REVIEW ARTICLE

INTEGRATED MANAGEMENT OF FALL ARMYWORM (*SPODOPTERA FRUGIPERDA*) IN MAIZE CROP

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ARTICLE DETAILS

Article History:

Received 05 September 2020

Accepted 07 October 2020

Available online 21 October 2020

ABSTRACT

Fall armyworm is an important pest of maize crop and native of America. Fall armyworm distributed in tropical and subtropical regions of many countries in the World. Eggs, larva, pupae & adults are the 4 stages of life -cycle. Eggs are covered with grey -pink colour layer. Larvae are 35-90mm long in size. The size of male & female pupae are 1.3 to 1.5 cm & 1.6 to 1.7 cm. grey, light brown & silver colour wings are observed in fall armyworm. The larvae of *Spodoptera frugiperda* larvae feed by scrapping green tissue of leaves & grown up larvae feed large amount of leaf tissues. Window pane like damage should be observed on leaves area. Fall armyworm affects on leaf corn and all sweet tissue part of the maize crop. Deep ploughing before onset of rains & wide sowing practices is best cultural practices for the management of all armyworm. Using of sex pheromone traps @2traps/acre at the time of sowing & hand picking and squashing of eggs are also found effective to control fall armyworm. Spraying of azadirachtin 1 Ec @2ml/liters of water, Emmamectin benzoate 5 SG @0.5g/liters of water, Chlorpyrifos 50% + Cypermetharin 5% Ec. @2ml/liters of water, lambda-Cyhalothrin 5% EC. @2ml/liters of water should be found effective chemical control on armyworm.

KEYWORDS

Maize, Fall Armyworm, Life cycle, Biological control, IPM.

1. INTRODUCTION

Maize (*Zea mays*) is a second major cereal crops in the world and originated from America. Maize is a cross-pollinated and non-tiller plant having chromosome number $2n=20$. Presence of yellow colour in maize due to cryptoxanthin and also it is known as queen of cereals. Maize is a monoecious plant and two different types of inflorescences. The optimum temperature required for germination is 21°C and having good source of carbohydrates and protein, its grain contain 10% protein, 4% oil and 70% carbohydrates. The protein of maize is known as 'zein'. The terminal male flower cluster are called tassel and removal of tassel is known as detasseling. A group researchers reported that fall armyworm (*Spodoptera frugiperda*) is the most harmful pest of maize crop and It's also attacks to sorghum, sugarcane, soybean, alfalfa, tomato, onion, cotton and many others vegetables crops (Smith, 1797). In Nepal armyworm mostly occurs at vegetative stage of maize in central/western mid-hills, mid/far-western mid-hills, terai and high hills. The level of damage/losses in crops varies from place to place, but some farmers have reported more than 80% crop losses in extreme cases. In Nepal, armyworm has potential to cause maize yield losses of 20-25%. A single generation of fall armyworm can spread 500km away from the point of emergence. FAW is key insect of maize in tropical region. The effect of this insect is likely to be more in summer than in winter, the fall armyworm is a Lepidoptera pest the feeds in large numbers on the stems, leaves and reproductive parts of more than 350 plant species. In maize growing area, weather conditions from March to September provide fertile ground to mass multiply and

spread easily. Warm, humid and heavy rainfall favours in reproduction of fall armyworm. Some of researchers reported that this insect has ability to spread quickly over large area and adult butterflies can fly up to 500 kilometers in search of food and shelter (Prasanna et al., 2018). FAW moth can fly up to 100Km/night and first time reported in karnataka on rice field. The FAW had been recorded first time in year of 9th May, 2019 in Nepal from district of Nawalparasi.

2. LIFE CYCLE OF FALL ARMYWORM

The life cycle of this insect consists of 4 stages (egg, larva, pupa and adult) and completed in about 30 days (at a daily temperature of $\sim 28^{\circ}\text{C}$) during the months of summer. But may extend to 60-90 days in cooler weather conditions and sometimes it took 27-32 days at 27°C . In the cooler place, the first generation invades from elsewhere. It is then estimated to last up to 4-6 generations per year in areas with hot climates and up to 2 generations in areas with cold weather. The life cycle stages are:

2.1 Eggs

Adult female butterflies usually flock to the lower surface of the leaf at night in an average number of 100-200, Total eggs production per female averages about 1500 with a maximum of over 2000 the eggs are dome in shaped and having 0.4mm in diameter & 0.3 mm in height. Eggs are golden colour and turn black after maturity. Duration of eggs stage is only 2-3 days during summer.

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DOI:
[10.26480/rfna.01.2020.27.29](http://doi.org/10.26480/rfna.01.2020.27.29)

2.2 Larva

The larvae have a Y-shaped white stripe on the head and in the last section of the larva, four large black dots appear square. Three yellow stripes are found on the upper part of the larvae and parallel to the back of the head. The larval stage can last up to 14-18 days, depending on diet and temperature. 20-30 ° C temperature is suitable for larvae. The mature caterpillar is about 38-51 mm (1.5-2.0 inches) in length. Larva is a damaging stage and generally feeds on the leaf by scraping green tissues. As appearing only as a scratch should be found on the leaf and later changed into ragged and elongated holes on the leaf.

