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Insects pest (Maize Stem Borer) management: A review article

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Abstract
Insect pests attacking maize crop in India are maize stem borer, *Chilo partellus;* pink borer, *Sesamia uniformis;* corn aphid, *Rhopalosiphum maidi;* cutworm, *Agrotis ipsilon;* shoot bug, *Peregrinus maidis;* stemfly, *Atherigona soccata;* Red hairy caterpillar, *Amsacta moorei;* thrips, *Baliothrips holorphnus;* coreid bug, *Riptortus linearis; Heteronychus loideres* and webber, *Sathrobrota simplex***.** Maize stem borer damage to maize crop includes tunneling within the stalk, production of "Dead hearts", interruption in the flow of nutrients to the ear, and leaf feeding. Appearance of "shot-hole" damage to whorl leaves is the first symptoms of Maize stem borer injury. Inspite of the rich diversity of plants of economic importance in India and little is known about the biological aspect of plant extracts in India. The plant extracts must be given top priority in integrated pest management (IPM).

Keywords: dead hearts, *Chilo partellus*, tunneling, integrated pest management (IPM), shot-hole

Introduction
Insects are the most diverse species of animals living on earth. Apart from the open ocean, insects can be found in all habitats; swamps, jungles, deserts, even in highly harsh environments such as pools of crude petroleum Insects are undoubtedly the most adaptable form of life as their total numbers far exceed that of any other animal category. The majority of insects are directly important to humans and the environment.

Less than 0.5 percentage of the total number of the known insect species are considered pests and only a few of these can be a serious menace to people. Insect pests inflict damage to humans, farm animals and crops Insects are said to be responsible for destroying one fifth of the world's total crop production annually. Insect pests are capable of evolving bio-types that can adapt to new situations, for example, overcome the effect of toxic materials or bypass natural or artificial plant resistant, which further confounds the problem. Amongst different food crops, maize is of considerable economic importance. Maize is a versatile crop with great genetic diversity and can be grown over a range of agro-ecological zones

In India too, Maize is emerging as the third most important crop, after rice and wheat. Apart from other parts of the country, Madhya Pradesh is one of the traditional and potential maize growing state and contributing equally to the total maize production in the country because of its conductive climatological condition's. Madhya Pradesh occupies first place amongst maize producing states of the country (area 13.51%, production 14.57%). Most of the production comes from Indore, Ratlam, Ujjan, Jhabua district as major producers.

According to the studies done by Kfir *et al.* (2002) [24] loss in the maize yield production is characterized by the physiological effects on size of ear, complete loss or lodging of ears. Tunneling by larvae within the stalk are also prone to fungal pathogens, which further lead in compromising the quality of food products and long-term storability. Depending upon the fertilization, maize variety and country season, maize yield loss by Maize stem borer (MSB) vary greatly (Kfir *et al.*, 2002) [24]. So, for this reason various strategies were adopted to manage the damage caused by *Chilo partellus.*

They have been the subject of much scientific interest due to the agricultural importance of maize crop and therefore to eradicate the MSB is the need of hour. From 500 BC up to 19th century, Pesticides came into existence and were defined as any mixture of substances used for destroying, preventing, mitigating or repelling any pest. According to US Environmental (2007) they included arsenic, sulphur, mercury and lead. In, DDT was synthesized in 1874 and its insecticidal activity was discovered during the second half of World War II. It become the first synthetic organic pesticide and WHO (1979) [42] reported in a report that it was used after the war for agricultural purpose. However, it was then alarmed to discontinue the use of organic synthetic pesticides, especially the toxic hydrocarbons that are chlorinated such as DDT and derivatives that have caused critical environmental pollution like water, air and soil, affecting non-target fauna (plants, animals and fish) and human health. This situation ultimately led to the ban of DDT in 2004 (UNEP, 2005) [41].

