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Varietal screening of local and hybrid maize cultivars against *Chilo partellus* (Swinhoe) under field conditions

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Abstract

The yield of maize crop is incredibly affected by many herbivores with stem borer (*Chilo partellus* Swinhoe) being recognized as one of the considerable limiting factor that causes serious losses to corn production all over the world. As the knowledge regarding its susceptibility is lacking, therefore studies on its occurrence and prevalence was carried out in six local (Sahiwal-2002, Neelam, Agaiti-85) and hybrid (Mon-6714, TG-46B90, Mon-6789) maize cultivars during the year 2017, at Post Graduate Entomological Research Farm, University of Agriculture Faisalabad Pakistan. The results indicate that amongst various maize genotypes screened; hybrid TG 46B90 (0.0357), Mon-6714 (0.0470) and Mon-6789 (0.0537) were found least susceptible while local Sahiwal-2002 (0.0674), Agaiti-85 (0.0675) and Neelam (0.0869) were found susceptible to plant percent infestation on the basis of plant infestation rating scale. The hybrid genotype TG 46B90 (0.2), Mon-6714 (0.2666) and Mon-6789 (0.2) were found least susceptible while local check Sahiwal-2002 (0.5), Agaiti-85 (0.5) and Neelam (0.2866) were found susceptible to percent dead heart formation. Maximum mean larval infestation was found on Agaiti-85 (1.1333), Mon-6714 (1.0666) and Neelam (1.2) while larval infestation in Sahiwal-2002 (1), Mon-6789 (0.8666) and TG 46B90 (0.9333) was found minimum. Genotypes TG 46B90 (0.1533), Agaiti-85 (0.1733) and Mon-6789 (0.0733) were found resistant while genotypes Sahiwal-2002 (0.3333), Mon-6714 (0.2066) and Neelam (0.2733) were found moderately resistant to pupal infestation. These results affirm higher ability of resistant genotypes to resist against stem borer infestation and are therefore recommended for cultivation in stem borer sensitive areas.

Keywords: Maize, *Chilo partellus*, swinhoe, field and hybrid

Introduction

Agriculture has much importance and is playing a vital role in economics development of Pakistan. Pakistan agriculture improvement to Gross Domestic Product (GDP) is 21% along with an annual progress of 2.7% (GOP, 2004-05). Maize is a monoecious and very well cross pollinated plant being the topmost yielding cereal crop in the world with significance importance in countries like Pakistan due to constantly increasing population pressure (PBS, 2014). Maize is the third most important crop after wheat and rice. It is planted on a supposed area of 1334 thousand hectares with an annual yield of 6.13 million tones displaying an increase of 5.271 percent over the last decade (GOP, 2017).

Maize has much greater nutritional composition as it consists of 71.88g starch, 8.84g protein, 4.57g fat, 2.15g fiber, 2.33g ash, 10.23g moisture, 348mg phosphorous, 15.9mg sodium, 114mg sulfur, 0.10mg riboflavin, 1.78mg amino acids, 1.5g minerals, 10mg calcium, 2.3mg iron, 286mg potassium, 0.42mg thiamine, 0.12mg vitamin C, 139mg magnesium, 0.14mg copper (Shah, 2015; Kumar, 2013; Gopalan, 2007; Prasad, 2016; Balasubramanian, 2007).

There are many factors which are accountable for low average yield of maize crop (Shah *et al*., 2009) among these factors insect pests are of major importance (Gara, 2007). Maize is attacked by 140 different insect pests' species with their various level of infestation percentage (Anonymous, 2015) among these 140 insect pest species only few are serious pests of maize crop causing infestation from sowing to harvesting and in storage conditions. Most substantial pests are (stem borer, army worm, termites, aphids, seed corn maggots, white grub, thrips, Indian meal moth, root worm, grain weevil, and grain borer (Lina and Luthe, 2018) among these insect pests stem borers are most serious pests of maize. The level of pest infestation depends upon the environmental conditions, cultivation practices and mode of storage conditions (Arabjafari and Jalali, 2007).

Infestation due to Maize stem borer, (*Chilo partellus*) at seedling stage may cause huge damage to maize crop and in some cases exhaustive failure of crop (Kavita *et al*., 2016; Yonow *et al*., 2017). It has been recorded to cause infestation to the range of 42.29% and in severe condition it causes yield reduction up-to 50% and 75% (Sharma and Gautam, 2010; Dejen *et al*., 2014). It is the fundamental pest of low land areas (Yonow *et al*., 2017). Maize stem borer (*Chilo partellus*) larvae bore into stem by making tunnels, and take 30-40 days to complete its life cycle (Lella and Srivastav, 2013). Feeding style of this pest conserves it from natural enemies like parasitoids and insecticides (Siddalingappa *et al*., 2010). The larvae grow rapidly and 4th instars larvae use more food than rest (Shahbaz *et al*., 2015; Khan *et al*., 2017; Yonow *et al*., 2017).