2.3 Pupa

Full grown larvae usually go into the soil and combine the soil and organic matter with silk thread to form cocoons and go into a stationary (pupa) state. The Pupa is observed reddish brown in colour the pupal stage depends upon weather which generally completed 20-30 days in winter and it takes 8-9 days in summer season (CABI, 2019). 14-18 days old larvae go into pupa stage. Pupae spend 7-9 days in the soil within 2-8 cm and emerge as adult butterflies. The larva binds the particles of soil together to form a loose, oval and 20-30 mm long cocoon. Which is reddish-brown in colour and pupa are 4.5 mm in width and 14-18 mm in length (Igyuve et al., 2018). The full-grown larva stops feeding turns from greenish to bright brown in colour during prepupal period and survival of pupa depends upon the temperature and weather (Sharanabasappa et al., 2018).

2.4 Adult

Adult is medium sized moth and exhibits sexual dimorphism. In male, forewings are shaded with gray and brown with a triangular bright spot on the apical region of forewings and a circular spot in the center. In female, forewings are uniformly greyish brown to a fine mottling of grey and brown. Hindwings are silvery white in color with a narrow dark border, both in the male as well as in the female. Duration of adult life is estimated to average about 10 days, with a range of about seven to 21 days. Adult pupa was 1.6 cm long. The female butterfly lays eggs in clusters on the lower surface attached to the base and stalk of the corn leaf. There are 100-200 eggs in a group. After the egg is laid, the female mother lightly rubs her stomach to cover the whole egg. A female butterfly lays more than 1000 eggs in her life.

3. SYMPTOMS OF DAMAGE

Larva is the damaging stage. Neonate larva feed by scraping the green tissues. Grown up larva feed large amount of green tissue, causing glass window -pane like damage on the leaves in the early stages. These larvae then spread to other plants with the help of self-made fibers and air. Scratches are found on the leaf and at later stages ragged and elongated holes are found on the leaf, leading to shredded appearance. In case of several attacks by FAW, the leaves appear to be torn like hail damage in maize. Wood dust is also abundant in insect infested areas. A group of researchers reported that the effects of fall armyworm injury to early vegetative growth of sweet corn in Florida (Marenco et al., 1992). They reported that the early whorl stage was least sensitive to injury, the midwhorl stage intermediate, and the late whorl stage was most sensitive to injury. Further, they noted that mean densities of 0.2- 0.8 larvae/plant during the late whorl stage could reduce yield by 5 - 20 %. A study of larval feeding behaviour, and reported that although young (vegetative stage) leaf tissue is suitable for growth and survival, on more mature plants the leaf tissue is unsuitable, and the larvae tend to settle and feed in the ear zone, and particularly on the silk tissues (Pannuti et al., 2015). However, silk is not very suitable for growth. Larvae attacking the corn kernels display the fastest rate of development. Also, although the closed tassel was suitable with respect to survival, it resulted in poor growth. Thus, tassel tissue may be suitable for initial feeding, perhaps until the larvae locate the silk and ears, but feeding only on tassel tissue is suboptimal.

4. MANAGEMENT METHOD OF FALL ARMYWORM

The management of armyworm includes various options like cultural,

trap, mechanical, physical, chemical, biological and integrated pest management.

4.1 Cultural Method

The cultural method is nothing but a kind of an agronomic practice, that a farmer practices for growing his crop we can say that this is a method where without making any kind of an additional expenditure so for managing the pest. Through any of the agronomic practices which helps in improving the crop condition but at the same time so it is going to affect the pest population and so manages it. So, what are the various techniques or the cultural practices that a farmer follows. As you are aware that deep summer ploughing. This is a very common practice that a farmer practices for a fine tillage of the soil to keep the good aeration and as well which going to help in very good plant vigor. But at the same time so this type of practice will also expose some of the, the pest stages which are hidden in the soil or resting in the soil, such as the pupae or the egg stage or whatever the stage for that matter. So, this will lead to the destruction of the pest before the crop actually raised. Then putting some kind of a Bird perches in a cropping area so which allows some of these insectivorous birds to perch on it so that they can actually pick these insects and then eat them.