In recent years, biologists have been attracted towards natural products extracted from plants especially secondary metabolites as potential sources of new pesticides. The traditional use of terrestrial higher plants by the peoples of many parts of the world as antimicrobial, antifeedant, repellant and insecticidal or pesticidal materials has been well known. The first plant recorded so far having pesticidal/insecticidal activity was tobacco (*Nicotiana tabacum*). The alkaloid (nicotine) was isolated from it and was used as tobacco leaf infusion to kill aphids whiles the active constituent rotenone, was chemically extracted from the Japanese plant, Roh-ten (*Rhododendron hortense*) in

1902 (Tooley, 1971) [39].

Medicinal Values and Other Activities

Many researchers have found botanical plant extracts of certain plant families like Meliaceae, Lilaceae, Lamiaceae, Myrtaceae, Fabaceae and Rutaceae possessing anti-feedant, insecticidal, repellent and growth controlling activities against insect pests of stored commodities and are considered major source for the manufacturing of different types of medicines in pharmaceutical industries (Yankanchi and Gadache, 2010) [43].

Neem plant extracts have been in use form a quiet prolonged time and their effective and potent nature, for the control of sucking and chewing pests and borers on many grain crops and vegetables have been exhibited with alterable success (Bhanukiran and panwar, 2000) [11]. The natural plant products like spinosad and Abamectin obtained from *Streptomyces spp.* and *Saccharopolyspora spinosa* have been recently introduced respectively. They have been found effective against cotton bollworm complex *Ostrinia nubilalis* and *Leptintarsa sp.* (Anonymous, 2000) [7].

Garlic (*Allium sativum*) also called as stinking rose, is a perennial pungent herb (active throughout the year) with globose bulbs. According to Khokar (2004) *Allium* belonging to the family Lilaceae is a very large and geographically cosmopolitan species. It has been investigated that the chief constitute of its volatile oils are 2-propene sulfenic acid, allicin, propylene, 2-propene thiol, ajoene and thioacrolein (Gurusubramaniana and Krishna, 1996) [19] while Huang *et al.* (2000) [22] have studied its two chief constituents which are diallyl trisulfide and methyl allyl disulfide. Several scientists have reported its antimicrobial effect, antifungal and insecticidal properties (Benkeblia, 2004) [12].

Studies over the decades have shown that garlic also exhibits most of the fungicidal, acaricidal, nematicidal, insecticidal and bactericidal properties (Lalla *et al*., 2013) [26]. It possess a extensive antimicrobial activity and when compared to those of common antibiotics like penicillin (Cavallito *et al*., 1944) [14] and ampicillin (Curtis *et al*., 2004), it is hardly surprising that this compound has shown various activities against some of the world's most notable plant pathogens like *Pseudoperonospora cubensis* and *Phytophthora infestans* (Portz *et al.*, 2008) [31].

Bindu *et al.* (2013) [13] carried out investigation on *Damalinia caprae* (goat louse) using filter paper method in in-vitro conditions. It was concluded that these plant extracts caused 100% mortality of adult lice during 32 hour post exposure at a concentration of 100 mg/ml whereas during 48 hour post-exposure at 50 mg/ml concentration, the same mortality was observed. Preliminary studies of *A. Sativum* extracts for its lousicidal activity are encouraging so that one more effective herbal lousicide can be used to control *D. caprae* infestation.

Gaherwal *et al*. (2016) [18] studied the antifeedent effect of different plant extracts on Maize stem borer, *Chilo partellus.* Three medicinal plant material like *Azadirachta indica*-Leaves, *Allium sativum*- Bulbs and *Oscimum sanctum*- Leaves extract were tested against Maize stem borer, *Chilo partellus* (Swinhoe). The plant extract was prepared by soxhlet extraction method using two solvents like distilled water and ethanol at different percent concentrations (2.0 %-10 %) were used. Phytochemical screening were conducted using standard methods of analysis and the antifeedant effect of plant extract were carried out by using leaf disk choice bioassays. The result of the phytochemical screening was done to check the presence of flavonoids, alkaloids, saponins, tannins and cardiac glycosides. The antifeedant effect of plant extracts were recorded at 12, 24 and 48 hours. All three plant extract in both solvents showed the antifeedant activity. The ethanolic extract of *Azadirachta indica* (leaves) followed by *Allium sativum* (bulbs) were found effective and showed the highest antifeedant effect as compared to *Oscimum sanctum.*10.0 % concentration of Ethanolic extract of *Azadirachta indica showed* the maximum antifeedant effect (80.33 %) followed by *Allium sativum* (74.37 %) at 48 hours and the minimum antifeedant (2.09 %) was observed in 2 % aqueous extract of *Oscimum sanctum* at 12 hours. The concentration of plant extracts increases, the antifeedant effect also increased. Therefore, in general the antifeedant effect of different concentrations, irrespective of the extracts decreased with decrease in concentration from 10 % to 2 %.