Pupal period lasts for 7-10 days and eggs hatch within 5-6 days (Panchal and Kachole, 2013) larval stages are more destructive than adults (Yonow et al., 2017). The Maize stem borer not only causes mechanical infestation but also cause aperture of crop, resulting in reduction of photosynthetic area of leaves followed by poor cereal yield (Kumar, 2002).

Huge damages of maize stem borer, (*Chilo partellus*) are due to deficiencies of resistant cultivars which play a substantial role in the management of these dangerous pests. There is no perpetual solution to manage this pest except chemical control (Rauf *et al*., 2017). Nevertheless bio-control agents like, pathogens, parasitoids and predators restrain the population outgrowth of maize stem borer but their movement is not enough to minimize the pest infestation below the economic injury level (Divyal *et al*., 2009). Resistant maize cultivars can be a safe solution for minimizing pesticide use and may help in reconstructing natural balance along with enhancing the movement of bio-control agents (Jindal, 2008; Hafeez, 2009; Anuradha, 2012; Vishvendra *et al*., 2017).

Physico-morphic parameters of maize plant contribute a lot in positive correlation and level of resistance (Saeed *et al*., 2006). The chemical and physical plant parameters of the host plant also clout the nutrition of the insect by inhibiting the amount of feeding (Rasool *et al*., 2017) due to color, texture and shape (Ali *et al*, 2015) which may restrict the ingestion of nutritive food but also influence the digestibility and usage of food by the insect pest (Chavan *et al*., 2007).

Maize stem borer, (*Chilo partellus*) feeding in cereals is advanced by sugar constituents present in stem (Sarwar, 2012). An important constituent of Integrated Pest Management (IPM) which is compatible with other restriction methods, environment friendly and is packaged in seed is the Host Plant Resistance. Herbivores and natural enemies are affected positively or negatively by the structure of plant (Afzal and Bashir, 2007) morphological features of maize plant play a vital role in host plant resistance against stem borer (Rebe *et al*., 2004).

A significant factor due to which augment behavior of maize stem borer influences is leaf decisiveness (Malvar *et al*., 2008). Now days with the advancement of insect resistance to insecticides, detrimental effects of insecticides on natural enemies, and public alertness of environment conservation, there has been a refreshed interest in the recognition and advancement of maize genotypes with resistance to field pests as well as storage insect pests (Khan *et al*., 2017; Ali *et al*., 2015). The maize cultivars featured with high ability to resist and tolerate stem borer prevalence can play a major role in maize breeding programs and economics value of various pests' management practices (Anuradha, 2012; Yonow *et al*., 2017).

Keeping the aspect of significance of maize stem borer, *Chilo partellus* in the region, research was projected with an objective to identify and screen out the resistant cultivars from majority of the accessible material in Pakistan and to analysis the role of morphological plant features as mechanism of resistance to this pest.

Material and Methods

Experiment site

A field experiment was directed in the summer season of from August 2017 to January 2018 at Post Graduate Entomological Research Farm, University of Agriculture Faisalabad, Pakistan to screen comparative resistance or susceptibility of 6 local and hybrid maize cultivars against the insect pest, maize stem borer (*Chilo partellus*).

Plant material

The genetic substantial in this research experiment include 6 advanced local (Sahiwal-2002, Agaiti-85, Neelam) and hybrid (Mon-6714, Mon-6789, TG 46B90) maize cultivars acquired from different research farms to estimate their resistance/ susceptibility against stem borer, (*Chilo partellus*). The research experiment was carried out in Randomized Complete Block Design with each treatment consisting of three replications. Planting was done manually in plots consisting of 8 rows, 3.4 meter long which spaced 75 cm between rows and 20 cm between plant, size of single plant was 12.5 x 11.43 ft^2 while total area was planted 505.86 Esq.

Cultural practices

The soil of the experiment plot was sandy clay in nature and well prepared. Weeding was done properly from sowing till harvesting, with first weeding after 25 days of sowing. No control measures opposite to maize stem borer were attempted.

Data Collection

Plant infestation percentage (%), number of dead hearts, larvae and pupae were taken from trialed cultivars (Lella and Srivastav, 2013) to check out the resistance level of maize cultivars against maize stem borer. The percent maize plant infestation was recorded from 5 plants randomly preferred (Afzal *et al*., 2007; Bhandari *et al*., 2016) for maize stem borer from each plot at two weeks interval and was collected 60, 74, 88 and 102 DAS. Plant percent infestation was directly computed by using the following formula.

$$\text{Infestation Percentage (\%)} = \frac{\text{Number of infested plants/plot}}{\text{Total number of plants/plot}} \times 100$$

Dead heart formation

Five plants from field from tested cultivar were randomly modeled for dead heart formation caused by stem borer, *C. partellus*. The data of randomly preferred five plants were taken at 60 DAS and means was determined. The data was subjected to statistical analyze to grasp some outcomes.