4.2 Trap crops

Trap crops are nothing but so growing one of the crops so which is very much attractant to the pest when compared to the main crop. So, like that, so we can actually what is called as attract the pest to a particular trap crop and so that the management is going to be very very easy. The intercropping is actually means growing to a more crop in a definite proportion. And these crops are like of a different group so that the pest which comes on the main crop so is not going to come on this inter crop, and this inter crop will act as a barrier so, for this pest to colonize on the main crop. Similarly, other cultural practices such as Mixed cropping and then Crop rotation which is nothing but growing the crop so one susceptible crop followed by the non host crop. So, which again disturb or disrupt the pest population. Then the destruction of the alternative host is another very important like such as weeds which act as alternative host so they can be actually been destroyed, so that we reduce the pest population (Shelton et al., 2006). This is again a very important cultural practices that Balanced nutrition, balanced irrigation then the earthing up kind of a practice. So, these things are all we're not going to do keeping in view of the pest management but in the view of the agronomic practices but at the same time they take care of destructing or destroying the pest population. In case of fall armyworm, when maize is inter-cropped with drought-tolerant greenleaf desmodium and planting Brachiaria as a border crop around this intercrop. Intercropping maize with edible legumes found 40% reduction in armyworm incidence and damage (Gebreziher et al., 2020).

4.3 Physical method

The physical method includes the use of certain physical sources in order to either monitor it or combat the pest. Say for example so we have the Light traps. set up light traps @ 2 traps per acre at the time of sowing for monitoring the pest. The light traps such as using an electric bulb or using a Petromax or some kind of a bonfire so what it does is basically so it attracts a lot of insects to these traps and then kill them. So, majority of you know the pest belongs to Lepidoptera. So, there is moths and moths are very active in the night, it will be very active, busy in mating and as well as laying eggs on the crop, will get attracted to these traps and so these adults are going to be killed. Similarly, as you know that on the storage condition draining of the grain is a very important practice to kill or to destroy the pest population. Then Hot water treatment is another important practice so which actually is employed before sowing to the seeds and so this is going to destroy many pests. The storing of corn in the food grains or the cop either in the cold storage or in a controlled atmosphere are some of the methods in the physical methods.

4.4 Mechanical method

Mechanical method includes soil solarization, deep ploughing in summer helps in expose larvae and pupae to the upper surface of the soil, regularly

weeding of field, hand picking and squashing of caterpillars. So, these are some of the important mechanical practices or the mechanical ways by which the pest can be actually controlled.

4.5 Biological method

Biological method is the most important method for controlling armyworm. See as we already know that these pests do have a lot of natural enemies on them either in nature so or which is artificially produced or released in the field are going to suppress the pest population. These natural enemies may be there may be predators or parasitoids or even the microbial pathogens are going to suppress the pest very effectively (Bhusal, et al., 2020). Ground beetles, striped earwig (*Labidura riparia*), spined soldier bug (*Podisus maculiventris*) and insidious flower bug (*Orius insidiosus*) are the predators which are attacks on eggs and larvae of fall armyworm. Extracts are also helping in controlling armyworm like azadirachtin (from neem), pyrethrins (from pyrethrum). Application of ash and detergent also found effective control on armyworm. *Telenomus remus* is one of the important biological agents that is used to control FAW in the maize and vegetable fields and It's so small that it can enter inside the FAW eggs and lay offspring inside. These offspring grow and eat the egg of fall armyworm. When the offspring develop into adult, it comes out breaking the shell and hence the FAW can be controlled.

4.6 Chemical method

The chemical method so which is a last result we can say that even with all these kinds of practices if the pest becomes serious and leads to an outbreak kind of a situation then as a last result we can always have an option to employ the synthetic insecticides, it's a green molecules we call that those can be employed and manage the pest population. So, all these methods need to be used judiciously, intelligently as and when it is required so that a combination of these methods will not only bring the pest population below the injurious level but also keep the environment and health of the non-target organism so clean and as well as safe. For the control of FAW pest, carbamate insecticide like Methomyl, Pyrethroid insecticide and common household pesticide, Cyfluthrin and organophosphate insecticide, methyl parathion can be used (Tumma and Chandrika, 2018). Spraying of azadirachtin 1% Ec @2ml/liters of water, Emamectin benzoate 5% SG @0.5g/liters of water, Chlorpyrifos 50% + Cypermetharin 5% Ec @2ml/liters of water, lambda-Cyhalothrin 5% Ec @2ml/liters of water, Azadirachtin @ 2ml/liter of water Chlorantraniliprole @ 0.4ml per liter of water, Spinetoram @ 0.4ml per liter should be found effective chemical control on armyworm. If spraying is difficult, then you can apply poison bait in the evening hours.

4.7 Integrated management of FAW

Integrated Pest Management (IPM) is the best and preferred method of FAW management (Day et al., 2017). Control methods need to be utilized in a way that are sustainable and cost-effective and the risks caused by them to the environment and humans are as minimum as

possible (Bateman et al., 2018). Due to the devastating loss caused by the pest, many farmers do not want to take the risk of IPM and use chemicals to control the pest directly. However, in Nepal, the pest is in the phase of incidence, thus the IPM method of pest control will be the best method for management. IPM method of pest management includes various practices of pest control like cultural, physical, Trap cropping, Mechanical and biological methods.

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