PERFORMANCE OF SOME TOMATO VARIETIES AGAINST WHITEFLY AND FRUIT BORER

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CERTIFICATE

This is to certify that the thesis entitled **"PERFORMANCE OF SOME TOMATO VARIETIES AGAINST WHITEFLY AND FRUIT BORER"** submitted to the Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. ROMANUL ISLAM**, Registration No. **15-06918** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: December, 2016
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ABSTRACT

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during November to March, 2017 to evaluate varietal performance of tomato against the infestation of white fly and tomato fruit borer. This is the single factor experiment. Ten varieties of tomato T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12 were used as the experiment materials. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. At 50 DAT the maximum number of white fly plant^{-1} (27.97) was recorded from T_8 (Sonali 35) and the minimum number of white fly plant^{-1} (19.23) was recorded from T_2 (BARI Tomato 3) variety. The highest number of branches, leaves, inflorescence plant^{-1} was recorded in T_2 (BARI Tomato-3) and lowest was recorded in T_7 (Sonali 35). The highest percentage of branches, leaves, inflorescence infestation was recorded in T_7 (Sonali-35) and lowest was recorded in T_2 (BARI Tomato-3). At 85 DAT the maximum number of fruit borer plant^{-1} (10.70) was recorded from T_7 (Sonali 35) variety and the minimum number of fruit borer plant^{-1} (9.06) was recorded from T_2 (BARI Tomato-3). At 85 DAT the highest number of infested fruit plant^{-1} (4.13) was recorded from T_5 (BARI Tomato 16) variety and the lowest number of infested fruit plant^{-1} (3.12) was recorded from T_2 (BARI Tomato-3). Total number of fruit plant^{-1}, individual fruit weight, and weight of fruit plot^{-1} and yield of different varieties varied significantly due to different variety. The highest yield (53.83 t ha^{-1}) was obtained from T_2 (BARI Tomato 3) variety and the lowest yield (47.01 t ha^{-1}) was obtained from T_4 (BARI Tomato 15) variety. All varieties were infested by whitefly and fruit borer. But the BARI Tomato 3 (T_2) variety is better among 10 varieties regarding more tolerant to the whitefly and fruit borer and resulted higher yield.

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CHAPTER 1

INTRODUCTION

Bangladesh is predominantly an agriculture based country. But it has a huge deficit in vegetable production. Total annual vegetable production of Bangladesh is 1.6 million M tones in winter and 1.5 million M tones in summer season while the cultivated area of Bangladesh 0.47 million acres in winter and 0.65 million acres in summer season (BBS 2012). The consumption of vegetable in Bangladesh is about 50 g day^{-1} capita^{-1} which is the lowest amongst the countries of South Asia and South Africa (Rekhi 1997). But dietitian recommended a daily allowance of 285 g vegetable for an adult person for a balance diet (Ramphall and Gill 1990). Here people have been suffering from inadequate supply of vegetables since decades. As a result, chronic malnutrition is often seen in Bangladesh.

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important, popular and nutritious vegetable crops in Bangladesh which belongs to the family Solanaceae. It is widely grown not only in Bangladesh, but also in every parts of the world. Tomato ranks third in terms of world vegetables production (FAO 1997).The largest producer China (41,864,750 tons), accounted for about one quarter of the global production followed by United States (12,902,000 tons) and India (11,979,700 tons) (FAO, 2013). The popularity of the tomato and its products continues to rise. It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, puree, marmalade, chutney and juice. They are extensively used in the canning industry. Nutritive value of the fruit is an important aspect of quality in tomato. It's food value is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som 1990). Tomato adds variety of colour and flavour to the foods. It is also rich in medicinal value.

The soil and climatic condition of winter season of Bangladesh are congenial for tomato cultivation. Among the winter vegetable crops grown in Bangladesh, tomato ranks second in respect of production to potatoes and third in respect of area (BBS 2015). The yield of tomato quite low as compared to other leading tomato producing countries of the world such as China, Egypt, USA, Turkey where per hectare yield was reported as 30.39, 34.00, 65.22 and 41.77 t ha^{-1}, respectively. The recent statistics shows that tomato was grown in 23886.639 ha of land and the total production was approximately 190 thousand tons in 2011-2012 (BBS 2013). The average yield of tomato was 40.36 ton per acre (BBS 2013). The yield of the tomato is very low compared to those of some advanced countries (Sharfuddin and Siddique 1985).

Tomato production in Bangladesh is affected by many factors, among them insect pest attack is the major one. There are many insect pests attacking tomato have been reported which create havoc by causing both quantitative and qualitative loss to the crop. Some common tomato pests of tomato in the world are stink bugs, cutworms, tomato hornworms, tobacco hornworms, aphids, cabbage loopers, whiteflies, tomato fruit worms, flea beetles, red spider mite, slugs, and Colorado potato beetles. The tomato plants are attacked by different species of insect pests such as whitefly, aphid, tomato fruit borer and leaf miner in Bangladesh. Among them whitefly and fruit borer is highly devastating.

Whitefly, *Bemisia tabaci*, Gennadius, the insect breeds throughout the year and the female lays stalked yellow spindle shaped eggs singly on the lower surface of the leaf. Nymphs and adults suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold (Jayaraj *et al.* 1986). Damage caused by whitefly on the tomato crop can either be direct, by feeding onthe phloem sap and excretion of honeydew, or indirect, by transmission of virus diseases (Van Lanteren and Noldus, 1990). The notoriety of *B. tabaci* as pest is obscured by its role as an efficient vector of large number of viral diseases of tomato in the tropical and sub-tropical parts of the world. The prevalence and distribution of *B. tabaci* transmitted viral maladies have increased during the past decade and the impact has often been devastating (Basu 1995). The whitefly serves as the vector for the spread of yellow mosaic disease causing damage to tomato crop.

Tomato fruit borer, *Helicoverpa armigera* (Hubner) is one of the serious pests and causes damage 50-60 % (Singh and singh 1977) and up to 85-93% (Tewari 1985). Due to severe infestation, fruit as well as seed maturation hampered greatly and the viability of the seeds are also reduced. In Bangladesh tomato insect pest severely attacked the leaves and fruit of tomato and reduced the yield of tomato. Cultural practices formed one of the accepted and well conceived approach in reducing the pest incidence in many crops and more so in tomato (Kulagod 2009).

The damage by *H. armigera* starm soon after fruiting periods of the crop and the newly hatched larvae bore into the fruit and feed inside. As a result the fruits become unfit for human consumption. Though the pest is serious in status, the management of this pest through non-chemical metrics (cultural, mechanical, biological and host plant resistance etc.) undertaken by the researcher throughout the world is limited. The research works on non-chemical control measures of this pest are scanty. The use of chemical insecticides is regarded to be the most useful measure to combat this pest. Now, our slogan is “save the environment in order to save us.

For that reasons, the Ecologist, Entomologist and Zoologist gave great impormnce on the IPM programme. There are six steps in IPM among them, use of resistant cultivars ranks the first. Research works in this discipline are few in Bangladesh. To minimize the use of synthetic insecticides and problems arising out of their frequent use, it is very essential to screen tolerant variety against insect-pest specially whitefly and tomato fruit borer. In view of this requirement, an experiment was undertaken to find the tolerant tomato varieties with the following objectives

- to find out the infestation level of whitefly and tomato fruit borer on different varieties of tomato and
- to evaluate varietal performance against the whitefly and tomato fruit borer.

CHAPTER II
REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse conditions, which received much attention to the researchers throughout the world. Whitefly (*Bemisia tabaci*) and fruit borer (*Helicoverpa armigera*) are the major insect pest of different vegetables including tomato, which causes significant damage to crop every year. The incidence of these pests occurs sporadically or in epidemic throughout Bangladesh and affecting adversely the quality and yield of the crop. It causes great yield reduction, which is considered as an important obstacle for economic production of these crops. Substantial works have been done globally on these pest regarding their origin and distribution, host range, life cycle, nature of damage, rate of infestation yield loss, seasonal abundance and management. but published literature on this pest especially on its infestation status and management are scanty in Bangladesh. Literatures cited below under the following headings and sub-headings reveal some information about the present study.

2.1 Taxonomic position of Whitefly

Phylum: Arthropoda
Class: Insecta
Order:Homoptera
Suborder: Sternorrhyncha
Superfamily: Aleyrodoidea
Family: Aleyrodidae
Sub family: Aleurodicinae
Genus: *Bemisia*
Species: *B. tabaci*

Origin and Distribution of Whitefly

Bemisia tabaci was first described as a pest of tobacco in Greece in 1889. Outbreaks in cotton occurred in the late 1920 and early 1930 in India and subsequently in Sudan and Iran from the 1950 and 1961 in EL Salvador (Hirano *et al.* 1993). *B. tabaci* is widespread in the tropics and subtropics and seems to be on the move, having been recorded in many areas outside the previously known range of distribution. The whitefly has been reported as a green house pest in several temperate countries in Europe, e. g., Denmark, Finland, France, Norway, Sweden and Switzerland. Besides in green houses, the species has been reported on outdoor plants in France and Canada (Basu 1995). *B. tabaci* has a global presence. However, certain areas within Europe are still *Bemisia* free, e.g. Finland, Sweden, Republic of Ireland and the UK (Cuthbertson and Vänninen 2015).

Host Range: *B. tabaci* is highly polyphagous and has been recorded on a very wide range of cultivated and wild plants. Greathead (1986) updated the information reported by Mound and Hasley (1978) and listed 506 species of plants belonging to 74 families. It may be pointed out that 50% of the total number of host plants belonging to only 5 families, namely, Leguminosae, Compositae, Malvaceae, Solanaceae and Euphorbiaceae. A survey of the literature from the early 1900s suggests that the number of host plants colonized by *B tabaci* has increased over time, probably as agricultural practices have shifted to irrigated monoculture and as different species have been cultivated during the century . Current records indicate that *B. tabaci* can successfully colonize a multitude of host-plant species worldwide (Cock 1986). Early documentation cited at least 155 plant species as hosts in Egypt alone (Azab *et al* 1970), whereas by 1986, a worldwide detailed survey yielded an estimate of 420 host plant species (Brown *et al*. 1995) .

The recently introduced B-biotypc has the broadest host range among whiteflies in the genus Benasta; some estimales range up to 500 species (Brown *et al.* 1995). Basu (1995) reported that *Bemisia tabaci* is a highly polyphagous pest and it has been recorded on more than 500 species of plants including numerous field crops, ornamentals and weeds. Bloch and wool (1995) similarly reported that hosts of *B. tabaci* include vegetables, Cotton, and other agricultural crops and ornamental plants. According to Panwar (1995), the host plants of *Bemisia tabaci* include cotton, tomato, tobacco, sweet potato, cassava, cabbage, cauliflower, melon, brinjal, okra and many wild and cultivated plants.

In a study on host range, it was observed that more than 100 species and varieties belonging to 16 families, 7 species of Solanaceac and 8 in other families became systemically infected following inoculation by *Bemisia tabaci*. In the field, the virus was found from tomato at all growth stages and in all seasons, also from naturally infected *Datura stramoniunt*, tobacco, 3 wild *Lycopersicon* spp. and from breeding lines of tomato (Ioannou *et al.* 1987).

In an experiment conducted in Mexico during 1990-1995 it was observed that a total of 58 wild and 14 cultivated plant species were found to host *Bemisia tabaci* at some of its life cycle. The most important species of wild species were Leguminosae, Euphorbiaceae, Asteraceae, Convulvulalaceac, and Malvaccac (Aviles Bacza 1995).

Seasonal Abundance of Whitefly

Maximum pest population (7.99/3 leaves) was build up at temperature ranged from 26ºC to 35ºC, relative humidity ranges from 84 and 67 per cent, zero rainfall, wind velocity 6.30 km/hr, total sunshine hours (9.4 hrs/week), evaporation (52.20 mm) and dewfall (0.708 mm). The highest incidence of whitefly population was recorded in SPCH 22 followed by SVPR 3 and MCU 7 (Selvaraj et al. 2010). Whitefly population was build up showed a significant and positive correlation with maximum and minimum temperature whereas, it was significant and negative association with evening relative humidity. The determination of effects of different weather factors on population of whiteflies in cotton was essential for effective pest management. Kaur *et al.* (2009) who reported the peak population of whiteflies was observed when the maximum temperature and minimum temperature range of less than 36ºC and more than 26 ºC, respectively and the number of sunshine hours variably more than 8 hrs. Similarly, Prasad *et al.* (2008); Reddy and Rao (1989) who reported that a maximum and minimum temperature range of 29ºC to 32ºC and 18ºC to 22ºC respectively, was highly favourable for the population build up of whiteflies. Selvaraj et al. (2010); Dhaka and Pareek (2008); Arif *et al.* (2006); Gupta et al. (1998); Rao and Chari (1993), Rote and Puri et al. (1991); Singh and Butter (1985) who reported significant positive association between maximum temperature and the population.

