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Insect pest succession on hybrid maize and management of pink stem borer, *Sesamia inferens* Walker

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Abstract
The present investigation entitled "Insect pest succession on hybrid maize and management of pink stem borer, *Sesamia inferens* Walker" was conducted during *Kharif* 2014-15 at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Regarding the insect pests succession on hybrid maize crop and their natural enemies, five insect species *viz*., pink stem borer (*Sesamia inferens*), green stink bug (*Nezara virudula*), maize leaf hopper (*Cicadulina spp*.), maize black aphid (*Rhopalosiphum maidis*) and maize cob borer (*Helicoverpa armigera*) were observed as the major insects pests on maize. While, rove beetle, lady bird beetle and spider observed as major natural enemies against insects of maize. In the evaluation of the bioefficacy of granular insecticide molecules against pink stem borer, it was found that the minimum leaf injury rating was recorded with carbofuran (3.00) which was at par with flubendamide (3.23) followed by thiamethoxam (3.43), emamectin benzoate (3.57), rynaxypyr (4.03) and cartap hydrochloride (4.17) treated plots. The highest leaf injury mean was recorded 4.20 with fipronil. The minimum per cent of dead heart damage was recorded with carbofuran 36.67% which was at par with flubendamide 43.33% followed by rynaxypyr 45.50%, thiamethoxam 46.67%, emamectin benzoate 50.0%, and cartap hydrochloride 56.67% treated plots. The highest per cent dead heart damage was recorded with fipronil 60.0%. The grain yield was also significantly highly influenced by carbofuron 3 G followed by flubendamide 20 WG, thiamethoxam 25 WG, emamectin benzoate 5 SG and cartap hydrochloride 4 G, rynaxypyr 0.4% G and fipronil 0.3% G.
In the study of the relative performance of popular maize hybrids against pink stem borer it was observed that the genotype HISHELL gave maximum grain yield whereas genotypes IAHM-2013-26 and IAHM-2013-09 showed maximum number of pinholes, leaf injury rating, dead heart per cent, stem tunneling and stem exit hole.

Keywords: *Zea mays*, Maize stem borer, *Sesamia inferens*, evaluation, genotype

Introduction
Maize (*Zea mays* L.) being the highest yielding cereal crop in the world is of significant importance for countries like India, where rapidly increasing population already out stripped the available food supplies. Maize crop possesses great genetic diversity and can be grown across varied agro ecological zones (*Ferdu et al*., 2002) [20]. In India, maize is emerging as third most important crop after rice and wheat. Its importance lies in the fact that it is not only used as human food and animal feed but at the same time it is also widely used in corn starch industry, corn oil production, and as baby corn in different recipes (Singh, 2014) [7, 64]. The leafy stalk produces ears which contain the grain, which are seeds called kernels. Maize kernels are often used in cooking as a starch. The six major type of maize are dent, flint, pod, popcorn, flour, and sweet corn (Smith, 2013) [65].
Insects attack maize throughout the cropping cycle and during storage, resulting in as little as 10% to complete loss (Bergvinson *et al*., 2002) [12].
In India, maize production is greatly affected by the infestation of two insect pests, spotted stem borer *Chilo partellus* (Swinhoe) and pink borer *Sesamia inferens* (Walker). Spotted stem borer is restricted to the northern part of the country during rainy season, pink borer causes extensive damage to the crop in the peninsular India throughout the year and across the country (Santosh *et.al*, 2012) [54], pink stem borer,
Sesamia inferens (Walker) is one of the major borer pests recorded mainly during *rabi* season (Jalali and Singh, 2002) [12, 27]. Larvae are found feeding on immature cobs, silks and tassel and severe infestation result in stunted plant growth and appearance of cob and tassel at one place (Reddy *et al*., 2003) [49].

Insects attack on the maize crop throughout the cropping season and pink stem borer, *Sesamia inferens* is major insect pest of maize in Peninsular India during *Kharif* and *Rabi*. The loss primarily due to *S. inferens* in *Kharif* varies from 60 to 81.7% and in *Rabi* (winter) it varies from 25.7 to 78.9% (Sekhar *et al*., 2009) [56, 57].

