EVALUATION OF SOME SELECTED TOMATO VARIETIES FOR RESISTANCE AGAINST WHITEFLY, *BEMISIA TABACI* GENNADIUS

MD. ZIAUR RAHMAN

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Approved by

Research Supervisor	Co-supervisor
Md. Razzab Ali	**Md. Mizanur Rahman**
Associate Professor	Associate Professor
Department of Entomology	Department of Entomology

Professor Jahanara Begum
Chairman
Department of Entomology

CERTIFICATE

This is to certify that the thesis entitled, "**EVALUATION OF SOME SELECTED TOMATO VARIETIES FOR RESISTANCE AGAINST WHITEFLY, *BEMI SIA TABACI* GENNADIUS"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M. S.) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. ZIAUR RAHMAN** bearing Roll No. 00707, Registration No. 00707/27532 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

(Md. Razzab Ali)
Research Supervisor
Advisory Committee

Dated:
Place: Dhaka, Bangladesh

Dedicated

To

MY BELOVED PARENTS

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EVALUATION OF SOME SELECTED TOMATO VARIETIES FOR RESISTANCE AGAINST WHITEFLY, *BEMISIA TABACI* GENNADIUS

By

MD. ZIAUR RAHMAN

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2006 to March 2007 to screen some tomato varieties/genotypes for their resistance to whitefly, *Bemisia tabaci* Gennadius. Incidence and abundance of whitefly as well as Tomato yellow leaf curl virus (TYLCV) disease and several morphological traits of the tomato varieties were studied to identify resistance source(s) among nine released tomato varieties. Out of nine tomato varieties, BARI-2 showed the most preferred host followed by BARI-8, whereas BINA-3, BARI-7 and BINA-1 performed as least preferred host for whitefly, *Bemisia tabaci* in terms of adult whitefly incidence. Considering the TYLCV infection transmitted by whitefly, none of them were found to be free from TYLCV infection. Disease incidence varied from 22.57 to 53.04%. Only three tomato varieties were resistant, which include BARI-2 (Ratan), BARI-8 and BARI-9. The varieties BARI-3, BARI-7 and BINA-1 and BINA-2 were found as moderately resistant to TYLCV infection and the varieties BINA-3 and BINA-4 were found as moderately susceptible. In this study, the incidence of TYLCV infected leaves and plants were not directly proportional to the density of vector (whitefly) population, but were related either with the proportion of the viruliferous whitefly rather than total number of whitefly or the morphological and or physiological properties of the host plant.

Considering mean whitefly infestation, cumulative TYLCV infection and comparative yield of different tomato varieties, it was observed that the tomato BARI-2 had significantly the highest whitefly infestation (28.95 per plant) and but with the lowest TYLCV infection (22.57%) and the highest yield (73.00 t/ha). On the other hand,

BINA-2 showed significantly the second lowest whitefly infestation (16.90 per plant) and second highest TYLCV infection (46.71%) and yielded the highest (73.24 t/ha). The variety BARI-7 showed significantly maximum height (290.4 cm) per plant but produced lowest yield (54.98 t/ha), whereas BARI-2 (265.5 cm) and BINA-2 (250.3 cm) showed third highest height as well as produced significantly highest yield (73.00 and 73.24 t/ha, respectively). In consideration of number of branch and leaves per plant, the maximum numbers (13.78 and 86.77 respectively) were produced by the variety BARI-2. In terms of the number of flower bunch per plant and number of flower per bunch, the maximum number (99.33 and 5.67) were produced by the variety BINA-2, which was statistically similar with the variety BARI-2 (79.33 and 5.33). The number of fruits was not positively related to the yield except few cases. The increase in yield per hectare due to the increase of single fruit weight was justifiable.

CHAPTER – I

INTRODUCTION

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INTRODUCTION

Tomato (*Lycopersion esculentum* Mill.) is a popular vegetable crop in Bangladesh as well as in many countries around the world. It belongs to the family Solanaceae and is normally a self-fertilized annual crop. Cultivated types of tomato belong to *Lycopersicon esculentum* (Kinnet and Peet, 1997). The tomato, *Lycopersicon esculentum* Mill. is grown for its high nutritive and commercial value. It is one of the most popular vegetables in Bangladesh. The area under tomato cultivation in Bangladesh during the year 1980, 1990 and 2000 respectively was 8.9, 11.7 and 15 thousand hectares with a production of 64, 98 and 100 thousand metric tons (Anonymous, 2004). In world it was 2470, 2653 and 3984 thousand hectares with a production of 52,650, 76,298 and 108,485 thousand metric tons in during these periods (Anonymous, 2005). The average yield of tomato in Bangladesh is very low as compared to world average or some other tomato growing countries. Average yield of tomato in the world is 27 ton /ha whereas in Bangladesh it is around 7 t/h. (Anonymous, 2005).

Although the total cultivated area and production of tomato in our country has increased gradually over the last few years but the productivity is very low compared to many countries of the world. One of the major constraints for tomato production in our country is the attack of insect pests. Of them, the attack of whitefly, *Bemisia tabaci* Genn.is considered the most important one (Taleker *et al.*, 1983).

Damage caused by whitefly to the tomato crop can either be direct by feeding on the phloem sap and excretion of honeydew, or indirect by transmission of virus diseases (Byrne *et al.*, 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 subtropical parts of the world. The prevalence and distribution of *B. tabaci* as pest is observed by its role as an efficient vector of large number of viral diseases of tomato in the tropical and sub-tropical parts increased during the past decade and the impact has often been devastating (Basu, 1995).

Over 70 plant viruses are transmitted by whiteflies (Duffas, 1987; Muniyappa, 1980). The major virus diseases being efficiently transmitted by *B. tabci* include Tomato yellow leaf curl virus (TYLCV), tomato leaf curl virus (TLCV), tomato yellow top virus etc. These are caused either by the same virus, or by closely related strains of the virus (Ponti *et al.*,1989 Makkouk and Laterott. 1983). Among the identified viruses the TYLCV is the most damaging and widely distributed virus infecting tomato in Bangladesh (Akanda, 1994). Sastry and Singh (1973) estimated 20-25% loss in tomato yield due to Tomato yellow leaf curl virus (TYLCV) disease in India. Friedmann *et al.* (1998) reported that TYLCY could cause losses up to 100% in tropical and subtropical regions.

The incidence of virus infected plant is directly proportional to the density of vector population, although economic damage is caused by a low vector density (Makkouk and Laterott, 1983). Green and Kalloo (1994) reported that a single viruliferous whitefly is able to transmit the virus disease to a healthy plant and the rate of transmission increases with the increased population density of the vector. But Aboul Ata *et al.* (2000) reported that TYLCV intensity is related to proportion of viruliferous whitefly rather than total number of whitefly. In Bangladesh, Mahmud (2004) observed the positive correlation between whitefly (*Bemisia tabaci* Genn.) population (adult and nymphs) with increasing temperature and relative humidity.

Occurrence of TYLCV is very common in winter tomatoes in Bangladesh. But in recent years the problem has been increased manifold. Hence, prevention of virus infection in tomato plants is largely dependent on the effective management of vector (*Bemisia tabaci*) population.

Plant resistance could target both individual viruses and their vectors. Resistance to insect vectors of plant viruses is likely to alter the population size, activity, and probing and feeding behaviors of vectors, thereby influencing the pattern of virus spread. Berlinger and Dahan (1989) reported that some wild *Lycopersicon* accessions are whitefly resistant. Certain ecotypes of *Lycopersicon pennelli* (Corr.) have been identified as possessing very high degree of resistance to whiteflies (Ponti *et al.*, 1975; Berlinger *et al.*, 1984). The resistance observed in the wild relatives of tomato (especially *L. pennelli*) suggests that the observed resistance is genetically based and this resistance trait may be incorporated into a breeding program to develop higher resistance in tomato cultivars (Heinz and Zalom 1995).

However, the most effective and environmentally safe method is the planting of tolerant varieties if available. Thus development of resistant varieties is considered to be the best option for the control of TYLCV (Friedmann *et al.*, 1998). Already some tomato varieties available in Israel, Brazil and USA (Polston and Anderson, 1997). At present there is no TYLCV resistant tomato variety available for cultivation in Bangladesh. Many varieties have been released by different research organizations without testing their reaction against TYLCV. Muqit (2006) reported that out of fifteen tomato varieties only four (BINA-3, BARI-1, BARI-2 and BARI-11) were found to be moderately resistant to whitefly, *Bemisia tabaci*. Rashid *et al.* (2002) also reported that out of 32 tomato varieties none of them were found to be free from TYLCV infection. Disease incidence varied from 3 to 100%. They graded 12 varieties as resistant, which include Ratan (BARI-2), BARI-7, BARI-10, BARI-11 and BARI-13.

Considering the importance of host plant resistance in pest management and possibilities of obtaining locally available genotypes as resistance source, the present study was undertaken to fulfill the following objectives:

1. To evaluate the available tomato varieties/genotypes for resistance against whitefly
2. To determine the damage potential of whitefly on different tomato varieties
3. To correlate between the incidence of whitefly population and TYLCV infection.

CHAPTER – II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Tomato, *Lycopersicon esculentum* (Mill.) plants are attacked by many serious insect pests. Among them whitefly, *Bemisia tabaci* is the most important pest damaging the plants in three means. The whitefly adults and nymphs feed on the plant sap from the underside of the leaves. They secrete honeydew, which later helps the growth of sooty mould fungus thus reducing the photosynthetic area. The infested plant became weakened due to sucking of the plant sap from the leaves and also due to the reduction of photosynthesis of the infested plant parts (Naresh and Nene, 1980). Young plant may even be killed in case of severe whitefly infestation in tomato (Srivastava and Singh, 1976). The whitefly acts as a mechanical vector of tomato yellow leaf curl virus (TYLCV) in tomato, *L. esculentum*. The principal economic loss from whitefly infestation is due to the injury from whitefly transmitted virus disease rather than loss from whitefly feeding (Nene *et al.*, 1972). Research works on this kind of study are scanty in Bangladesh but review of literatures on the relevant field were searched and discussed under the following sub-headings. The origin and distribution of whitefly, *Bemisia tabaci*, its biology and life history, seasonal abundance, host range, nature of damage on tomato, disease transmitted by them, host plant resistance were given special emphasis.

ORIGIN AND DISTRIBUTION OF WHITEFLY, *Bemisia tabaci* Genn.

Bemisia tabaci was first described in 1889 as a pest of tobacco in Greece and named as *Aleyrodes tabaci*, the tobacco whitefly (Gennadious, 1889). The first whitefly specimen was discovered shortly thereafter (collected in 1887) in the US on sweet potato (Quintance, 1900). In 1957, this species and 18 other previously described whitefly species were synonymized into a single taxon, *Bemisia tabaci* (Russel, 1957). Although it is known as various crop-based common name as tobacco whitefly, cotton whitefly or sweet potato whitefly.

The outbreaks in cotton occurred in the late 1920s and early 1930s in India and subsequently in Sudan and Iran from the 1950s 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. In South Asia it has been reported from India (Nariani, 1960), West Pakistan (Ahmad and Harwood, 1973), Srilanka (Shivanathan, 1977), Thailand (Thongmearcom *et al.*, 1981). The whitefly has been reported as green house pest in several temperate countries in Europe, e.g., Denmark, Finland, Norway, Sweden and Switzerland. Besides in greenhouses, the species has been reported on outdoor plants in France and Canada (Basu, 1995). In Bangladesh TYLCV was first reported by Akanda (1991).

From 1926 to 1981, *B. tabaci* was reported as sporadic pest and was the most important vector of plant viruses in subtropical, tropical and temperate zones where winters are mild enough to permit year round survival (Cock, 1986). However, whitefly related problems have historically occurred after the introduction of intensive cropping regimes that require relatively high inputs of fertilizers and pesticides (Brown *et al.*, 1995).