In a study in Sudan Kranz *et al.* (1977) found a sharp increase in whitefly population in September and October which was directly correlated with higher relative humidity (80-90%) and increasing temperature (36-38ºC). These conditions favour the development of the juvenile stages by shortening the duration of each stage. They indicated that the population decreases due to high mortality rate at eggs and free juvenile stages in March, April and May when the temperature is high (43-45ºC) and RH is low (8-17).On the other hand, Gerling *et al.* (1986) observed that the extreme RH, both high and low, was unfavorable for the survival of immature stages. Thus in Sudan, Horowitz (1986) found significant drop of whitefly population levels at heavy rainy condition.

Gerling *et al.* (1986) found that the lower and upper developmental thresholds of temperature are 11 and 33ºC, respectively. Rates of development are maximal at 28 ºC. At that temperature, development from egg to adult takes 20 days. Avidov (1956) considered low humidity as the major mortality factor in Israel, leading to cessation of oviposition and adult mortality. Low humidity of 20% or less during hot weather has been reported to be highly detrimental to the immature stages of whitefly (Gameel 1978; Avidov 1956). In Sudan heavy rains were usually followed by a drop in population levels (Gameel 1978; Khalifa and El-Khidir 1964). Ohnesorge *et al*. (1981) found that the oviposition was impaired by rain.

Nature of Damage: According to Butani and Jotwani (1984) the white, tiny, scale like insects may be seen darting about near the plants or crowding in between the veins on ventral of leaves, sucking the sap from the infested parts. The pest is active during the dry season and its activity decreases with the on set of rains. As a result of their feeding the affected parts become yellowish, the leaves wrinkle and curl downwards and are ultimately shed. Besides the feeding damage, these insects also excrete honeydew which favors the development of sooty mould. In case of severe infestation, this black coating is so heavy that it interferes with the photosynthetic activity of the plant resulting in its poor and abnormal growth. The whitefly also acts as a vector, transmitting the leaf curl virus disease, causing severe loss. Sastry and Singh (1973) estimated 20-75% loss in tomato yield due to tomato leaf curl virus disease in India.

Bemisia tabaci continues to be an economically important pest of greenhouse and field crops throughout equatorial areas of the world (De Barro 1995). Both nymph and adult cause direct damage to the plants by sucking from the phloem and by secreting honeydew. This weakens the plants by sap extraction and allows black shooty mold fungus to develop on honeydew. However, direct damage due to feeding would not appear to have been a matter of much concern. The main damage caused by *Bemisia tabaci* to the tomato is indirect-by transmitting virus diseases in plants (Cohen and Berlinger 1986). This is one of the most important limiting factors for tomato production in wormer climates. Schuster *et al.* (1990) reported a new disorder of fruit on tomatoes in Florida. The disorder termed irregular ripening, was associated with field populations of the *Bemisia* abaci and is characterized by incomplete ripening of longitudinal sections of the fruit. An increase in internal white tissue was also associated with whitefly populations. In field-cage studies, fruit on uninfected tomato plants exhibited slight or no irregular ripening, whereas fruit from infested plants did the same.

Stansly and Schuster (1990) reported that damage in tomato resulted from irregular ripening and transmission of tomato mottle geminivirus. Crop damage in tomato due to this pest was estimated to more than 500 million dollars in the United States in 1991 (Perring *et al.* 1993).

Whiteflies suck phloem sap and large populations can cause leaves to yellow, appear dry, or to fall off of plants. Due to the excretion of honeydew plant leaves can become sticky and covered with a black sooty mould. The honeydew attracts ants, which interfere with the activities of natural enemies that may control whiteflies and other pests. Feeding by the immature whiteflies can cause plant distortion, silvering of leaves and possibly serious losses in some vegetable crops. This devastating global insect pest caused damage directly by sucking the plant sap from phloem, indirectly by excreting honeydews that produce sooty mould, and by spreading 111 plant virus diseases. Among the plant viruses, Tomato Yellow Leaf curl Virus (TYLCV) is most important (Mughra *et al.* 2008).

Life History

Egg: Eggs are pear shaped and 0.2 mm long. They are laid indiscriminately almost always on the undersurface of the young leaves (Hirano *et al.* 1993). The female can lay 119 eggs in captivity (Hussain and Trehan 1933) and 300 eggs on egg plant under field conditions (Avidov 1956). Initially the eggs are translucent, creamy white and turn into pale brown before hatching. The incubation period varies widely mainly due to varying environmental conditions especially temperature. Under outdoor condition the incubation period has been reported to be range between 3-5 days in summer and 7-33 days during winter (Azab *et al.* 1971; Hussain and Trehan 1933).The first instar nymphs (crawlers) move a very short distance over the leaf surface. Once settled, they remain sessile until they reach the adult stage, except for brief periods during molts (Hirano *et al.* 1993).

Nymphal and pupal Stages

The first instar nymphs are pale, translucent white, oval, with a convex dorsum and flat central side. They measure 0.267± 0.007 mm in length and 0.144±0.010 mm in width (Lopez- Avila, 1986). The second instar nymphs are quite distinct from first instar for its size. These nymphs are 0.365± 0.026 mm long and 0.218± 0.012 mm wide at the broadest part of the thorasic region. The body of the third instar nymph is more elongated than the earlier instars, measuring 0.489± 0.022 mm in length and 0.295± 0.018 mm in breadth. The fourth instar nymphs have elliptical body measuring 0.662± 0.023 mm long and 0.440 ± 0.003 mm broad. This fourth instar (the so- called "pupae") has red eye spots, which become eyes at the adult stage, are characteristic of this instar (Hirano *et al.* 1993).10

Two distinctive characters of the pupa are the eyes and the caudal furrow. Dorsal surface of the elliptical body is convex and the thoracic and abdominal segments are pronounced. Mound (1963) showed that the pupae from which females emerge are larger than those producing males. Duration of these stages varies and has generally been correlated with temperature or seasonal factor. Under constant conditions of 25ºC, RH 75% and light: dark 16:8 hours, the fourth instar nymph lasted 3.4 days on bean, 2.1 days on cotton and 2.0 days on tomato .The duration of pupal stage were 4.4 days on bean, 2.4 days on tomato and 1.7 days on cotton (Lopez-Avila 1986). The total duration of the immature stages of *B. tabaci* varies widely and is correlated with climate and host- plant conditions. The shortest duration of 11 days during summer (Pruthi and Samuel 1942) and the longest of 107 days during winter (Hussain and Trehan 1933) were observed in India.

Adults: Adults are soft and pale yellow, change to white within a few hours due to deposition of wax on the body and wings. Byre and Houck (1990) revealed sexual dimorphism in wing forms: the fore and hind wings of females were larger than those of males. The mean wing expanses of females and males are 2.13 mm and 1.81mm, respectively (Byrne *et al* 1991). Adult longevity of males on tobacco was 4 days in summer and 7days in winter, corresponding female lifespan was 8 and 12 days, respectively in India (Pruthi and Samuel 1942).

The maximum adult emergence occurs before 0800 and 1200 hours (Musuna 1985; Butler *et al.* 1983; Azab *et al.* 1971; Husain and Trehan 1933). *Bemisia tabaci* is arrhenotokus and is known to lay unfertilized eggs which give rise to males only (Sharaf Batta 1985; Mound 1983; Hussain and Trehan 1933; Azab *et al.* 1971). Unmated females produce male offsprings while mated females produce both males and females. Monsef and Kashkooli (1978) recorded 10-11 generations per year on cotton in Iran. Husain and Trehan (1933) and Pruthi and Samuel (1942) found 12 overlapping generations in India on cotton.

Virus Diseases Transmitted by *B. tabaci* on Tomato

Among the six or seven classes of whitefly-borne viruses in tomato, geminivirus group is by far the most important both in terms of number of diseases and their economic importance in various parts of the world (Brown and Bird 1992; Byrne *et al*. 1990; Duffus 1987; Bock 1982). The brief description of some geminivirus diseases of tomato are given below:

Tomato Leaf Curl Virus (TLCV): This is the most important disease of tomato in India (Chenulu and Giri 1985) and perhaps in many tropical countries (Thanapase *et al.* 1983; Yassin 1978). They described that the main symptoms are vein clearing, stunting and marked reduction in leaf size with mild or severe mosaic pattern or chlorosis with marginal curling of leaves. Severely affected plants show complete yellowing of interveinal areas and puckering of leaves. Losses in tomato yield depend on severity and the stage of the crop at the time of infection. Early infection may result in losses of over 90%.

Tomato yellow leaf curl virus (TYLCV): TYLCV was first reported in Israel in 1939-40 associated with outbreaks of *Bemisia tabaci*. The causal agent was described in 1964 and named *Tomato yellow leaf curl virus* (TYLCV) (Cohen and Harpaz 1964). *Tomato yellow leaf curl virus* (TYLCV) has been a major constraint to tomato production in the Near East since 1966. It is the best characterized virus causing yellowing and leaf curl disease of tomato (Green and Kallool 1994). Czosnek and Laterrot (1997) published world wide survey report on TYLCV. They pointed out that the name TYLCV has been given to several whitefly transmitted geminiviruses affecting tomato cultures in many tropical and subtropical regions. Their result based on DNA and protein sequence revealed that tomato geminiviruses fall into three main clusters representing viruses from 1) The Mediterranean / the Middle East / the African region, 2) India/ the Far East and Australia and 3) The Americas. They also pointed out that TYLCV diseases increased considerably between 1990 and 1996. Early diagnosis of TYLCV is essentially based on symptom observation, although symptoms vary greatly as a function of soil, growth conditions and climate.

Fruit Borer

Taxonomic position of Fruit Borer

Tomato fruit borer, *Helicoverpa armigera* (Hub.) is a polyphagous insect, belonging to the family Noctuidae of the order Lepidoptera. There are several genera under this family, and the genus *Helicoverpa* contains more number of species, including *Helicoverpa armigera*, which is the serious pest of tomato (Mishra *et al.* 1996). Taxonomic position of the fruit borer is given below:

Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Superfamily: Noctuoidea
Family: Noctuidae
Genus: *Helicoverpa*
Species: *H. armigera*

Origin and Distribution of Fruit Borer

Tomato fruit borer is a versatile and widely distributed polyphagous insect. Besides Bangladesh, this pest occurs in Southern Europe, probably the whole of Africa, the middle East, India, Central and South East Asia to Japan, the Philippines, Indonesia, New Guinea, the eastern part of Australia, New Zealand and a number of pacific islands except desert and very humid region (Singh 1972).

Host Range of tomato fruit borer

A wide range of host tomato fruit borer are cotton, tobacco, maize, sorghum, pennisetum, sunflower, various legumes, citrus, okra and other horticultural crops. Wild plants considered important include species of Euphorbiaceae, Amaranthaceae, Malvaceae, Solanaceae, Compositae, Portulaceceae and Convolvulaceae, but many other plant families are also reported to be the hosts of this insect pest (Jiirgen *et al.* 1977).

Tomato fruit borer, *Helicoverpa armigera* Hubner is a cosmopolitan, polyphagous pest, distributed widely in Indian subcontinent (Sing *et al.* 1990, Fenemore, 1990). Apart from tomato, *H. armigera* is reported to infest cotton, maize, chickpea, pigeon-pea, sorghum, sunflower, soyabean and groundnut (Fitt, 1989). Larvae affect almost all the aerial parts of the tomato plant from the early growth till to the fruit maturation stage (Lal *et al*. 1996, Tripathy *et al.* 1999). Loss incurred to growing tomato crop is insurmountable and may extend up to 51.20 per cent in Punjab (Sing *et al.* 1990); 40-50 per cent in Bangalore (Khaderkhan *et al*. 1997) and 32.52 per cent in Madhya Pradesh (Ganguly *et al.* 1998). Severe infestation causes necrosis to the leaf chlorophillus tissue, suppresses tomato flowers to bloom and makes the mature fruit unfit to consume (Jallow *et al.* 2001). In Jalpaiguri, Bengal considerable losses to tomato due to this pest have been reported (Chaudhuri 2000).