Review and literature

Fletcher (1914) [21] reported that maize crop was attacked by more than 11 different insects in south India.

Gurney (1918) [24] reported that about 25 species of insects in New South Wales and more than 120 species in South U.S.S.R.

Butani (1961) [15] reported that the maize crop was visited by a number of pests. Some chew the leaves, other snip off the stems and still other concentrate on the cobs. Some important pests of maize include maize stem borer, bihar hairy caterpillar, hairy caterpillars and brown field cricket. Minor ones are termites, aphids, rice grasshopper and wheat stem borer.

Shapiro *et al.* (1962) [59] made an extensive survey of the insects associated with maize in Thailand during 1959-65. They reported about 75 species of insects infesting the standing crop.

Rajagopal and Channabasavanna (1975) [47] recorded nine species of insects on maize *viz., Chilo zonellus* Swinhoe, *Sesamia inferens* Walker, *Heliothis armigera* (Hubner), *Marasmia trapezalis* Guen, *Mythimna seperata* Walker, *Rhopalosiphum maidis* Fitch, *Cicadulina bipunctella bipunctella* (Mats). *Carpophilus* sp. and *Myllocerus discolor* Boh. were common.

Ghouri *et al*. (1978) [23] reported that application of granules containing diazinon 10 percent or cartap hydrochloride 4G and carbaryl @ 0.2 per cent twice during crop growth was profitable in Nagpur.

Hirai (1991) [26] reported some major pests of maize in Japan including *Pseudaletia separata* [*Mythimna separata*], *Ostrinia furnacalis*, wireworms [Elateridae], *Rhopalosiphum maidis, R. padi*, pink borer [*Sesamia inferens*], black cutworm [*Agrotis ipsilon*], seedcorn maggot [*Delia platura*] Among these, *M. separata, O. furnacalis*, the aphids, were found economically most important pests.

Lutfallah *et al*. (1993) [36] recorded high infestation of *R. maidis* in the tasselling stage during the pollination period (70 days after sowing) on maize in Egypt.

Atiyeh *et al*. (1996) [11] observed that the aphid population was significantly higher at the silking stage (8.29 aphids /leaf) on maize in Pakistan.

Ganguli and Ganguli (1998) [22] evaluated effect of cypermethrin 25 EC @ 0.005%, deltamethrin 2.8 EC @ 0.002%, endosulfon 35 EC @ 0.035%, Green mark @ 0.4%, Achook @ 0.04%, triazophos 40 EC @0.04% and carbofuran 3G @ 7.5 kg/ha in leaf whorl for their residual toxicity against *C. partellus* under laboratory and field conditions. Carbofuran 3G @ 7.5 kg/ha in leaf whorl was the most persistant amongst all treatments registering maximum PT and Lt 50 *i.e.* 1163.06 and 271.25 hrs, under laboratory conditions and 831.41 and 194.30 hrs under field conditions, respectively. Endosulfan 35 EC @ 0.035% was next best in order of effectiveness.

Harjit and Deol (1999) [25] observed that the population growth of the maize leaf aphid, *R. maidis* on wheat variety HD 2329 and barley variety PL 172. The highest population build up in both the crops was during mid March at heading stage. Among the various hosts, barley was the most preferred crop wheat was more preferred than maize, oat and sugarcane were the least preferred crops.

Khan *et al*. (1999) [33] reported that carbofuran 3G @ 10 kg ha^{-1} and phorate 10G @ 12 kg ha^{-1} were the most effective against *C. partellus* on maize in Pakistan.

Nsami *et al.* (2001) [41] considered the distribution and species composition of cereal stem borers in the eastern zone of Tanzania. They found that field infestation by the stem borers ranged between 2 and 40 per cent. Most of the fields that were between tasseling and maturity stages recorded infestation of 5 to 15 per cent while fields that were still at the vegetative stage recorded 20 to 40 per cent infestation.

Parikh (2001) [44] reported that the established significant positive correlation between predatory coccinellids and sunshine hours on maize where as bright sunshine hours influenced positively with the population of C. sexmaculata on maize and wheat crops. Rainfall and wind speed showed negative influence on the activity of coccinellid beetles.