The presumably related to its close association with agricultural mono-crop cultivated by human. *B. tabaci* was documented in tropical and subtropical localities of all the continents except in equatorial South America (Cock, 1986). The inadvertent transport of the B-biotype on ornamental plants beginning in 1985-1986 established *B. tabaci* throughout the Europe, the Mediterranean Basin, Africa, Asia, Central America, North America (Mexico and the US) and South America (Costa *et al.*, 1993). Worldwide distribution of whitefly, *B. tabaci* was updated by CAB International Institute of Entomology, London (Table 1) below:

Table 1. Global distribution of whitefly as updated by CAB International Institute of Entomology, London (Cock, 1986)

Continent/Subcontinent	Countries
Europe	Cyprus, Denmark, Finland, Greece, Switzerland, Turkey, UK etc
USSR (Former)	Azerbaijan SSR, Georgian SSR
Africa	Angola, Cape Verde Island, Egypt, Ethiopia, Ivory coast, Sierra Leone, Somalia, South Africa etc.
Asia	Afghanistan, Myanmar, China, India, Indonesia etc
Pacific Islands and Australia	Australia, Hawaii etc
North West Atlantic	Bermuda
America, Northern USA	California, Florida, Texas etc
Canada	British Columbia, Quebec etc
Central America and Caribbean	Barbados, Costa Rica, Puerto Rico etc
South America	Argentina, Brazil, Venezuela, Colombia etc

BIOLOGY AND LIFE HISTORY OF WHITEFLY, *Bemisia tabaci*

The majority of whitefly species cannot be identified by the morphological characters of the adults. Genera and species are usually defined according to the structure of the fourth nymphal instar, the so-called "pupal case" (Mound and Hasley, 1978). Unfortunately, polyphagous whitefly species such as *Trialeurodes vaporariorum* (Westwood) and *B. tabaci* vary in the appearance (shape and size) of their pupal case, depending on the cuticle of the host plant on when they feed. This host-correlated morphological variation and host plant diversity have led to large number of synonyms of *B. tabaci* (Lopez-Avilla, 1986), which have been listed by Mound and Hasley (1978). The adult whitefly, *B. tabaci* is a tiny soft bodied and pale yellow, change to white within a few hours due to deposition of wax on the body and wings (Haider, *et al.*, 1996). The different developmental stages of whitefly, *B. tabaci* are described on the following sub-headings:

Egg

White eggs generally are pyriform or ovoid and posses a pedicel that is a peg like extension of the chorion (Byrne and Bellows, 1991). Eggs are pear shaped and they are laid indiscriminately almost always on the underside of the young leaves (Hirano *et al.*, 1993). Basu (1995) reported that eggs are laid indiscriminately almost always on the under surface of the leaves, anchored by the labium which remains closely apposed to the leaf surface. Lopez-Avila (1986) observed by that the egg dimensions are length 0.211±0.005 mm; width at the broadest part 0.096±0.002 mm and length of pedicel 0.24±0.003 mm. The female can lay 119 eggs in cotton captivity (Hussain and Trehan, 1933) 300 eggs on brinjal 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 ranged between 3-5 days in summer and 7-33 days during winter (Hussain and Trehan, 1933 and Azab *et al.*, 1970).

Nymphal and Pupal stages

After completion of development, the egg crakes at the apical end along a longitudinal line of dehiscence. As the first instar nymph of *B. tabaci* begins to emerge, it bends in half until its forelegs can clasp the leaf, after which nymph walk away from the spent chorion (Poinar, 1965). The first instar nymph is often called crawler (Basu, 1995). When the first instar nymphs hatch they only move a very short distance over the leaf surface before settling down again and starting to feed. Once a feeding site is selected the nymphs do not move and they remain sessile until they reach the adult stage, except for brief periods during molts (Hirano *et al.*, 1993). The first instar nymphs are pale, translucent white, oval with a convex dorsum and flat ventral side. They measure 0.267±0.007 mm in length and 0.144±0.010 mm in width (Lopez-Avila, 1986). They have functional walking legs (with three apparent segments). Legs of second and third nymphal instars appear to have only one segment (Gill, 1990).

The second instar nymphs are quite distinct from first instar for its size. These nymphs are 0.218±0.012 mm wide at the broadest part of the thoracic region. The body of third instar nymph is more elongated than the early instars, measuring 0.489±0.022 mm in length and 0.295±0.018 mm in breath.

The fourth instar nymphs have elliptical body measuring 0.662±0.023 mm broad. This fourth instar nymph has red eye-spots, which become eyes at the adult stage, are characteristic of this instar (Hirano *et al.*, 1993). This fourth instar is commonly referred to as a pupa (Gill, 1990). Hinton (1976) reported that certain whiteflies have pupal stage in the sense that this stage serves as a mold for some of the imaginal muscles. Two distinctive characters of these pupae are the eyes and the caudal furrow. Dorsal surface of the elliptical body is convex and the thoracic and abdominal segments are pronounced. Mound (1983) showed that the pupae from which female 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 25°C, 75% RH and light:dark 16:8 hours, the fourth instar nymphs lasted 3.4 days on bean, 201 days on cotton and 2.0 days on tomato. The duration of pupal stage was 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

The adult (Plate 1) emerges leaving the empty pupal case. Under a constant temperature of 29.5°C±0.6°C and a photoperiod of 14:10 LD, 90% of the *B. tabaci* emerged from their pupal cases between 0600 and 0930 hours (lights occurred at 0600 hours). Adults are tiny, soft bodied and pale yellow, change to white within a few hours due to deposition of wax on the body and wings (Haider *et al.*, 1996). Their antennae are long and slender and mouthparts are constructed for piercing and sucking. The forewings are slightly longer than the hind wings. At least, the wings cover the abdomen like a roof (Berlinger, 1986). Byrne and Houck (1990) reported that sexual dimorphism in wing forms: the fore and hind wings of females are larger than those of males. The mean wing expanses of females and males are 2.13 mm and 1.81 mm respectively (Byrne and Bellows, 1991). Adult longevity of males on tobacco was 4 days 7 days in winter; corresponding female life span was 8 and 12 days respectively in India (Pruthi and Samuel, 1942).

Plate 1. Adult whitefly, *Bemisia tabaci* Genn. resting on host

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

INFLUENCE OF TEMPERATURE, HUMIDITY AND RAINFALL ON THE BIOLOGY OF WHITEFLY, *B. tabaci*

Gerling *et al.* (1986) reported that extreme relative humidities, both high and low, were unfavorable for the survival of immature stages. In Sudan, heavy rain was usually followed by a drop in population levels (Horowitz 1986).

Gerling *et al.* (1986) found that the lower and upper developmental thresholds of temperature are 11 and 33°C, respectively. Rates of development are maximal at 28°C. At that temperature, development from egg to adult whitefly takes 20 days.

Avidov (1956) considered low humidity as the 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 (Avidov, 1956; Gameeel, 1978). In Sudan, heavy rains were usually followed by a drop in population levels (Khalifa and El-Khidir, 1964; Gemeel, 1978).

Ohnesorge *et al.* (1981) found that the oviposition was impaired by rain. Climatic factors are not a major in fluctuations in the population density of *B. tabaci* in regions such as Java, which have a mild climate. Neither were parasitoids important (Kajita *et al.*, 1992).

Darwish (2000) investigated on the development of different stages of the whitefly, *Bemisia tabaci* (Genn.) was under four constant temperatures to determine its developmental threshold, thermal requirements and theoretical number of generations. Temperatures of 25° C and 30° C were found to be the most favorable for the development of egg and nymphal stages. Threshold temperatures of 10.52°, 4.59° and 7.06° C were calculated for the development of egg, nymph and from egg to adult stages, respectively. Based on these thresholds the stages respectively needed about 81.5, 371.7 and 426.7 day-degrees to complete their development. About twelve theoretical generations were calculated for the pest per year under suitable conditions, out of which 7 generations could develop during the cotton growing season.

The major factor seems to be spatio-temporal variations in the quality of host plants in the area. If large numbers of host plants are cultivated continuously in time and space, *B. tabaci* will cause greater damage to host plants grown later in the planting season. In fact, outbreaks of *B. tabaci* in Brazil occurred under such circumstances (Kogan and Turnipseed, 1987).

SEASONAL ABUNDANCE AND POPULATION DYNAMICS OF WHITEFLY

Whitefly population has the potential for rapid, perhaps exponential increase under favorable conditions of climate and host plant availability. The seasonal migration of whiteflies from one host plant to another has been reported by various authors.

In Jordan, decline in the whitefly population on tomato due to extreme conditions in spring, either directly or indirectly affect host plants. In Egypt, the whitefly population on tomato was found to be low during winter and increased during dry period, peaking during August to October (Sharaf *et al.*, 1984).

In Sudan, a study was conducted by Kranz *et al.* (1977) and 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 to 38°C). These conditions favor the development of juvenile stages by shortening the duration of each stage. They also indicated that the population decreases due to high mortality rates at eggs and free juvenile stages in March, April and May, when temperature is high (43 to 45°C) and relative humidity is low (8 to 17%).

Eichelkraut and Cardona (1989) reported that dry conditions were more favourable for whitefly, *B. tabaci*, than those of high precipitation. Salinas (1994) reported that temperature, relative humidity and the number of rainy days had a highly significant correlation with the adult whitefly population. A high significant correlation was also noted between relative humidity and the egg counts. On the other hand, Horowitz *et al.* (1984) and Gerling *et al.* (1986) observed that the extreme RH, both high and low were unfavorable for the survival of immature stages. Thus in Sudan, Horowitz (1986) found significant drop of whitefly population levels at heavy rainy condition.

Gameel (1970) attributed the occasional population whitefly in the Sudan to high temperatures (43 to 45°C) and low humidity levels (8-17%) or to low temperature and low humidity levels.

Lal, *et.al.* (1981) found high humidity and stable maximum temperatures (29.4°C to 32.9°C) to be congenial for whitefly development on cassava in Kerala, India. High humidity and rainfall and relatively low temperature during July to October in Southern India were found to be uncongenial to the whitefly population development (Muniyappa, 1983).

In Bangladesh, Mahmud (2004) also observed the positive correlation between whitefly (*Bemicia tabaci* Genn.) population (adult and nymphs) with increasing temperature and relative humidity.

NATURE OF DAMAGE OF WHITEFLY, *B. tabaci*

B. tabaci continues to be an economically important pest of greenhouse and field crops throughout equatorial areas of the world (De Barro, 1995). Berlinger (1986) reported that whitefly, *Bemisia tabaci* damaging the plants in three means that were discussed below:

Direct damage

Direct damage is caused by the piercing and sucking of sap from the plant foliage. Both nymphs and adults cause direct damage by feeding sap from the underside of the leaves (Naresh and Nene, 1980; Berlinger, 1986). This feeding cause weakening and early wilting of the plants and reduces the plant growth rate and yield. It may also cause leaf chlorosis, leaf withering, premature dropping of leaves (Berlinger, 1986). Young plants even may be killed in case of severe whitefly infestation (Scalan, 1995) in mungbean (Srivastava and Singh, 1976).

Indirect damage

It results by the accumulation of honeydew secreted by the whitefly. This honeydew serves as substrate for the growth of black sooty mold fungus on leaves and fruits. The mold reduces photosynthetic capacity of the infested plant parts (Naresh and Nene, 1980; Berlinger, 1986).

Virus transmission

The type of damage caused by the vector of plant viruses and virus transmission is the main damage caused by the *Bemisia tabaci* (Cohen and Berlinger, 1986). A number of reviews of whitefly-transmitted diseases have been published during the last three decades (Verma, 1992; Costa, 1976; Bird and Maramorasch, 1978; Muniyappa, 1980; and Bock, 1982; Francki *et al.*, 1985; Duffus, 1987; Brown and Bird, 1992).