Life history of tomato fruit borer

Egg

Eggs are 0.4-0.5 mm in diameter, nearly spherical with flattened base, glistering yellowish- white in colour, changing to dark brown prior to hatching (Singh and Singh, 1975).

Larva

The fully grown larva is about 40 mm in length, general colour varies from almost black, brown or green to pale yellow or pink and is characterized by having a dark band along the back to each side of which there is a pale band. The larval period varies from 15.35 days (Singh and Singh 1975).

Pupa

The light brown pupa, living in the soil, is seldom seen unless special sampling techniques are used (Nachiappan and Subramanium 1974).

Adult

Stout bodied moth has a wing span of 40 mm. General colour varies from dull yellow or olive grey to brown with little distinctive marking. The moths become sexually mature and mate about four days after emergence from the pupae having fed from the nectars of plants. The moth is only active at night and lays eggs singly on the plant. On hatching, the larva normally eats some or all of its egg shell before feeding on the plant. The larva passes through six instars and the larval period varies from 15-35 days (Ewing *et al.* 1947). Damage by the pest was found to be independent of all these characters except ascorbic acid content, which was positively correlated with damage.

Resistant cultivar against fruit borer

Gajendra *et al*. (1998) screened twenty four tomato cultivars against of tomato fruit borer, *H. armigera* during the spring in Madhya Pradesh. Cultivars Pusa early dwarf, Akra Vikas and Pusa Gourva with highly hairy peduncles were less susceptible to the pest damage than those with less hairs on the peduncles. Negative correlation between ascorbic acid content of the fruit and fruit damage by the pest was observed. Sivaprakasam (1996) observed the leaf trichome (number/mm$^{2)}$, petioles, internodal stems and calyx on 9 tomato genotypes. Results suggested that the low fruit borer damage in Paiyur-1 and X-44 might be due to the presence of long calyx, trichomes, physically preventing feeding by *H. armigera* larvae, rather than to trichome number/mm^2. Paiyur-1 had lowest number of trichomes on all plants parts studied, but the largest calyx area per fruit (3.4 cm^2). Rath and Nath (1995) conducted field screening of 112 tomato genotypes at Uttar Pradesh, India, during the Kharif season against *H. armigera*. Leaf trichome density, sepal length, number of branches, fruit diameter and P^H of ripe fruit showed a significant and positive impact on infestation level. The increased fruit number in a plant enhanced numbers of *H. armigera*. The percentages of plant infestation were negatively correlated with fruit pericarp, thickness and the percentages of fruit damage were negatively correlated with fruit per plant but positively correlated with trichome density. Information on genetic variability, and genetic advance is derived from data on number of fruits/plant, fruit weight, fruit borer (*Heliothis armigera*) incidence, wilt (*Fusarium oxysporum f. sp Lyopersics*) incidence and yield of 16 tomato varieties grown at Ghumsar, Udayagiri was observed by Mishra and Mishra (1995). The cultivars BT 6-2, BT 10, BT 17, T 30 and T 32, exhibiting resistance to both wilt and fruit borer, could be utilized as donors in future multiple resistance breeding programmes.

Money-Maker and Royesta were evaluated to screen out the suitable resistant/susceptible genotypes against the fruit borer in Pakistan (Sajjad *et al*., 2011). The results imparted that the percentage of fruit infestation and larval population per plant on tested genotypes of tomato varied significantly. Lower values of host plant susceptibility indices (HPSI) were recorded on resistant genotypes. Sahil, Pakit and Nova Mecb could be used as a source of resistance for developing tomato genotypes resistant to tomato fruit borer.

Khanam *et al*. (2003) conducted an experiment on the screening of thirty tomato varieties/lines to tomato fruit borer, *Helicoverpa armigera* (Hub.) infestation in relation to their morphological characters and conducted in different laboratories of BAU and BINA, Mymensingh during Rabi season, November, 1999 to March 2000. The tomato fruit borer infestation varied significantly among the varieties/lines and also with the age of the tomato plants. Among the varieties/lines, V-29 and V-282 were found moderately resistant and susceptible, respectively. Plant height, stem diameter, total number of branches/plant, total number of leaves/plant, 2^{nd} leaf area, total leaf chlorophyll, number of leaf hair and number of fruits/plant of V-29 line were 81.74 cm, 1.45 cm, 14, 453, 19.58 sq. cm, 1.13 mg/g, 12 and 48, respectively. Again the aforementioned characters for V-282 line were 80.74 cm, 1.18 cm, 9.396, 21.57 sq.cm, 1.24 mg/g, 17 and 30, respectively.

Karabhantanal and Kulkarni (2002) reported that the tritrophic interactions were assessed under net cage conditions among tomato cultivars L-15, PKM-1, Arka Vikas, Arka Sourabh, Arka Ashish on *Helicoverpa armigera* and egg hyperparasitoids (*Trichogramma chilonis* and *Trichogramma pretiosum*). Significantly lower oviposition by *H. armigera* was observed on local genotypes, L-15 and PKM-1, while the oviposition was higher on IIHR genotypes, Arka Sourabh, Arka Vikas and Arka Ashish. Irripective of *T. pretiosum* recorded higher hyperparasitism than *T. chilonis*. Further, it was observed that as the trichome density increased there was an increase in oviposition by *H. armigera* and a decrease in hyperparasitism by *Trichogramma* species.

Saha *et al*. (2001) reported that an investigation was conducted in Uttar Pradesh, India to determine the effect of intercropping. Tomato fruit borer (*Helicoverpa armigera*) heavily infested sole tomato plots compared to all intercrop treatments. The borer population was also found on sole lentil plots but was less than that on sole tomato plots. The fruit borer population was, more or less, similar in all intercropped plots even in the sole lentil plot. Their populations were higher on sole lentil but were less than tomato.

Rath and Nath (2001) reported that tomato genotypes were assessed for fruit damage by fruit borer *Helicoverpa armigera* in a field experiment conducted in Varanasi, Uttar Pradesh, India, during 1991 (112 genotypes) and 1992 (27 genotypes, along with wild type *Lycopersicon pimpinellifolium*). The genotypes were categorized according to percent fruit damage by the pest. Five genotypes, HT-64, Hybrid No.37, PTH-104, PTH-103, recorded the lowest level of per cent fruit damage (< 10) in both years. The wild genotype showed less than 10% fruit damage during 1992. H-86-82, ZLE-006, Parm-mitra and HS-173 recorded the highest fruit damage of more than 40% during 1991. During 1992, the highest fruit damage of more than 30% were recorded from Shrestha, Kalyanieunush, PTH-102, PTH 101, HS-173 and XLE-006.

Saha *et al*. (2000) reported that intercrops of tomato cv. Pusa Ruby were infested with different species of insect pests of tomato fruit borer, *Helicoverpa armigera*, showed significant differences in infestation levels in various intercrop situations in Varanasi, Uttar Pradesh, India, during Rabi season of 1996-97. However, there was a general downward trend in infestation level of different pests in intercrop combinations compared to their numbers in sole crops as preferred host. The intercrops were thus, found to be more suitable for natural suppression of pest populations.

Seasonal abundance

Parihar and Singh (1986) reported that the larval population of *Heliothis armigera [Helicoverpa armigera]* on tomato and losses caused by this pest were studied in the Meerut district of Uttar Pradesh, India, In 1983-84 and 1984-85. The larval population was low until the first week of February in both years and increased rapidly thereafter, reaching a peak in the last week of March. In the last week of April, the population declined to 4 larvae/10 plants. Percent fruit infestation was low up to the end of February, while in the 2nd week of April 50.08 and 33.04% of fruits were infested in 1984 and 1985, respectively. By the 2nd week of May, 1.441% of fruits were infested in 1984 and 2.84% in 1985. It was recommended that control measures should be applied at the time of flowering, which is also the time of mass oviposition.

Patel and Koshiya (1997) worked on seasonal abundance of *Heliothis armigera* during Kharif season, the pest started its activity in groundnut from first week of July. There after, the pest moves to cotton crop from last week of July and started to build up its population during the month of August to mid-September. Simultaneously the pest infestation was also noticed in sunflower and pearl millet during this period but the population was very low in sunflower. However, in pearl millet, it was at peak during September. In Rabi season, post activity was observed in chickpea during November to February. However, its population was at peak during December. In summer season, the pest started its activity on groundnut in February and was active up to June. The seasonal history of tomato fruit borer, *Heliothis armigera* varies considerably due to different climatic conditions throughout the year. A Study revealed that the population of *Heliothis armigera* began to increase from the mid-January and peaked during the last weed of February. The population of this pest was positively correlated with average temperature, mean relative humidity and total rainfall. Parihar and Singh (1986) in India showed that, the larval population of *Heliothis armigera* on tomato was low until the first week of February and increased rapidly there after, reaching to 4 larvae/ 10 plants, percent fruit infestation was low up to the end of February, while in the second week of April 50.08% and 33.04% of fruits were infested in 1984 and 1985, respectively.

Nature of damage of tomato fruit borer (TFB)

Hussain and Bilal Ahmed (2006) conducted an experiment during two years where fruit damage due to TFB was highest (19.59%) in Noorbagh of district Srinagar and lowest (1.61%) in Awneera of district Pulwama. Whereas, on an overall mean basis district Anantnag recorded lowest (1.85%) and district Srinagar recorded highest (17.36%) fruit damage. However, hybrids were generally more damaged than local varieties. The effect of marigold which act as a trap crop along with various combinations of tomato showed that 3:1 combination recorded lowest fruit damage and larval population but trapped more larvae on trap crop. Thus, the yield was higher than other treatments. However, tomato equivalent yield was 2455714 kg/ha in 2003 and 28399.99 kg/ha in 2004.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to evaluate the performance of some tomato varieties against whitefly and fruit borer during the period from November 2016 to March 2017. A brief description of the experimental site, climatic conditions, soil characteristics, experimental design, treatments, cultural operations, data collection and analysis of different parameters were used for conducting this experiment are presented under the following headings:

3.1 Location of the experimental field

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2016 to March 2017. The location of the experimental site was at 23^0 $46^,$ N latitude and 90^0 $22^,$E longitudes with an elevation of 8.24 meter from sea level (Khan, 1997).

3.2 Climate condition during the experiment

The experimental area is characterized by subtropical rainfall during the month of April to September and scattered rainfall during the rest of the year. Information regarding average monthly temperature as recorded by Bangladesh Meteorological Department (climate division) during the period of study has been presented in Appendix I.

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ No. 28) (UNDP and FAO, 1988) with pH 5.8-6.5, ECE-25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka.

3.4 Experimental materials

Ten different varieties of tomato were used for this study as treatments and the seeds of these crops were collected from different seed stores. Different varieties of tomato were as follows:

T_1: BARI Tomato 2
T_2: BARI Tomato 3
T_3: BARI Tomato 14
T_4: BARI Tomato 15
T_5: BARI Tomato 16
T_6: BARI Tomato 17
T_7: Sonali 35
T_8: Solar
T_9: Bijli 11
T_{10}: Sonli 12

3.5 Experimental design and layout

The experiment consisted of tenvarieties of tomato and was laid out in Randomized Complete Block Design (RCBD) with three replications. Experimental plot was sub-divided into three blocks where two pits were in each plots. Thus there were 30 (3 × 10) unit plot in the experiment. The size of each plot was 3.50 m × 2.0 m.

3.6 Cultivation procedure

3.6.1 Seedling raising

The land selected for nursery bed was well drained and was of sandy loam type soil. The area was well prepared and converted into loose friable and dried mass to obtain fine till. All weeds and dead roots were removed and the soil was mixed with well rotten cow dung at the rate of 5 kg/bed. The size of each seed bed was 2 x 1 m raised above the ground level maintaining a spacing of 50 cm between the beds. One seed beds were prepared for raising the seedlings. Ten grams of seeds were covered with light soil. Miral 3-GN was applied in each seed bed as precautionary measures against ants and worms. Complete germination of the seeds took place with 6 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. Weeding, mulching and irrigation were done as and when required. No chemical fertilizer was used in the seed bed.

3.6.2 Land preparation

The land for growing the crop was opened with a tractor on 15 October, 2016. Thereafter, it was gradually ploughed and cross ploughed several times with power tiller. Each plugging was followed by laddering to break the clods and to level the soil. During land preparation, weeds and other stubbles of the previous crop were collected and removed from the land. These operations were done to bring the land under a good tilt conditions. Irrigation channels were prepared around the plots four days before transplanting the seedlings.

