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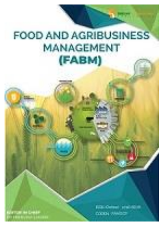

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RESEARCH ARTICLE

EFFECT OF DIFFERENT METHODS OF APPLYING INSECTICIDAL TREATMENTS FOR THE MANAGEMENT OF FALL ARMYWORM (*SPODOPTERA FRUGIPERDA)* IN DANG, NEPAL

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ABSTRACT

Fall Armyworm is an invasive pest causing damage to more than eighty plant species which mainly prefers maize. It damages maize leaf as well as whorl resulting in yield reduction. An experiment was carried out using different methods of applying insecticidal treatments for the management of fall armyworm. The experiment was laid in Randomized Complete Block Design with three replications and eight treatments. The treatments included Spinosad @0.3ml/L normal spray, Spinosad - whorl treatment, Spinetoram @0.75ml/L - normal spray, Spinetoram - whorl treatment, Emamectin benzoate @0.4gm/L normal spray, Emamectin benzoate - whorl treatment, Azadirachtin - whorl treatment, Azadirachtin @3ml/L normal spray (Check). Total of three sprays were applied at 15 days interval and whorl treatments were applied at 15 days. Damage percentage was recorded from four rows in each plot excluding two outer rows. The observed measurements was statistically analyzed and presented. Results revealed that highest damage percentage (40.02, 38.20 and 29.29) was recorded with Azadirachtin-normal spray(3ml/L) and lowest damage percentage (23.02, 19.37 and 11.66) was recorded with Spinosad normal spray at three different scouting after each insecticidal treatment. As there is less amount insecticide applied through whorl treatment, whorl treatments are suggested to be more environmentally friendly. However, with highest (3.07) benefit cost ratio, most economic method was found to be normal spray of Emamectin benzoate (0.4gm/L).

KEYWORDS

Damage, Ecological, Fall Armyworm, Maize, Scouting, Sporadic pest, Whorl treatment, Yield

1. INTRODUCTION

Maize (*Zea mays* L.*)* is the world's third most important crops after paddy and wheat and second most important crop in Nepal. It is used for both food and feed. Agriculture shares 27.6% of the total GDP while maize alone contributes 7.46% to AGDP (MoAD, 2017). The Fall armyworm (FAW), *Spodoptera frugiperda* has a voracious appetite and feeds on more than 80 plant species, including maize, rice, sorghum, and sugarcane (Goergen et al., 2016). Another feature which makes it an incredibly successful invasive species is its ability to spread and reproduce quickly. They can migrate over 500 km (300 miles) before oviposition (Prasanna et al., 2018). The life cycle of the Fall Armyworm includes egg, 6 growth stages of caterpillar development (instars), pupa and adult moth (Luginbill, 1928). 100-200 eggs are generally laid on the underside of the leaves typically near the base of the plant, close to the junction of the leaf and the stem (Sharanabasappa and Pavithra, 2018).

These are covered in protective scales rubbed off from the moth's abdomen after laying. When populations are high, the eggs may be laid higher up the plants or on nearby vegetation. After hatching, the young caterpillars feed superficially, usually on the undersides of leaves. Feeding results in semi-transparent patches, or "windows", on the leaves. Young caterpillars can spin silken threads which catch the wind and transport the caterpillars to a new plant. The leaf whorl is preferred in young plants, whereas the leaves around the cob silks are attractive in older plants. If the plant has already developed cobs then the caterpillar will eat its way through the protective leaf bracts into the side of the cob where it begins to feed on the developing kernel (Abrahams et al., 2017). The first case in Nepal was reported from Nawalparasi district of western Nepal on May 9, 2019 (Bajracharya and Bhat, 2019). Because the pest's favorite, maize, is the second most cultivated food crop in terms of area and production after rice in Nepal, the caterpillar may infest the entire farmland across the country. There are very limited researches being carried out in managing this pest. Keeping this problem in view**,** a research was conducted.

Therefore, it is an utmost need to identify economic and ecological management practices so that the farmers in this area will adopt recently developed efficient management methods. It could thus be helpful for policymakers and stakeholders for formulating integrated pest management trainings and programs too. Many farmers are known only about the pesticides available to control FAW but unaware of effective methods, concentration as well as frequency to apply them. This research will be helpful in managing fall armyworm there by preventing the yield reduction of maize in Dang valley. This study was conducted to determine the effect of different methods of applying insecticidal treatment for the management of fall armyworm, damage in maize, yield of maize and economics of applying different insecticidal treatments.

2. MATERIAL AND METHODS

The site of study was the field at Bodhipur village of Gadhwa rural municipality, Lamahi, Dang. It lies from 195 meter to 885 meter above sea level. The farmers of Dang district are actively involved in maize cultivation.