Oparaeke *et al.* (2007) [30] revealed that there were significantly reduced populations of the *Clavigralla tomentosicollis* and *Maruca vitrata* on cowpea when treated with aqueous garlic bulb extracts as compared with the untreated control.

Some of the phytochemicals extracted from *Ocimum sanctum are* of medicinal importance and have already been detected (Deshpande *et al.,* 1997) [16]. *Ocimum sanctum* acts as an antimicrobial compound, nematicide, insecticide and fungicide (Mishra *et al.,* 2011) [27]. *Ocimum sanctum* also exhibits insecticidal, anti-convulsant, repellant effects and anti-microbial activities against various insects especially mosquitoes (Singh *et al.,* 2000) [34].

Murthy *et al*. (2014) [28] studied efficacy of *Ocimum sanctum* leaf extracts against *Ralstonia solanacearum* causing bacterial wilt of tomato in tomato. They extracted leaves of *Ocimum sanctum* using methanol, ethyl acetate hexane and ethanol. The result illustrated the highest zone of inhibition of the leaf extracts more in the methanol extracts than in hexane, ethanol, ethyl acetate and methanol.

Sharma (2010) [35] worked on the toxic effect of *Ocimum sanctum* plant extract against *Acrida exaltata* (Orthoptera : Acrididae) adults stages and during the investigation, different concentrations of leaf extract of *Ocimum sanctum ranging from* 0.005-1.0% (0.005%, 0.01%, 0.025%, 0.05%,0.1%, 0.25%, 0.5% and 1.0%) were used against *Acrida exaltata*, adults respectively. These concentrations were used to dip the maize leaves, upon which the insects were allowed to feed. The observation illustrated that least or no mortality was determined in case of *Ocimum sanctum* (leaves) at 0.005% concentration while as *Acrida exaltata* adult indicated the highest mortality 50.00% at 1.0% concentration of *Ocimum sanctum* (leaves) respectively.

Keita *et al.* (2000) [25] have assessed many essential oils of different botanical species like O. *basilicum, Hyptis suaveolens, Tagetus minuta* and *Ocimum canum* against *C. maculatus.* The results illustrated that plants of the genus *Ocimum* could be used to manage various insect pests as an alternative to synthetic pesticides. (Singh *et al.,* 2000) [34]. evaluated 31 essential oils of plant species for insecticidal and repellent activities against *Musca domestica* (housefly). 100% repellent activity was showed by the essential oils obtained from *Ocimum gratissimum* and *A. calamus* showed 40% activity among all of them.

Aziz and Gaherwal (2016) [18] taken up to evaluate the toxic

effect of aqueous and ethanolic extracts of *Azadirachta indica-leaves*, *Allium sativum-bulbs* and *Oscimum sanctum*-leaves against *C. partellus*, maize stem borer. The toxic effect of the plant extracts was carried out at five different concentrations, viz. 2.0%, 4.0%, 6.0%, 8.0% and 10% respectively. All the aqueous and ethanolic extracts showed high to moderate mortality. Complete mortality of larvae was recorded from ethanolic extract of *Azadirachta indica-leaves* giving 100 % percent average and corrected mortality followed by aqueous extract of *Azadirachta indica-leaves* giving 99.2 % of percent average and corrected mortality and than ethanolic extract of *Allium sativum-bulbs* giving 94.0% percent average and corrected mortality after 48 hours of treatment. The lowest mortality was recorded from aqueous extract of *O. sanctum* having 66.6% percent average and corrected mortality at 12 hours of treatment. The estimated LC50 calculated for total mortality for *Azadirachta indica-leaves* extracts which caused highest mortality were 86.1 mg/ml respectively. The results suggest that extract from *Azadirachta indica*-leaves and *Allium sativum bulbs* may potentially be used for the management of *C. partellus.*