Larval infestation

In order to check larval infestation 5 randomly preferred plants were taken from tested cultivar and counted for total number of larvae. Data related to larva infestation were examined and their mean were deliberated.

Pupa observation

In order to document pupa infestation 5 plants were randomly selected from each examined genotype and counted for total number of pupae. Data were eminent and their mean was estimated.

Statistical Analysis

The data so collected has been subjected to statistical analysis using Excel and GENSTAT.

Result

Plant Infestation Percentage

The quantitative and qualitative losses in maize are associated to many logics of which the maize stem borer, *Chilo partellus* ranks first. Data presented in Table 1 and illustrated in Graph. 1 and 2 showed that the mean plant % infestation ranged from 0.0357 to 0.1829 percent. Among the distinct checked maize genotypes TG 46B90 recorded minimum plant % infestation (0.0357) at 74 DAS while Mon-6714 (0.047) at 60 DAS. The genotype Neelam recorded maximum plant % infestation (0.1829) at 88 DAS while Sahiwal-2002 (0.1247) at 88 DAS. The remaining genotypes Agaiti-85 and Mon-6789 showed moderate level of plant % infestation ranging from 0.0537 to 0.1026 percent.

Significant differences between the genotypes tested supply a strong support to the present examination (Khan and Monobrullah, 2003; Marulasiddesha *et al*., 2007). Ali *et al*., 2015 stated that hybrid genotypes (6.58 to 1945) are more susceptible to *C. partellus* infestation as compared to commercial maize varieties (5.63 to 8.73 %) which is in agreement with the instant examination.

In comparison to these genotypes local lines Sahiwal-2002 (0.0674) at 60 DAS, Agaiti-85 (0.0675) 74 at DAS, Neelam (0.0869) at 74 DAS, while hybrid lines Mon-6714 (0.0470) at 60 DAS, Mon-6789 (0.0537) at 60 DAS and TG 46B90 (0.0357) at 74 DAS show minimum plant % infestation. Maximum infestation was observed in local Sahiwal-2002 (0.1247), Agaiti-85 (0.1086), Neelam (0.1829) and hybrid Mon-6714 (0.0995), Mon-6789 (0.0898) and TG 46B90 (0.0807).

All the genotypes face maximum stem borer infestation at 88 and 102 DAS while show minimum plant % infestation at 60 and 74 DAS. Hybrid cultivars were most resistant then local cultivars at 60, 74, 88 and 102 DAS (Graph 1 and

2). The present findings are in accordance with the achievements of Ali *et al*. (2015), who performed an experiment to evaluate the resistance influencing factors in maize genotypes against stem borer (*Chilo partellus*).

Dead heart formation

Since the plant % infestation was present on most of the genotypes but dead heart formation symptoms were found on few plants. Even in case of some cultivars dead heart formation symptoms were nil. It means that the larvae outset feeding on genotypes but most of them died or left the plants which resulted in lower dead heart formations. In the present findings the minimum and maximum dead heart was reported in TG 46B90 (0.2),

Mon-6714 (0.2), Neelam (0.2866) and Sahiwal-2002 (0.8, 0.666), Agaiti-85 (0.6) TG 46B90 (0.4133) respectively.

Some genotypes Neelam, at 60 DAS, TG 46B90 at 74 DAS, Mon-6714 at 88 DAS and Agaiti-85 at 102 DAS were found with no dead heart formation. Maximum dead heart was found on Sahiwal-2002 with (0.666) at 60 DAS, (0.5666) at 74 DAS, (0.8) at 88 DAS and (0.5) at 102 DAS respectively. The plant growth and development was hampered considerably after a critical level of damage.

The minimum number of dead hearts were recorded in Neelam with zero at 60 DAS, TG 46B90 with zero at 74 DAS, Mon-6714 with zero at 88 DAS and Agaiti-85 with zero at 102 DAS, respectively. Genotypes Neelam (0.46666) at 74 DAS, Mon-6789 (0.36) at 74 DAS, Sahiwal-2002 (0.5666) at 74 DAS and TG 46B90 (0.4133) at 102 DAS showed maximum number of dead hearts which was similar to the results reported by Lella and Srivastav, (2013).