Rao and Panwar (2001) [48] evaluated seven genotypes against maize stalk borer, on the basis of leaf injury rating. Antigua Gr-1 and Deccan-103 were found resistant to maize stalk borer, pusa Comp.-I, Cm-300 and Deccan-105 were highly susceptible, while Kiran and Ganga-11 were moderately resistant.

Ding *et al*. (2002) [19] found four aphid species attacking on the maize plants. *R. maidis* was the dominant species. The fluctuation in the mixed populations of aphids exhibited two peaks in mid and late May and late June. *R. maidis, R. padi*. and *Sitobion avenae* Fabricius, showed a collective distribution on the plants throughout the whole growth period.

Muhammad and Khawaja (2002) [39] reported that maize stem borer, *C. partellus* is most dominant contributing 90-95 per cent of the total damage in *Kharif* season.

Talpur *et al*. (2002) [67] reported that carbofuran 3G @ 9 kg/acre, cartap hydrochloride 4G @ 9kg/acre, diazinon 10 per cent G @ 9 kg/acre and phonrate 5G @ 10 kg/acre were effective against *C. infuscatellus* in sugarcane.

Kakar *et al*. (2003) [30] tested four granular insecticides *viz*., diazinon 10G @ 19.75 kg ha^{-1}, aldicarb 10G @ 17.75 kg ha^{-1}, carbofuran 3G @ 19.76 kg $ha^{-1}$and cartap hydrochloride 4G @ 22.23 kg ha^{-1} against maize stem borer *C. partellus*. Maximum net benefit (Rs. 4851.77 over the control) was obtained with application of carbofuran 3G, followed by cartap hydrochloride 4G (Rs. 3636.17), aldicarb 10G (Rs. 3431.17) and diazinon 10G (Rs. 2214.97) under field conditions.

Khan and Monobrullah (2003) [32] screened 40 maize germplasm/entries, including seven hybrids (KH-510, KH-517, Hybrid Maize-47, GS-2, K-26, Apna Makka and HM-4640), against *C. partellus* during *Kharif* 2001 (June-August) in Rajouri, Jammu and Kashmir, India. All the 7 hybrids and 5 other entries (VL-90, Harsha Composite, Surya, Ageti FS and VL Makka-16) had no infestation by stem borer. The entries C-14, Arun, Ageti S1, Aeti S3, Ageti HS, Ageti-76, Him-123, Him-123, Him-129, Ashwani, Super-1 and HS-5 recorded less than 10 per cent infestation. The third group comprised NE Composite HS, Dhaned, Vivek-5, FH-3077, Pusa Composite, Keshri, CM-140 and Prabhat HS where the stem borer damage was 10-20 percent plants. The other entries, namely Suwan Composite, Dholi, Navjot, NE Composite FS, Pratap, Megha, CM-139, Vijay Composite and VL Makka-42 were found comparatively more susceptible to *C. partellus* recording more than 20 per cent infestation. The

most susceptible to genotype was VL Makka-42 followed by Vijay Composite with a mean infestation of 42.22 and 35.55 per cent, respectively.

Jalali and Singh (2003) [28] studied the seasonal activity of stem borers and their natural enemies on fodder maize in Bangalore district from June 1994 to May 1996. The highest infestation of 39 per cent and 31.70 per cent was recorded during first year and second year of *Kharif* season, respectively. Data recorded for two years showed that infestation started building up in late summer season resulting in high infestation during ensuing *Kharif* season.

Sohail *et al*. (2003) [66] reported that carbofuran 3G (11kg/acre), cypermethrin 10 EC (150 ml/acre) and fipronil 10G (220 ml/acre) were effective against *C. partellus* on maize.

Lavakumar *et al.* (2004) [50] studied the bio-efficacy of insecticides, based on leaf injury and stem tunneled by the borer, grain yield and cost benefit ratio showed that endosulfan (0.1%) at 15 days after germination (DAG) followed by NSKE (0.5%) spray at 15 DAG + endosulfan (0.1%) spray at 30 DAG and two sprays of NSKE (0.5%) at 15 DAG and 25 DAG proved highly effective.

