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Spotted Stem Borer (*Chilo partellus*) in Maize

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Maize is a species of family Poaceae botanically known as Zea mays and firstly described by Carl Linnaeus (Yadav *et al*.2021). Maize is a multipurpose crop, providing food and fuel for human beings, feed for animals, poultry and livestock (Rashool *et al*.2017). Maize has become a staple food in many part of the world with the total production of maize Up that wheat or rice. Maize is the second most widely grown crop in the world and cultivated in tropics, sub-tropics to temperate climate. Maize grain is used for various purpose including food, field corn, sweet corn, popcorn, and baby corn. Currently nearly 1147.7 million MT of maize is being produced together by over 170 countries from area of 193.7 million hac with average productivity of 5.75 tone/hac (FAOSTAT 2020). The global consumption of maize is feed 61% , food 17% , and industry 22% . India rank 4th in area and 7th in production representing around 4% of the world maize area and 2% of total production. During 2018-19 in India maize area reached to 9.2 million/hac. In India 83% of maize in kharif , while rabi maize correspond to 17% maize area(IIMR). Maize has very high yield potential that it is called "queen of cereals".

Causes behind the low productivity

There are many causes behind the low productivity of maize in India like very less mechanization, use of indigenous seeds, using old tactics of crop production as well as protection and insect-pests in all the above mentioned threats, insects-pests alone can cause huge damage up to 80 per cent to the crop during both the seasons. There are several pests reported to be causing damage to the maize crop on different crop stages (Yadav *et al*.2021). In maize damage 140 species of insects from sowing to harvesting and even in storage in different growth stages. The Spotted stem borer , Chilo partellus is an important pest of maize in several Asian and African continents. It causes yield loss about 18 to 25% under different agro-climatic conditions in Asia and Africa (Bhoi *et al.*2019). The Chilo partellus is native to Asia and from there it spread into eastern Africa in early 1930s. Since than it has continuously expanded it presence in the warm, low altitude regions of eastern southern African. In Asia it has widely distributed into India, Srilanka, Pakistan, Thailand, Cambodia, Indonesia, Afghanistan, Vietnam, Yemen, and Iran. Based on biological attributes and biochemical profiles of Chilo partellus population from different locations of India, It was found that population from Hisar, Hyderabad, Parbhani and Coimbatore were distinct from each other, which indicated presence of four biotypes of Chilo partellus (Sau *et al.*2022).

Identification of Insect

The first symptoms of Chilo partellus damage are the appearance of "Shot hole" injury to whorl leaves. Plants survive the initial attack show reduced inter-nodal length resulting in shoot 'rosetting'. Yield loss is attributed the physiological effects on final ear size, lodging or the complete loss of ears and formation of "dead hearts". In India Chilo partellus infestation

reduced the yield about 27-30% (Behera and Mishra.2019). In Chilo partellus four developmental stages- Egg, Larva, Pupa, and Adult with complete metamorphosis. There are 4-5 generations in a year and complete life cycle in 28-42 days (Kumar and Nigam.2008).

Egg- The female lays scale yellowish eggs in cluster on the lower surface of leaf near the mid-rib. Each cluster may have about 4-20 eggs and eggs hatch in 3-5 days.

Larva- The freshly hatched larva is white in colour and about 2mm in length with black head and prothorax and a dirty white body with four long brown stripes on its back. They feed about a week on leaves then enter into stem and remain inside whole life. The larva become full grown in 14-18 days and measure about 25mm in length.

Pupa- The pupation takes palace in specially constructed chamber in the stem. Pupal period is 6-8 days. Pupa is reddish brown in colour and the tip of its abdomen is furnished with 6 spines arrange in a group of three.

Adult- The adult moth is medium sized with yellowish brown insect, measuring 25-30 mm size across the wings. The for-wings are pole straw coloured and the hind wings posses a double row of black spots along their outer margins. The moth are nocturnal in habit, during the day they are hidden under plants, dry leaves and clods etc. The adult moth copulate after emergence the male die after copulation and female die after 2-3 days of egg laying.

Nature of damage

The insect Chilo partellus belongs to family Crambidae sub family Crambinae of order Lepidoptera. The larval stage of the maize spotted stem borer is responsible for causing damage in many crops including maize. The pest Chilo partellus appears during kharif in both tropics and sub-tropical zones typical damage symptoms include pinholes, shot holes, and window feeding on leaves ,dead hearts, exit holes and dwarfing while internal symptoms includes stem tunnelling (Yadav *et al*.2021). spotted stem borer , Chilo partellus is generalist herbivore and feed on several species of cultivated and wild plants of Poaceae family. It is most damaging Lepidopteran pest of maize in Asia, eastern and southern Africa. The presence, abundance and intensity of infestation by Chilo partellus is influenced by both biotic and abiotic factors in different geographical region. The newly emerged larvae of Chilo partellus prefers to feed on young leaves whorls causing scars and holes, then move towards growing points of plant and bore in the central whorl, which causes a characteristics symptoms known as “dead-heart”.(Sahu *et al*.2022).

Management of *Chilo partellus*

Maize stem borer Chilo partellus is a major pest of economic important damaging maize crop. Damage of stem borer directly regulated on yield factors including effective panicle number and density of fertile tiller. These are important methods to manage and control the pest of maize like- cultural practices, Biological control, and chemical control are the best promising alternatives compatible strategies.