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Figure 1: Map of field study area Gadhawa, Dang

The research site lies in the sub-tropical zone of Nepal which is characterized by three distinct seasons namely, rainy monsoon (June – October), cool winter (November – February), and hot summer (March – May). Research was conducted during the month of February to May. The highest amount of rainfall is received during July to September. The temperature in Dang averages 21.5^{0}C and annual rainfall is 1577mm.

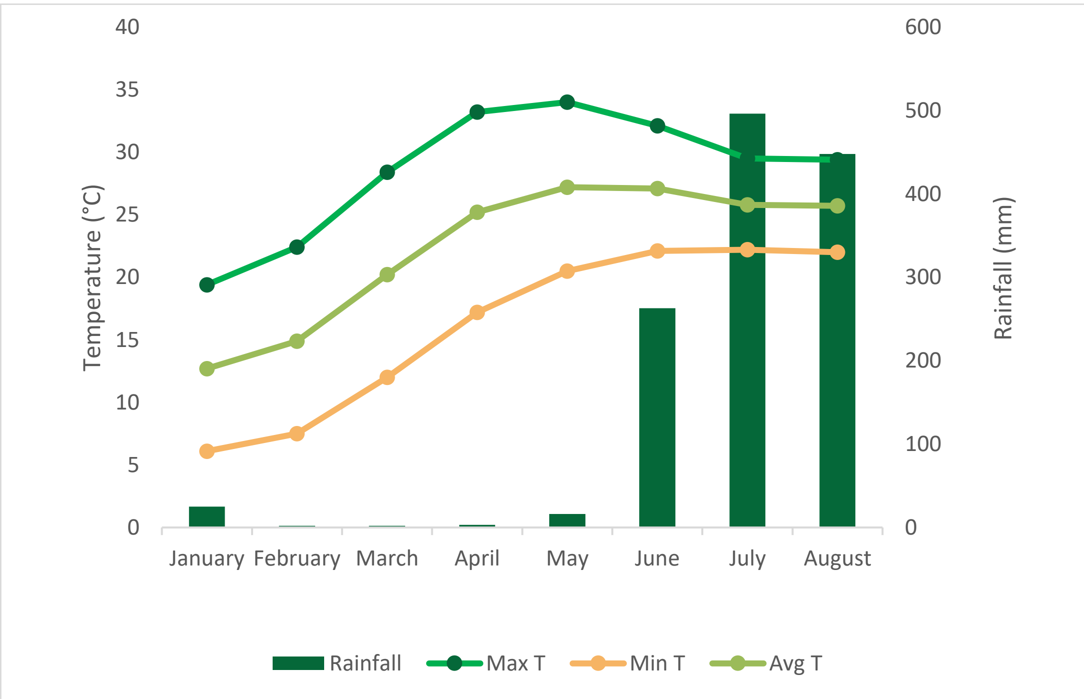

Figure 2: Weather data of experimental site during crop growing at Dang in 2020

The experiment was conducted in Randomized Complete Block Design (RCBD) design. There were a total of eight treatments and each treatment was replicated three times. So, the total no. of plots was 24 and each plot with 6 rows and each row containing 20 maize plants. Each plot size was 5m length and 3.6m breadth, with spacing of 60cm between rows and 25cm between plants. Distance between two plots was 1m and between two replications was kept 3m. Gross experimental field area was 789.6 m^2. Newly released variety for general cultivation in Terai and Inner Terai of Nepal i.e. Rajkumar hybrid corn was used for cultivation. It attains maturity within 110-120 days. It has productivity of 8-9 ton/ha. The treatments applied were different chemicals with different methods, as shown below:

Table 1: Treatments Detail	
Treatment	**Details**
T1	Spinosad (0.3 ml/L)- Normal spray
T2	Spinosad- Whorl treatment
T3	Spinetoram (0.75 ml/L)- Normal spray
T4	Spinetoram- Whorl treatment
T5	Emamectin benzoate (0.4 gm/L)- Normal spray
T6	Emamectin benzoate- Whorl treatment
T7	Azadirachtin- Whorl treatment
T8	Azadirachtin- Normal spray (3 ml/L)-Check

1Kattha =0.0338 ha

Normal spray: 20 liter of chemical solution per kattha was applied at every 15 days interval. Whorl treatment: One kilogram of corn flour added a pinch of vegetable oil, mixed with 100 ml of chemical solution as prepared for normal spray and applied at 15 days interval

2.1 Damage Percentage

Fresh window pane as well as damaged whorl were counted from each plots excluding two outer rows and was converted into percentage (Sisay et al., 2019).

Damage percentage = (Damaged plants/total plants excluding two outer rows) *100

2.2 Barren Cobs

The number of cobs without grain obtained from net plot was counted and divided by net plot area to obtain cobs harvested per m^2.