Aziz *et al.* (2017) [3] evaluated the effect of aqueous and ethanolic extracts of leaves of *A.indica*, bulbs of *A. Sativum* and leaves of *O. sanctum* for maize seed germination at 2.0, 4.0, 6.0, 8.0 and 10% concentration for 12, 24, and 48 hours of treatment. Maximum and significant activity was observed in ethanolic extract of *A. Indica* at 6.0 % concentration at 24 hours of duration and the maximum germination percentage was recorded as 90.15 ± 0.2 followed by aqueous extract of *A. Indica* (90.02 ± 0.2) and than by ethanolic extract of *A. Sativum* (78.15 ± 0.2) . The lowest maize seed germination (60.45 ± 0.1) was observed in aqueous extract of *O. Sanctum* at 10 % concentration during 12 hours of treatment. The concentration (10%) at duration of treatment (24 and 48 hours) resulted in total germination failure suggesting that the higher concentrations with longer duration of treatment are highly phytotoxic to maize seeds. This phytotoxicity may be due to organic acids, chemical decomposition or microbial degradation of organic compounds.

Kfir *et al.* (2002) [24] studied management and biology of lepidopteron cereal stem borers in Africa which were economically more important and reported that when *Cotesia flavipes* (a parasitoid) was introduced from Pakistan for biological control of *Chilo partellus* and it caused 32–55% reduction in stem borer densities.

In regions where there is an affluence of host plants and the climate is warm, *C. partellus* develops normally throughout the year continuously. In other regions with prolonged dry periods in summer or winter, the stem borer enters into a resting phase. *C. partellus* was observed to diapauses in the dry season in India (Tams and Bowden, 1953) [38].

Many factors may be responsible for the competitive superiority of *C. partellus* over some native stem borers. (Ofomata, 2000) [29], observed that the *C. orichalcociliellus* takes more time to Completes one generation while *C. partellus* completes a generation in very less time which may result in increased rate of population growth. However, *C. partellus* completes diapauses more fast which may allow *C. partellus* to colonize host plants at the starting of growing seasons than *C.orichalcociliellus.*

Aziz *et al.* (2017) [2] conducted an experiment to determine the distribution of stem borers (*Chilo partellus*) in four agro-ecological zones of Indore district of M. P. Our study evaluated that of the various insect pests attacking cereals crops in Indore, lepidopteran stem borer, *Chilo partellus* are by far the most injurious causing maize yield losses. Severe damage is caused by the larvae that feed on the plant from early stage up to maturity causing a devastating impact on maize yield. Their distribution follows a define pattern with *Chilo partellus* dominating and is most abundant and widely distributed species occurring at all sites. *C. partellus* distribution is highly influenced by altitude \and moisture gradients. Present study was an attempt to evaluate the status of economically important cereal stem borers with emphasis on their distribution, borer density and percent infestation.

Gupta *et al.* (2010) reported that in India, *C. partellus,* is one of the destructive and important pests of maize crops. The infestation levels of *Chilo partellus* were highest as compared to *Sesamia inferens* during the pre and post tasselings stage. These levels of high infestations are relatively similar to those observed by Kfir, (2002) [24] in a area where on young plants maximum level of larval infestations were recorded during January and August. The larval numbers on old plants during March and November were at peak. This study is also in agreement with present investigation.

Aziz and Gaherwal, (2017) [3] carried out to determine the numbers of egg batches and eggs per batch in the maize fields of selected sites of Indore. Moreover, discovery efficiency and parasitism efficiency was also determined. The result revealed that highest mean discovery efficiency rates of *Trichogramma spp.* was found from Mhow and was therefore having low parasitism per field and lowest mean discovery efficiency rate was recorded from Mangliya and was having high parasitism per field. There was generally a high variation in the numbers of egg batches and eggs per batch among the sites surveyed. The predominant parasitoid species was *Trichogramma spp*. This study showed that although egg parasitoid species diversity was higher, egg parasitism was considerably lower in selected sites of Indore.

