MANAGEMENT OF WHITEFLY (*Bemisia tabaci* Gennadius) IN TOMATO

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CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Lin.) a member of the Solanaceae family, is one of the most widely grown vegetables. Tomato outranks all others in terms of total contribution of vitamins and minerals to the diet, mainly because of the large volume consumed both in fresh and processed forms (Opena 1987). It is one of the most important popular salad vegetables and is used to make soups, conserves, pickles, ketchup's, sauces, juices etc. It is also excellent source of vitamin C and is commonly referred to as poor man's orange.

The area under tomato cultivation in Bangladesh during the year 1980, 1990, and 2000 was 8.9, 11.7, and 15 thousand hectares respectively with a production of 64, 98 and 100 thousand metric tons (Anonymous 2005).

The average yield of tomato in Bangladesh is very low as compared to world average or some other tomato growing countries. The average yield of tomato in Bangladesh 7.3 ton / hectare (Anonymous 1999) is remarkably poor compared to world average 27.8 metric tons / hectare (Anonymous 1997).

The whitefly, *Bemisia tabaci* (Gennadius Homoptera: Aleyrodidae) feeds on a wide range of vegetables and is an important pest of many crops including soybean and many types of ornamental plants (Hirano *et al.*, 1993). The whitefly also attack cucumber, okra, pumpkin, lablab bean and eggplant (Kajita and Alam 1996).

Sucking of plant sap by large populations of whitefly nymphs and adults can greatly reduce the plant vigor. Chlorotic spots appear at feeding sites on the leaf surface, followed by wilting and resulting leaf shedding. Such damage to foliage at the early stages of plant growth, affects development of the reproductive structures and consequently the yield may be greatly reduced. However, direct damage due to feeding would not appear to have been a matter of much concern, as reflected by the general lack of attention to this aspect in the literature (Basu 1995).

Heavy colonization of *B. tabaci* can cause serious indirect damage to this crop due to honeydew excreted by all insect stages, particularly the late nymphal instars. Accumulation of honeydew on leaf or on fruit surfaces encourages growth of sooty moulds, which affect yield both in quantitative and qualitative terms (Basu 1995).

The notoriety of *B. tabaci* as a pest obscured by its role as an efficient vector of a large number of important diseases of tomato in the tropical and subtropical parts of the world. The prevalence and distribution of *B. tabaci* viral maladies have increased during the past decade and the impact has often been devastating (Basu 1995). Among the insect borne diseases, tomato yellow leaf curl virus (TYLCV) cause devastating damage to tomato all over the world. This viral disease is exclusively transmitted by whitefly (Hinata 1986). Sastry and Sing (1973) estimated 20-75% loss in tomato yield due to tomato leaf curl virus (TYLCV) disease in India.

Due to virus diseases enormous yield loss of tomato is recoded all over the world. Cohen and Harpez (1996) described yellow leaf curl symptom in tomato leaves caused by a virus transmitted by whitefly (*Bemisia tabaci*) in Israel which was extensively studied by Cohen and Nitzany in 1966 and named the virus as Tomato yellow leaf curl virus.

The whitefly population during growing period of tomato plants contributes to the spread of virus in the field. TYLCV is not mechanically transmitted and genetic resistance in cultivated varieties is absent, (Brunt *et al*. 1990; Tomlinson 1987). Plostron & Anderson (1997) suggested that control of *Bemisia tabaci* could be possible to a good extent by growing tomato seedling in insect proof net house.

For profitable cultivation of tomato in Bangladesh, management of whitefly is urgently needed. Among the various control practices in tomato plant to suppress the prevalence of whitefly insecticides are the mostly used.

The synthetic pyrethroids are powerful contact insecticides with a quick knockdown effect, a highly deserved quality to inactivate vector individuals within the period required for virus transmission (Basu 1995). Kisha (1981) found that foliar sprays of a synthetic pyrethroid reduced the number of nymphs and adults of *B. tabaci* as a chemical measure to restrain tomato leaf curl virus disease.

