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SENSITIVITY OF FALL ARMYWORM, *SPODOPTERA FRUGIPERDA* (J.E. SMITH) (LEPIDOPTERA: NOCTUIDAE) TO INSECTICIDES ON *RABI* SORGHUM

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ABSTRACT

The present study aimed to assess the sensitivity of conventional insecticides against *Spodoptera frugiperda*, a pest in sorghum, across four distinct districts in Karnataka, India. These districts include Dharwad, Belagavi, Gadag, and Haveri. The findings of this study revealed that Dharwad district exhibited highest LC_{50} values, indicating a lower sensitivity to the tested insecticides. Specifically, chlorpyriphos 20 EC demonstrated highest LC_{50} value (2112.869ppm), chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (69.683 ppm), spinetoram 11.5 SC (55.056ppm), and emamectin benzoate 5 SG with lowest LC_{50} value of 7.029ppm, while, for chlorantraniliprole 18.5 SC highest LC_{50} of 119.691ppm was obtained in Belagavi district. Conversely, Gadag district exhibited lower LC_{50} values, indicating a higher susceptibility to the insecticides. Belagavi and Haver districts fell within the moderate range of LC_{50} values.

***Keywords*:** *Spodoptera frugiperda,* Sorghum (*Sorghum bicolor* L.), LC_{50}.

Introduction

Sorghum (*Sorghum bicolor* L.) (Moench) is fifth most important cereal crop following rice, wheat, sorghum and barley. Due to its huge grain size compared to other millets, it is frequently referred to as "major millet". In India, it is also known as Jonna, Jowar, Cholam or Jola (Reddy and Patil, 2015). It is the staple food in semi-arid parts of the world the crop is well organized for its drought resistance character and is the most suitable for dry regions where their grains are used as human food and stalks as a fodder for feeding animals.

The pest problem in sorghum starts from sowing and continues till the harvest. Insect pest are one of the major limiting factors for sorghum production. About 32 per cent of the actual crop produce is lost due to insect pest in India. About 150 insect species complex of which the shoot fly is a major one followed by stem borers (Gahukar and Jotwani, 1980). Recently introduced fall armyworm is of great worry because of its high defoliating capacity. *Spodoptera frugiperda*, often known as the fall armyworm (FAW), is a destructive insect pest that is a member of the Noctuidae family in Lepidoptera order. It is a polyphagous pest that harms economically significant farmed cereal crops like maize, rice and sorghum. In India, first time the presence of pest was confirmed in May 2018 by the University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka (Sharanabasappa *et al.*, 2018). Since then, this destructive pest has rapidly spread within the country and extended its reach to neighboring countries. In India, the first occurrence of this pest on sorghum and bajrawas noticed during October 2018 at the fields of Agricultural Research Station, Ananthapuram district, Andhra Pradesh. The damage on sorghum fields was up to the extent of 70 per cent (Venkateswarlu *et al.*, 2018). In sorghum fall armyworm infestations in the whorl reduces grain yields of susceptible lines by 55 to 80 per cent (Andrews, 1988).

In order to control this destructive pest use of insecticide has become prime importance. Thus, multiple pesticide applications in Karnataka could hasten the emergence of resistance, as has already happened in other places. Since pest has developed resistance to various insecticides like methomyl (223 folds), thiodicarb (124 folds), permethrin (48 folds), chlorpyriphos (47 folds), cypermethrin (6 folds) (Yu, 1991 and Rebeca *et al.*, 2018), chances of the pest developing resistance to most commonly used insecticides since the appearance of the pest is higher.

Materials and Methods

The lab experiment was conducted at Department of Entomology, College of Agriculture, University of Agricultural Sciences, Dharwad. Population of fall armyworm (FAW) from different districts were maintained to conduct the bioassay studies for determining the sesnsitivity to various insecticides

Collection of *S. frugiperda*

The test insect *S. frugiperda's* egg masses were collected from *rabi* sorghum fields from four districts (*viz.*, Belgavi, Dharwad, Haveri and Gadag). The larvae were raised separately under controlled laboratory environment. The LC_{50} value of each population was calculated to assess the level of sensitivity in FAW to emamectin benzoate 5 SG, spinetoram 11.5 SC, chlorantraniliprole 9.3 % + lambda cyhalothrin 4.6 % ZC, chlorantraniliprole 18.5 SC and chlorpyriphos 20 EC.