Sahiwal-2002 (0.666), Agaiti-85 (0.5333), Neelam (0), Mon-6714 (0.2666), Mon-6789 (0.333) and TG 46B90 (0.2) indicate intermediary features that showed relatively medium percent dead heart formation at 60 DAS respectively.

By comparison of commercial and hybrid genotypes, hybrid genotypes have shown low plant % dead heart formation as compared o commercial genotypes, respectively (Graph No. 2). In local cultivars Sahiwal-2002 had found maximum dead heart formation symptoms (Graph No. 2).

Larval infestation

Six genotypes namely Sahiwal-2002, Agaiti-85, Neelam, Mon-6714, Mon-6789 and TG 46B90 were observed for mean number of larval infestation. Current research has provided that Agaiti-85 (1.1333) at 102 DAS, Neelam (1.2) at 102 DAS and Sahiwal-2002 (1) at 102 DAS, Mon-6714 (1.0666) at 102 DAS showed maximum larval infestation while Mon-6789 (0.8666) at 102 DAS and TG 46B90 (0.9333) at 102 DAS had less infestation as compared to others (Table No. 4).

Genotypes TG 46B90 showed zero infestation level at 102 DAS. The minimum infestation was recorded on Sahiwal-2002 (0.6) at 60 DAS, Agaiti-85 (0.4) at 88 DAS, Neelam (0.3) at 60 DAS, Mon-6714 (0.2666) at 88 DAS, Mon-6789 (0.3333) at 74 DAS and TG 46B90 (0) at 102 DAS. Genotypes Mon-6714 (0.1333) at 74 DAS, Sahiwal-2002 (0.6066) at 74 DAS showed moderate type of resistance to larval infestation. These results can be compared with those of Dindor *et al*. (2016) and Panwar *et al*. (2000) because they used various genotypes of maize other than used in present research but they found significant differences in larval infestation of *Chilo partellus.*

In comparison to local and hybrid genotypes larval infestation in local cultivars Sahiwal-2002 (0.6) at 60 DAS, (0.6066) at 74 DAS, (0.8666) at 88 DAS, (1) at 102 DAS, Agaiti-85 (0.5) at 60 DAS, (0.7) at 74 DAS, (0.4) at 88 DAS and (1.1333) at 102 DAS, Neelam (0.3) at 60 DAS, (0.7133) at 74 DAS, (0.6133) at 88 DAS and (1.2) at 102 DAS were found with highest larval infestation (Graph N0. 4).

Hybrid genotypes Mon-6714 (0.4) at 60 DAS, (0.1333) at 74 DAS, (0.2666) at 88 DAS and (1.0666) at 102 DAS, Mon-6789 (0.5) at 60 DAS, (0.3333) at 74 DAS, (0.8) at 88 DAS and (0.8666) at 102 DAS, TG 46B90 (0.2) at 60 DAS, (0) at 74 DAS, (0.7333) at 88 DAS and (0.9333) at 102 DAS were found more resistant then local genotypes (Graph No. 5).

Pupal observation

In case of pupal observation all genotypes was show very low degree of pupal presence. No pupal formation was observed on Sahiwal-2002 (60-DAS, 74-DAS), Agaiti-85 (102-DAS), Neelam (88-DAS), Mon-6714 (60-DAS, 88-DAS) and TG 46B90 (60-DAS, 74-DAS, 102-DAS) (Table No. 4).

Maximum pupae were observed on Sahiwal-2002 (0.3333) at 88 DAS, Agaiti-85 (0.1733) at 60 DAS, Neelam (0.27330 at 60 DAS, Mon-6714 (0.2066) at 74 DAS, Mon-6789 (0.2) at

74 DAS, (0.2) at 88 DAS and TG 46B90 (0.1533) at 88 DAS (Graph No. 6).

Among all tested genotypes the highest number of pupae was reported in Sahiwal-2002 (0.3333) and it was at par with genotypes Neelam and Mon-6714 (0.2733, 0.2066). Thus the higher number of pupae was reported in local genotypes whereas less in hybrid genotypes. The results of Dindor *et al*. (2016) also support the current findings. He conducted experiment in India on 10 maize genotypes for resistance against stem borer on the basis of leaf injury, percent damaged plants, dead hearts, stem tunneling, number of larvae, number of pupae and identified resistant varieties.