3.6.3 Manures and fertilizers and its methods of application

Fertilizer	**Quantity**	**Application method**
Cow dung	10 t /ha	Basal dose
Urea	69 kg/ha	20, 35 and 50 DAT
TSP	60 kg/ha	Basal dose
MOP	60 kg/ha	Basal dose

Rashid (1993)

The half of cow dung, TSP and MP and one third of urea were applied as basal dose during land preparation. The remaining cowdung, TSP and MP were applied in the pit 15 days before seed sowing. The rest of urea was top dressed after each flush of flowering and fruiting in three equal splits.

Layout of the field (Fig. 1) and plot (Fig. 2) are presened below:

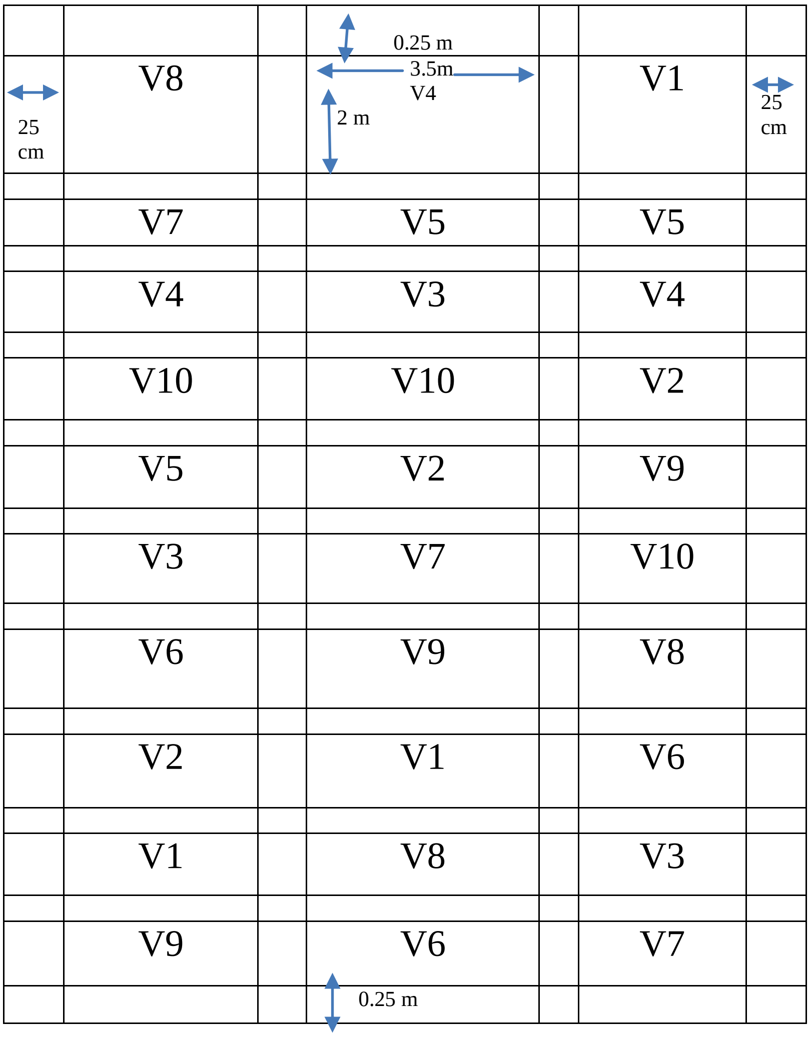

Fig 1. Layout of the field

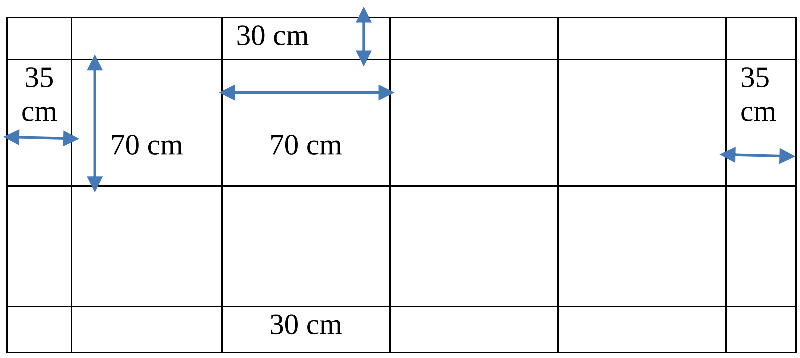

Fig 2. Layout of the plot

3.7 Seedlings transplanting

Healthy and uniform sized 25 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 01 December, 2016 maintaining a spacing of 70 and 70 cm between the rows and plants, respectively. The seed beds were watered before uprooting the seedlings so as to minimize damage to the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by pieces of banana leaf sheath for three days to protect the seedling from the direct sun. Seedlings were also grown around the experimental area to do gap filling and to check the border effect.

3.8 Intercultural operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants.

3.8.1 Gap filling

When the seedlings were established, the soil around the base of each seedlings was pulverized. A few gap filling was done by healthy plants from the border whenever it was required.

3.8.2 Weeding and mulching

Weeding and mulching were accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the crust. It also helped in soil moisture conservation.

3.8.3 Staking and pruning practices

When the plants were well established, staking was given to each plant by Bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were pruned uniformly having single main stem per plant.

3.8.4 Irrigation

Four irrigations were given throughout the growing period by watering can. The first irrigation was given 15 days after planting followed by next three 15 days interval each irrigation. Mulching was also done after each irrigation at appropriate time by breaking the soil crust.

3.9 Harvesting

Fruits were harvested at 4 days intervals during maturing and ripening stage. The maturity of the crop was determined on the basis of red coloring of fruits. Harvesting was started from 23February 2017 and completed by 16 March, 2017.

3.10 Data collection

Data on the following parameters were recorded from the sample during the course of experiment. Five plants were selected randomly from each plot in such a way that the border effect was avoided for the highest precision.

3.10.1 Number of infested plants plot^{-1}

Data on plant infestation plot^{-1} was recorded at 10 days interval which was started from 30 days after transplanting and continued up to 60 DAT. Mean number of infested plants plot^{-1} was calculated on the basis of the total infested plants of the selected plots divided by the total number of plants of the selected plots.

3.10.2 Number of branches plant^{-1}

The number of branches per plant was manually counted at 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of five plants were computed and expressed in average number of branches per plant.

3.10.3 Number of infested branches plant^{-1}

Data on branches infestation plant^{-1} was recorded at 10 days interval which was started from 30 days after transplanting and continued up to 60 DAT. Mean number of infested branch plant^{-1} was calculated on the basis of the total infested branches of the selected plants divided by the total number of branches of the selected plants.

3.10.4 Number of leaves plant^{-1}

The number of leaves per plant was manually counted at 30, 40, 50 and 60 days after transplanting from randomly selected tagged plants. The average of five plants were computed and expressed in average number of leaves per plant.

3.10.5 Number of infested leaves plant^{-1}

Data on leaf infestation plant^{-1} was recorded at 10 days interval which was started from 30 days after transplanting and continued up to 60 DAT. Mean number of infested leaves plant^{-1} was calculated on the basis of the total infested leaves of the selected plants divided by the total number of leaves of the selected plants.

3.10.6 Number of infested leaves plant^{-1}

The number of whiteflyper plant was manually counted at 30, 40, 50 and 60 days after sowing from randomly selected tagged plants. The average of five plants were computed and expressed in average number of whitefly per plant.

3.10.7 Number of fruit borer plant^{-1}

The number of fruit borerper plant was manually counted at 65, 75, 85, 95 and 105 days after sowing from randomly selected tagged plants. The average of five plants were computed and expressed in average number of fruit borerper plant

3.7.8 Infestation percentages of white fly

Infestation percentage of different tomato varieties was calculated on the basis of 30 days 60 DAT data. Because in that time the plants were highest susceptible and maximum whitefly infestation was occurred.

3.7.9 Infestation percentages of varieties by fruit borer

Infestation percentage of different tomatovarieties was calculated on the basis of 65 to 105 DAT data though the fruit borer infestation. Because at that time the plants were highly susceptible and maximum fruit borer infestation was occurred.

3.7.10 Number of fresh ripe fruit

Total number of ripe fruits was counted from selected plants and their average was taken as the number of ripe fruits per plant. Harvesting was done by five times at 90, 94, 98,102 and 106 DAT.

3.7.11 Weight of individual fruit (g)

Among the fiveharvest of marketable fruits during the period from first to final harvests, first and last harvests were omitted and five intermediate harvests were taken for individual fruit weight by the following formula:

Weight of individual fruit (g) =

$$\frac{\text{Total weigh of marketable fruits from four harvest of sample plant}}{\text{Total number of marketable fruit from four harvests of sample plant}}$$

3.7.12 Weight of fruit per plant (kg)

It was measured by the following formula

Weight of fruit per plant (kg) = Number of fresh ripe fruit per plant × weight of individual fruit.

3.7.13 Yield (tha^{-1})

A pan scale balance was used to take the weight of fruits per plant and convert into ton per hectare.

3.8 Statistical Analysis

The data obtained from experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel,1986). The mean values for all the parameters were calculated and the analysis of variance for the characters was accomplished and means were separated by Duncan's Multiple Range Test (DMRT) test at 5% levels of probability (Gomez and Gomez 1984).

CHAPTER IV

RESULT AND DISCUSSION

The present study was conducted to evaluate varietal performance against the infestation whitefly and tomato fruit borer. Data on different growth and yield contributing characters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are given in different table and graph. The results have been presented and discussed with the help of tables and graphs and possible interpretations were given under the following headings.

4.1 Number of whitefly

The significant difference was observed o number of whitefly plant^{-1}due to different varieties of tomato at30, 40, 50 and 60 DAT (Table 1). At 30DAT the maximum number of whitefly plant^{-1}(10.81) was recorded from T_7 (Sonali 35) variety which is statistically identical to T_8,T_9, and T_{10} variety and the minimum number of whitefly plant^{-1} (7.21) was recorded from T_2 (BARI Tomato 3) variety which is statistically identical to V_6 variety.

At 40 DAT the maximum number of whitefly plant^{-1} (10.59) was recorded from T_8 (Sonali 35) and T_9 (Solar) variety which is statistically identical to T_7 (Sonali 35)and the minimum number of whitefly plant^{-1} (16.91) was recorded from T_2 (BARI Tomato 3) variety which is statistically identical to T_6 variety.

At 50 DAT the maximum number of whitefly plant^{-1} (27.97) was recorded from V_8 (Sonali 35) and T_9 (Solar) variety which is statistically identical to T_7 (Sonali 35)and the minimum number of whitefly plant^{-1} (19.23) was recorded from T_2 (BARI Tomato 3) variety.

At 60 DAT the maximum number of whitefly plant^{-1} (2.57) was recorded from T_8 (Sonali 35) and T_9 (Solar) variety which is statistically identical to T_7 (Sonali

35)and the minimum number of whitefly plant^{-1} (1.77) was recorded from T_2 (BARI Tomato 3) variety.

At early flowering stage of tomato similar results were also obtained by Alam *et al*. (1994). Gerling *et al*. (1986) found that the lower and upper developmental thresholds of temperature are 11 and 33ºC, respectively. Rates of development are maximal at 28ºC. Avidov (1956) considered low humidity as the major mortality factor in Israel, leading to cessation of oviposition and adult whitefly mortality. Low humidity of 20% or less during hot weather has been reported to be highly detrimental to the immature stages of whitefly (Gameel 1978; Avidov 1956).

Table 1.Effect of different varieties on number of whitefly plant^{-1} at different days after transplanting

Treatments	**No. of whitefly plant^{-1}**			
	30 DAT	**40 DAT**	**DAT**	**60 DAT**
T_1	7.53de	17.68de	20.10de	1.85d
T_2	7.21e	16.91e	19.23e	1.77e
T_3	8.19c-e	19.22c-e	21.85c-e	2.01c-e
T_4	8.52cd	19.98cd	22.73cd	2.09cd
T_5	9.18bc	21.52bc	24.47bc	2.25bc
T_6	8.19c-e	19.22c-e	21.85c-e	2.01c-e
T_7	10.81a	25.36a	28.84a	2.65a
T_8	10.48a	24.59a	27.97a	2.57a
T_9	10.48a	24.59a	27.97a	2.57a
T_{10}	10.16ab	23.83ab	27.09ab	2.49ab
$LSD_{0.05}$	**1.09**	**2.55**	**2.91**	**0.26**
CV (%)	**7.00**	**5.98**	**6.43**	**6.97**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting.