Shukla and Kumar (2005) [61] reported that the maize stem borer, *C. partellus*, a serious pest of maize, sorghum and other cereals, is distributed in almost all maize growing areas like Africa and Asia.

Pal and Bandopadhyay (2006) [41] conducted an experiment was study the reaction of 14 maize germplasm against the stem borer, *C. partellus* and the aphid, *R. maidis* where in the germplasm reacted differentially against these two pests. The varieties *viz*., VL-88, HIM-129, JM-8, RCM-1-1 and KH-517 had no infestation of stem borer while the variety, FH-3477 showed more infestation. The varieties *viz*., VL-Popcorn and KH-517 were categorized as resistant to the aphid. On the other hand the varieties HIM-129 and RCM-1-2 were comparatively more susceptible to the aphid.

Sardana (2006) [55] who reported that the predatory spiders and coccinellids were present throughout the crop growth during September to mid-March.

Shahzad *et al.* (2006) [58] screened ten maize cultivars against maize borer (*C. partellus*) and shoot fly (*A. soccata*). EV-5098, EV-6098, EV-6089, Sahiwal-2002 and EV-1098 produced the highest grain yield of 3571, 3533, 3196, 3186 and 2915 kg/ha, respectively. Comparatively, the lower maize borer and shoot fly infestation was recorded in the promising strains *viz*., EV-5098, EV-6098, Agaiti-2002 and EV-1098. These genotypes were considered as tolerant to shoot fly and resistant to stem borer and had an average incidence of shoot fly up to 10.67, 15.21, 11.97 and 13.35 per cent and of stem borer up to 3.38, 4.17, 2.93, and 3.48 per cent, respectively.

Abid-Farid *et al.* (2007) [2] observed that the maize stem borer damage varied from 10 to 50 per cent in Peshawar valley during 2003. Most of the borer damage occurred when the crop was in early vegetative stage and by the time it reached tasseling, no further increase in damage was observed. The activity of adult moths started after the middle of March and continued to until the middle of May, after which a decline in population was observed in June.

Arabjafari and Jalali (2007) [10] screened 26 popular varieties of maize in Karnataka state (India) for resistance to *C. partellus*. In field trial, varieties CM 132, CM 137 and PMZ 103 showed the highest level of resistance, while the varieties GK 3014, HY 4642 and DK 984 had the lowest level of resistance.

Chavan *et al.* (2007) [16] evaluated 77 maize germplasm lines belonging to full season maturity (16 entries), medium maturity (31 entries) and extra early maturity group (30 entries) for resistance to stem borer. The leaf injury rating due to *C. partellus* damage ranged from 2.4 to 6.4 on 1-9 rating scale in different maturity groups. The least susceptible germplasms (<3.0 rating) included Arbhat, BIO 9681 and KMH-22202 (full season maturity); HKH-1191, L-166, CM-500 and KMH-22205 (medium maturity) and JH-31053, CHH-215 and CM-500 (extra early maturity). NECH-129, SEEDTEC-2324 (full season maturity); CHH-219, X-85, KH-510 (medium maturity) and FH-3277, VL-108, DEH-10103, HIM-129 (extra early maturity) were found highly susceptible (>6.0 rating).

Choudhary and Shrivastava (2007) [17] conducted an experiment on incidence of *Sesamia inferens* Walk. in Sugarcane. The Co 86032 recorded maximum infestation (19.0%) among the nineteen per cent bored canes, four types of damaging pattern were observed. First type canes were infested at apical portion (12.5%), which resulted in apical growing bud destruction and no further growth takes place. Second, third and fourth type, was observed as inter node borer and made one (4.0 %), two (1.8 %) and three entrance holes (0.7 %), respectively. In second, third and fourth types of bored canes, it was found that effect on growth was negligible, but buds germinated in standing cane.