Rearing and bioassay of fall armyworm

The egg masses of *S. frugiperda* collected from sorghum fields were kept separately in petri dishes lined with moist filter paper and provided with tender sorghum leaves. Larvae that hatched out from egg masses were reared on sorghum leaves and the feed was changed every day till pupation. Then the 3^{rd}instar of F_1 generation were used for the leaf dip bioassay. Fresh and uniform sized sorghum leaf bit (3cm length × 2cm width) obtained from 20dayold seedlings were immersed in aqueous insecticide solution for 10 seconds. For control the leaf bits were agitated gently in distilled water for the control. The treated leaf bits were air dried and that were transferred individually to plastic vials (5cm × 5cm) and secured. One 3^{rd} instar larvae was released on each leaf bit. Such leaf bits with 3^{rd} instar larvae were maintained for each concentration of the insecticide and control. The mortality of dead larvae was recorded at 24, 48, 72 hours of the treatment.

Median lethal concentrations (LC_{50} values) for these insecticides were estimated through leaf dip bioassay method. Prior to bioassays, bracketing was done for every insecticide to fix the concentrations causing approximately15 to 95 per cent mortality of *S. frugiperda.* Later, median lethal concentration (LC_{50}) values were calculated by probit analysis using statistical software SPSS version 15.

Results and Discussion

The log–probit analysis of different insecticides against *Spodoptera frugiperda* populations from various districts revealed marked differences in LC_{50} values. Among the insecticides tested, emamectin benzoate recorded the lowest LC_{50} range (5.801–7.029 ppm), indicating high toxicity to the insect. In contrast, chlorpyrifos showed the highest LC_{50} values (1725.700–2112.869 ppm), indicating comparatively lower toxicity. Among the districts, the Dharwad population consistently exhibited higher LC_{50} values for all insecticides**,** followed by Belagavi and Haveri, while the lowest LC_{50} values were recorded in the Gadag district. For emamectin benzoate 5 SG, the highest LC_{50} value was observed in the Dharwad population (7.029 ppm), followed by Belagavi (6.615 ppm), Haveri (6.592 ppm), and Gadag (5.801 ppm). In the case of spinetoram 11.5 SC, the highest LC_{50} value was recorded in Dharwad (55.056 ppm), followed by Belagavi (47.658 ppm) and Haveri (37.903 ppm). The lowest LC_{50} value was observed in Gadag (35.352 ppm).

The combination insecticide chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6% ZC recorded the highest LC_{50} value in Dharwad (69.683 ppm), while the lowest was observed in Gadag (54.172 ppm). Belagavi and Haveri showed intermediate LC_{50} values of 61.214 and 58.295 ppm, respectively. With respect to chlorantraniliprole 18.5 SC, the *S. frugiperda* population from Belagavi exhibited the highest LC_{50} value (119.691 ppm), followed by Dharwad (107.227 ppm) and Haveri (102.153 ppm). The lowest LC_{50} value was recorded in the Gadag district. **C**hlorpyrifos 20 EC, recorded the highest LC_{50} value in the Dharwad population (2112.869 ppm), followed by Belagavi (2037.429 ppm) and Haveri (1951.264 ppm), while the lowest LC_{50} value was recorded in Gadag (1725.700 ppm).

The lower LC_{50} values observed in the Gadag and Haveri districts compared to other districts may be attributed to better and more judicious use of insecticides. Another possible reason is that farmers in these districts **o**ften do not adopt plant protection measures in sorghum, resulting in very low exposure of larvae to insecticides. Consequently, there is minimal selection pressure, and the larvae do not develop resistance to insecticides even at sublethal concentrations. In addition, the use of insecticides closer to the recommended doses may also contribute to lower LC_{50} values specifically in the *rabi* sorghum. In these districts, sorghum is grown mainly for fodder and household grain needs under rainfed conditions. As it is regarded as a low-cost crop, farmers tend to minimize or avoid chemical use.