Whitefly borne viruses of six or seven morphological classes have been demonstrated so far (Duffus, 1987; Cohen, 1990). Of these, the geminivirus group is by far the most important, both in terms of number of diseases and their economic impact in various parts of the world (Brown and Bird, 1992). Diseases caused by whitefly transmitted Geminivirus on tomato are tomato yellow leaf curl (Navot *et al.*, 1991), tomato leaf curl, tomato golden mosaic (Maytis *et al.*, 1975; Stein *et al.*, 1983; Hamilton *et al.*, 1984), tomato mottle (Brown and Bird, 1992).

Acquisition and inoculation by adults can each be effected in a minimum time of 15 min. The latent period is less than 4 h (Nair, 1971). A single viruliferous adult can transmit the virus. The most efficient female and male adults in a population can retain infectivity for 10 days and 3 days, respectively. Neither female nor male adults can retain infectivity throughout the life span. Female adults are over three times more efficient as vectors than males (Rathi, 1972). Nymphs of *Bemisia tabaci* can acquire the virus from diseased leaves (Nene, 1972). The virus does not pass through eggs of *B. tabaci* (Rathi, 1972; Ahmad & Harwood, 1973).

Navot *et al.* (1991) reported that the whitefly, *Bemisia tabaci* acts as a mechanical vector of tomato yellow leaf curl virus (TYLCV) in tomato. The principal economic loss in tomato from whitefly infestation is due to the injury from whitefly transmitted TYLCV rather than loss from whitefly feeding directly.

HOST RANGE OF WHITEFLY, *BEMISIA TABACI*

A survey of the literature from the early 1900s suggests that the number of host plants colonized by *Bemisia tabaci* has increased over time, probably as agricultural practices have shifted to irrigated monoculture and as different species have been cultivated during the century. 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). Current records indicate that *B. tabaci* can successfully colonize a multitude of host plant species worldwide (Cock, 1986).

The recently introduced B-biotype has the broadest host range among whiteflies in the genus *Bemisia;* some estimates range up to 500 species (Brown *et al.*, 1995). Basu (1995) reported that *Bemisia tabaci* is highly polyphagous and has been recorded on a very wide range of cultivated and wild plants comprising more than 500 species of plants including numerous field crops, ornamentals and weeds. According to Panwar (1995), the host plants of *Bemisia tabaci* include cotton, tomato, tobacco, sweet potato, cassava, cabbage, cauliflower, melon, brinjal, okra and many cultivated plants.

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

Greathead (1986) also updated the information reported by Mound and Hasley (1978) and listed 540 species of plants belongs to 77 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. The compilation of the list of Greathead (1986) presented here including 540 plant species belonging to 77 families. Plant families have been ranked in Table 2 according to the number of plants recorded as hosts of *B. tabaci:*

Table 2. Ranking of plant families as hosts of *B. tabaci* as listed by Greathead (1986)

Plant family	Number of host species
Liguminosae	99
Compositae	62
Malvaceae	37
Solanaceae	37
Euphorbiaceae	35
Convolvulaceae	20
Verbenaceae	18
Cucurbitaceae	17
Labiatae	16
Amaranthaceae	15
Cruciferae	15
Rosaceae	12
Moraceae	10
Chenopodiaceae	09
Oleaceae	08
Tiliaceae	05
Umbeliferae	05
5 families, each with 4 species	20
12 families, each with 3 species	36
13 families, each with 2 species	26
29 families, each with 1 species	29
Total 77	**540**

TOMATO YELLOW LEAF CURL VIRUS (TYLCV) DISEASE

The disease was first reported in Israel in 1939-40 associated with the outbreak of *Bemisia tabaci*. The causal agent was described in 1964 and named Tomato yellow leaf curl virus (TYLCV) (Cohen and Harpaz, 1964). Since, the TYLCV has been reported from all over the tropics, subtropics, the Mediterranean, the Caribbeans, the American (Czosnek and Laterrot 1997; Jones, 2003 and Nakhla, 1994). In Bangladesh TYLCV was first reported by Akanda (1991).

Whitefly borne viruses of six or seven morphological classes have been demonstrated so far (Duffus, 1987; Cohen, 1990). Of these, the geminivirus group is by far the most important, both in terms of number of diseases and their economic impact in various parts of the world (Brown and Bird, 1992). Among them, tomato yellow leaf curl virus (TYLCV) is the most important virus disease of tomato, which is caused by whitefly (*Bemisia tabaci*) transmitted Geminivirus in a semi-persistent manner in the field (Navot *et al.*, 1991).

Tomato yellow leaf curl virus (TYLCV) has been a major constraint to tomato production in the Near East since 1996. It is the best characterized virus causing yellowing leaf curl disease of tomato (Green and Kalloo, 1994).

OCCURRENCE AND SYMPTOMS OF TYLCV DISEASE

Greenand Kalloo (1994) described many aspects of TYLCV and reported that the TYLCV infected tomato plants are stunted, branches and petioles tend to assume erect position, leaf lets are smaller than those of healthy plants, puckered and often show upward curling, margins with or without yellowing.

Gafni (2003) also reported that the characteristic symptom of TYLCV disease on tomato are chlorotic margin, small leaves that *are* cupped, thick and rubbery, flower or fruit drop, stunted growth. Sinisterra *et al.* (2000) described the symptoms of TYLCV on tomato and these include stunting, curling, marginal chlorosis of leaves, reduced leaf size and marked reduction in fruit number.

CORRELATION BETWEEN VECTOR (WHITEFLY) POPULATION AND SPREAD OF TYLCV

Aboul Ata *et al.* (2000) studied some epidemiological aspects of TYLCV in the field. It was found that TYLCV intensity is related to proportion of viruliferous whitefly rather than total number of whitefly. Five percent of viruliferous vector density as detected by cDNA hybridization led to 46.4% TYLCV in the field and same percentage as determined by bioassay led to 67.9% infection.

EFFECT OF TYLCV ON YIELD OF TOMATO

Al-Musa (1982) reported that TYLCV is a major factor for lower tomato production during summer, fall and winter in the Mediterranean region. Yield loss range from 28 to 92% depending on the age of the plants at the time of infection and percentage of plants infected.
The disease can cause up to 100% yield loss in tropics and subtropics depending upon severity and stage of infection (Ahmed *et al.* 2001).
Sastry and Singh (1973) estimated 20 to 75% yield loss in tomato leaf curl virus disease in India. In the United States, crop damage in tomato due to this pest was estimated to more than 500 million dollars in 1991 (Perring *et al.*, 1993).

Polizzi *et al.* (1994) reported that Tomato yellow leaf curl virus (TYLCV) is a limiting factor for tomato production in Italy. Yield loss ranges from 25 to 80%.

Tomato yellow leaf curl virus (TYLCV) is a whitefly transmitted geminivirus. It has been a major limiting factor for tomato production over the last 30 years in many tropical and subtropical areas causing yield loss as high as 50-99% (Pico *et al.*, 1998).

Tomato yellow leaf curl virus (TYLCV) comprises of a group of geminivirus species of the genus Begomovirus under the family Geminiviridae that causes severe damage to tomato in tropical and subtropical region. In Spain it can cause even 100% yield loss (Sanchez-Campos *et al.*, 1999).

Kung (1999) described that Tomato yellow leaf curl virus (TYLCV) is one of the most devastating virus diseases of cultivated tomato. Most commercial cultivars are susceptible to disease and losses in some regions can reach up to 100%. The disease has a world wide distribution i.e. from Taiwan in the Far East, the Middle East, the tropical and subtropical Africa, the Mediterranean basin to the Americas.

Lapidot *et al.* (2001) described Tomato yellow leaf curl virus (TYLCV) as one of the most devastating begomoviruses of cultivated tomato in the tropical and subtropical region. Tomato leaf curl disease has long been known in the Middle East, the North and Central Africa and the Southeast Asia. It has even spread to southern Europe. TYLCV has also been identified in the Caribbean region, Mexico and in the United States. TYLCV epidemics tend to be associated with high population of whitefly. In the Mediterranean region yield loss can be up to 100%. In many tomato growing areas, TYLCV has become a limiting factor for production both in the field and in the protected net houses.

Tomato yellow leaf curl virus *is* a geminivirus transmitted by whitefly *(Bemisia tabaci)*. It causes most destructive disease of tomato throughout the Mediterranean region, the Middle East and the tropical regions of Africa and Central America. It is also reported from Japan, Australia and the USA. In many cases yield loss can be up to 90% (Gafni, 2003).

Polston *et al.* (2005) reported that TYLCV is causes 90% reduction of marketable yield if infected within 8 weeks after transplanting and 45% if infection occurs between 8-14 weeks after transplanting.

TOMATO SUSCEPTIBILITY TO TYLCV AND ITS VECTOR, WHITEFLY

Pilowsky and Cohen (1974) reported that TYLCV resistance from

Lycopersicon pimpinellifolium is monogenic with incomplete dominance inheritance. Geneif (1984) worked on transfer of TYLCV resistance from a resistant breeding line *(L. pimpinellifolium)* to a commercial susceptible line. The study revealed that resistance character is monogenic and complete dominance type.

Rashid *et al.* (2001) reported that Tomato yellow leaf curl virus (TYLCV) is one of the most damaging diseases of tomato Bangladesh. They screened several tomato entries against TYLCV. Tomato accessions ATY-14 and 17 were found to be resistant which might be helpful in breeding program. Accession ATY-10, 11 and 22 were found to be resistant.

Rashid et *al.* (2002) screened 32 varieties of tomato against TYLCV transmitted by whitefly, *Bemisia tabaci*. Disease incidence varied from 3 to 100%. None of them were found to be free from infection. Out of 32 varieties they graded 12 as resistant, which include Ratan, BARI-7, BARI-10, BARI-11 and BARI-13.

Muqit (2006) conducted an experiment on field screening of 15 tomato varieties against whitefly and he found that out of 15 varieties, only four (BINA-3, BARI-1, BARI-2 and BARI-11) were found to be moderately resistant.

DISEASE INTENSITY

Rashid et *al.* (2002) screened 32 varieties of tomato against TYLCV. None of them were found to be free from infection. Disease incidence varied from 3 to 100%. They used following scale for grading the varieties. R = Resistant (1-25%), MR = Moderately Resistant (26-50%), MS = Moderately susceptible (51-75%)) and S = Susceptible (76-100%). Out of 32 varieties they graded 12 as resistant, which include Ratan, BARI-7, BARI-10, BARI-11 and BARI-13.

Pico *et al.* (1998) followed 0 to 4 scales to asses the severity of TYLCV infected tomato plants. 0 = No visible symptom, 1 = Slight symptom (slight marginal yellowing (curling); 2 = Moderate symptom (slight marginal/interveinal yellowing, moderate puckering and curling); 3= Severe symptom (severe marginal/ interveinal yellowing, puckering and curling); 4 = Very severe symptom (foliar symptom is similar to 3 accompanied by reduction in leaf size, branching and severe stunting).

Sukkharom (1999) used 1-3 scale to determine severity of TYLCV in the field. 1 = light yellowing along the leaf margin; 2= moderate plant stunting, leaf curling and yellowing; 3 severe plant stunting and leaf curling/yellowing.

CHAPTER – III

MATERIALS AND METHOD

CHAPTER III

MATERIALS AND METHODS

The study has been conducted on screening of some selected tomato varieties to find out the resistance source(s) against whitefly, *Bemisia tabaci* Genn. during October, 2006 to March 2007 at the experimental fields of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla nagar, Dhaka, Bangladesh .

Other details of the experiment are furnished below:

TITLE OF THE EXPERIMENT: EVALUATION OF SOME SELECTED TOMATO VARIETIES FOR RESISTANCE AGAINST WHITEFLY, *BEMISIA TABACI* GENNADIUS

TREATMENTS OF THE EXPERIMENT

The nine varieties of tomato, *Lycopersicon esculentum* Mill collected from different sources, used under the present study are given in Table 1 and each of which was considered as an individual treatment.