Discussion

In the present research, differences in the incidence and prevalence of maize stem borer were evaluated in six important local and hybrid maize genotypes at University of Agriculture Faisalabad, Pakistan. The results of the current studies were critically scrutinized, discussed in detail and the relevant literature in support of the achievements has been cited at suitable places. In the current chapter, results were obtained on basis and applied aspects i.e., screening of maize genotypes against stem borer, *Chilo partellus* (Swinhoe) have been explained in the light of previous findings under the subsequent appropriate heads. Maximum incidence of maize stem borer was observed in genotypes Sahiwal-2002 (0.1247) and Neelam (0.1829). The results of Afzal *et al*. (2009) also support the current findings. He conducted experiment on 20 selected maize genotypes for resistance to *Chilo partellus* in the field. The genotype Sahiwal-2002 showed maximum infestation to *Chilo partellus* as compared to others. Genotypes Mon-6714 (0.0995), Mon-6789 (0.0898), TG 46B90 (0.0807) and Agaiti-85 (0.1086) showed intermediate infestation to *Chilo partellus*. The current research results can't be compared with those of Panwar *et al*. (2000), Afzal *et al*. (2009) and Dindor *et al*. (2016) because they used various genotypes of maize other than used in this research and observed significant differences in percent infestation of *Chilo partellus*. Maximum percent dead hearts formation was recorded in local genotypes Sahiwal-2002 (0.8), Neelam (0.68) and Agaiti-85 (0.6) while hybrid genotypes showed intermediate formation of dead hearts. These results are almost in accordance with Lella and Srivastav (2013) who reported that dead hearts symptoms were higher in more susceptible cultivars than least susceptible cultivars. In some cultivars there were no sign of dead heart formation, while some cultivars HUZM 227, QPM 169 showed maximum occurrence of dead hearts. The population of maize stem borer fluctuated throughout the crop season. The genotypes Neelam (1.2), Agaiti-85 (1.1333) and Mon-6714 showed maximum larval infestation while other genotypes Mon-6789 (0.8666), TG 46B90 (0.9333) and Sahiwal-2002 (1) had minimum. Genotypes Neelam (0.2733), Mon-6714 (0.2066) and Sahiwal-2002 (0.3333) showed intermediate level of pupal infestation while remaining genotypes Agiti-85 (0.1733) Mon-6789 (0.2) and TG 46B90 (0.1533) had very less. The present achievements are also agreement of Dindor *et al*. (2016) who performed an experiment on different maize genotypes for resistance against stem borer, *Chilo partellus* (Swinhoe) on the basis of stem tunneling, number of larvae, number of pupae and percent infestation. They found lowest number of larvae in genotype GM-3 (0.16/plant) which was found highly resistant, while highest number of larvae was recorded in genotype GM-4 (0.93) which was found moderately resistant. Lowest number of pupa was observed in GM-3 (0.26/plant), while the genotype GM-4 (0.66) recorded highest number of pupa. Khan and Monobrullah (2003) and Marulasiddesha *et al*. (2007) recorded significant differences among the genotypes tested which give strong support to current research. Patel *et al*. 2012 also made an experiment to study the host plant resistance against maize stem borer, *Chilo partellus* on different maize cultivars which provide significant variation. On the basis of maize genotypes, it is inferred that the maize genotypes varied extensively in their ability to withstand the pest attack.

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Table 1. List of different maize cultivars used against *C. partellus*

1	Local	5	Hybrid
2	Sahiwal-2002	6	Mon-6714
3	Neelam	7	TG-67B46
4	Agaiti-85	8	Mon-6789

Table 2. Plant % Infestation of 6 preferred local and hybrid maize genotypes against Maize stem borer, *Chilo partellus* (Swinhoe) at particular data observing periods* (60, 74, 88 and 102)*.

GENOTYPE	PLANT % INFESTATION (MEAN VALUE)			
	AT 60 DAS	AT 74 DAS	AT 88 DAS	AT 102 DAS
Sahiwal-2002	0.0674	0.0685	0.1247	0.0835
Agaiti-85	0.0892	0.0675	0.1086	0.1026
Neelam	0.1163	0.0869	0.1829	0.1076
Mon-6714	0.0470	0.0567	0.0995	0.0766
Mon-6789	0.0537	0.0579	0.0811	0.0898
TG 46B90	0.0488	0.0357	0.0773	0.0807