Cultural and mechanical method: The main goal of these practices is to change the condition of the soil and crops, which creates unfavorable conditions for the growth and development of the pest. Maize can be grown throughout the year, the *Chilo partellus* larva undergoes diapause in crop residues, it is important to destroy maize stubble, stalks and ears during the dry season. Post harvest tillage can destroy larvae by exposing them to predators, adverse weather conditions, or causing mechanical damage to aestivation structures. (Deepa *et.al* 2021). Trap crops are plants grown along side the main crop to manipulate insect behavior to manage insect pests and are used as a cultural management strategy in several crops such as Napier grass and Sudan grass that can be used trap crops to control *Chilo partellus* . (Anamika *et.al* 2019). Insect light traps can be used to trapping both male and female moths, reducing carry over population. Male moths were found to be more attracted to light traps than female moths.

Biological control: Biological control with microbial pathogens offers an alternative method of controlling pest. Chilo partellus attacked at the different stages by wide array of parasitoids in natural conditions and some of them are commercially used to manage this pest in agro-ecosystem. Trichogramma spp. eggs parasitoids are used against the Lepidopteran insect-pests. The rate of paratism by Trichogramma chilonis on Chilo partellus eggs up to 63% with significantly reduction in stem tunnelling when parasitoids release at 5 day interval. The combined application of Trichogramma and B.thuringiensis resulted in significantly less pest infestation and stem tunnelling compared to individual treatments (Jalali and Singh.2006). For better control use more than one pathogen for the successful management of Chilo partellus the combined application of B.thuringiensis and B.bassiana could be cost-effective and eco-friendly approach for Chilo partellus. Application of B.bassiana (1×10×8 spore/ml) and B.thuringiensis (0.75ug/g) together exhibited highest larval mortality of larvae while 2nd instar larvae were more susceptible to it than 4th larval instars (Sau et al.2022). In India, Trichogramma chilonis (maize strain) was found most promosing for field studies and Cotesia flavipes (Cameron) was found to be most promosing larval parasitoid in fodder maize ecosystem. The reason for Cotesia flavipes not being effective as Trichogramma chilonis due to it preference for 3rd to 5th instar larvae. By that time, larvae go inside the stem and cause damage (Jalani and Singh.2003). Cotesia flavipes is used as a classical biological control agent against Chilo partellus. It parasitoid showed preference toward late instar larvae of Chilo partellus. Cotesia flavipes was dominant natural enemy of Chilo partellus in maize (Behera and Mishra.2019). The percentage of larvae yielding Cotesia flavipes cocoons was lower on the two wild host plant species compared to maize and sorghum.

Efficacy of insecticides: For the management of Chilo partellus all the insecticidal treatments are used the highest benefit: cost ratio was evinced in insecticidal treatment Flubendiamide 480 SC @ 0.2ml/litre then sequence with Carbofuran 3G @ 7kg/hect. and all other remaining treatments, Cartaphydrochloride 50% SP (T5) and Deltamethalin 2.8 EC (T3) which are least effective against control of Chilo partellus (Reddy and Kumar.2021). Some novel chemical insecticides are used to evaluate the efficacy against Chilo partellus in maize are Spinosad treatment and second most effective treatment is Befenthrin in which yield 38.44q/hect and other treatment in descending order Cartap hydrochloride, Carbofuran, Phorate, and Imidachlorid with grain yield 36.93, 35.91, 32.63 and 28.41 q/hect (Kumar *et al*.2017). Spinosad 45%SC @ 0.5ml/litre and Trichogramma chilonis @100,000 eggs/hect. These treatments were effective in reducing plant infestation and dead heart formation by Chilo partellus and increased yield as compared to untreated control. Trichogramma chilonis proved safer to natural enemies as compared to insecticides (Bhandari *et al*.2020). The application of Flubendiamide 480 SC @ 0.2 ml/litre resulted in minimum leaf injury and can be recommended to manage Chilo partellus in maize ecosystem (Lekha *et al*.2019). For the maximum protection against Chilo partellus with application of Imidacloprid 70WS @ 7.5g/kg seed as seed treatment and sprays the application of Profenophos 0.05% or Fenobucarb o.1% for least infestation (Chaudhary et al.2021). Imidacloprid 17.8 SL @ 250ml/hect is the most effective treatment to minimize the number of dead heart and stem tunnelling by Chilo partellus (Prakash *et al*.2017). The granular application of insecticides better control of Chilo partellus as compared to emulsifiable concentrates (EC) as foliar application (Mashwani et al.2011). Granular insecticides were effective than other formulation regarding least of Chilo partellus infestation and high yield.

Yield Losses due to *Chilo partellus*

The average avoidable yield losses caused by Chilo partellus were reported to be 13% to maize crop sown in month of June which calculated based on protection provided with chemical spray in Punjab, India (Dhaliwal *et al*.2018). In a study it was found that the combined effect of ears and stem tunnelling accounted for 34-43% yield reduction while other traits cause less than 2% reduction (Yadav *et al*.2021). Maximum damage is caused in the month of August to maize the pest remain active in field from March to November. ETL is 10% dead hearts estimated 83.7% loss in grain yield (Mathur and Upadhyay).