4.2 Plant Infestation

Significant difference was observed in plant infestationof different tomato varieties at30, 40, 50 and 60 DAT (Table 4.2). At 30 DAT the maximum number of infested plants plot^{-1} (11.00) was recorded from T_4 (BARI Tomato 15) variety and the minimum number of infested plants plot^{-1} (7.33) was recorded from T_2 (BARI Tomato 3) variety. The highest percentage of infestation at 30 DAT was found (73.33) in T_4 (BARI Tomato 15) variety which was statistically identical to V_5 (BARI Tomato 16), T_7 (Sonali 35) and T_{10} (Sonli 12) variety and the lowest was (48.87) in T_2 (BARI Tomato 3) variety (Table 2).

At 40 DAT the maximum number of infested plants plot^{-1} (13.67) was recorded from T_3 (BARI Tomato 14) variety and the minimum number of infested plants plot^{-1} (10.33) was recorded from T_2 (BARI Tomato 3) variety. The highest percentage of infestation at 40 DAT was found (91.13) in T_3 (BARI Tomato 14) variety which is statistically identical to T_4 (BARI Tomato 15), T_5 (BARI Tomato 16), and T_{10} (Sonli 12) variety and the lowest was (68.87) in T_2 (BARI Tomato 3) variety (Table 2).

At 50 DAT the maximum number of infested plants plot^{-1} (15.00) was recorded from T_8 (BARI Tomato 14) and T_{10} (Sonli 12) variety and the minimum number of infested plants plot^{-1} (12.33) was recorded from T_2 (BARI Tomato 3) variety. The highest percentage of infestation at 50 DAT was found (100) in T_8 (BARI Tomato 14) and T_{10} (Sonli 12) variety and the lowest was (82.22) in T_2 (BARI Tomato 3) variety (Table 2).

At 60 DAT the maximum number of infested plants plot^{-1} (3.00) was recorded from T_8 (BARI Tomato 14) and T_{10} (Sonli 12) variety and the minimum number of infested plants plot^{-1} (0.00) was recorded from T_2 (BARI Tomato 3) variety. The highest percentage of infestation at 60 DAT was found (20) in T_8 (BARI Tomato 14) and T_{10} (Sonli 12) variety and the lowest was (0.00) in V_2 (BARI Tomato 3) variety (Table 2).

Stansly and Schuster (1990) reported that damage in tomato resulted from irregular ripening and transmission of tomato mottle geminivirus. Crop damage in tomato due to this pest was estimated to more than 500 million dollars in the United States in 1991 (Perring*et al.* 1993). The main damage caused by *Bemisiatabaci* to the tomato is indirect-by transmitting virus diseases in plants (Cohen and Berlinger 1986).

Table 2. Effect of different varieties on plants infestedby whitefly at different days after transplanting

Treatments	30 DAT			40 DAT		50 DAT		60 DAT	
	No. of plant plot^{-1}	**No. of infested plant plot^{-1}**	**% of infestation**	**No. of infested plant plot^{-1}**	**% of infestation**	**No. of infested plant plot^{-1}**	**% of infestation**	**No. of infested plant plot^{-1}**	**% of infestation**
T_1	15	9.33c	62.20c	11.67b	77.80e	13.667b	91.11b	1.33c	8.87c
T_2	15	7.33d	48.87d	10.33c	68.87f	12.333c	82.22c	0.00d	0.00d
T_3	15	10.67ab	71.13ab	13.67a	91.13a	14.667a	97.78a	2.66b	17.73b
T_4	15	11.00a	73.33a	13.33a	88.87a	14.667a	97.78a	2.33b	15.53b
T_5	15	10.33a-c	68.87a-c	13.33a	88.87a	14.667a	97.78a	2.66b	17.73b
T_6	15	9.67bc	64.47bc	12.67ab	84.47bc	14.667a	97.78a	2.66b	17.73b
T_7	15	10.00a-c	66.67a-c	13.00a	86.67ab	14.667a	97.78a	2.66b	17.73b
T_8	15	9.67bc	64.47bc	12.67ab	84.47bc	15.000a	100.00a	3.00a	20.00a
T_9	15	9.33c	62.20c	12.33ab	82.20cd	14.667a	97.78a	2.66b	17.73b
T_{10}	15	10.33a-c	68.87a-c	13.33a	88.87a	15.00a	100.00a	3.00a	20.00a
LSD $_{0.05}$		**1.14**	**4.64**	**1.21**	**3.62**	**0.83**	**5.77**	**0.34**	**3.42**
CV (%)		**6.85**	**3.54**	**5.58**	**3.89**	**3.56**	**5.66**	**8.66**	**4.36**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting

4.3Branch infestation

At 30DAT the maximum number of branches plant^{-1}(2.99) was recorded from V_2 (BARI Tomato 3) and the minimum number of branches plant^{-1} (2.43) was recorded from T_4 (BARI Tomato 15) and T_8 (Solar).At 30DAT the maximum number of infested branches plant^{-1}(0.68) was recorded from T_9 (Bijli 11) and T_5 (BARI Tomato 16) and the minimum number of infested branches plant^{-1} (0.53) was recorded from T_2 (BARI Tomato 3) variety which is statistically identical to T_1 (BARI Tomato 2),The highest percentage of infestation at 30 DAT was found (30.84) in T_7 (Sonali 35) and the lowest was (6.324) in T_2 (BARI Tomato 3)(Table 3).

At 40 DAT the maximum number of branches plant^{-1}(6.38) was recorded from T_2 (BARI Tomato 3) which is statically similarwith T_5, T_9, $T_{10}$and the minimum number of branches plant^{-1} (2.43) was recorded from T_7 (Sonali 35) At 40 DAT the maximum number of infested branches plant^{-1}(1.91) was recorded from T_9 (Bijli 11) and T_5 (BARI Tomato 16) and the minimum number of infested branches plant^{-1} (1.49) was recorded from T_2 (BARI Tomato 3) variety which is statistically identical to T_1 (BARI Tomato 2). The highest percentage of infestation at 40 DAT was found (38.06) in T_7 (Sonali 35) and the lowest was (23.58) in T_2 (BARI Tomato 3) (Table 3).

At 50 DAT the maximum number of branches plant^{-1} (8.51) was recorded from T_2 (BARI Tomato 3) which is statically similar with T_5, T_9, T_{10} and the minimum number of branches plant^{-1} (6.44) was recorded from T_7 (Sonali 35) At 50 DAT the maximum number of infested branches plant^{-1}(4.06) was recorded from T_9 (Bijli 11) and the minimum number of infested branches plant^{-1} (1.94) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 50 DAT was found (47.05) in T_{10} (Sonali 12) which is statically similar with T_5, $T_9$and the lowest was recorded (22.79) in T_2 (BARI Tomato 3) (Table 3).

At 60 DAT the maximum number of branches plant^{-1} (12.69) was recorded from T_2 (BARI Tomato 3) which is statically similar with T_{10} and the minimum number of branches plant^{-1} (11.07) was recorded from T_7 (Sonali 35) At 60 DAT the maximum number of infested branches plant^{-1}(0.97) was recorded from T_{10} (Bijli 11) and the minimum number of infested branches plant^{-1} (0.74) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 60 DAT was found (9.52) in T_7 (Sonali 35) and the lowest was recorded (5.91) in T_2 (BARI Tomato 3) (Table 3).

Table 3. Effect of different varieties on branch infestation by whitefly at different days after transplanting

Treatments	30 DAT			40 DAT			50 DAT			60 DAT		
	No. of branch plant^{-1}	**No. of infested branch plant^{-1}**	**% of infestation**	**No. of branch plant^{-1}**	**No. of infested branch plant^{-1}**	**% of infestation**	**No. of branch plant^{-1}**	**No. of infested branch plant^{-1}**	**% of infestation**	**No. of branch plant^{-1}**	**No. of infested branch plant^{-1}**	**% of infestation**
T_1	2.50bc	0.55c	22.05bc	5.66b	1.54c	27.22bc	7.60b	3.10c	40.77b	11.33c	0.77	6.82bc
T_2	2.99a	0.53c	17.77c	6.34a	1.49c	23.58c	8.51a	1.94d	22.79	12.69a	0.74	5.91c
T_3	2.60bc	0.60b	23.14a-c	5.52b	1.68b	30.62b	7.40b	2.90c	39.21b	11.04c	0.84	7.67a-c
T_4	2.43c	0.63a	26.25ab	5.52b	1.78b	32.36ab	7.40b	2.90c	39.21b	11.04c	0.89	8.12ab
T_5	2.68d	0.68a	25.35a-c	6.08a	1.91a	31.34b	8.15a	3.65b	44.79a	12.16b	0.95	7.83a-c
T_6	2.43c	0.60b	24.82a-c	5.52b	1.68b	30.62b	7.40b	2.90c	39.21b	11.04c	0.84	7.67a-c
T_7	2.11d	0.65a	30.84a	4.80c	1.82a	38.06a	6.44c	1.99d	30.90c	9.60d	0.91	9.52a
T_8	2.43c	0.53c	21.91bc	5.52b	1.50c	27.07bc	7.40b	2.90c	39.21b	11.07c	0.91	8.35ab
T_9	2.68bc	0.68a	25.35a-c	6.08a	1.91a	31.34ab	8.15a	3.65b	44.79a	12.10b	0.95	7.83a-c
T_{10}	2.74b	0.62b	22.46bc	6.37a	1.74b	26.88bc	8.56a	4.06a	47.05a	12.91a	0.97	7.53bc
LSD $_{0.05}$	**0.24**	**0.04**	**7.06**	**0.31**	**0.11**	**6.29**	**0.40**	**0.36**	**2.58**	**0.50**	**-**	**1.71**
CV (%)	**5.49**	**8.15**	**7.17**	**3.16**	**7.99**	**8.06**	**3.05**	**7.34**	**3.66**	**2.57**	**13.44**	**12.92**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting

4.4 Leaf infestation

At 30DAT the maximum number of leaves $plant^{-1}$ (8.51) was recorded from T_2 (BARI Tomato 3) which is statistically similar with T_5, T_9, T_{10} and the minimum number of leaves $plant^{-1}$ (6.44) was recorded from T_7 (Sonali 35). At 30 DAT the maximum number of infested leaves $plant^{-1}$ (0.68) was recorded from T_9 (Bijli 11) and the minimum number of infested leaves $plant^{-1}$ (0.53) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 30 DAT was found (10.12) in T_7 (Sonali 35) variety which was statistically different than other varieties and the lowest was (6.27) in T_2 (BARI Tomato 3) which was statistically identical to T_1 and T_{10} variety (Table 4).

At 40 DAT the maximum number of leaves $plant^{-1}$ (17.02) was recorded from V_2 (BARI Tomato 3) which is statistically similar with T_5, T_9, T_{10} and the minimum number of leaves $plant^{-1}$ (12.89) was recorded from T_7 (Sonali 35). At 40 DAT the maximum number of infested leaves $plant^{-1}$ (11.46) was recorded from V_9 (Bijli 11) which is statistically similarwith T_4,T_5,T_8,$T_9$and the minimum number of infested leaves $plant^{-1}$ (8.96) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 40 DAT was found (85.01) in T_7 (Sonali 35) variety which is statistically different than other varieties and the lowest was (52.69) in T_2 (BARI Tomato 3) (Table 4).

At 50 DAT the maximum number of leaves $plant^{-1}$ (36.60) was recorded from T_2 (BARI Tomato 3) which is statistically similar with T_5, T_9, T_{10} and the minimum number of leaves $plant^{-1}$ (27.70) was recorded from T_7 (Sonali 35). At 50 DAT the maximum number of infested leaves $plant^{-1}$ (19.48) was recorded from V_9 (Bijli 11) and T_5 (BARI Tomato 16) and the minimum number of infested leaves $plant^{-1}$ (15.23) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 50 DAT was found (67.22) in T_7 (Sonali 35) variety which is statistically different than other varieties and the lowest was (41.66) in T_2 (BARI Tomato 3) (Table 4).