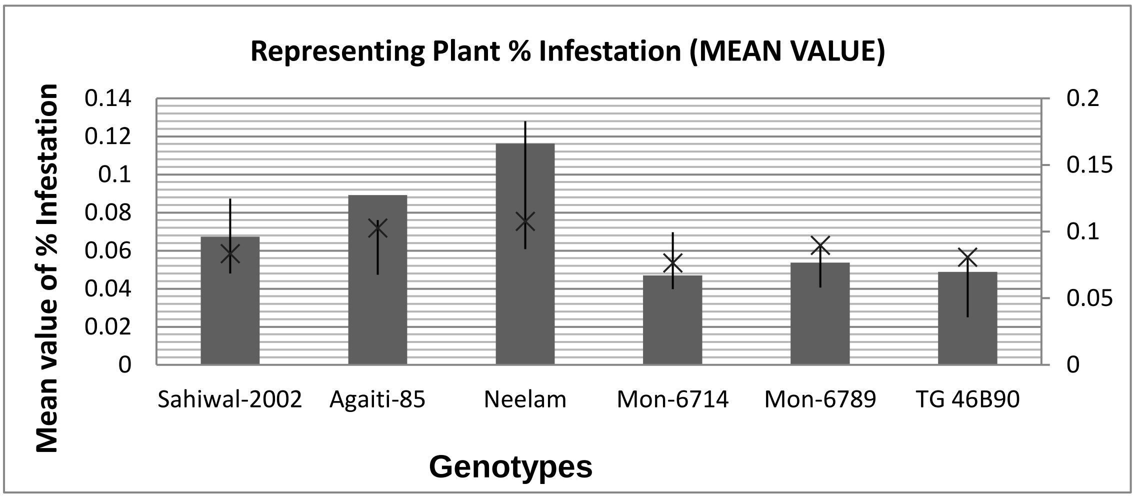
Table 3. Plant % dead heart formation in 6 maize genotypes against *Chilo partellus* (Swinhoe) at particular data observing periods* (60, 74, 88 and 102) DAS.*

GENOTYPE	DEAD HEART % INFESTATION (MEAN VALUE)			
	AT 60 DAS	AT 74 DAS	AT 88 DAS	AT 102 DAS
Sahiwal-2002	0.666	0.5666	0.8	0.5
Agaiti-85	0.5333	0.6	0.5	0
Neelam	0	0.4666	0.68	0.2866
Mon-6714	0.2666	0.36	0	0.2733
Mon-6789	0.333	0.2	0.34	0.0666
TG 46B90	0.2	0	0.4133	0.2133

Table 4. Mean infestation caused by *Chilo partellus* (Swinhoe) larvae and mean presence of pupa in 6 local and hybrid maize genotypes at 60, 74, 88 and 102 days after sowing (DAS*).

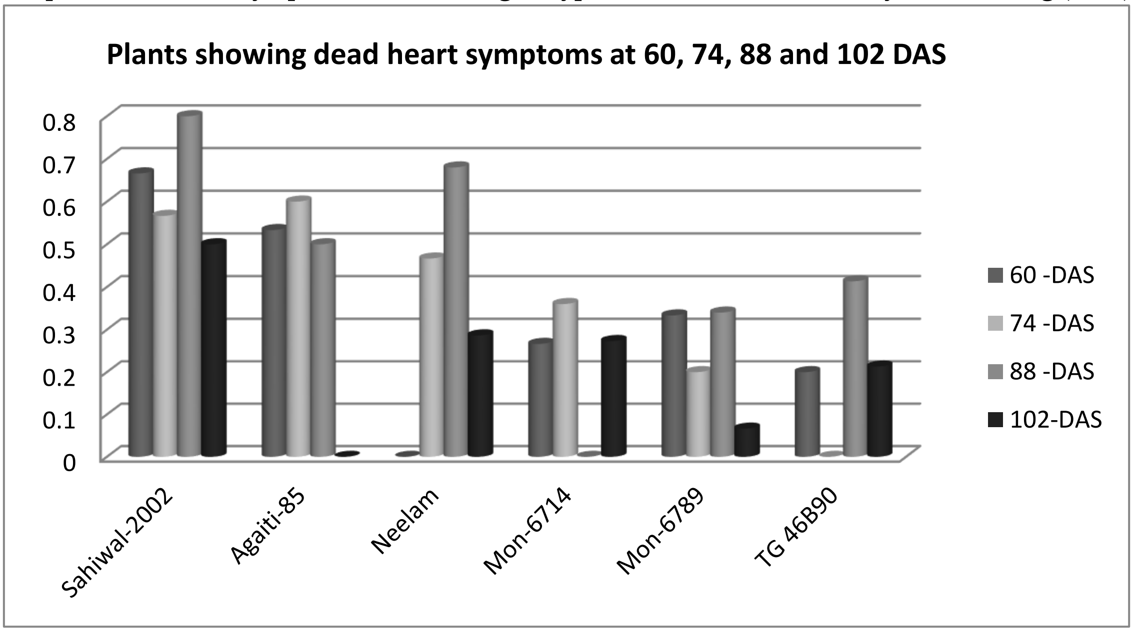
GENOTYPES	SHOWING LARVAL INFESTATION (MEAN VALUE)*				SHOWING PUPA PRESENCE (MEAN VALUE)*			
	At 60 DAS	At 74 DAS	At 88 DAS	At 102 DAS	At 60 DAS	At 74 DAS	At 88 DAS	At 102 DAS
Sahiwal-2002	0.6	0.6066	0.8666	1	0	0	0.3333	0.0666
Agaiti-85	0.5	0.7	0.4	1.1333	0.1733	0.0666	0.1333	0
Neelam	0.3	0.7133	0.6133	1.2	0.2733	0.14	0	0.14
Mon-6714	0.4	0.1333	0.2666	1.0666	0	0.2066	0	0.2
Mon-6789	0.5	0.3333	0.8	0.8666	0.1	0.2	0.2	0.0733
TG 46B90	0.2	0	0.7333	0.9333	0	0	0.1533	0

Graph 1. Plant % infestation in different genotypes at 60, 74, 88 and 102 days after sowing*.