Table 3. Name and sources of tomato varieties used under the present trial

Treatment	Variety	Source of availability
T_1	BARI 2 (Ratan)	Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh
T_2	BARI 3	
T_3	BARI 7 (Apurbo)	
T_4	BARI 8 (Shila)	
T_5	BARI 9 (Lalima)	
T_6	BINA 1	Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh
T_7	BANA 2	
T_8	BANA 3	
T_9	BINA 4	

LOCATION OF THE EXPERIMENTAL FIELD

The experiments were conducted in the experimental farm of SAU, Dhaka situated at latitude 23.46 N and longitude 90.23E with an elevation of 8.45 meter the sea level. Laboratory studies were done in the laboratory of Entomology department, SAU. Required materials and methodology are described below under the following sub heading.

CLIMATE OF THE EXPERIMENTAL AREA

The experimental area is characterized by subtropical rainfall during the month of May to September (Annon., 1988) and scattered rainfall during the rest of the year (Appendix I).

SOIL OF THE EXPERIMENTAL FIELD

Soil of the study site (Appendix II) was silty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, CEC-25.28 (Haider *et al.*, 1991).

LAND PREPARATION

The soil was well prepared and good tilth was ensured for commercial crop production. The target land was divided into 21 equal plots (3m×1.5m) with plot to plot distance of 1.0 m and block to block distance is 1.0 m. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was ready. The field layout and design of the experiment were followed immediately after land preparation.

MANURE AND FERTILIZER

Recommended fertilizers were applied at the rate of 500 kg urea, 400kg triple super phosphate (TSP) and 20kg muriate of potash (MP) per hectare (Rashid, 1993) were used as source of nitrogen, phosphorus and potassium, respectively. Moreover, well-decomposed cowdung (CD) was also applied at the rate of 10 ton/ha to the field at the time of land preparation.

DESIGN OF EXPERIMENT AND LAYOUT

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The whole area of experimental field was divided into 3 blocks and each block was again divided into 9 unit plots. The size of the unit plot was 3.0 m×1.5 m. The block to block and plot-to-plot distance was 1.0 m and 1.0 m, respectively.

COLLECTION OF SEED, SEEDLING RAISING AND TRANSPLANTING

The seeds of nine selected tomato varieties BARI 2 (Ratan), BARI 3, BARI 7 (Apurbo), BARI 8 (Shila), BARI 9 (Lalimma), BINA 1, BINA 2, BINA 3, and BINA 4 were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur and Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Each of these 9 selected tomato varieties was treated as an individual treatment. Before sowing seeds, the germination test was done and 90% germination was found for all varieties. Seeds were then directly sown in the 16th October, 2006 in seedbed containing a mixture of equal proportion well decomposed cow dung and loam soil. After sowing seeds, the seedbeds were irrigated regularly. After germination, the seedlings were spayed with water by a hand sprayer. Soil was spaded 3 or 4 days for a week.

SEEDLING TRANSPLANTING

The 30 days old healthy seedlings of nine tomato varieties (Table 1) were transplanted on November 18th, 2006 in the pits of the randomly selected each unit plot assigned for each variety in the main field. Other intercultural operations were done mentioned earlier.

CULTURAL PRACTICES

After transplanting, a light irrigation was given. Subsequent irrigation was applied in all the plots as and when needed. After 15 days of transplanting a single healthy seedling and luxuriant growth per pit was allowed to grow discarding the others, propping of each plant by bamboo stick was provided on about 1.0 m height from ground level for additional support and to allow normal creeping. Weeding and mulching in the plot were done, whenever necessary.

DATA COLLECTION AND CALCULATION

For data collection three plants per plot were randomly selected and tagged. Data collection was started at 14 days after transplanting (14 DAT) the seedlings up to fruit set. All the data were collected once in a week. The data were collected on number of whitefly; percent TYLCV infected leaf and plant, weight and number of tomato, yield and yield contributing characters of different tomato varieties. After collecting, data were calculated as where needed as follows:

Percent TYLCV infected plant in number

Number of infected plant was counted from total plants per plot and percent plant infection by TYLCV was calculated as follows:

$$\% \text{ TYLCV infected plant} = \frac{\text{No. of TYLCV infected plant}}{\text{Total no. of plants per plot}} \times 100$$

Percent TYLCV infected leaf in number

Number of infected leaves was counted from total leaves per three tagged plants per plot and percent leaf infection by TYLCV was calculated as follows:

$$\% \text{ TYLCV infected leaf} = \frac{\text{No. of TYLCV infected leaf}}{\text{Total no. of leaves}} \times 100$$

DISEASE SEVERITY

Total number of tomato plants and the number of TYCV infected plant(s) in each plot were counted. The percentage of TYLCV infected plants was then graded by grading designation used by Rashid *et al.* (2002) as follows:

% TYLCV infection	Grade
1-25	1 Resistant
26-50	2. Moderately resistant
51-75	3. Moderately susceptible
Above 75	4. Susceptible

STATISTICAL ANALYSIS

Data statistically analyzed by randomized complete block design through MSTAT-C software and Duncan's multiple range test was used to determine the levels of significant differences among tomato varieties with regards to studied tomato fruit borer infestation.

CHAPTER – IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to evaluate nine selected tomato varieties/genotypes (BARI-2, BARI-3, BARI-7, BARI-8, BARI-9, BINA-1, BINA-2, BINA-3 and BINA-4,) against whitefly, *Bemisia tabaci* Genn. to find out the resistance source(s). The results have been presented and discussed, and possible interpretations have been given under the following sub-headings:

4.1 INCIDENCE OF WHITEFLY ON DIFFERENT TOMATO VARIETIES DURING WINTER 2006-2007

Statistically significant variation was observed by number of whitefly on different tomato varieties used under the present trial represented in Table 4. At first week of data collection (14 DAT), the highest number of whitefly per plant (16.67) was recorded in the variety BARI-2, which was significantly different from all other varieties followed by variety BARI-3 (9.33), BARI-8 (9.33). On the other hand, the lowest number (6.00) of whitefly per plant was recorded in BARI-7, which was statistically similar with BINA-1 (6.67) and BINA-2 (6.67), BINA-2 (7.33) and BARI-9 (7.67) (Table 4). From these findings the trend of results was found at 14 DAT is BARI-2 > BARI-3 > BARI-8 > BARI-9 > BINA-3 > BINA-4 > BINA-2 > BINA-1 > BARI-7.

Table 4: Weekly incidence of whitefly population by number among different tomato varieties during winter 2006-2007

	Number of whitefly per plant on different weeks							
Variety	1st week (14 DAT)	2nd week (21 DAT)	3rd week (28 DAT)	4th week (35 DAT)	5th week (42 DAT)	6th week (49 DAT)	7th week (56 DAT)	Mean
BARI-2	16.67 a	25.00 a	25.33 a	45.00 a	51.67 a	25.67 a	13.33 a	28.95 a
BARI-3	9.33 b	15.00 c	25.00 ab	35.00 b	40.67 bc	25.33 a	9.00 b	22.76 b
BARI-7	6.00 c	13.33 c	23.67abc	22.00 cd	26.33 d	14.33 c	4.33 c	15.71 d
BARI-8	9.33 b	13.00 c	24.33 ab	38.67 b	45.67 b	20.67 ab	8.33 b	22.85 b
BARI-9	7.67 c	12.33 c	20.00 cd	25.33 c	25.33 d	14.67 c	6.67 bc	16 cd
BINA-1	6.67 c	12.00 c	19.00 d	26.33 c	27.00 d	16.00bc	3.67 c	15.81 d
BINA-2	6.67 c	18.00 b	25.00 ab	22.00 cd	26.00 d	14.33 c	6.33 bc	16.90 cd
BINA-3	7.33 c	14.33 c	18.00 d	17.67 d	26.00 d	18.67 bc	4.00 c	15.14 d
BINA-4	7.00 c	14.33 c	20.67 bcd	27.00 c	34.00 c	18.00 bc	6.33 bc	18.19 bc

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT

At second week (21 DAT) of data collection, the highest number of whitefly per plant (25.00) was recorded in the variety BARI-2, which was significantly different from all other varieties followed by BINA-2 (18.00), BARI-3 (15.00), BINA-4 (14.33) and BINA-3 (14.33) (Table 4). On the other hand, the lowest number (12.00) of whitefly per plant was recorded in BINA-1, which was statistically similar with BARI-9 (12.33) and BARI-8 (13.00), BARI-7 (13.33) (Table 4). From these findings it is revealed that more or less similar trend of results was found with few exception observed earlier at 14 DAT and the trend is BARI-2 > BINA-2 > BARI-3 > BINA-4 > BINA-3 > BARI-7 > BARI-8 > BARI-9 > BINA-1.

At third (28 DAT), fourth (35 DAT), fifth (42 DAT), sixth (49 DAT) and seventh (56 DAT) week of data collection, more or less similar trends of results were found earlier at first (14 DAT) and second (21 DAT) week of data collection except few cases. That is the highest number of whitefly per plant for each week of data collection were recorded in the variety BARI-2, which was significantly different from all other varieties (Table 4). But the dissimilar trends were found in case of recording the lowest number of whitefly per plant and it was found in the variety BINA-3 (18.00), BINA-3 (17.67), BARI-9 (25.33), BINA-2 & BARI-7 (14.33) and BINA-3 (4.00) at third, fourth, fifth, sixth and seventh week of data collection respectively.

In an average, the highest number of whitefly per plant (28.95) was recorded in the variety BARI-2, which was significantly different from all other varieties followed by variety BARI-8 (22.85), BARI-3 (22.67) and BINA-4 (18.19). On the other hand, the lowest number (15.14) of whitefly per plant was recorded in BINA-3, which was statistically similar with BARI-7 (15.71) and BINA-1 (15.81) followed by BARI-9 (16.00) and BINA-2 (16.90) (Table 4).

In an average, the trend of results found in terms of comparative host preference among nine tomato varieties against whitefly is BARI-2 > BARI-8 > BARI-3 > BINA-4 > BINA-2 > BARI-9 > BINA-1 > BARI-7 > BINA-3.

From these findings it is revealed that BARI-2 showed the most preferred host followed by BARI-8, whereas BINA-3, BARI-7 and BINA-1 performed as least preferred host for whitefly, *Bemisia tabaci* in terms of incidence of whitefly population in number on different tomato varieties under the present trial.

Results revealed that whitefly incidence was lower at the early stage of crop growth while it was the highest in mid stage and then it declined at the late stage of the crop.

4.2. INCIDENCE OF TYLCV ON DIFFERENT TOMATO VARIETIES

4.2.1. Incidence of TYLCV infected leaves of different tomato varieties

Statistically significant variation was observed in the incidence of percent TYLCV infected leaves of different tomato varieties used under the present trial represented in Table 5. At first week of data collection (14 DAT), the highest percent TYLCV infected leaves per plant (4.33%) was recorded in the variety BINA-1, which was significantly different from all other varieties followed (3.33%) by variety BARI-3 & BINA-4, BINA-3 (3.00%) and BARI-2 (2.33%). On the other hand, the lowest percent (1.00%) TYLCV infected leaves per plant was recorded in BARI-8, which was statistically similar with BARI-7 (1.33%), BARI-9 (1.33%), BINA-2 (1.67) (Table 5). From these findings the trend of results was found at 14 DAT is BINA-1 > BARI-3 > BINA-4 > BINA-3 > BARI-2 > BINA-2 > BARI-7 > BARI-9 > BARI-8.

Both second (21 DAT) and third (28 DAT) weeks of data collection, the highest percent TYLCV infected leaves per plant (8.00% and 22.67% respectively) were recorded in the variety BINA-4, which was significantly different from all other varieties and the lowest percent (4.67% and 6.67% respectively) TYLCV infected leaves per plant was recorded in BARI-9 (Table 5). From these findings it is revealed that more or less similar trends of results were found with few exceptions observed earlier at 14 DAT.