Teli *et al*. (2007) [68] studied the efficacy of seven insecticides including biopesticides against *C. partellus* on maize plants releasing ten one day old neonate larvae on next day after application of insecticides. The single application of deltamethrin @ 175 ml in 250 liters of water at 15 days after germination proved to be the most effective treatment, exhibiting lowest infestation (5.79%) and lowest leaf injury rating score (1.07) with no dead hearts. Fipronil 5 EC was the next best treatment followed by the treatment with endosulfan 35 EC. However, considering overall data and B: C ratio, deltamethrin and endosulfan emerged as effective and economical treatments.

Ahad *et al.* (2008) [4] studied population dynamics of maize stem borer. The mean seasonal incidence of *C. partellus* was found maximum (47.00) in the 29th SMW. Whereas the mean incidence (dead heart + leaf Infestation) was maximum (23.16) in 41st SMW.

Jindal and Hari (2008) [29] evaluated five maize genotypes for their response to *C.partellus* under laboratory and field conditions. The number of egg masses and total number of eggs per plant on different genotypes did not differ significantly in no choice test, however it was significantly more on Basi local than CML 67 in dual- choice test. The leaf area feed, larval weight gained, leaf injury ratings, larval recovery and stem tunneling were less in CML 67 and CN 500. However, larval survival did not vary among different cultivars. Data on regression of FPLI indicated that antibiosis and tolerance mechanism were present in cultivars CML 67 and CN 500 but absent in Basi local. The cultivars PMH 1 and JH 3459 showed the presence of tolerance mechanism against *C. partellus.*

Adda *et al.* (2009) [3] observed the effect of various Planting dates on the incidence and damage to maize by *Sesamia calamistis* (Hampson). The variables measured included population density of *S. calamistis*, percentage of infested plants and cob damage. In the main cropping season, incidence of stem borers and percentage of infested plants

were higher in the late planting than in the early planting and intermediate planting treatments.

Sekhar *et al.* (2009) [56, 57] worked at Directorate of Maize Research, Hyderabad and reported appropriate method of infestation for screening maize genotypes against pink borer. Release of 15-20 neonates between first leaf sheath and stem it was observed to be the most reliable method. Appropriate larval load and crop stage for effective infestation were also determined.

Biradar (2010) [14] found that the higher number of shoot fly eggs per leaf was in the month of September, March and April. The higher number of pin holes due to stem borer was in the month of August, while December and June recorded lower numbers. Similarly, maximum (62%) dead hearts by stem borer were noticed during the month of July and minimum (32%) in the month of June, December and January.

Ahmad *et al.* (2011) [5] studied the relative efficacy of different insecticides as seed dressers, granules and foliar formulations against maize stem borer (MSB) (*Chilo partellus*) in maize crop. The results of both the field experiments were some what similar where seed dressers (Confidor® and Actara®) were found considerably more effective as compared to granules and foliar sprays. As a whole the insecticides treatments resulted in 50% reduction of MSB infestation as compared to control. Confidor® was the most effective among the treatments causing 97.30 % reduction in *C partellus*. infestation. This was followed by Actara® with 88% infestation reduction as compared to control.

Biradar *et al.* (2011) [13] carried out an experiment on seasonal incidence of insect pest. The higher number of shoot fly an egg per leaf was noticed during the month of September, March and April (3.00 eggs/sq cm leaf area). The higher number of pin holes due to stem borer was noticed during the months of August and lower during the months of December and June. Similarly, maximum dead hearts due to stem borer were noticed during the month of July (62%) and minimum during the month of June, December and January (32%). The peak population of aphids was observed during the month of April, higher larval population of cob worm was noticed during April, while lower population was during June. Correspondingly, maximum damage by cob worm was during February and minimum damage was observed during June.

Li *et al.* (2011) [35] conducted an experiment on insecticides against pink stem borer, *Sesamia inferens* (Walker). Among the insecticides that were used to control *C. suppressalis*, cartap and permethrin were more effective than chlorpyrifos and carbofuran against *Sesamia inferens*. Compared to the Hsinchu susceptible strain, < 3-fold resistance of cartap, chlorpyrifos and carbofuran, 3 to 9 fold resistance of permethrin, and up to 17-fold resistance of spinosad have been found in the field strain of *Sesamia inferens*. However, *Sesamia inferens* was 25-fold less sensitive to chlorpyrifos than *C. suppressalis* whcih has developed 1000-fold resistance to carbofuran.

