of percent incidence.

The results presented in Table 2 revealed that Chlorantraniliprole 18.5% SC has recorded the highest population reduction of fall armyworm (80.60%) among all the treatments, followed by Chlorantraniliprole 18.5% SC + (Azoxystrobin18.2% + Difenoconazole 11.4% SC) (76.87%), Chlorantraniliprole 18.5% SC + (Carbendazim 12% + Mancozeb 63% WP) (75.76%), (Lambdacyhalothrin 4.6%+Chlorantraniliprole 9.3% ZC) (75.27%), Flubendiamide 39.35% SC(71.48), (Lambdacyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC) + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC) (70.28%), (Lambdacyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC) + (Carbendazim 12% + Mancozeb 63%WP) (68.85%), Flubendiamide 39.35% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4%SC) (67.29%), Azadirachtin 1500ppm (62.28%), Flubendiamide 39.35% + (Carbendazim 12% + Mancozeb 63%WP) (60.01%), Azadirachtin 1500ppm + (Azoxystrobin 18.2%+ Difenoconazole 11.4% SC) (59.01%), Azadirachtin 1500 ppm + (Carbendazim 12% + Mancozeb 63% WP) (54.91%), (Azoxystrobin 18.2% + Difenoconazole 11.4%SC) (34.29%), (Carbendazim 12% + Mancozeb 63% WP) (25.55%) in the decreasing order of percent population reduction.

The results revealed that the mean percent population reduction ranged from 80.60 (chlorantraniliprole 18.5% SC) to 25.55 (untreated control) which indicates that there was high reduction of fall armyworm population in chlorantraniliprole 18.5% SC (Table 1). Among all the treatments chlorantraniliprole 18.5% SC recorded less incidence of fall armyworm compared to remaining treatments (Table 2). The cumulative per cent incidence of fall armyworm ranged from 8.04 (chlorantraniliprole 18.5% SC) to 79.62 (untreated control).

Among all the treatments chlorantraniliprole 18.5% SC was highly effective due to the high insecticidal property, it acts on ryanodine receptors of insects which make the insect inactive and knock down the insect quickly due to which the damage on leaves was reduced, whereas (carbendazim 12% + mancozeb 63% WP) was least effective due to its fungicidal property.

The present results were in conformity with earlier reports of Hardke *et al.* (2011) reported that chlorantraniliprole 18.5% SC, flubendiamide 39.35% SC, novaluron provided an effective reduction in infestation of fall armyworm in sorghum. Recent results of Bhuvaneswari and Krishnam Raju (2013) reported that chlorantraniliprole @ 0.3 ml in combination with hexaconazole @ 2 ml l^1 recorded less incidence (8.3%), severity (12.8%) of sheath blight and also recorded less stem borer and leaf folder damaged leaves (1.9) per hill, concluding chlorantraniliprole 18.5% SC is very effective against lepidopteran caterpillars.

In the present study also, it is very effective against *S. frugiperda.* Results of Sharanabasappa Deshmukh *et al.,* (2020) revealed that chlorantraniliprole followed by emamectin benzoate, spinetoram, flubendiamide, indoxacarb, lambda cyhalothrin and novaluron were highly effective in the decreasing order of efficacy.

Table 2: Mean per cent incidence of two sprayings in different treatments against fall armyworm, *S. frugiperda*on maize during *rabi* 2020-2021.

Treatments	Mean per cent reduction in fall armyworm population over control			Overall Mean
	3 DAS	7 DAS	14 DAS	
(Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC)	4.99 (2.44)	7.60 (2.92)	14.99 (3.96)	9.19 (3.12)
Chlorantraniliprole 18.5% SC	3.32 (2.07)	6.38 (2.71)	14.44 (3.92)	8.04 (2.90)
Flubendiamide 39.35% SC	6.66 (2.75)	7.99 (2.99)	21.38 (4.72)	12.01 (3.49)
Azadirachtin 1500 ppm	7.21 (2.85)	9.38 (3.21)	27.99 (5.38)	14.86 (3.82)
(Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC) + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	8.33 (3.05)	10.38 (3.35)	16.88 (4.22)	11.86 (3.55)
Chlorantraniliprole 18.5% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	6.38 (2.71)	7.22 (2.86)	15.55 (4.06)	9.71 (3.21)
Flubendiamide 39.35% SC + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	6.55 (2.69)	10.27 (3.34)	30.99 (5.65)	15.93 (3.92)
Azadirachtin 1500 ppm + (Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	8.49 (3.06)	11.10 (3.47)	35.99 (6.07)	18.52 (4.21)
Lambda cyhalothrin 4.6%+ (Chlorantraniliprole 9.3% ZC + Carbendazim 12% + Mancozeb 63% WP)	9.71 (3.26)	11.32 (3.50)	29.99 (5.56)	17.00 (4.11)
Chlorantraniliprole 18.5% SC + (Carbendazim 12% + Mancozeb 63% WP)	5.21 (2.44)	9.32 (3.19)	22.77 (4.85)	12.43 (3.52)
Flubendiamide 39.35% SC + (Carbendazim 12% + Mancozeb 63% WP)	14.43 (3.90)	17.21 (4.26)	29.94 (5.55)	20.52 (4.58)
Azadirachtin 1500 ppm + (Carbendazim 12% + Mancozeb 63% WP)	16.10 (4.13)	19.43 (4.52)	45.77 (6.82)	27.10 (5.16)
(Azoxystrobin 18.2% + Difenoconazole 11.4% SC)	29.16 (5.47)	32.21 (5.76)	61.05 (7.87)	40.80 (6.37)
(Carbendazim 12% + Mancozeb 63% WP)	34.99 (5.99)	43.27 (6.65)	71.05 (8.48)	49.77 (7.04)
Untreated control	71.11 (8.48)	79.16 (8.95)	88.61 (9.46)	79.62 (8.97)
C.D.	0.62	0.40	0.60	0.61
SEM	0.21	0.13	0.20	0.21
F test	S	S	S	S
C.V%	10.01	5.83	6.20	8.08