Table 5. Weekly incidence of TYLCV infected leaves among different tomato varieties during winter 2006-2007

Percent TYLCV infected leaves per plant on different weeks								
Variety	1st week (14 DAT)	2nd week (21 DAT)	3rd week (28 DAT)	4th week (35 DAT)	5th week (42 DAT)	6th week (49 DAT)	7th week (56 DAT)	Mean
BARI-2	2.33 ab	7.00 b	9.33 b	14.33 bc	13.33 b	16.33 b	16.00 b	11.23 c
BARI-3	3.33 ab	7.66 b	11.67 b	14.33 b	17.33 b	18.00 b	16.33 b	12.67 c
BARI-7	1.33 b	5.00 c	10.67 b	14.67 b	15.67 b	17.00 b	17.67 b	11.72 c
BARI-8	1.00 b	5.67 c	7.00 b	11.33 de	19.67 b	20.33 b	16.00 b	11.57 c
BARI-9	1.33 b	4.67 d	6.67 b	13.67 bcd	15.67 b	20.00 b	19.33 b	11.62 c
BINA-1	4.33 a	5.33 c	18.00 a	24.00 a	35.67 a	36.33 a	35.67 a	22.76 a
BINA-2	1.67 b	6.33 c	8.00 b	10.33 e	14.00 b	16.00 b	15.67 b	10.28 c
BINA-3	3.00 ab	5.00 c	8.67 b	11.67 cde	13.00 b	18.00 b	16.67 b	10.85 c
BINA-4	3.33 ab	8.00 a	22.67 a	11.33 de	18.33 b	20.00 b	19.00 b	14.67 b

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT

At fourth (35 DAT), fifth (42 DAT), sixth (49 DAT) and seventh (56 DAT) weeks of data collection, more or less similar trends of results in respect of percent TYLCV infected leaves per plant were found except few cases. That is the highest percent (24.00, 35.67, 36.33 and 35.67% respectively) TYLCV infected leaves per plant for each week of data collection were recorded in the variety BINA-1, which were significantly different from all other varieties (Table 5). On the other hand, the lowest percent (10.33, 16.00 and 15.67% respectively) TYLCV infected leaves per plant 4th, 6th and 7th week of data collection were found in the variety BINA-2, whereas 13.00% in BINA-3 at 5th week.

Considering the percent TYLCV infected leaves per plant, in an average, the highest percent TYLCV infected leaves per plant (22.76%) was recorded in the variety BINA-1, which was significantly different from all other varieties and the lowest percent (10.28%) TYLCV infected leaves were recorded in BINA-2, which was statistically similar with BARI-3 (12.67%), BARI-7 (11.72%), BARI-9 (11.62), BARI-8 (11.57%), BARI-2 (11.23%) and BINA-3 (10.85%) followed by BINA-4 (14.67%) (Table 5).

In an average, the trend of results found in terms of percent TYLCV infected leaves per plant among nine tomato varieties is BINA-1 > BINA-4 > BARI-3 BARI-7 > BARI-9 > BARI-9 > BARI-2 > BINA-3 >BINA-2.

4.2.2. Incidence of TYLCV infected plants of different tomato varieties

Statistically significant variation was observed in the incidence of percent TYLCV infected plants of different tomato varieties used under the present trial represented in Table 6. At first week of data collection (14 DAT), the highest percent TYLCV infected plants per plot (6.67%) was recorded in the variety BARI-3, BARI-8, BARI-9 and BINA-3 and no TYLCV infected plant (0.00%) was recorded in BARI-2, BARI-7, BINA-1, BINA-2 and BINA-4 (Table 6).

At second (21 DAT) week of data collection, the highest percent TYLCV infected plants (13.33%) per plot was recorded in the variety BINA-4, which was statistically similar with the varieties BINA-1 and BINA-2 followed (10.00%) by BARI-3 and BINA-3. On the other hand, the lowest percent (3.33%) TYLCV infected plants per plot was recorded in BARI-8 and BARI-2 followed (6.67%) by BARI-7 and BARI-9 (Table 6). As a result, the trend of percent TYLCV infected plants per plot on different tomato varieties is BINA-1/BINA-2/BINA-4 > BINA-3/BARI-3 > BARI-7 /BARI-9 > BARI-2/BARI-8.

Both third (28 DAT) and fourth (35 DAT) weeks of data collection, the highest percent TYLCV infected plants (40.00% and 56.67% respectively) per plot were recorded in the variety BINA-3 and the lowest percent (13.33% and 26.67% respectively) TYLCV infected plants per plot was recorded in BARI-3 (Table 6). From these findings it is revealed that more or less similar trends of results were found with few exceptions observed earlier at first week (14 DAT) of data collection.

At fifth (42 DAT), sixth (49 DAT) and seventh (56 DAT) weeks of data collection, more or less similar trends of results in respect of percent TYLCV infected plants per plot were found. That is the highest percent (81.33, 86.67, and 90.00% respectively) TYLCV infected plant per plot for each week of data collection were recorded in the variety BINA-3, which were significantly different from all other varieties (Table 6). On the other hand, the lowest percent (33.33, 33.33 and 36.67% respectively) TYLCV infected plants per plot 5th, 6th and 7th week of data collection were found in the variety BARI-8 (Table 6).

Table 6. Weekly incidence of TYLCV infected plants among different tomato varieties during winter 2006-2007

Percent TYLCV infected plants per plot on different weeks										
Variety	1st week (14 DAT)	2nd week (21 DAT)	3rd week (28 DAT)	4th week (35 DAT)	5th week (42 DAT)	6th week (49 DAT)	7th week (56 DAT)	Mean	Ranked order	Level of resistance
BARI-2	0.00 b	3.33 c	16.67bc	30.00b	33.33 d	34.67 d	40.00bc	22.57 d	9	R
BARI-3	6.67 a	10.00b	13.33 c	26.67 b	35.33 d	43.33 c	51.33 b	26.67c	6	MR
BARI-7	0.00 b	6.66 bc	16.67 c	33.33 b	43.33c	43.33 c	53.33 b	28.09 c	5	MR
BARI-8	6.67 a	3.33 c	20.00bc	26.67 b	33.33 d	33.33 d	36.67c	22.85 d	8	R
BARI-9	6.67 a	6.67 bc	16.67bc	30.00 b	33.33 d	36.67cd	40.00bc	24.28cd	7	R
BINA-1	0.00 b	13.33 a	26.67 b	53.33 a	75.33 b	80.00 b	86.67 a	47.90 b	3	MR
BINA-2	0.00 b	13.33 a	30.00ab	53.33 a	73.67 b	76.67 b	80.00 a	46.71 b	4	MR
BINA-3	6.67 a	10.00 b	40.00 a	56.67 a	81.33 a	86.67 a	90.00 a	53.04 a	1	MS
BINA-4	0.00 b	13.33 a	36.67 a	56.33 a	80.33 a	85.67 a	89.33 a	51.71 a	2	MS

Resistant (R): 1-25% plant infection; Moderately resistant (MR): 26-50% plant infection and Moderately Susceptible (MS): 51-75% plant infection (Rashid *et al.*, 2002)

In a column, numeric data represents the mean value of 3 replications; each replication is derived from 3 plants per treatment
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT

Considering the percent TYLCV infected plants per plot, in an average, the highest percent TYLCV infected plant per plot (53.04%) was recorded in the variety BINA-3, which was statistically similar with BINA-4 (51.71%) followed by BINA-1 (47.90%), BINA-2 (46.71%) and the lowest percent (22.57%) TYLCV infected plants were recorded in BARI-2, which was statistically similar with BARI-8 (22.85%) followed by BARI-3 (26.67%) and BARI-7 (28.09%) (Table 6). In an average, the trend of results found in terms of percent TYLCV infected plants per plot among nine tomato varieties is BINA-3 > BINA-4 > BINA-1 > BINA-2 > BARI-7 > BARI-3 > BARI-9 > BARI-8 > BARI-2.

As per grading designation, among the nine tomato varieties evaluated against TYLCV transmitted by whitefly, none of them were found to be free from TYLCV infection. Disease incidence varied from 22.57 to 53.04%. Out of nine varieties only three were resistant, which include BARI-2 (Ratan), BARI-8 and BARI-9. The varieties BARI-3, BARI-7 and BINA-1 and BINA-2 were found as moderately resistance to TYLCV and the varieties BINA-3 and BINA-4 were found as moderately susceptible (Table 6). Similar findings were observed by Rashid *et al.* (2002). Muqit (2006) also reported that out of 15 tomato varieties only four (BINA-3, BARI-1, BARI-2 and BARI-11) were found to be moderately resistant to TYLCV transmitted by whitefly (Plate 2 to Plate 10).

Plate 2. Symptom of TYLCV infection on BARI Tomato-2

Plate 3. Symptom of TYLCV on BARI -3

Plate 4. Symptom of TYLCV on BARI -7

Plate 5. Symptom of TYLCV on BARI -8

Plate 6. Symptom of TYLCV on BARI -9

Plate 7. Symptom of TYLCV on BINA -1

Plate 8. Symptom of TYLCV on BINA -2

Plate 9. Symptom of TYLCV on BINA -3

Plate 10. Symptom of TYLCV on BINA-4

4.2.4. Relationship between number of whitefly population and percent TYLCV infected leaves and plants

In case of different tomato varieties the incidence of TYLCV infected leaves and plants were different. Initially the incidence of TYLCV infected leaves and plants were less but the incidence of TYLCV infected leaves and plants gradually increased for all varieties.

The rate of TYLCV infection is not related to the rate of whitefly population incidence. The highest number of whitefly but lowest percent TYLCV infected leaves and plants found in the variety BARI-2 and the lowest number of whitefly but highest percent TYLCV infected leaves and plants were observed in the varieties BINA-1 and BINA-3 respectively (Figure 1 and 2). From the findings it is revealed that TYLCV intensity is related either with the proportion of viruliferous whitefly rather than total number of whitefly or the morphological and/or physiological properties of the host plant. About similar results were also reported by Aboul Ata *et al*. (2000) and Green and Kalloo (1994).

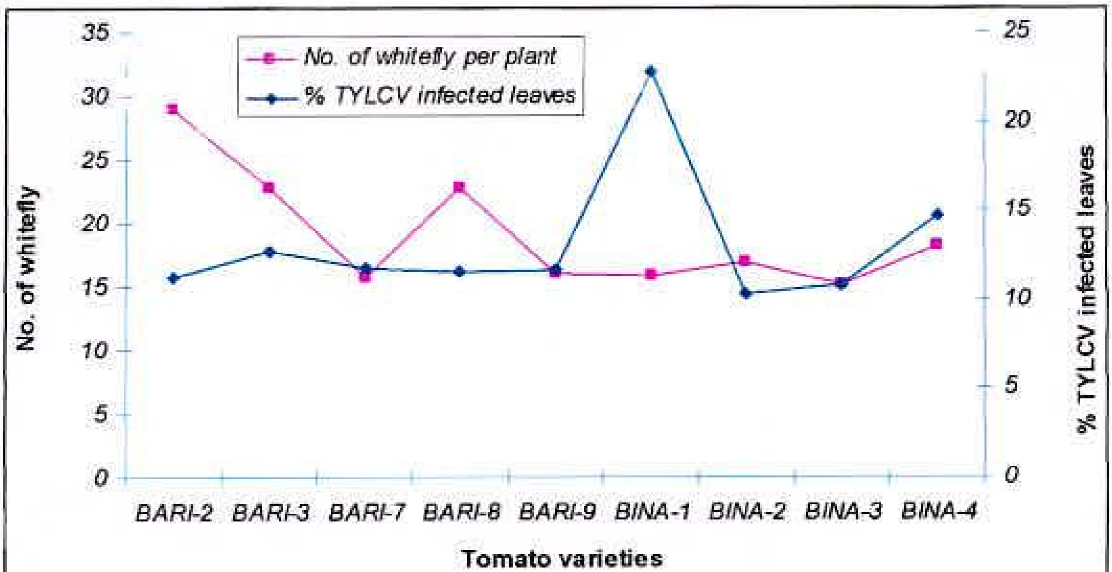

Figure 1. Relationship between number of whitefly incidence and % TYLCV infected leaves per plant among different tomato varieties