Pavani *et al.* (2011) [46] conducted screening of twenty maize genotypes *viz.*, HQPM 1, DHM 117, 30V92, Winsynthetic, HKI 163-1, HKI 193-1, BML 6, BML 7, HKIMBR-139, HKIC322, V351, DMRQPM58, CM 132,CM137, CM 139, CM 144, CM 202, CM 212, CM 500 and Basi local with artificial infestation of *S. inferens*, the LIR ranged from 2.8 to 9.0 and per cent dead hearts from 0.0 to 100.The genotypes, showing maximum LIR ranging from 7 to 9 indicated their susceptibility with more than 50.0 per cent dead hearts. Some genotypes showing LIR of more than 7 indicating moderate susceptibility recorded low percent dead hearts. Among the twenty maize genotypes none of them recorded mean LIR less than or equal to the resistant check (2.8).

Ahmad (2012) [6] observed the relative efficacy of granule insecticides against the sugarcane stem borer, *Chilo infuscatellus* Snellen. Minimum infestation of sugar cane stem borer was observed after the treatments with Furadan (10.22%) followed by Thimet (11.35%), Padan (12.45%) and Monomehypo (13.84%) when compared with the control (26.13%). Findings of the present study could be helpful in the chemical based management of sugarcane stem borer using Furadan.

Anuradha (2012) conducted a field experiment during *Kharif* 2009 and *Rabi* 2009-10 to evaluate the different doses of Thiamethoxam30FS as seed treatment chemical for controlling maize stem borers, *Chilo partellus* Swinhoe and *Sesamia inferens* Walker. Among the doses tested, higher dose of thiamethoxam 30FS (8 ml/kg) proved superior resulting in 0.38 per cent dead hearts during *Kharif* and 6.43 per cent dead hearts during *Rabi* compared to 0.79 per cent and 14.76 per cent in untreated check.

Anuradha *et al.* (2012) conducted an experiment to evaluate three modules against cob borer complex in corn (hybrid-30V92) at silking stage. First module comprised of chlorantriniliprole 20 SC, pheromone traps with helilure and litlure. Second module comprised of chlorantriniliprole 0.4 G, flubendamide 480 SC, pheromone traps with helilure and litlure. Both modules were effective than the untreated control (31.86% undamaged cobs). Cobs with live larvae of *Spodoptera litura*, *Sesamia inferens*, *Helicoverpa armigera* and *Euproctis sp* in the first module was 3.46%, 9.86%, 1.42% and 0.04% respectively compared to 12.65%, 16.02%, 8.25% and 1.95% respectively in control.

Mallapur *et al.* (2012) surveyed the incidence of stem borers in maize. The survey data indicated that stem borers and *Sesamia inferens* Walker incidence was quite prominent in all the places surveyed. Endosulfan 35EC, Phorate 10G and Carbofuran 3G were used to combat stem borer menace. The stem borer infestation varied enormously among different cultivated maize hybrids (2.33 to 32.60%).

Sahito *et al.* (2012) conducted an experiment on fluctuation of insect pests and predators in maize, *Zea may* L. Result showed the overall seasonal mean population of thrips (5.69) followed by black aphid (4.17), leaf stem borer (0.61), leaf aphid (0.96), shoot fly (0.08)/ plant. In case of predators, the big eyed bug was recorded (1.27) followed by seven spotted ladybird beetle (0.44), zigzag beetle (0.69), eleven spotted beetle (0.07), *brumus* (0.50), green lacewing (0.78) /plant, respectively, in the field of maize.

Sailaja *et al.* (2012) conducted an experiment at Rajendranagar, Hyderabad on field screening to study the reaction of *S. inferens* to ten maize genotypes *viz.*, BML 7, BML 6, MP 717, BH 1576, HQPM 1, HKI 163, Madhuri, BH 40625, Basi local and CM 500. All the plants were infested in each plot with ten neonate larvae of *S. inferens*. The leaf injury by *S. inferens* in ten maize genotypes varied from 5.03 to 7.9.