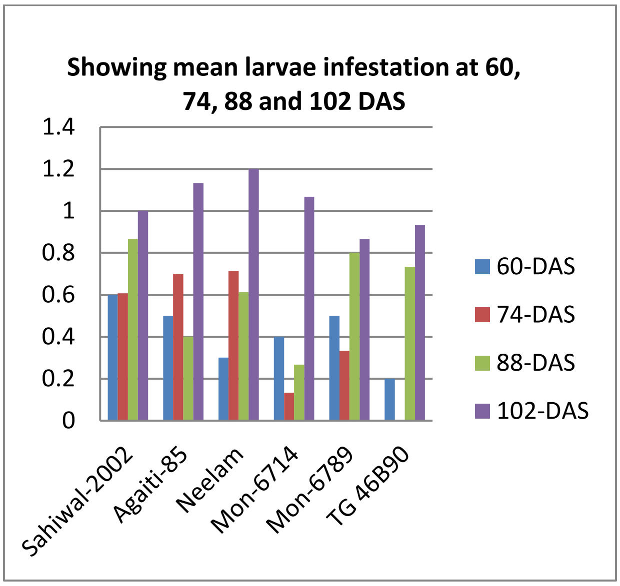


X-axis-Genotypes Y-axis-Mean value of % Infestation

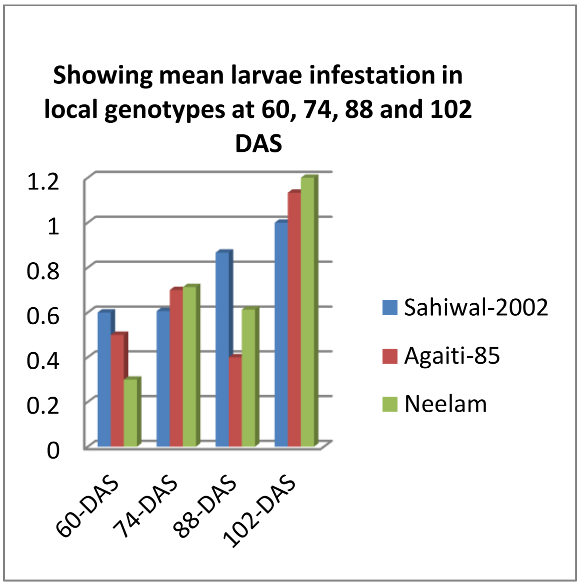
Graph 2. Dead heart symptoms in different genotypes at 60, 74, 88 and 102 days after sowing (DAS)



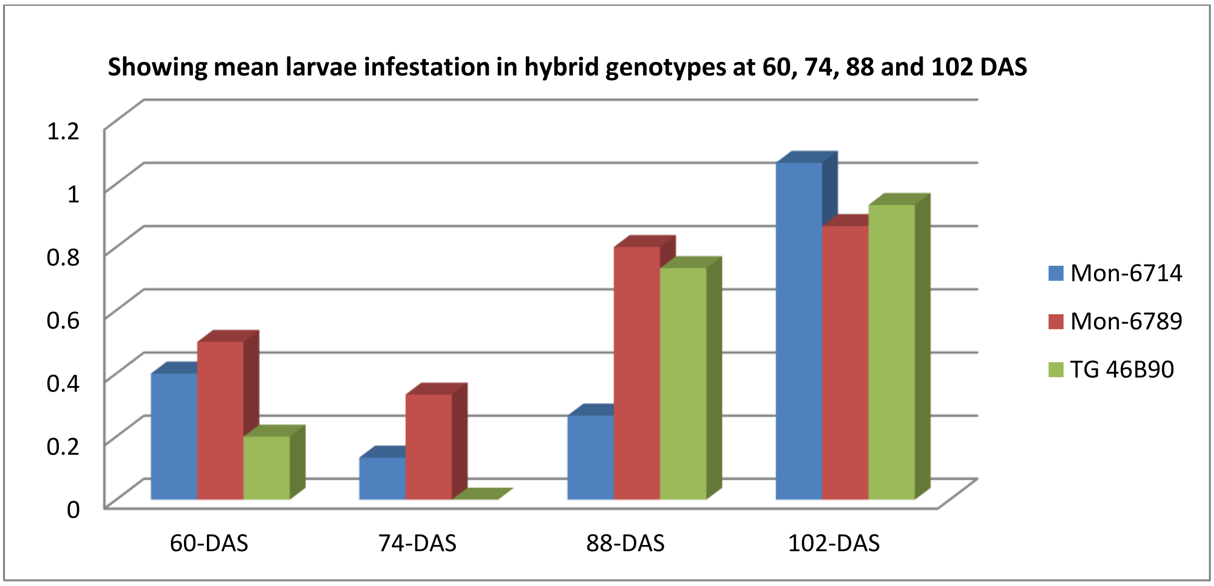
X-axis—Genotypes Y-axis—Mean value of dead heart