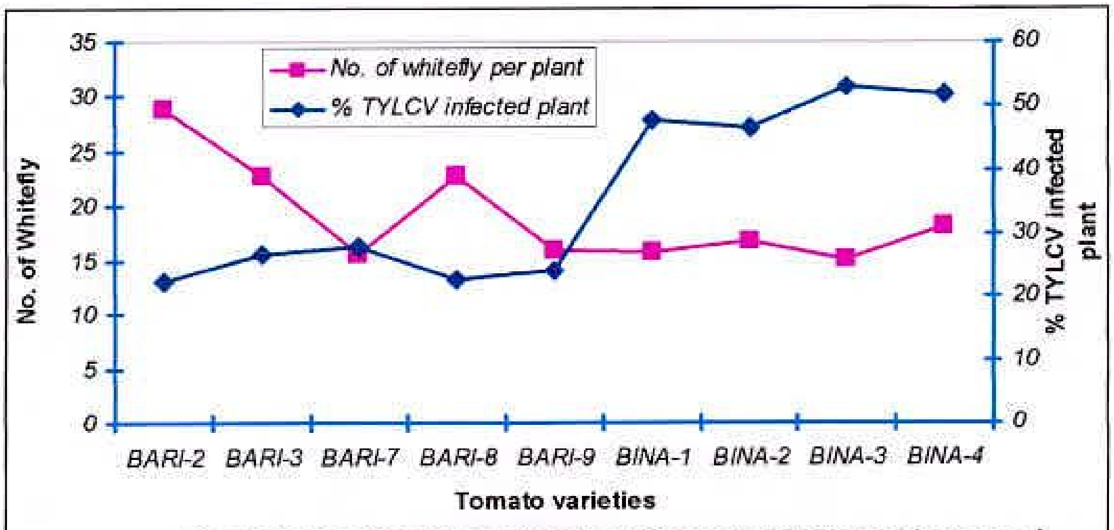

Figure 2. Relationship between number of whitefly incidence and percent TYLCV infected plant among different tomato varieties

4.2.5. Relationship between the trend of adult whitefly incidence and spread of TYLCV infection during the different stages of crop growth

During the progress of time the incidence of TYLCV infected leaves and plants increased. Initially the incidence of TYLCV infected leaves and plants were less but the incidence of TYLCV infected leaves and plants gradually increased and went to the highest peak at 49 DAT and 56 DAT respectively and found 16.33% and 40.00% TYLCV infected leaves and plants respectively at later stage of the growing season (Figure 3 and 4). From these findings it is revealed that incidence of TYLCV increases up to a certain period with the increased adult whitefly population in the tomato field. With the increase of the age of the host plants, the trend of adult whitefly incidence is declining but the trend of TYLCV incidence retains increasing. Similar results were also supported by Green and Kalloo (1994) and they reported that a single viruliferous whitefly is able to transmit the virus disease to a healthy plant and the rate of transmission increases with the increased population density of the vector.

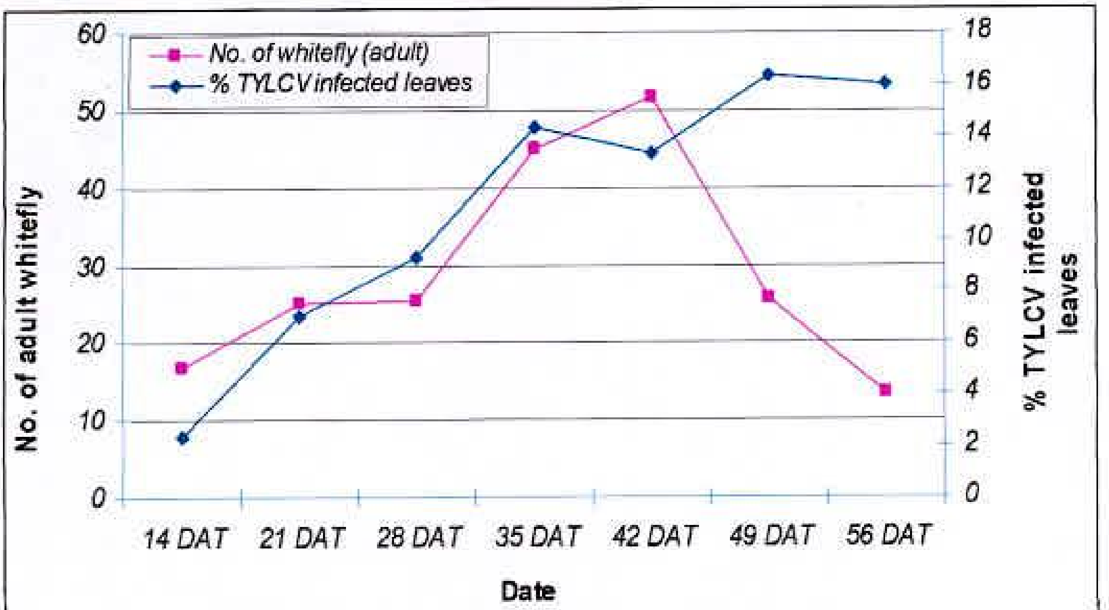

Figure 3. Trend of adult whitefly population and number of TYLCV infected leaves in tomato field

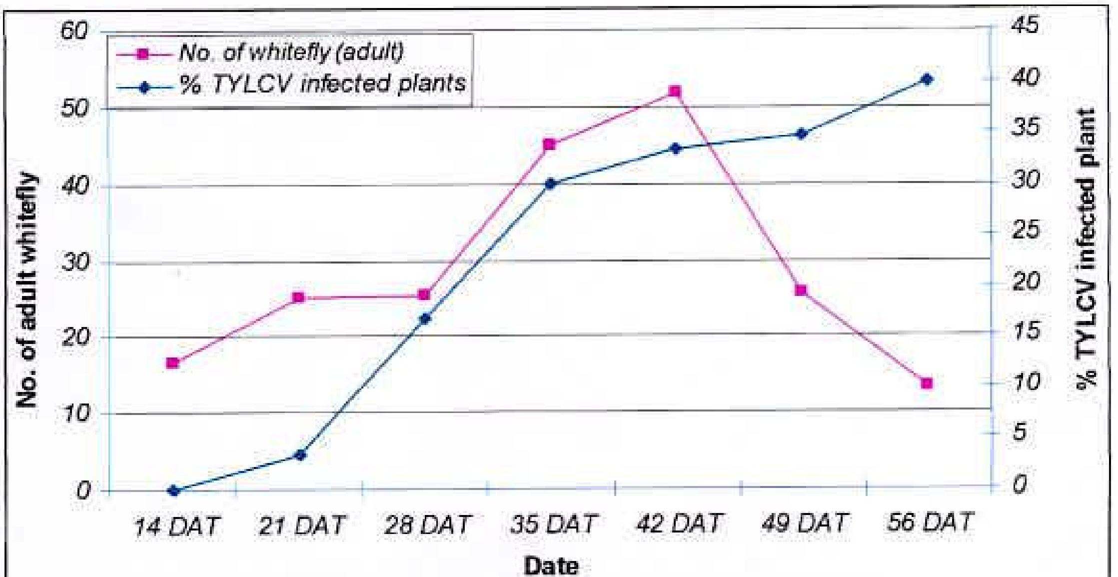

Figure 4. Trend of adult whitefly population and percent TYLCV infected plants in tomato field

4.3. INFLUENCE OF TYLCV ON FRUIT YIELD ON DIFFERENT TOMATO VARIETIES

4.3.1. Influence of whitefly on number of tomato fruit

Statistically significant variation was recorded by number of total fruit per plot at early, mid and late fruiting stage in different tomato varieties screening against TYLCV transmitted by whitefly under the present trial represented in Table 7. At early fruiting stage, the highest number of total fruit per plot (165.51) was recorded in the variety BINA-2, which was significantly different from all other varieties followed by BARI-7 (81.89), BARI-3 (80.43) and BARI-8 (78.25) (Table 7). On the other hand, the lowest number (58.61) of total fruit per plot was recorded BINA-1, which was significantly different from all other varieties followed by BARI-2 (64.67), BINA-3 (67.22), BARI-9 (71.47) and BINA-4 (71.80). As a result, the trend of results is BINA-2 > BARI-7 > BARI-3 > BARI-8 > BINA-4 > BARI-9 > BINA-3 > BARI-2 > BINA-1.

In terms of the number of fruit per plot at mid and late fruiting stages, the more or less similar trends of results were also found with few exception at late fruiting stage in respect of lowest number of fruit per plot that was found in BARI-3 (80.43) (Table 7).

Considering the total number of fruit per plot, more or less similar trend of results was found among different tomato varieties evaluated against TYLCV and trend is BINA-2 > BARI-8 > BARI-9 > BARI-2 > BINA-3 > BINA-4 > BARI-3 > BARI-7 > BINA-1 (Table 7). From the findings it is revealed that the variety BINA-2 produced maximum number (650.32) of tomato fruit per plot, whereas BINA-1 produced minimum number (240.53) of fruit per plot.

Table 7. Influence of TYLCV on fruit yield by number among different tomato varieties at different harvesting stages during winter 2006-2007

Number of tomato fruits per plot				
Variety	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Total
BARI-2	64.67 bc	91.25 c	123.40 b	279.32 bc
BARI-3	80.43 b	85.37 c	80.43 c	246.23 d
BARI-7	81.89 b	82.77 c	84.28 c	248.94 d
BARI-8	78.25 b	116.23 b	115.18 b	309.66 b
BARI-9	71.47 b	103.84 b	105.02 b	280.33 bc
BINA-1	58.61 c	82.29 c	99.63 c	240.53 d
BINA-2	165.51 a	230.77 a	254.04 a	650.32 a
BINA-3	67.22 bc	88.74 c	120.71 b	276.67 bc
BINA-4	71.80 b	84.35 c	103.16 b	259.31 cd

In a column, numeric data represents the mean value of 3 replications
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT

4.3.2. Influence of whitefly on tomato fruit in weight

Statistically significant variation was recorded by weight (kg) of total fruit per plot at early, mid and late fruiting stage in different tomato varieties screening against TYLCV transmitted by whitefly under the present trial represented in Table 8. At early fruiting stage, the maximum weight of total fruit per plot (8.33 kg) was recorded in the variety BARI-9, which was significantly different from all other varieties followed by BARI-2 (6.79 kg), BINA-2 (6.80 kg) and BINA-1 (7.00 kg) (Table 8). On the other hand, the minimum weight (4.55 kg) of total fruit per plot was recorded BARI-7, which was significantly different from all other varieties followed by BARI-3 (5.30 kg), BARI-8 (5.66 kg) and BARI-9 (5.66 kg).

In terms of the fruit weight per plot at mid and late fruiting stages, the more or less similar trends of results were found, where the maximum fruit weight (16.85 kg and 11.67 kg respectively) per plot were recorded in BINA-1 and the minimum fruit weight (13.74 kg and 6.45 kg respectively) were recorded in BARI-7 (Table 8).

Considering the total fruit weight per plot, the maximum fruit weight (35.52 kg) per plot was recorded in BINA-1 and the minimum fruit weight (24.74 kg) was recorded in BARI-7 (Table 7). As a result, the trend of results is BINA-1 > BINA-2 > BARI-2 > BINA-3 > BARI-9 > BARI-8 > BINA-4 > BARI-3 > BARI-7 (Table 8).