At 60 DAT the maximum number of leaves $plant^{-1}$ (47.67) was recorded from T_2 (BARI Tomato 3) which is statistically similar with V_9 and the minimum number of leaves $plant^{-1}$ (41.47) was recorded from T_7 (Sonali 35). At 60 DAT the maximum number of infested leaves $plant^{-1}$ (1.97) was recorded from T_{10} (Sonali 12) and T_5 (BARI Tomato 16) and the minimum number of infested leaves $plant^{-1}$ (15.23) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 60 DAT was found (5.30) in T_7 (Sonali 35) variety which was statistically different from other varieties and the lowest was (3.67) in T_2 (BARI Tomato 3) (Table 4).

Table 4. Effect of different varieties on leaf infestation by whitefly at different days after transplanting

Treatments	30 DAT			40 DAT			50 DAT			60 DAT		
	No. of leaves plant^{-1}	**No. of infested leaves plant^{-1}**	**% of infestation**	**No. of leaves plant^{-1}**	**No. of infested leaves plant^{-1}**	**% of infestation**	**No. of leaves plant^{-1}**	**No. of infested leaves plant^{-1}**	**% of infestation**	**No. of leaves plant^{-1}**	**No. of infested leaves plant^{-1}**	**% of infestation**
T_1	7.60b	0.55	7.25b	15.20b	9.24b	60.88cd	32.68b	15.71	48.14bc	42.56c	1.77	4.16b
T_2	8.51a	0.53	6.27b	17.02a	8.96b	52.69d	36.60a	15.23	41.66d	47.67a	1.75	3.67c
T_3	7.41b	0.60	8.14ab	14.81b	10.12ab	68.33bc	31.84b	17.21	54.03bc	41.47c	1.84	4.45b
T_4	7.41b	0.64	8.59ab	14.81b	10.68a	72.16b	31.84b	18.16	57.06bc	41.47c	1.89	4.56b
T_5	8.16a	0.68	8.37ab	16.31a	11.46a	70.29bc	35.06a	19.48	55.58bc	45.66b	1.95	4.28b
T_6	7.41b	0.60	8.14ab	14.81b	10.12ab	68.33bc	31.84b	17.21	54.03bc	41.47c	1.84	4.45b
T_7	6.44c	0.65	10.12a	12.89c	10.96a	85.01a	27.70c	18.64	67.22a	36.08d	1.92	5.30a
T_8	7.41b	0.54	7.20b	14.81b	9.00b	60.52cd	31.84b	15.31	47.86bc	41.47c	1.92	4.62b
T_9	8.16a	0.68	8.37ab	16.31a	11.46a	70.29bc	35.06a	19.48	55.58bc	45.66b	1.95	4.28b
T_{10}	8.56a	0.62	7.18b	17.12a	10.41a	60.28cd	36.80a	17.71	47.66bc	47.92a	1.97	4.13bc
$LSD_{0.05}$	**0.39**	**-**	**2.3**	**0.80**	**1.35**	**9.23**	**1.74**	**-**	**5.41**	**1.82**	**-**	**0.46**
CV (%)	**3.05**	**8.51**	**10.98**	**3.06**	**7.49**	**6.91**	**4.63**	**10.94**	**9.56**	**4.94**	**6.92**	**6.24**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting

4.5 Inflorescence infestation

At 30 DAT the highest number of inflorescence plant^{-1}(3.32) was recorded from T_2 (BARI Tomato 3) variety and the lowest number of inflorescence plant^{-1} (2.44) was recorded from T_7 (Sonali 35) variety. At 30 DAT the highest number of infested inflorescence plant^{-1}(1.09) was recorded from T_{10} (Sonli 12) variety and the lowest number of infested inflorescence plant^{-1} (0.75) was recorded from T_2 (BARI Tomato 3) variety which is statistically identical to T_7 variety.The highest percentage of infestation in inflorescence per plant at 30 DAT was found (33.32) in T_5 (BARI Tomato 16) and T_9 (Bijli 11) and the lowest was (22.59) in T_2 (BARI Tomato 3) which is statistically identical to T_7 variety (Table 5).

At 40 DAT the highest number of inflorescence plant^{-1} (8.85) was recorded from V_2 (BARI Tomato 3) variety and the lowest number of inflorescence plant^{-1} (7.11) was recorded from T_7 (Sonali 35). At 40 DAT the highest number of infested inflorescence plant^{-1} (4.49) was recorded from T_{10} (Sonli 12) variety and the lowest number of infested inflorescence plant^{-1} (2.85) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in inflorescence plant^{-1} at 40 DAT was found (52.61) in T_{10} (BARI Tomato 16) which is statistically identical to T_5 and T_9 variety and the lowest was (32.20) in T_2 (BARI Tomato 3) (Table 5).

At 50 DAT the highest number of inflorescence plant^{-1} (15.69) was recorded from T_2 (BARI Tomato 3) variety and the lowest number of inflorescence plant^{-1} (12.22) was recorded from T_7 (Sonali 35). At 50 DAT the highest number of infested inflorescence plant^{-1} (7.12) was recorded from T_{10} (Sonli 12) variety and the lowest number of infested inflorescence plant^{-1} (4.69) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in inflorescence plant^{-1} at 50 DAT was found (46.60) in T_{10} (BARI Tomato 16) and the lowest was (29.89) in T_2 (BARI Tomato 3) (Table 5).

At 60 DAT the highest number of inflorescence plant^{-1} (17.69) was recorded from T_2 (BARI Tomato 3) variety and the lowest number of inflorescence plant^{-1} (14.22) was recorded from T_7 (Sonali 35). At 60 DAT the highest number of infested inflorescence plant^{-1} (8.65) was recorded from T_{10} (Sonli 12) variety and the lowest number of infested inflorescence plant^{-1} (6.09) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in inflorescence plant^{-1} at 60 DAT was found (51.74) in T_{10} (BARI Tomato 16) and the lowest was (34.42) in T_2 (BARI Tomato 3) (Table 5).

Table 5. Effect of different varieties on inflorescence infestation by whitefly at different days after transplanting

Treatments	30 DAT			40 DAT			50 DAT			60 DAT		
	No. of inflorescence plant^{-1}	**No. of infested inflorescence plant^{-1}**	**% of infestation**	**No. of inflorescence plant^{-1}**	**No. of infested inflorescence plant^{-1}**	**% of infestation**	**No. of inflorescence plant^{-1}**	**No. of infested inflorescence plant^{-1}**	**% of infestation**	**No. of inflorescence plant^{-1}**	**No. of infested inflorescence plant^{-1}**	**% of infestation**
T_1	2.82bc	0.82bc	29.02ab	8.03bc	4.03bc	50.12ab	14.07bc	6.07bc	43.01bc	16.07b	8.06a	50.12bc
T_2	3.32a	0.75c	22.59c	8.85a	2.85e	32.20d	15.69a	4.69e	29.89e	17.69a	6.09b	34.42e
T_3	2.93bc	0.93bc	31.52ab	7.41d	3.41d	45.97c	12.81cd	4.81cd	37.52d	14.81c	6.81b	45.97d
T_4	2.76c	0.76c	27.37b	7.41d	3.41d	45.97c	12.81cd	4.81cd	37.52d	14.81c	6.81b	45.97d
T_5	3.00bc	1.00bc	33.32a	8.16b	4.16b	50.92a	14.34b	6.34b	44.19ab	16.31b	8.30a	50.92b
T_6	2.76c	0.76c	27.37b	7.51cd	3.51cd	46.68bc	13.01cd	5.01cd	38.48cd	15.01c	7.01b	46.68cd
T_7	2.44d	0.54d	22.14c	7.11d	3.11d	43.59c	12.22d	4.22d	34.30d	14.22c	6.22b	43.59d
T_8	2.76c	0.76c	27.37b	7.41d	3.41d	45.97c	12.81cd	4.81cd	37.52cd	14.81c	6.81b	45.97d
T_9	3.00bc	1.00bc	33.32a	8.19b	4.19b	51.13a	14.32b	6.32b	44.09ab	16.32b	8.31a	50.95b
T_{10}	3.06b	1.09a	35.19a	8.49ab	4.49a	52.61a	15.12ab	7.12a	46.60a	16.65b	8.65a	51.74a
LSD $_{0.05}$	**0.24**	**0.21**	**5.23**	**0.55**	**0.51**	**3.66**	**1.17**	**1.17**	**5.04**	**1.03**	**1.03**	**3.47**
CV (%)	**4.88**	**10.95**	**10.14**	**4.14**	**8.44**	**4.16**	**5.01**	**12.01**	**6.78**	**3.86**	**7.88**	**4.32**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting

4.6 Fruit infestation by fruit borer

At 65 DAT the highest number of fruit plant^{-1} (3.11) was recorded from T_8 (Solar) variety and the lowest number of fruit plant^{-1} (2.44) was recorded from T_2 (BARI Tomato 3) variety. At 65 DAT the highest number of infested fruit plant^{-1} (1.09) was recorded from T_5 (BARI Tomato 16) variety and the lowest number of infested fruit plant^{-1} (0.36) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in fruit plant^{-1} at 65 DAT was found (28.81) in T_6 (BARI Tomato 17)and the lowest was recorded (15.52) in T_2 (BARI Tomato 3) (Table 6).

At 75 DAT the highest number of fruit plant^{-1} (8.37) was recorded from V_8 (Solar) variety and the lowest number of fruit plant^{-1} (3.53) was recorded from V_6 (BARI Tomato 17) variety. At 75 DAT the highest number of infested fruit plant^{-1} (2.40) was recorded from T_5 (BARI Tomato 16) variety and the lowest number of infested fruit plant^{-1} (1.17) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 75 DAT was found (33.29) in T_6 (BARI Tomato 17) and the lowest was recorded (18.90) in T_2 (BARI Tomato 3) (Table 6).

At 85 DAT the highest number of fruit plant^{-1} (14.48) was recorded from T_8 (Solar) variety and the lowest number of fruit plant^{-1} (6.11) was recorded from T_6 (BARI Tomato 17) variety. At 85 DAT the highest number of infested fruit plant^{-1} (4.13) was recorded from T_5 (BARI Tomato 16) variety and the lowest number of infested fruit plant^{-1} (3.12) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in fruit plant^{-1} at 85 DAT was found (31.70) in T_{10} (Sonli 12) and the lowest was recorded (27.46) in T_7 (Sonali 35) (Table 6).

At 95 DAT the highest number of fruit plant^{-1} (11.71) was recorded from T_8 (Solar) variety and the lowest number of fruit plant^{-1} (4.94) was recorded from T_6 (BARI Tomato 17) variety. At 95 DAT the highest number of infested fruit plant^{-1} (2.54) was recorded from T_6 (BARI Tomato 17) variety and the lowest number of infested fruit plant^{-1} (1.70) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in fruit plant^{-1} at 95 DAT was found (25.15) in T_6 (BARI Tomato 17) and the lowest was recorded (19.60) in T_3 (BARI Tomato 3) (Table 6).

At 105 DAT the highest number of fruit plant^{-1} (3.52) was recorded from T_8 (Solar) variety and the lowest number of fruit plant^{-1} (1.48) was recorded from T_6 (BARI Tomato 17) variety. At 105 DAT the highest number of infested fruit plant^{-1} (0.51) was recorded from T_5 (BARI Tomato 16) variety and the lowest number of infested fruit plant^{-1} (1.71) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation in fruit plant^{-1} at 105 DAT was found (19.55) in T_6 (BARI Tomato 17) and the lowest was recorded (9.39) in T_2 (BARI Tomato 3) (Table 6).

The present results are in partial agreement with that of Gadhiya *et al.* (2014) who reported chlorantrailiprole, abamectin and spinosad as effective insecticides against H. armigera on groundnut. Abamectin was reported as significantly superior thanquinalphos (Patel *et al*. 2009) and spinosad (Tatagar *et al.* 2009) in reducing H. armigera population and fruit damage in tomato corroborates the present results. In the present investigation spinosad was found as moderately effective insecticide and superior than quinalphos get support from the finding of Ghosh*et al.* (2010) who reported spinosad as effective against *H. armigera* on tomato in comparison to quinalphos. Contrary to present results, Siddegowda *et al.* (2006), Patil *et al.* (2007), Kuttalam *et al.* (2008) and Jat and Ameta (2013) had reported spinosad as most effective and at par to the indoxacarb against tomato fruit borer.