Santosh *et al.* (2012) [54] conducted an experiment at pink borer (*Sesamia inferens* Walker). Among various control measures resistance breeding is one of the most viable and

sustainable options to control this insect pest. In the present investigation response of 48 promising maize inbred lines belonging to diverse sources to pink borer was analyzed and reported for the first time the inheritance pattern of resistance against pink borer in maize.

Saleem *et al.* (2012) studied on maize stem borer infestation. Results revealed that there was significant difference between granules and insecticides. Carbofuron 3G was recorded the most effective followed by Fipronil 4G. Average dead hearts count for Carbofuron 3G were 3.167 followed by 4.4 for Fipronil 4G.

Deole *et al.* (2013) conducted the field level trials and screened 26 hybrid maize genotypes and found the pink stem borer *Sesamia inferens* as the major stem borer in Chhattisgarh State.

Khamis *et al.* (2013) conducted an experiment at Maize Research Department, Agriculture Research Center, Giza, Egypt and evaluated twenty exotic maize populations to determine their level of resistance to the pink stem borer *Sesamia spp.* under natural infestation. Highly significant correlation coefficients were found among pairs of the three resistance expressing traits under artificial infestation which were exotic.

Lella and Srivastav (2013) carried out an investigations on the screening of Maize genotypes against maize stem borer *Chilo partellus* in *Kharif* season to screen the relative resistance /susceptibility of 19 genotypes of maize to the insect pest, maize stem borer (*Chilo partellus*). Entire screening was based on leaf damage, dead heart formation, no. of exit holes. No of larvae and pupae population and mean tunnel length. Dead heart formations were higher in more susceptible genotypes than least susceptible genotypes. There were no sign of dead heart was found in cultivar HUZQPM 242, HUZQPM 246, QPM 193, CM 119, AH 411, HUM 152, NMH 9858, HUZM 185, HUZM 217. Maximum occurrences of dead heart were in cultivar HUZM 227, QPM 169. Leaf damage was measured on visual rating scale. In context of leaf injury rating mean was 2.6 to 6.6. Maximum leaf damage was reported on cultivar QPM 169.

Mahesh *et al.* (2013) used dead heart incidence as the parameter for screening among all accessions across the years. The minimum incidence of The borer (1.47 %) was recorded in Ng 77–93 while The maximum (29.41 %) was in 57 Ng 111. grouping of accessions on The basis of dead heart showed 17 (15.45 %) as resistant,50 (45.45 %) as Moderately Resistant, 36 (32.72 %) as Susceptible and 7 (6.36 %) as Highly Susceptible.

Patra *et al.* (2013) conducted an experiment to study the pest complex and assess their damage in maize. Total twenty four insect pests and some natural enemies including seven coccinellid beetles and two predatory bugs and thirteen spider species were recorded in maize. Among these, stem borer (*Chilo partellus* Swin.), cob borer (*Stenachroia elongella* Hamp.) and shoot fly (*Atherigona soccata* Rond.) were found to be as major pests, seventeen insects as minor pest and others considered as stray pests. Crop damaged by major pests were estimated at 8.5 and 21.75% by shoot fly, 15.67 and 13.45% by stem borer and 11.95 and 6.5% by cob borer during 2010 and 2011, respectively.

Pavani *et al*. (2013) conducted an experiment at Rajendranagar, Hyderabad, Andhra Pradesh, on evaluation of efficacy of different insecticides and bioagents against *Sesamia inferens* Walker in maize. Endosulfan was found to be more effective with 4.55 leaf injury rating, 26.25 per cent dead hearts, 0.33 cm per meter stem tunneling, 0.45 exit holes per plant, and 41.66 percentage of live larval recovery as compared to carbofuran, *B. bassiana* and *B. thuringiensis* against pink stem borer of maize.

Shawkhatuzzaman *et al*. (2013) [60] carried out a field experiment to screen out the wheat varieties/lines that resistance to pink stem borer, *Sesamia inferens* (Walker). The infestation varied significantly among the varieties/lines and also with the age of wheat plant. The highest percentage (90) of infestation was observed at mature stage as white head and lowest percentage (31) was in early stage as dead heart. The rate of infestation gradually increases with the increase of plant age. Sonalika and Kanchan were found comparatively resistant against pink stem borer infestation.