Occurrence of whitefly is very common in winter tomatoes in Bangladesh. But in recent years the problem has increased manifold. To combat the disease problem disseminating by whitefly there is no effective management package or resistant variety available at present. Therefore, developing a sound and effective management package for whitefly is urgently needed. Under the existing circumstances combination of physical and chemical approaches seem to be a better option for the management of whitefly in Bangladesh.

Therefore, the present study was undertaken to evaluate two botanicals Neem seed Kernel Extract and Neem oil, three insecticides Admire 200 SL and a combination of carbosulfan (Marshal 20EC) and pyrethroid (Ripcord 10 EC), a neo-nicotinoid (Actara 25 WG) and Silver color strips as visual repellents for the management of whitefly. The specific objectives of this study are:

i) to evaluate the effectiveness of chemical insecticides, botanicals and physical methods for the management of whitefly and

ii) to determine the whitefly population and virus infestation level through out the growing season.

CHAPTER II

REVIEW OF LITERATURE

Tomato plants are attacked by many insect pests. Among them whitefly is the most important pest damaging the plants in three ways (Byrne *et al.* 1990). They reduce crop yield and act as vectors of viral pathogens (Kajita and Alam 1996). Furthermore, contamination of crops results from sooty mould on the honeydew excreted by whitefly nymphs. Research works on this kind of study are scanty but review of literatures on the relevant field were searched and discussed under the following sub-headings. The origin and distribution of whitefly, its nature of damage on tomato, seasonal abundance, life history, diseases transmitted by them and their management were given special emphasis.

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 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. 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).

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.

Nuture 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.

Seasonal Abundance: 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.

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).

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 1.7days 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.

Influence of Temperature, Humidity and Rainfall on Biology

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-Khidir1964). Ohnesorge *et al*. (1981) found that the oviposition was impaired by rain.

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.

Transmission of Virus Diseases

The **piercing-sucking mouthparts** of whiteflies provide an excellent mode for transmitting disease-causing **viruses** from one plant to another.

Cohen and Nitzany (1966) reported that in nature the virus mainly infects tomato. The experimental host range of TYLCV is narrow. It mainly infects some species of Solanaceae, Compositae and Caprifoliaceae.

Green and Kalloo (1994) in their review described many aspects of TYLCV. Infected tomato plants are stunted, branches and petioles tend to assume erect position, and leaflets are smaller than those of healthy plants, puckered and often show upward curling, margins with or without yellowing. The virus is transmitted by whitefly (*B. tabaci*) in a semi persistent (circulative) manner. A single viruliferous whitefly is able to transmit the disease to a healthy plant and the rate of transmission increases with the increased population density of the vector. Although the virus is graft transmissible but mechanical or seed transmission is not reported.

Ghanim *et al*. (1998) reported that whitefly (*B. tabaci*) is the only vector of TYLCV, which transmits the virus in a persistent (circulative) manner. They found TYLCV DNA in the insect progeny, which acquired the virus through eggs. They reported that TYLCV could be transmitted through egg for at least two generations. In the absence of an available host, whitefly may serve as a reservoir of the virus between growing seasons.

Symptoms of Whitefly affected Plants

Sinisterra *et al*. (2000) described the symptoms of TYLCV on tomato. These include stunting, curling, marginal chlorosis of leaves, reduced leaf size and marked reduction in fruit number.

For the first time Avgelis *et al.* (2001) reported TYLCV in tomato in Greece. They described the disease symptom as leaf curling, reduced leaf size, yellowing, shortened internodes and a bushy appearance. Mechanical inoculation was unsuccessful while transmission was obtained by grafting on to healthy tomato plants

Gafni (2003) reported that TYLCV is a ssDNA plant virus, a member of geminiviridae of the genus Begomovirus. TYLCV like all members of geminiviridae has geminate (twinned) particle, 18-20 nm in diameter and 30 nm long with 22 pentameric capsomeres and 110 identical protein units. Symptoms become visible in tomato in approximately 2-3 weeks after infection. Leaf symptoms include chlorotic margins, small leaves that are cupped, thick and rubbery. The majority (90%) of flowers abscises after infection and therefore few fruits are produced.