2.3 Total Cobs

The total number of cobs obtained from net plot was counted and divided by net plot area to obtain cobs harvested per m^2.

Figure 3: Bait preparation for whorl treatment

Figure 4: Normal spray of insecticides

2.4 Grain Yield

The harvested cobs were threshed and sun dried, cleaned and finally grain yield of net plot was measured and corresponding moisture content was measured with help of moisture meter. The grain yield per hectare was computed and standardize at 14% moisture content using the formula suggested by (Tandzi and Mutengwa 2020).

$$\text{Grain yield (kg/ha)} = \frac{(100 - \text{MC}) \times \text{plot yield(kg)} \times 10000}{(100 - 14) \times \text{net plot area (m}^2)}$$

Where MC is the moisture content of grains in percentage.

2.5 Data Analysis

All the data collected and analyzed by using R studio and R Stat. The significance was determined computing Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was employed to find out the significant differences between mean values at 5% level of significance.

3. Results and Discussions

3.1 Damage Percentage

Table 2 represents effect of different methods of insecticidal treatments for the management of FAW on damage percent of maize at Dang in 2020. First scouting was carried out at 15 days after emergence of seedlings but before any insecticidal treatment. There was not any significant difference of damage percentage among the treatments before application of insecticidal treatment. An average of 23.53% damage was recorded at this time. However, significant variation of damage percentage among different insecticidal treatments was recorded after each insecticidal treatment. After first insecticidal treatment, highest damage percentage (40.02%) was recorded with azadirachtin-normal spray (T_8) which was on par with azadirachtin-whorl treatment(T_7) and lowest damage percentage (23.02%) was recorded with spinosad-normal spray (T_1). Damage percentage after 2nd and 3rd insecticidal treatments was found to be highest (38.20% and 29.29%) on azadirachtin-normal spray (T_8) and lowest (19.37% and 11.66%) on spinosad-normal spray (T_1).

Table 2: Effect of Different Methods of Insecticidal Treatments for The Management of FAW, Damage Percent of Maize				
Treatments	Damage % before insecticidal treatment	Damage % after 1st insecticidal treatment	Damage % after 2nd insecticidal treatment	Damage % after 3rd insecticidal treatment
T_1	24.35	23.02 d	19.37f	11.66d
T_2	23.18	33.53 abc	32.08bc	21.52 abc
T_3	23.38	34.72 ab	28.29cd	22.04 abc
T_4	24.60	30.23bcd	29.39cd	17.41 bcd
T_5	22.19	25.82 cd	24.59e	13.16 cd
T_6	21.24	28.26bcd	27.65d	16.40 cd
T_7	24.19	38.77a	34.21b	26.63 ab
T_8	25.12	40.02a	38.20a	29.29 a
Grand Mean	23.53	31.80	29.30	19.77
Level of Significance	NS	**	***	**
LSD		7.73	3.053	8.57
SEm(±)		2.44	0.88	2.70
CV		13.89%	5.95%	24.77%

CV= Coefficient of Variance, LSD= Least Significant Difference, Treatments means followed by the common letter (s) are not significantly different from each other based on DMRT at 5% level of significance

3.2 Effect on Damage % At Tasseling, Barren Cobs, Total Cobs, And Grain Yield

Table 3 represents effect of different methods of insecticidal treatments for the management of FAW on damage % before harvest of Maize at Dang in 2020. The results revealed significant variation of insecticidal treatments on damage percentage with highest damage percentage before harvest (19 %) on azadirachtin-normal spray (3ml/L) and lowest damage percentage before harvest (4%) on spinosad-normal spray (0.3 ml/L). Table 3 represents Effect of different methods of insecticidal treatments for the management of FAW on Barren cobs Maize at Dang in 2020. There was significant variation of barren cobs among different insecticidal treatments with highest (3.11) barren cobs with azadirachtin-whorl treatment (T_7) and lowest barren cobs (0.78) recorded with spinosad-normal spray (T_1).

Table 3 shows effect of different methods of insecticidal treatments for the management of FAW on total cobs of (Maize at Dang, 2020. There was significant difference of total cobs among insecticidal treatments. Highest total cobs (7.67) was recorded with spinosad-normal spray and lowest no of total cobs (4.17) was recorded with normal spray of azadirachtin. Table 3 represents effect of different methods of insecticidal treatments for the management of FAW on yield of Maize at Dang in 2020. Significant difference of yield was recorded among different methods of insecticidal treatments. Highest yield (12.62 ton/ha) was recorded with normal spray of spinosad while lowest yield (6.79) was recorded with normal spray of azadirachtin.