Aziz *et al*. (2017) [2] Investigation was carried out during 2015 and 2016 in some regions of Indore (Depalpur, Mhow, Sanwer and Mangliya). Among the predators, the major insect groups included *Coccinellids, Chrysopa spp., Pheidole spp., Reduvid spp., Mantis religiosa, Scolothrips* and *Euborellia spp.* The relative abundance of predators was higher during 2016. *Coccinella septumpunctata* was having high relative abundance followed by *Chrysopa spp.* the least abundant predator was *Pantala spp.* find out the most abundant predators among all predators.

Swaminathan *et al.* (2016) [37] reported that th common aphidophagous predators on maize belonged to the insect families Chrysopidae, Coccinellidae, Nabidae and Syrphidae; types of soil, forerunner crops and manures affected the population dynamics of predator system to our observation, among coccinellids, *transversalis*, *Brumoides suturalis sexmaculata* are the most widespread. Thus, it can be inferred that coccinellids happen to be the most dominant aphidophagous predators of maize aphids as recorded during the present investigation. Riyes *et al.* (2018) [33] carried out an investigation to compare the dominance of natural enemy complex (parasitoids and predators) against maize stem borer, *Chilo partellus* during 2015 and 2016 by determining their dominance coefficient. The dominance coefficient of

natural enemy complex varied in both 2015 and 2016. In comparison with the natural enemy complex recorded in 2015, the year 2016 showed highest abundance of natural enemies. During both the years, *Trichogramma spp.* was at the uppermost peak followed by *Cotesia flavipes* and then by *Coccinella septumpunctata.* These species were common in all the selected regions of Indore, showing high to moderate effect on the mortality of eggs, larvae and pupa of *Chilo partellus.* Furthermore, *Ants* belonging to the family formicidae *(Componotus spp and Pheidole sp.)* were also common in all selected regions among the entire natural enemy complex.

Biologists have illustrated the importance of natural enemies in the eradication of aphid populations at the field scale (Dennis and wratton, 1991). *Trichogramma spp.* (Trichogrammatidae) are small parasitoid wasps that act as a biological control agents of many lepidopterous insect pests. Several among them have been used victoriously in the management of insect crop pests (Borror *et al*., 1981) [9]. One of the active biocontrol principal is *Trichogramma spp*. as it can manage the pest in the egg stage (Boumier, 1982) .These results are also in agreement with present study. (Barpete and Shinde, 1991) [8] Studied the seasonal appearance of *Cotesia flavipes* on *C. partellus* larvae in Madhya Pradesh. (Sutar and Sathe, 2016) [36] Worked on diverseness and biocontrol nature of the genus *Cotesia*. Therefore, reported *Cotesia flavipes* as verygood substitute for pesticides in insect pest management. This work supports the present investigation. (Ghoneim, 2014) [21] Also were in agreement with present investigation and found that spiders and coccinellids were most common species among predators complex followed by chrysopids and anthocorids and also recommended the role of *C. septempunctata* as dominant predator responsible for alteration in population of pests.

Conclusion

Economy, public health and livestock are at a great risk due to the adaptation and feeding of an innumerable insect species over a variety of animals and plants and such pernicious insects are called as pests. In other words, with the increase in the population of insect species, when there is an apprehensible economic loss, and then it attains a status of the pest. With the result these pests are a great threat to our economy by damaging our precious crops like maize, rice and wheat etc. Being the staple crop of most of the countries, maize is the third largest crop produced in India. Maize is used to feed animals and poultry directly and is sold as a raw material for the extraction and fermentation industries. Insect pests have made significant contribution in lowering or reducing the maize productivity to its half year by year and globally, it has been estimated that approximately 21% of the total grain produced is consumed as food. Insect pest is the responsible factor for its low yield. The major pest causing enough damage to maize crop is *Chilo partellus.* It leads to the formation of dead hearts, shot or pin holes in the leaves and cause stem tunneling within the stalk. Various strategies have been undertaken for the management of the pest but yet the result remain still dream to come true and therefore requires further analyses for its absolute control through the use of plant extracts that are ecofriendly.

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