Figures in parenthesis are square root transformed values.
S = Significant; NS = non – Significant; DAS = Days After Spraying

CONCLUSION

Many chemicals have been effective in managing *S. frugiperda*. As many of the diseases also coincide with pest attack farmers go for wrong combinations for both insect pest and disease which will lead to phytotoxicity and reduced efficacy. Experiments conducted on evaluation of efficacy on different insecticides and fungicides against *S. frugiperda* in maize clearly indicated chlorantraniliprole 18.5% SC was highly effective due to the high insecticidal property, quick knock down effect whereas carbendazim 12% + mancozeb 63% WP was least effective due to its non-insecticidal property. Among combinations chlorantraniliprole 18.5% SC + azoxystrobin 18.2% + difenoconazole 11.4% SC was highly effective. But there was no significant difference in the efficacy of combination chlorantraniliprole 18.5% SC with fungicides. Therefore, by knowing the compatibility of a particular insecticide in combination with a pesticide helps to reduce the cost of cultivation indirectly by reducing the number of sprayings.

FUTURE SCOPE

Based on the research word done, it can be used as reliable source for further research. The present research can be further extended by using fertilizers, micronutrients along with insecticides, fungicides against pest, diseases, nutritional deficiencies in maize. Studies need to be undertaken to evaluate the effect of pesticides in combination against predators of maize pests through real time compatibility studies in maize.

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REFERENCES

Bhuvaneswari, V., and Krishnam Raju, S. (2013). Compatibility of fungicides and insecticides targeting sheath blight and major rice pests. *Journal of Rice Research, 6*: 64-71.

CABI (2017). Invasive species compendium. *Spodoptera frugiperda* (Fall armyworm). http://www.cabi.org/isc/datasheet/29810.Accessed4May2017.

Department of Agriculture and Cooperation (DACNET, 2020). Directorate of Economics and Statistics,

Ministry of Agriculture and Farmer's Welfare, Government of India.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons, New York, 680p.

Hardke, J. T., Temple, J. H., Leonard, B. R., Jackson, R. E. (2011). Laboratory toxicity and field efficacy of selected insecticides against fall armyworm (Lepidoptera: Noctuidae). *Florida Entomologist, 94*: 272–278.

Kubendran, D., Kannan, G. S. and Ganesh, S. (2009). Assessment of phytotoxicity and compatibility of Flubendamide + Thiacloprid 480 SC (RM) with other agrochemicals. *Pestology, 33*(5): 9-12.

Miller, D. K., Downer, R. G. and Stephenson, D. O. (2010). Interactive effects of tank- mixed application of insecticides, glyphosate and pendimethalin on growth and yield of second – generation glyphosate resistant cotton. *The Journal of Cotton Science, 14*: 186-190.

Peshney, N. L. (1990). Compatibility of fungicides with some insecticides with reference to fungitoxicity and phytotoxicity. *PKV research journal, 14*: 3-37.

Sharanabasappa Deshmukh, Pavithra, H. B., Kalleshwaraswamy, C. M., Shivanna, K. B., Maruthi, M. S., David, Mota-Sanchez (2020). Field Efficacy of Insecticides for Management of Invasive Fall Armyworm, *Spodoptera frugiperda* (J. E Smith) (Lepidoptera: Noctuidae) on Maize in India. *Florida Entomologist, 103*(2): 221-227.

Sisay, B., Simiyu, J., Mendesil, E., Likhayo, P., Ayalew, G., Samira, M., Subramanian, S. and Tefera, T. (2019). Fall Armyworm, *Spodoptera frugiperda* Infestations in East Africa: Assessment of Damage and Parasitism. Insects. *10*, 195.

Vyvasaya Panchagam, (2018-2019). Professor Jayashankar Telangana State Agricultural University.

Williams, W. P. and Davis, F. M. (1990). Response of corn to artificial infestation with fall armyworm and southwestern corn borer larvae. Southwestern Entomology, *15*(2): 163-166.

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