Table 6. Effect of different varieties on fruit infestationby fruit borer different days after transplanting

Treatments	65 DAT			75 DAT			85 DAT			95 DAT			105 DAT		
	No. of fruit plant^{-1}	No. of infested fruit plant^{-1}	% of infestation	No. of fruit plant^{-1}	No. of infested fruit plant^{-1}	% of infestation	No. of fruit plant^{-1}	No. of infested fruit plant^{-1}	% of infestation	No. of fruit plant^{-1}	No. of infested fruit plant^{-1}	% of infestation	No. of fruit plant^{-1}	No. of infested fruit plant^{-1}	% of infestation
T_1	2.17de	0.43bc	20.00cd	6.19e	1.86c	30.03b-c	10.83d	3.26c	30.04ab	8.66e	1.99c	22.90b	2.60d	0.32d	12.35e
T_2	2.32d	0.36c	15.52e	6.19e	1.17c	18.90e	10.98d	3.12c	28.36bc	8.67e	1.70d	19.60 c	2.60d	0.24e	9.39f
T_3	2.10e	0.43bc	20.24cd	5.33f	1.58d	29.50b-c	9.23e	2.77d	30.10ab	7.47f	1.71d	22.96b	2.24e	0.28de	12.47e
T_4	2.62c	0.56ab	21.41c	7.03d	2.15b	30.55a-d	12.17c	3.66b	30.06ab	9.85d	2.31b	23.40b	2.96c	0.40c	13.68d
T_5	2.80b	0.67a	23.96b	7.61bc	2.40a	31.48a-c	13.38b	4.13b	30.86a	10.65c	2.54a	23.90b	3.19b	0.51a	15.93b
T_6	1.29f	0.37c	28.81a	3.53g	1.18e	33.29a	6.11f	1.92e	31.39a	4.94g	1.24e	25.15a	1.48f	0.29de	19.55a
T_7	2.60c	0.62a	23.85b	7.61bc	2.38a	31.35a-c	13.08bc	4.03a	30.80a	10.65c	2.54a	23.87b	3.20b	0.50ab	15.61bc
T_8	3.11a	0.60ab	19.12d	8.37a	2.36a	28.24d	14.48a	3.97a	27.46c	11.71a	2.51a	21.43c	3.52a	0.46a-c	12.97de
T_9	2.85b	0.61ab	21.30c	7.78b	2.37a	30.50b-d	13.59b	4.12a	30.30ab	10.85b	2.52a	23.27b	3.25b	0.45bc	13.62d
T_{10}	2.59c	0.62a	24.06b	7.20cd	2.31a	32.18ab	12.81bc	4.04a	31.70a	9.89d	2.34b	23.67b	2.97c	0.45bc	14.99c
LSD $_{0.05}$	**0.17**	**0.16**	**1.82**	**0.42**	**0.15**	**2.49**	**0.88**	**0.23**	**1.98**	**0.17**	**0.14**	**1.04**	**0.16**	**0.05**	**0.88**
CV (%)	**4.18**	**4.48**	**3.76**	**3.64**	**3.86**	**4.87**	**4.38**	**3.96**	**3.74**	**3.40**	**4.86**	**5.65**	**4.78**	**5.87**	**3.67**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting

4.7 Number of fruit borer

The significant difference was observed on number of fruit borer plot^{-1}due to planting different varieties of tomato at 65, 75, 85, 95 and 105 DAT (Table 7). At 65 DAT the maximum number of fruit borer Plot^{-1} (4.07) was recorded from T_7 (Sonali 35) variety which is statistically identical to T_2 variety and the minimum number of fruit borer Plot^{-1} (3.43) was recorded from T_2 (BARI Tomato 3) variety. At 75 DAT the maximum number of fruit borer Plot^{-1} (8.01) was recorded from T_7 (Sonali 35) variety which is statistically identical to V_8 and V_9 variety and the minimum number of fruit borer Plot^{-1} (6.76) was recorded from V_2 (BARI Tomato 3) variety. At 85 DAT the maximum number of fruit borer Plot^{-1} (10.70) was recorded from T_7 (Sonali 35) variety and the minimum number of fruit borer Plot^{-1} (9.06) was recorded from T_2 (BARI Tomato 3). At 95 DAT the maximum number of fruit borer Plot^{-1} (5.65) was recorded from T_7 (Sonali 35) which was statistically similar T_8, T_9 and the minimum number of fruit borer Plot^{-1} (4.77) was recorded from T_2 (BARI Tomato 3). At 105 DAT the maximum number of fruit borer Plot^{-1} (4.77) was recorded from T_7 (Sonali 35) which was statistically similar T_8, T_9 and the minimum number of fruit borer Plot^{-1} (5.65) was recorded from T_2 (BARI Tomato 3).

Table 7. Effect of different varieties on number of fruit borer plot^{-1} at different days after transplanting

Treatment	No. of fruit borer plot^{-1}				
	65 DAT	**75 DAT**	**85 DAT**	**95 DAT**	**105 DAT**
T_1	3.49d	6.87de	9.21e	4.85de	1.85de
T_2	3.43d	6.76e	9.06f	4.77e	1.77e
T_3	3.60cd	7.10c-d	9.52d	5.01c-d	2.01c-d
T_4	3.66b-d	7.21cd	9.67d	5.09cd	2.09cd
T_5	3.78a-d	7.44bc	9.97c	5.25bc	2.25bc
T_6	3.60cd	7.10c-e	9.52d	5.01c-d	2.01c-e
T_7	4.07a	8.01a	10.70a	5.65a	2.65a
T_8	4.01ab	7.90a	10.58b	5.57a	2.57a
T_9	4.01ab	7.90a	10.58ab	5.57a	2.57a
T_{10}	3.95a-c	7.78ab	10.43b	5.49ab	2.49ab
LSD $_{0.05}$	**0.35**	**0.37**	**0.15**	**0.26**	**0.26**
CV (%)	**2.94**	**3.00**	**5.98**	**2.97**	**6.97**

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato-2, T_2: BARI Tomato-3, T_3: BARI Tomato-14, T_4: BARI Tomato-15, T_5: BARI Tomato-16, T_6: BARI Tomato-17, T_7: Sonali-35, T_8: Solar, T_9: Bijli-11 and T_{10}: Sonli-12. DAT: Days after transplanting

4.8 Comparative yield component of different varieties

4.8.1 Total number of fruit plant^{-1}

Total number of fruit plant^{-1} of different varieties varied significantly variety (Fig. 3). The highest total number of fruit plant^{-1} (53.83) was obtained from T_8 (Solar) variety and the lowest total number of fruit plant^{-1}(47.01) was obtained from T_6 (BARI Tomato 17) variety.

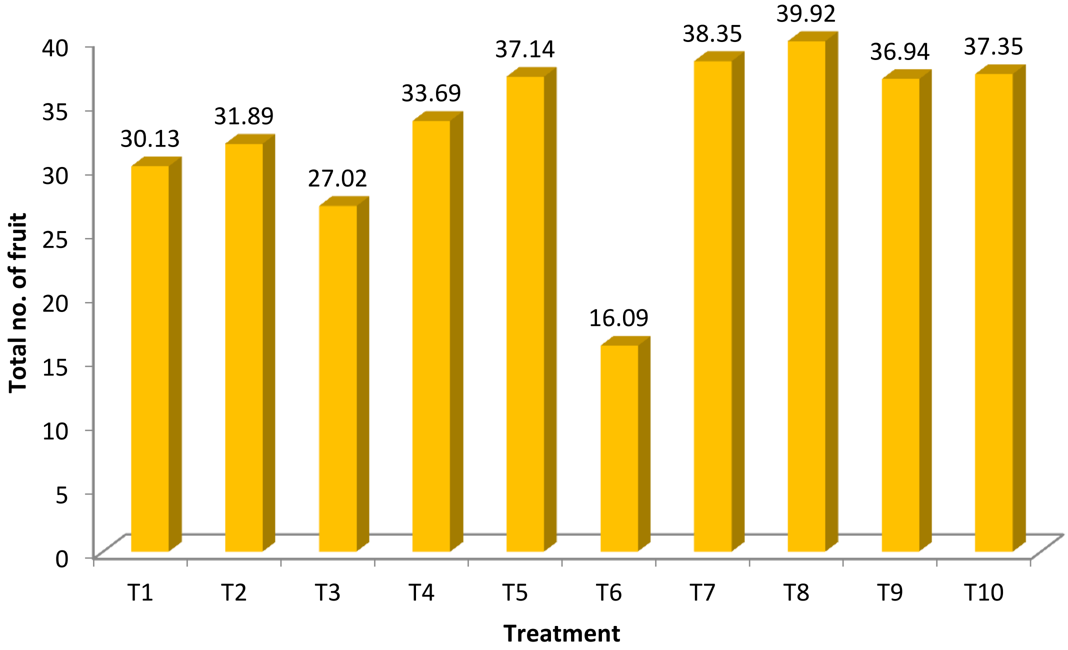

Fig.3 Number of fruits in different varieties

4.8.2 Individual fruit weight (g)

Individual fruit weightof different variety varied significantly (Fig. 4). The highest individual fruit weight(137.43 g) was obtained from T_6 (BARI Tomato 17) variety and the lowest individual fruit weight(59.11 g) was obtained from T_4 (BARI Tomato 15) variety.

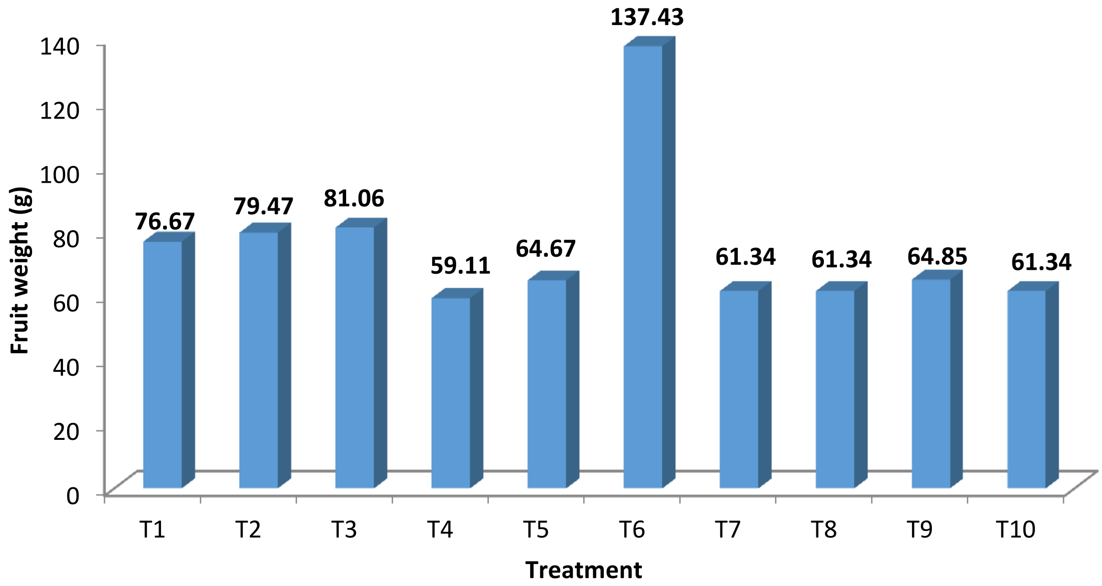

Fig.4 Single fruit weight in different tomato varieties

4.8.3 Weight of fruit plant^{-1} (kg)

Weight of fruit plant^{-1}of different variety varied significantly (Fig. 5). The highest weight of fruit plant^{-1}(2.53 kg) was obtained from T_2 (BARI Tomato 3) variety and the lowest weight of fruit plant^{-1} **(**1.99 kg) was obtained from T_4 (BARI Tomato 15) variety.