Abdalla and Raguraman (2014) [1] evaluated thirty four maize genotypes for resistance to stem borer *Chilo partellus* (Swinhoe). This study reveals that the leaf injury rating ranged from 1.25 to 7 on a 1-9 rating scale.

Ali *et al.* (2014) [7] conducted field experiments to determine the comparative efficacy of different management practices against *Chilo partellus* (Swinhoe) in *Kharif* maize. All the treatments were found significantly effective in reducing the infestation of stem borer and increasing the yield compared with control. Treatment indoxacarb 14.5 SC @ 500 ml/ha was found best with minimum per cent infestation and leaf injury followed by endosulfan 35 EC @ 1.5 lit/ha. The minimum number of dead hearts was also recorded with treatment indoxacarb 14.5 SC @ 500 ml/ha and next effective treatments were maize+cowpea (intercropping) and imidacloprid 17.8 SL @ 7 ml/kg.

Nyukuri (2014) [42] reported the effect of agro meteorological factors on population fluctuation of lady bird beetle to be the highest among coccinellids. Rainfall and relative humidity ($F = 3.675$, $P < 0.05$) effects on a lower level. Rainfall ($r = -0.162$) and relative humidity ($r = -0.084$) were both inversely correlated with the abundance of Coccinellids. On the other hand, temperature were significant positively correlated ($r = 0.159$) with the abundance of coccinellid.

Nagarjuna *et al*. (2015) [40] studied varietal screening of maize hybrids against stem borer on nine hybrids of maize *i.e*. Allrounder, 900-M-Gold, NAH-2049, Topstar, Topclass, Rajkumar, Bioseed-9544, CP- 818 and CP- 828. Significant differences among hybrids regarding per cent infestation, per cent cob damage, pin holes, dead hearts, weight of stalks and grains. CP- 828 recording lowest of 3.87 per cent infested plants, 3.92 per cent cob damage, 4.04 dead hearts, 13.00 pin holes/plant and maximum of 96.54 qha^{-1} straw and 44.69 qha^{-1} grain yield proved to be the most tolerant variety.

Sidar *et al.*, (2015a) [62] reported some major pest on maize crop in Chhattisgarh plains including incidence of Pink stem borer (*Sesamia inferens*), green stink bug *(Nezara viridula)*, leaf hopper (*Cicadulina spp.*), black aphid (*Rhopalosiphum maidis)* and cob borer (*Helicoverpa armigera*) were appeared on the maize crop during crop growing period. The higher number of pin holes (24 plant-1) and percentage of dead hearts (60%) of pink stem borer were recorded during the second week of September and fourth week of September as compare to other months, respectively. The peak population mean of black aphid (30 plant-1) was recorded in the third week of September, while the green sting bug (1.80 plant-1) attained their highest in second week of September and the

highest population mean of cob borer was recorded during the fourth week October.

Sidar *et al*., (2015b) [63] study the seasonal incidence of major natural enemies of maize crop pests under Chhattisgarh plains. The study revealed that, the incidence of lady bird beetle, rove beetle and spider spp. In this context, peak activity of the lady bird beetle was notice during the fourth week of September which was associated with 33.4°C maximum temperatures, 24.0°C minimum temperature, 93% morning R.H., 57% evening R.H., 2.1Km/h wind velocity and Sunshine hours of 8.3 lux. The peak activity of rove beetle was notice during the second week of September, during this period, maximum and minimum temperature, morning and evening relative humidity, wind velocity and bright sunshine hours were observed as 30.50C, 24.30C, 95%, 79%, 5.8 km/h and 3.4 h/day. The peak activity of spider spp (*Oxyopidae* sp., *Araneidae* sp., *Amphinectidae* sp. and *Agelenidae* sp.) was observed during the fourth week of September which was associated with 33.4 0C maximum temperature, 24.00C minimum temperature, 93% morning R.H., 57% evening R.H., 2.1Km/h wind velocity and Sunshine hours of 8.3 lux.

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