Table 8. Influence of TYLCV on fruit yield by weight among different tomato varieties at different harvesting stages during winter 2006-2007

Weight of tomato fruits per plot				
Variety	Early fruiting stage	Mid fruiting stage	Late fruiting stage	Total
BARI-2	6.79 b	15.80 a	10.26 ab	32.85 a
BARI-3	5.30 c	15.00 ab	7.46 c	27.76 bc
BARI-7	4.55 d	13.74 c	6.45 c	24.74 c
BARI-8	5.66 c	14.30 b	9.28 b	29.24 b
BARI-9	8.33 a	13.66 c	10.24 ab	32.23 ab
BINA-1	7.00 b	15.85 a	10.67 a	33.52 a
BINA-2	6.80 b	15.09 ab	11.07 a	32.96 a
BINA-3	6.00 bc	16.01 a	10.34 ab	32.35 ab
BINA-4	5.66 c	14.30 b	8.13 b	28.09 bc

In a column, numeric data represents the mean value of 3 replications
In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT

4.4. INFLUENCE OF TYLCV ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF DIFFERENT TOMATO VARIETIES

4.4.1. Influence of whitefly on plant and flower related yield contributing characters

Significant variation was recorded in terms of height per plant for different tomato varieties evaluated against TYLCV under the present trial represented in Table 9. In terms of height of single plant in cm, the maximum height (290.4 cm) was recorded for the variety BARI-7, which was significantly different from all other varieties followed by BINA-1 (268.7 cm), BINA-4 (267.0 cm) and BARI-2 (265.5 cm). On the other hand, the minimum height (195.7 cm) was recorded in the variety BARI-9 followed by BARI-8 (206.5 cm.), BARI-2 (237.5 cm) and BINA-3 (256.6 cm) (Table 9).

In consideration of number of branch per plant, the maximum number (13.78) was recorded in the variety BARI-2, which was statistically identical with the variety BINA-4 (11.11) and BINA-2 (10.89), BARI-7(10.44), BINA-3(10.11) (Table 9). On the other hand, the lowest number of branch per plant (6.88) was recorded for variety BARI-8, which was statistically different from all other varieties followed by BARI-9 (7.89), BARI-3 (9.00).

In terms of number of leaves per plant among nine tomato varieties, the maximum number of leaves per plant was recorded for the variety BARI-2 (86.77), which was statistically similar with BINA-1 (80.33) and the minimum number of leaves per plant (59.11) in BARI-9, which was statistically similar with BARI-8 (66.77), BINA-4 (61.77), BARI-7 (63.22) BARI-3 (64.44) and BINA-3 (69.10) (Table 9).

Table 9. Influence of TYLCV on plant and flower related yield contributing characters of nine tomato varieties evaluated against whitefly during winter 2006-2007

Plant and flower related yield contributing characters					
Variety	Height /plant (cm)	No. branch /plant	No. leaves /plant	No. of flower bunch /plant	No. of flower /bunch
BARI-2	237.5 abc	13.78 a	86.77 a	79.33 ab	5.33 ab
BARI-3	265.8 ab	9.00 bcd	64.44 b	71.67 b	5.33 ab
BARI-7	290.4 a	10.44 bc	63.22 b	60.00 b	4.67 b
BARI-8	206.5 bc	6.88 d	60.77 b	65.00 b	5.33 ab
BARI-9	195.7 c	7.89 cd	59.11 b	70.67 b	4.33 b
BINA-1	268.7 ab	10.11 bc	80.33 a	75.00 ab	4.33 b
BINA-2	250.3 abc	10.89 abc	73.44 b	99.33 a	5.67 a
BINA-3	256.5 abc	10.11 bc	69.10 b	62.67 b	5.33 ab
BINA-4	267.0 ab	11.11 ab	61.77 b	71.00 b	4.67 b

In a column, numeric data represents the mean value of 3 replications

Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT

In consideration of the number of flower bunch per plant, the maximum number of flower bunch per plant (99.33) was recorded for the variety BINA-2, which was statistically similar with the variety BARI-2 (79.33) and BINA-1 (75.00) and the minimum number of flower bunch per plant (60.00) was recorded in the variety BARI-7 (Table 9). In term of number of flower per bunch, the highest number of flower per bunch (5.67) was recorded for the variety BINA-2, which was statistically identical with the variety BINA-3, BARI-3, and BARI-8 (5.33) (Table 9). On the other hand, the lowest number of flower per bunch (4.33) was recorded in the variety BARI-2 (Table 9).

4.4.2. Influence on fruit related yield contributing characters

Significant variation was recorded in terms of number fruit per plant, single fruit weight, fruit yield (ton/ha) of different tomato varieties/genotypes evaluated against TYLCV under the present trial represented in Table 10. In consideration of number of fruit per plant, the maximum number of fruit (64.79) was recorded in the variety BINA-2, which was statistically different from all other varieties followed (31.33) by BARI-3, BARI-8, BARI-7 (29.00), BARI-9 (27.67), BARI-2 (27.33) and BINA-3 (27.33). On the other hand, the minimum number (23.33) of fruit per plant was recorded for the variety BINA-1 followed by BINA-4 (25.67) (Table 10).

In terms of single fruit weight, the maximum single fruit weight was recorded for the variety BINA-1 (143.33 g), which was significantly different from all other varieties followed by the variety BARI-2 (120.00 g), which was statistically similar with BARI-9 (117.00 g), BINA-3 (118.67 g) and BINA-4 (109.33 g) and the minimum single fruit weight (50.93 g) was recorded in the variety BINA-2 followed by BARI-7 (85.33 g), which was statistically similar with BARI-3 (88.67 g) and BARI-8 (99.33 g) (Table 10). From the results it was found that the minimum number of fruit for each plant contributed maximum weight per single fruit.

Table 10. Influence of TYLCV on plant and flower related yield contributing characters of nine tomato varieties evaluated against whitefly during winter 2006-2007

Plant and flower related yield contributing characters			
Variety	Number of fruit per plant	Single fruit weight (g)	Yield (t/ha)
BARI-2	27.33 b	120.00 b	73.00 a
BARI-3	31.33 b	88.67 c	61.69 bc
BARI-7	29.00 b	85.33 c	54.98 c
BARI-8	31.33 b	93.33 c	64.98 abc
BARI-9	27.67 b	117.00 b	71.62 ab
BINA-1	23.33 c	143.33 a	74.49 a
BINA-2	64.79 a	50.93 d	73.24 a
BINA-3	27.33 b	118.67 b	71.89 ab
BINA-4	25.67 bc	109.33 b	62.42 bc

In a column, numeric data represents the mean value of 3 replications

Figures in a column accompanied by similar letter(s) do not differ significantly at 0.05 level of probability as per DMRT

The highest yield (74.49 t/ha) was recorded for the variety BINA-1, which was statistically similar with the variety BINA-2 (73.24 t/ha) and BARI-2 (73.00 t/ha) followed by BINA-3 (71.89 t/h) and BARI-9 (71.62 t/h). On the other hand, the lowest yield (54.98 t/ha) was recorded in the variety BARI-7, which was statistically different from all other varieties tested under the trial followed by BARI-3 (61.69 t/ha), BINA-4 (62.42) and BARI-8 varieties (Table 10) and similar trend of results observed that was found in terms of fruit weight (kg/plot).

4.4.3. Relationship between adult whitefly incidence and yield of different tomato varieties

Considering mean adult whitefly incidence, cumulative TYLCV infection and comparative yield among nine tomato varieties, it was observed that the tomato BARI-2 had significantly the highest whitefly infestation (28.95 per plant) (Figure 5) but with the lowest TYLCV infection (22.57%) (Figure 6) and produced second highest yield (73.00 t/ha). On the other hand, BINA-2 showed significantly the second lowest whitefly infestation (16.90 per plant) but second highest TYLCV infection (46.71%) and produced highest fruit yield (74.49 t/ha) (Figure 5 and 6). From the findings it is revealed that BARI-2 is the most preferred host by the whitefly but resistant against TYLCV infection and carry the high yield potentiality, whereas BINA-2 is the least preferred host by the whitefly but moderately resistant to TYLCV infection and carry the high yield potentiality, which may increase through the management of TYLCV.

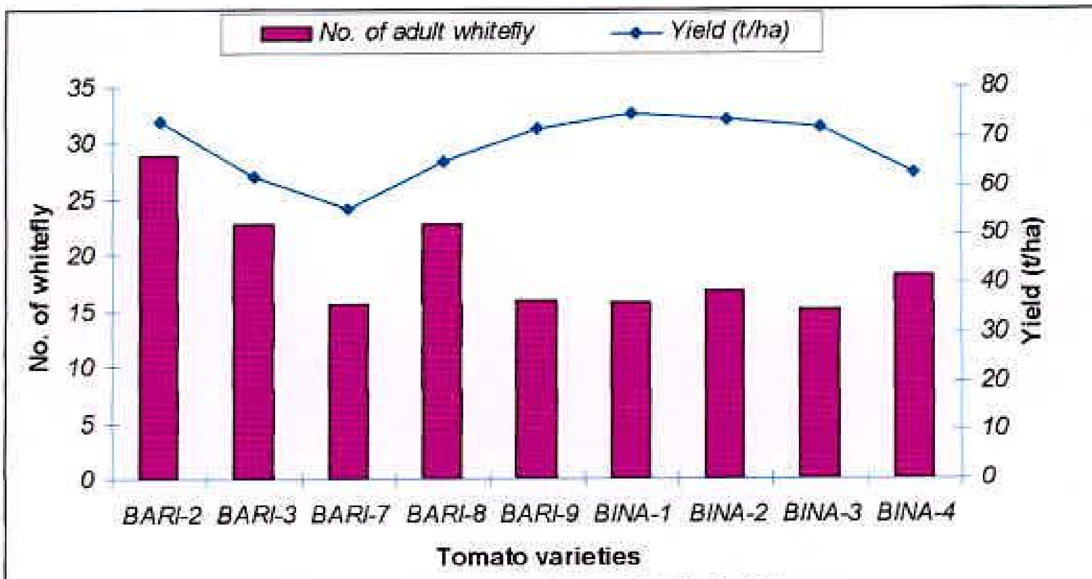

Figure 5. Influence of adult whitefly incidence on yield of different tomato varieties

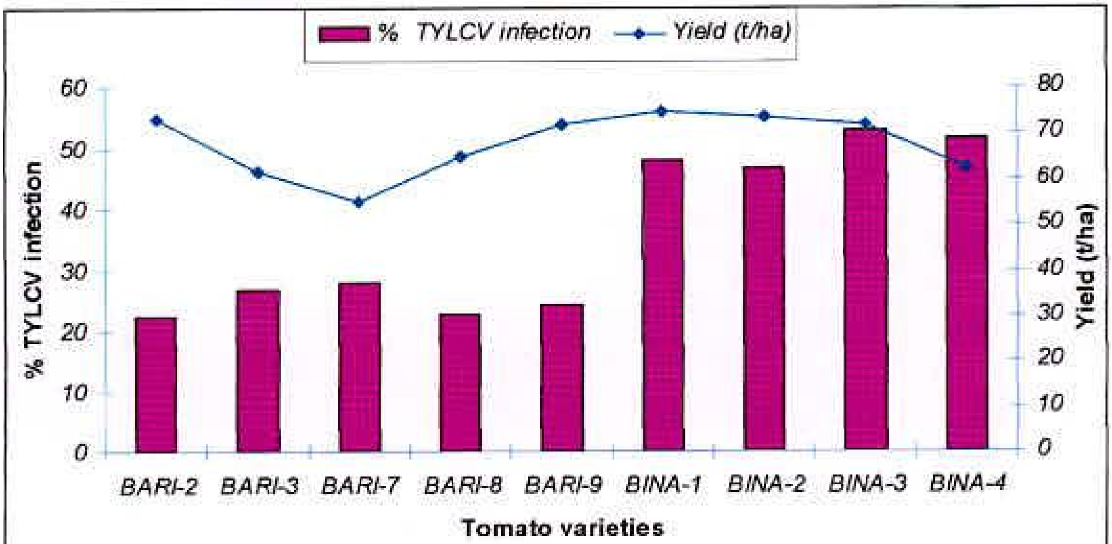

Figure 6. Influence of TYLCV incidence on yield of different tomato varieties

4.5. Relationship between number of fruits per plant and yield (t/ha)

Relationship between number of fruits per plant and yield (t/ha) of nine tomato varieties was done. From the study it was revealed that a significant relationship was existed between the characters (Figure 7). From this it can be concluded that number of fruits was not positively related to the yield except BINA-2, in which yield increased with increases the number of fruit per plant.