3.3 Benefit-cost ratio

Table 4 represents Benefit-cost ratio. There was highest gross income (NRs.315580ha^{-1}) with normal spray of spinosad followed by normal spray of emamectin benzoate (NRs. 293330 ha^{-1}). However, the highest benefit-cost ratio (3.07) was recorded on treatment provided with normal spray of emamectin benzoate followed by normal spray of spinosad (3.03). There was lowest benefit cost ratio (2.02) recorded with normal spray of spinetoram(0.75 ml/L). Significant variation on damage percentage might be due to insect population. In the field, where insect population are high, resources are high (resource concentration theory), plant starts to show the damage threshold, which could potentially damage some plots by more intensively and more obvious than the other plots (Russell, 1989). Severe infestations by pest resulted in barren plants. In addition, such infestations also increased the production of nubbins (Ray, 1960). Plants have the certain threshold level of pest damage which could not influence the yield. Beyond the threshold level, there is influence on yield and variation on yield is seen. Chemicals contain charged particles due to which they are easily mobilized and give fast response. Using normal spray technique, high amount of chemicals are applied but same amount can cover the large area through whorl treatment. There is limited application of chemicals through whorl treatment but significant management of pest is recorded by applying chemicals through this method as compared to normal spray techniques. The current use of pesticides in maize has influenced the health, biodiversity, and declining of pollinators in agro-ecosystem. The cost related to health deterioration, and biodiversity loss have been realized is far higher than the immediate cost of pesticide and yield increased by pesticide use. Hence, the selection of safe pesticide and encouraging farmers to use them is the main aim of this research.

Table 3: Effect of different methods of insecticidal treatments for the management of FAW on Damage % at tasseling, Barren cobs, Total cobs, and Grain yield in ton per ha of Maize at Dang in 2020				
Treatments	Damage % at tasseling	Barren Cobs	Total cobs	Grain yield (tonha^{-1})
T_1	4.00 e	0.78d	7.67a	12.62 a
T_2	13.67 bc	2.22bc	5.84bc	11.10 abc
T_3	15.67 ab	2.33abc	6.50abc	9.60 c
T_4	10.00 cd	1.22d	6.67ab	10.46 bc
T_5	6.67 de	1.00 d	7.00ab	11.97 ab
T_6	9.67 cd	1.56cd	6.67ab	11.31 abc
T_7	17.67 ab	3.11 a	5.00cd	7.8 d
T_8	19.00 a	3.00ab	4.17d	6.79 d
Grand Mean	12.04	1.90	6.19	10.21
Level of Significance	***	***	**	***
LSD(0.05)	3.95	2.24	2.90	1.64
SEm(±)	1.21	0.71	0.95	0.52
CV(%)	18.73	22.45	13.37	9.18

CV= Coefficient of Variance, LSD= Least Significant Difference, Treatments means followed by the common letter (s) are not significantly different from each other within column based on DMRT at 5% level of significance

Figure 5: Damage by FAW

Table 4: Benefit-cost ratio				
Treatments	Total cost of cultivation (NRs. 000ha^{-1})	Gross income (NRs. 000ha^{-1})	Net profit (NRs. 000ha^{-1})	B:C ratio
T_1	104	315.58^{a}	211.13^{a}	3.03^{a}
T_2	96	277.50^{abc}	181.53^{ab}	2.89^{a}
T_3	102	240.00^{c}	138.00^{cd}	2.02^{c}
T_4	101	261.50^{bc}	160.00^{bc}	2.59^{ab}
T_5	97.5	293.33^{ab}	201.83^{ab}	3.07^{a}
T_6	95	282.83^{abc}	187.83^{ab}	2.98^{a}
T_7	74	169.83^{d}	95.83^{d}	2.29^{bc}
T_8	76	195.00^{d}	119.00^{cd}	2.57^{ab}
Probability		***	***	**
LSD (=0.05)		41.03	41.03	0.48
SEm(±)		12.99	12.99	0.15
CV (%)		9.18%	14.46%	10.24%
Grand mean		254.38	161.89	2.68

CV= Coefficient of Variance, LSD= Least Significant Difference, Treatments means followed by the common letter (s) are not significantly different from each other within column based on DMRT at 5% level of significance.

4. Conclusion

The best alternative method of applying different insecticidal treatments i. e. normal spray of emamectin benzoate and the normal spray of spinosad could be adopted. Safe and eco-friendly insecticides with a higher potential to replace synthetic pesticides could be adopted. To provide a benign environment to the natural predators and service-providing units of multiple ecosystem services in the maize agroecosystem, a more suitable method of insecticidal treatment including whorl treatment could be implemented.It is concluded that the lowest damage percentage and highest grain yield was recorded with normal spray of spinosad. Spinosad normal spray, spinosad whorl treatment, emamectin benzoate normal spray, and emamectin benzoate whorl treatment were beneficial.

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