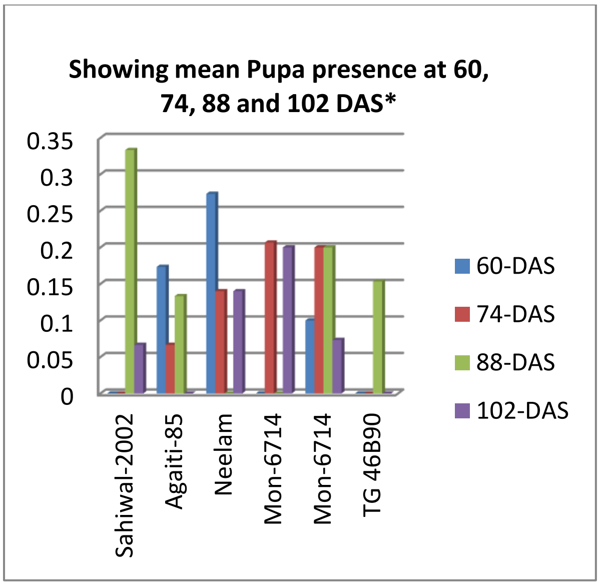
Graph 3. X-axis-genotypes Y-axis-Mean value of Infestation



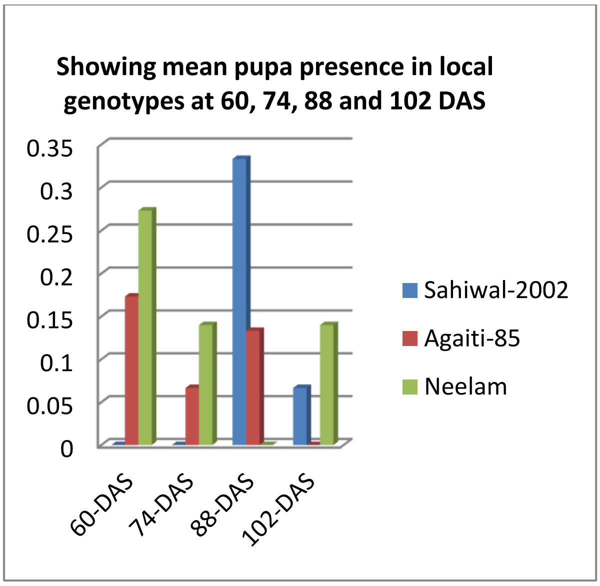
Graph 4. X-axis-genotypes Y- axis- Mean value of infestation



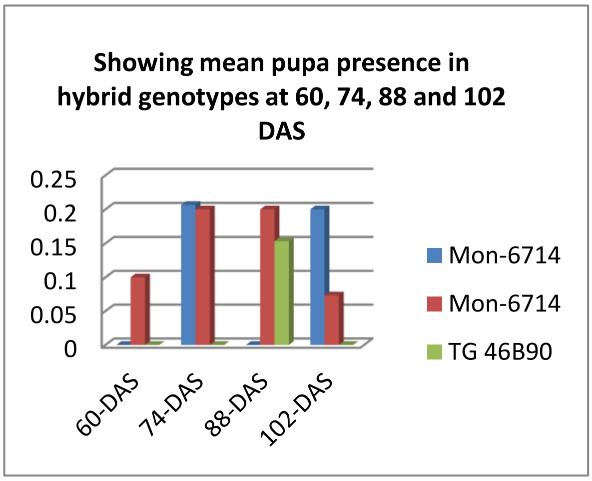
Graph 5. X-axis-genotypes Y- axis- Mean value of Infestation



Graph 6. X-axis-genotypes Y- axis- Mean value of presence



Graph 7. X-axis-genotypes Y- axis- Mean value of presence



Graph 8. X-axis-genotypes Y- axis- Mean value Of presence