4.1.5 Relationship between single fruit weight and yield (t/ha)

Considering the single fruit weight (g) and yield (ton/hectare) of nine tomato varieties was done. From the study it was revealed that a significant relationship was existed between the characters. From this it can be concluded that a positive relationship was obtained between single fruit weight (g) and yield of nine tomato varieties (Figure 8), where the increase in yield per hectare due to the increase of single fruit weight was justifiable except BINA-2, in which yield increased due to increase the number of fruit per plant.

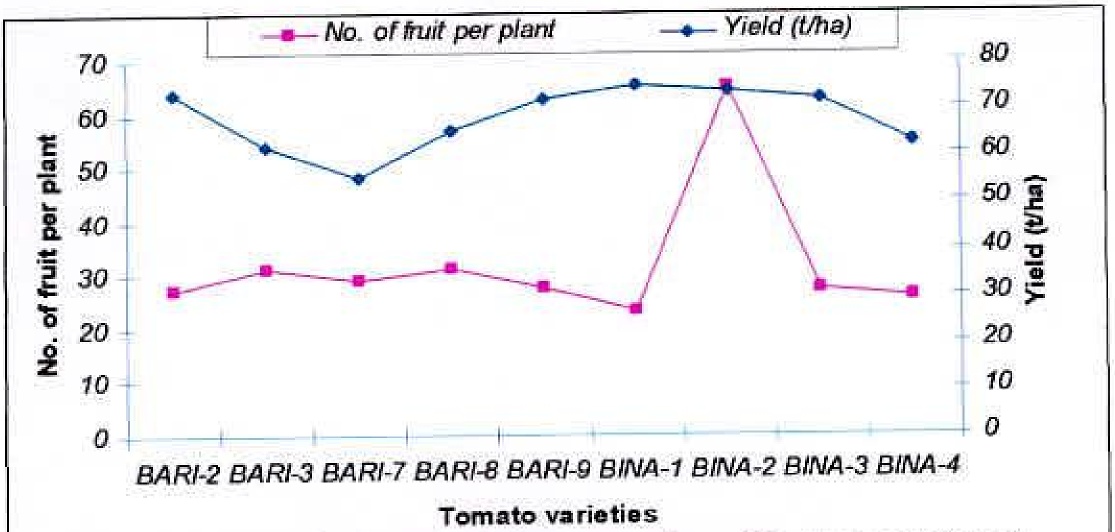

Figure 7. Relationship between number of fruit per plant and yield of different tomato varieties

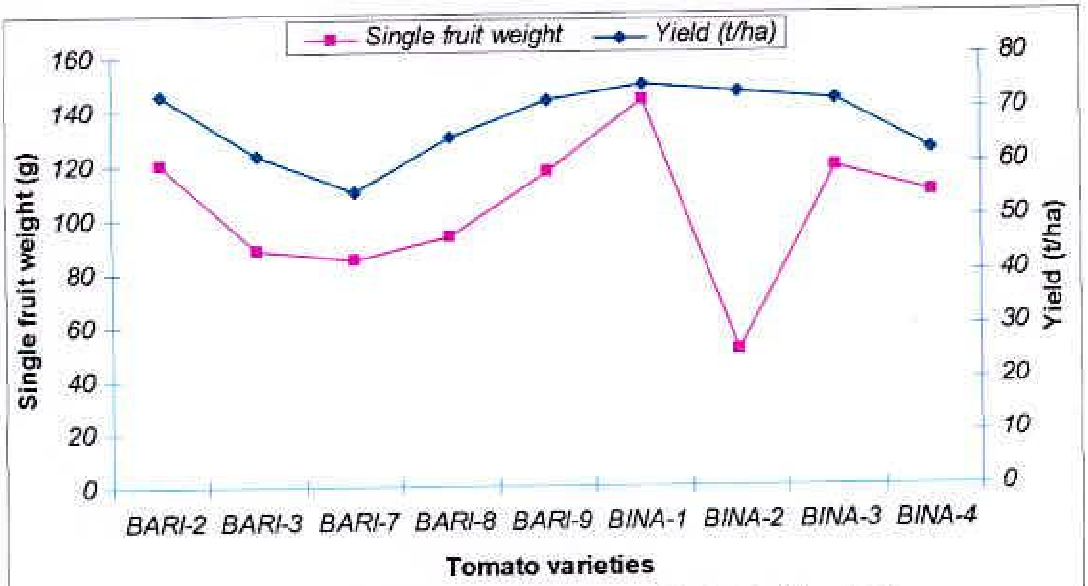

Figure 8. Relationship between single fruit weight and yield of different tomato varieties

CHAPTER – V

SUMMARY & CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2006 to March 2007 to screen some tomato varieties/genotypes for their resistance to whitefly, *Bemisia tabaci* Gennadius. Incidence and abundance of whitefly as well as Tomato Yellow Leaf Curl Virus (TYLCV) disease and several morphological traits of the tomato varieties were studied to identify resistance source(s) among nine released tomato varieties. The experiment was set up in a randomized complete block resign (RCBD) having three replications.

Incidence of whitefly population and TYLCV infection different tomato varieties/genotypes at different crop growth stages were documented in the present investigation. From the findings it is revealed that out of nine tomato varieties, BARI-2 (28.95) showed the most preferred host followed by BARI-8 (22.85), whereas BINA-3 (15.14), BARI-7 (15.71) and BINA-1 (15.81) performed as least preferred host for whitefly, *Bemisia tabaci* in terms of number of adult whitefly per plant. Is also revealed that whitefly incidence was lower at the early stage of crop growth while it was the highest in mid stage and then it declined at the late stage of the crop.

TYLCV infection gradually increased from early stage to late stage of crop growth. In an average, the highest percent TYLCV infected leaves per plant recorded in the variety BINA-1 (22.76%) and lowest was observed in BINA-2 (10.28%) followed by BINA-3 (10.85%) and BARI-2 (11.23%).

As per grading designation, among the nine tomato varieties evaluated against TYLCV transmitted by whitefly, none of them were found to be free from TYLCV infection. Disease incidence varied from 22.57 to 53.04% in terms of percent TYLCV infected plants per plot. Out of nine varieties only three were resistant, which include BARI-2 (Ratan), BARI-8 and BARI-9. The varieties BARI-3, BARI-7 and BINA-1 and BINA-2 were found as moderately resistance to TYLCV and the varieties BINA-3 and BINA-4 were found as moderately susceptible.

In the present study, not a positive relationship was observed between the incidence of YTLCV infection and the whitefly population density. The incidence of TYLCV infected leaves and plant is not directly proportional to the density of vector (whitefly) population, where the TYLCV infection intensity is related either to the proportion of viruliferous whitefly rather than total number of whitefly or the morphological and/or physiological properties of the host plant.

Considering mean whitefly infestation, cumulative TYLCV infection and comparative yield of different tomato varieties, it was observed that the tomato BARI-2 had significantly the highest whitefly infestation (28.95 per plant) and but with the lowest TYLCV infection (22.57%) and the highest yield (73.00 t/ha). On the other hand, BINA-2 showed significantly the second lowest whitefly infestation (16.90 per plant) and second highest TYLCV infection (46.71%) and yielded the highest (73.24 t/ha).

The variety BARI-7 showed significantly maximum height (290.4 cm) per plant but produced lowest yield (54.98 t/ha), whereas BARI-2 (265.5 cm) and BINA-2 (250.3 cm) showed third highest height as well as produced significantly highest yield (73.00 and 73.24 t/ha, respectively). In consideration of number of branch and leaves per plant, the maximum numbers (13.78 and 86.77 respectively) were produce by the variety BARI-2. In terms of the number of flower bunch per plant and number of flower per bunch, the maximum number (99.33 and 5.67) were produced by the variety BINA-2, which was statistically similar with the variety BARI-2 (79.33 and 5.33).

From this it can be concluded that number of fruits was not positively related to the yield except few cases. The increase in yield per hectare due to the increase of single fruit weight was justifiable.

From the present investigation it could be concluded that the locally available BARI-2, BARI-8 and BARI-9 have some potential to resist the TYLCV infection transmitted by

Bemisia tabaci and could serve as important resistant sources in developing commercial tomato varieties having whitefly resistance.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. The BARI-2, BARI-8 and BARI-9 tomato varieties may be cultivated as resistant to tomato yellow leaf curl virus (TYLCV) transmitted by whitefly, whereas BARI-3, BARI-7, BINA-1 and BINA-2 as moderately resistant to TYLCV as well as higher yield producing varieties.

2. Any other tomato varieties may be evaluated for comparative study for resistance to whitefly in any other location of the country.

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CHAPTER VI

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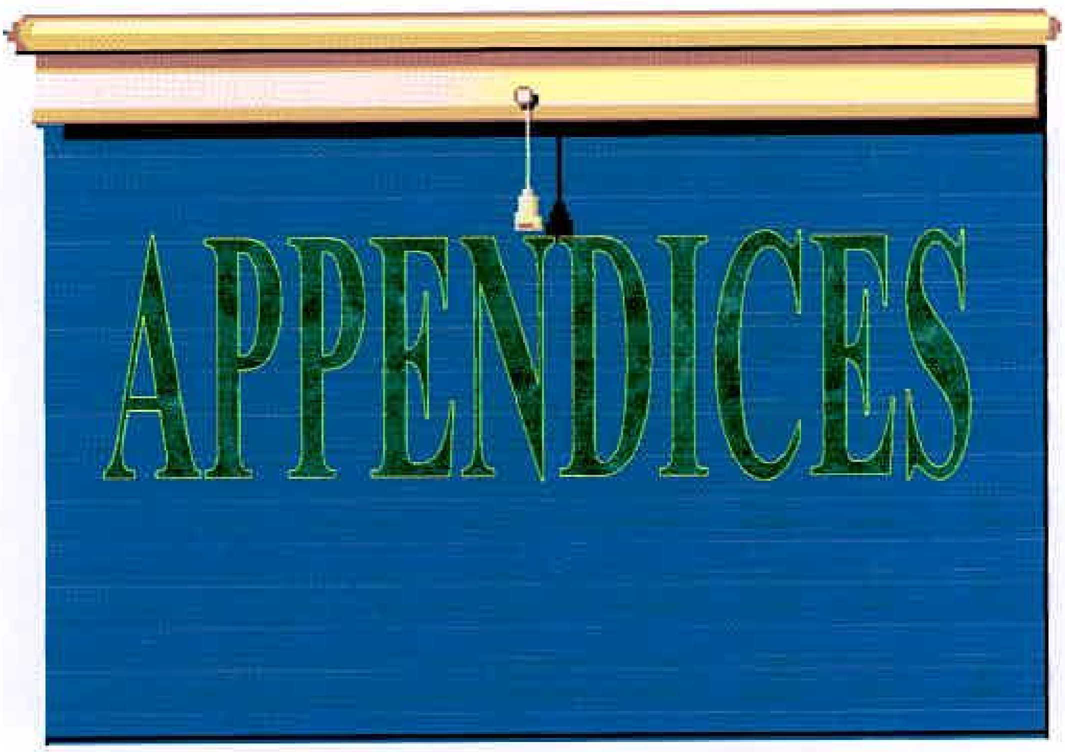
APPENDICES

APPENDICES

Appendix I. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from September 2006 to March 2007

Month	Air temperature (^{0}C)		R.H. (%)	Total rainfall (mm)
	Maximum	Minimum		
September 06	26.20	24.1	73	07
October 06	26.70	21.1	89	07
November 06	24.00	20.1	87	02
December 06	21.00	20.9	64	04
January 07	20.20	21.85	74	15
February 07	20.25	18.55	71	22
March 07	22.25	19.30	75	38

Source : Dhaka Metrological Center

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

Mechanical analysis

Constituents	Percent
Sand	33.45
Silt	60.25
Clay	6.20
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.12
Organic carbon (%)	1.32
Total nitrogen (%)	0.08
Available P (ppm)	20
Exchangeable K (%)	0.2

Source: Soil Resource Development Institute (SRDI)