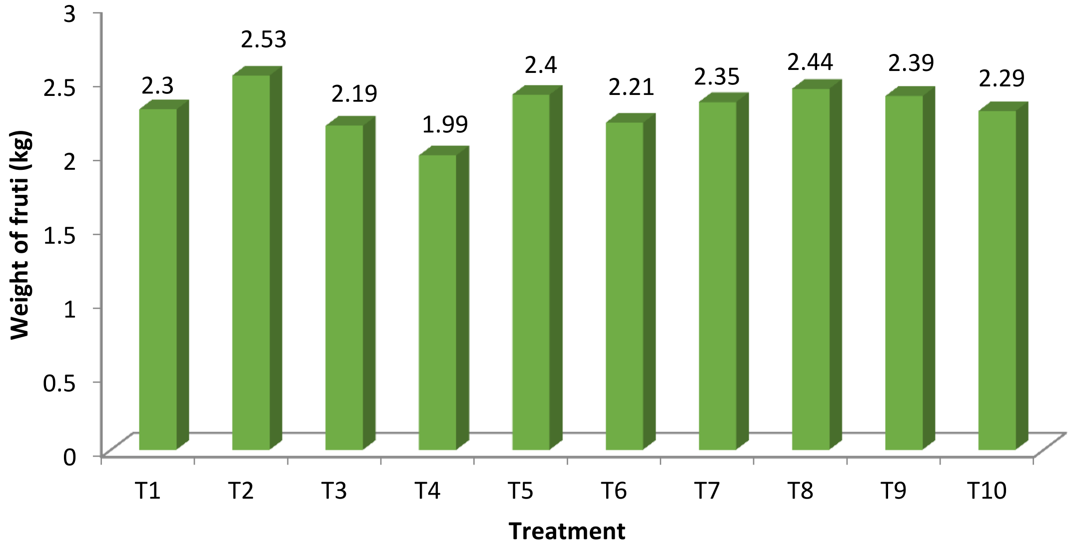

Fig.5 Weight of fruit plant^{-1} of different varieties of tomato

4.8.4 Yield tha^{-1}

Yield of different variety varied significantly due to different treatment (Fig.6). The highest yield (53.83 t ha^{-1}) was obtained from T_2 (BARI Tomato 3) variety and the lowest yield (47.01 t ha^{-1}) was obtained from T_4 (BARI Tomato 15) variety. The insect infestation of BARI Tomato 3 variety was less than the others variety. Due to the lower insect infestation all the leaves were good shape and good physiological activities occurred and the variety gave the highest yield. Similar findings were observed by Mishra *et al.* (1996) and Husain *et al.* (1998).

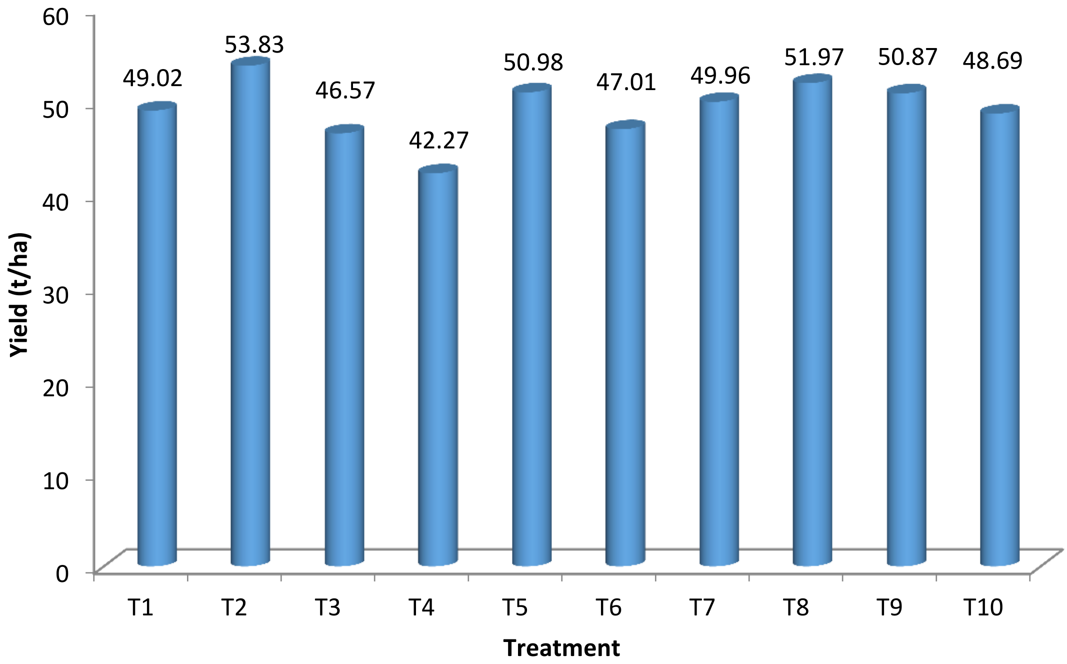

Fig.6 Fruit yield in different varieties of tomato

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The experiment was conducted in the central farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November to March, 2017to evaluate varietal performance of tomato against the infestation white fly and tomato fruit borer.This is the single factor experiment.Factor A: ten varieties of tomato. T_1: BARI Tomato 2, T_2: BARI Tomato 3, T_3: BARI Tomato 14, T_4: BARI Tomato 15, T_5: BARI Tomato 16, T_6: BARI Tomato 17, T_7: Sonali 35, T_8: Solar, T_9: Bijli 11 and T_{10}: Sonli 12. DAT: Days after transplanting. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth and infestation stage were recorded to find out the tolerant varieties of tomato for better production.

The significant difference was observed in number of whitefly plant^{-1}due to different varieties of tomato at30, 40, 50 and 60 DAT. At 50 DAT the maximum number of white fly plant^{-1} (27.97) was recorded from T_8 (Sonali 35) and T_9 (Solar) variety which is statistically identical to T_7 (Sonali-35) and the minimum number of whitefly plant^{-1} (19.23) was recorded from T_2 (BARI Tomato-3) variety. There wasa significant difference observed due to number of plant infestation of different tomato varieties recorded at 30, 40, 50 and 60 DAT.

Significant difference was observed in branches infestation plant^{-1} infestation of different tomato varieties at 30, 40, 50 and 60 DAT. At 60 DAT the maximum number of branches plant^{-1} (12.69) was recorded from T_2 (BARI Tomato 3) and the minimum number of branches plant^{-1} (11.07) was recorded from T_7 (Sonali 35). At 60 DAT the maximum number of infested branches plant^{-1} (0.97) was recorded from T_{10} (Bijli-11) and the minimum number of infested branches plant^{-1} (0.74) was recorded from T_2 (BARI Tomato-3). The highest percentage of infestation at 60 DAT was found (9.52) in T_7 (Sonali 35) and the lowest was recorded (5.91) in T_2 (BARI Tomato 3).

At 60 DAT the maximum number of leaves plant^{-1} (47.67) was recorded from T_2 (BARI Tomato 3) which was statistically similar with T_9 and the minimum number of leaves plant^{-1} (41.47) was recorded from T_7 (Sonali 35). At 60 DAT the maximum number of infested leaves plant^{-1} (1.97) was recorded from T_{10} (Sonali 12) and T_5 (BARI Tomato-16) and the minimum number of infested leaves plant^{-1} (15.23) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 60 DAT was found (5.30) in T_7 (Sonali 35) variety which was statistically different from other varieties and the lowest was (3.67) in T_2 (BARI Tomato 3).

At 60 DAT the highest number of inflorescence plant^{-1} (17.69) was recorded from T_2 (BARI Tomato 3) variety and the lowest number of inflorescence plant^{-1} (14.22) was recorded from T_7 (Sonali 35). At 60 DAT the highest number of infested inflorescence plant^{-1} (8.65) was recorded from T_{10} (Sonli 12) variety and the lowest number of infested inflorescence plant^{-1} (6.09) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 60 DAT was found (51.74) in T_{10} (BARI Tomato-16) and the lowest was (34.42) in T_2 (BARI Tomato 3).

Significant difference was observed in number of fruit borer plot^{-1} and fruit infestation due to planting different varieties of tomato at 65, 75, 85, 95 and 105 DAT. At 85 DAT the maximum number of fruit borer plot^{-1} (10.70) was recorded from T_7 (Sonali 35) variety and the minimum number of fruit borer plot^{-1} (9.06) was recorded from T_2 (BARI Tomato 3). At 95 DAT the highest number of fruit plant^{-1} (11.71) was recorded from T_8 (Solar) variety and the lowest (4.94) was recorded from T_6 (BARI Tomato 17) variety. The highest number of infested fruit plant^{-1} (2.54) was recorded from T_6 (BARI Tomato 17) variety and the lowest number (1.70) was recorded from T_2 (BARI Tomato 3). The highest percentage of infestation at 95 DAT was found (25.15) in T_6 (BARI Tomato 17) and the lowest was recorded (19.60) in T_3 (BARI Tomato 14).

Total number of fruit plant^{-1}, individual fruit weight, weight of fruit plot^{-1} and yield of different variety varied significantly due to different varieties. The highest number of fruit plant^{-1} (53.83) was obtained from T_8 (Solar) variety and the lowest number of fruit plant^{-1}(47.01) was obtained from V_6 (BARI Tomato 17) variety. The highest individual fruit weight (137.43 g) was obtained from T_6 (BARI Tomato 17) variety and the lowest individual fruit weight **(**59.11 g) was obtained from T_4 (BARI Tomato 15) variety. The highest weight of fruit plot^{-1} (2.53 kg) was obtained from T_2 (BARI Tomato-3) variety and the lowest weight of fruit plot^{-1} **(**1.99 kg) was obtained from T_4 (BARI Tomato-15) variety. Yield of different varieties varied significantly. The highest yield (53.83 t ha^{-1}) was obtained from T_2 (BARI Tomato 3) variety and the lowest yield (47.01 t ha^{-1}) was obtained from T_4 (BARI Tomato 15) variety. The insect infestation of BARI Tomato 3 variety was less than the others variety. Due to the lower insect infestation all the leaves were good shape and good physiological activities occurred and the variety gave the highest yield.

Conclusion

In a nutshell it can be concluded that BARI Tomato 3 (T_2) variety that is more tolerant to whitefly and fruit borer compared to other 9 varieties. Other varieties ranking in tolerant was T_3: BARI Tomato 14 > T_1: BARI Tomato 2 > T_4: BARI Tomato 15 > T_9: Bijli 11 > T_7: Sonali 35>T_8: Solar, >T_5: BARI Tomato 16 > T_{10}: Sonli 12 >T_6: BARI Tomato 17.

All varieties were infested by whitefly and fruit borer. But the BARI Tomato 3 (T_2) variety performed better than the other 9 varieties and found more tolerant to whitefly and fruit borer and which ensure higher yield.

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APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from October 2016 to March 2017

Month	Air temperature (^0C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
October,16	29.18	18.26	81	39
November,16	25.82	16.04	78	0
December,16	22.4	13.5	74	0
January,17	24.5	12.4	68	0
February,17	27.1	16.7	67	3
March,17	31.4	19.6	54	11

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix II. Results of morphological, mechanical and chemical analysis of soil of the experimental plot

A. Morphological Characteristics

Morphological features	Characteristics
Location	Field Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow redbrown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Mechanical analysis

Constituents	Percentage (%)
Sand	28.78
Silt	42.12
Clay	29.1

C. Chemical analysis

Soil properties	Amount
Soil pH	5.8
Organic carbon (%)	0.95
Organic matter (%)	0.77
Total nitrogen (%)	0.075
Available P (ppm)	15.07
Exchangeable K (%)	0.32
Available S (ppm)	16.17

Source: Soil Resource Development Institute (SRDI)

Appendix III Effect of different varieties on yield component at different days after transplanting

Treatment	Total no of fruit plant^{-1}	Individual Fruit weight (g)	Weight of fruit plot^{-1} (kg)	Yield (t ha^{-1})
T_1	30.13d	76.67c	2.30bc	49.02bc
T_2	31.89cd	79.47bc	2.53a	53.83a
T_3	27.02e	81.06b	2.19c	46.57c
T_4	33.69c	59.11e	1.99d	42.27d
T_5	37.14b	64.67d	2.40a-c	50.98a-c
T_6	16.09f	137.43a	2.21c	47.01c
T_7	38.35ab	61.34de	2.35a-c	49.96a-c
T_8	39.92a	61.34de	2.44ab	51.97ab
T_9	36.94b	64.85d	2.39a-c	50.87a-c
T_{10}	37.35b	61.34de	2.29bc	48.69bc
LSD $_{0.05}$	2.342	3.594	0.187	3.914
CV (%)	5.38	3.89	4.98	6.82

In a column, means with similar letter (s) are not significantly different by DMRT at 5% level of probability.

T_1: BARI Tomato-2, T_2: BARI Tomato-3, T_3: BARI Tomato-14, T_4: BARI Tomato-15, T_5: BARI Tomato-16, T_6: BARI Tomato-17, T_7: Sonali-35, T_8: Solar, T_9: Bijli-11 and T_{10}: Sonli-12. DAT: Days after transplanting

Dedicated To

MY BELOVED PARENTS

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