In contrast, farmers in the Belagavi and Dharwad districts tend to apply excessively high doses of insecticides, frequently exceeding the recommended levels. They commonly use profenophos, cypermethrin, combinations of cypermethrin and chlorpyrifos, and chlorantraniliprole in sorghum to manage *S. frugiperda*. Unfortunately, such practices often reduce the effectiveness of insecticides, particularly when applications are not made during the susceptible stage of the insect. Both districts are rich in water resources, and most of the populations collected from these districts originated from irrigated, high-input cropping systems, which involve frequent insecticide applications and experience higher pest pressure. Furthermore, the year-round availability of host crops supports an extended life cycle of the larvae, leading to continuous exposure to insecticides.

Improper application of insecticides can decrease the sensitivity of the pesticides among insect populations. The indiscriminate use of chemicals, without rotation of modes of action or adherence to recommended concentrations, further contributes to decrease in sensitivity towards pesticides. Moreover, *S. frugiperda* larvae primarily feed within the whorl region of sorghum plants, where insecticides may not adequately reach or may be present in insufficient quantities. This limited exposure could also play a significant role in the evolution of resistance.

The present findings are in agreement with earlier studies. Dileep Kumar and Murali Mohan (2022) reported the lowest LC_{50} values for emamectin benzoate (0.11–0.12 ppm), spinetoram (0.65–0.76 ppm), lambda-cyhalothrin (3.31–3.87 ppm), and chlorantraniliprole (6.86–7.64 ppm), while the highest LC_{50} values were recorded for chlorpyrifos (99.73–106.32 ppm). Similarly, Bird *et al.* (2022) reported higher LC_{50} values for chlorpyrifos (8.515–18.168 mg a.i./L), followed by chlorantraniliprole (0.039–0.091 mg a.i./L), spinetoram (0.080–0.127 mg a.i./L), and emamectin benzoate (0.017–0.029 mg a.i./L).

Conclusion

The highest range of LC_{50} value were obtained in chlorpyriphos and lowest in emamectin benzoate while among the districts, Dharwad had highest LC_{50} values and lowest were obtained in Gadag district.

Table 1: Dosage mortality response of the field populations of *S. frugiperda* to different insecticides

Sl. No.	Districts	LC_{50}(ppm)	Fiducial Limit		Slope	χ2	d.f.
			Lower	Upper			
Chlorpyriphos 20 EC							
1	Dharwad	2112.869	1509.140	4083.388	Y=-5.340+1.606X	0.567	3
2	Belagavi	2037.429	1523.591	3092.032	Y=-6.127+1.852X	0.509	3
3	Gadag	1725.7	1363.711	2088.287	Y=-8.506+2.628X	0.615	3
4	Haveri	1951.264	1409.687	2896.693	Y=-5.929+1.802X	1.232	3
Chlorantraniliprole 18.5 SC							
1	Dharwad	107.227	63.105	150.504	Y=-2.942+1.449X	2.128	3
2	Belagavi	119.691	72.959	176.775	Y=-2.86+1.376X	1.164	3
3	Gadag	98.19	44.888	143.066	Y=-2.543+1.277X	1.164	3
4	Haveri	102.153	37.882	158.424	Y=-2.283+1.136X	0.246	3
Chlorantraniliprole 9.3 % + Lambda cyhalothrin 4.6 % ZC							
1	Dharwad	69.683	42.122	87.345	Y=-3.798+2.130X	2.554	3
2	Belagavi	61.214	10.590	84.099	Y=-2.730+1.528X	0.254	3
3	Gadag	54.172	23.202	71.115	Y=-3.640+2.100X	0.097	3
4	Haveri	58.295	13.501	79.393	Y=-2.897+1.641X	0.103	3
Spinetoram 11.5 SC							
1	Dharwad	55.056	32.259	78.294	Y=-2.466+1.416X	0.525	3
2	Belagavi	47.658	24.732	66.593	Y=-2.390+1.424X	0.602	3
3	Gadag	35.352	0.068	59.570	Y=-1.408+0.910X	0.486	3
4	Haveri	37.903	9.296	56.885	Y=-1.884+1.193X	0.394	3
Emamectin benzoate 5 SG							
1	Dharwad	7.029	3.368	9.684	Y=-1.406+1.660X	3.183	3
2	Belagavi	6.615	2.961	9.229	Y=-1.352+1.648X	5.154	3
3	Gadag	5.801	1.573	8.718	Y=-1.074+1.406X	1.249	3
4	Haveri	6.592	2.672	9.356	Y=-1.273+1.554X	1.251	3

Plate 1 : Rearing and bioassay of fall armyworm in laboratory

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