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.

Nymph population of B. *tabaci* was counted on whole young tomato plants (up to 15 cm tall) or on the third and fourth leaves from the top of the older plants (Cohen and Melamed-Madjar 1978).

Whitefly adults are known for their phototropism i.e. they occur mainly on the lower surface of the leaf. Whitefly nymphs were counted on third and fourth leaves from top of the plants taken at random by Sharaf *et al*. (1984).

Basu (1995) reported two principal methods of whitefly count. One is the indirect estimation by trapping and other by direct count on the plant. Yellow sticky traps of various sizes have become a major tool in monitoring the adult population of B. *tabaci* for indirect estimation. Direct counting is very difficult because usually whiteflies are aggregated and fly away easily when disturbed. He suggested that direct counting should be done early in

the morning when adults are least mobile. For adult counting on cotton, first two fully expanded main terminal leaves and one leaf at mid level of the plant is sampled. Sampling is done in such a way that adults are not disturbed.

Csizinsky *et al*. (1997) counted whitefly adults in every 2-3 weeks on three fully expanded leaves. Leaves were carefully inverted and insects were counted. Counting was done in the morning hours when adults are less easily disturbed. Sampling was made on the middle 10 plants from middle row of each plant.

Ramappa *et al*. (1998) monitored adult *B. tabaci* population weekly in the plots for 10 weeks after transplanting using both yellow traps filled with water and by counting the number of adults on five randomly selected whole tomato plants. Four yellow plate traps were placed on the ground in each tomato plot, each one situated 3m from the corner along a diagonal line connecting opposite corners of the plot. The yellow plate traps were left out for 24h for each sampling date. They reported 3-4 to 13-15 adults/trap and 2.1 to 3.7/plant.

Geographical distribution and economic importance:

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.

Polizzi *et al*. (1994) reported that Tomato yellow leaf curl bigeminivirus (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. Common bean acts as a reservoir of TYLCV-Is (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 tomatos 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.

Management of Whitefly:

To manage whiteflies, it is necessary to know **which plants** are affected by whiteflies and to understand the nature of its damage to crops, the biology of the whiteflies and their **natural enemies**, and how to **monitor** whitefly populations (sites, **population dynamics**, **action thresholds**). Also, it is critical to know the limitations of various control tactics, which include **cultural** controls (such as altered planting practices and **physical barriers**), **host plant resistance**, chemical controls, and **natural controls**.

The use of insecticides and oils to affect virus transmission by whiteflies has yielded more or less satisfactory results in a limited number of cases. Cultural control measures to reduce the disease incidence included sanitation, mixed cropping, use of reflective surfaces by way of mulches, physical barriers and cultivation of resistant varieties. No strategy for control of whitefly borne geminiviruses has proved effective in practice (Brown and Bird, 1992).

Many reports, from cultural to transgenics have been published on the management of Tomato in the world. Few works are reviewed under the following subheading.

i) Sanitation: To manage the leaf curl disease tomato fields should be kept weed free and TYLCV infected plants should be clean out immediately. Tomato fields should be cleaned up immediately after

harvest. TYLCV resistant cultivars should be used if available (Schuster and Polston 1999).

ii) Use of Reflective Surfaces:

B. tabaci is strongly attracted to yellow plastic or straw mulches and killed by reflected heat. Mulching of tomatoes and cucumber fields with saw dust, straw or yellow polythene sheets markedly reduced the incidence of TYLCV and cucumber vein virus and populations of the whitefly vector (Cohen and Melamed-Madjar 1978). In West Bengal, India, the incidence of yellow mosaic disease of okra was 24.3% in plots with yellow polythene mulch against 58.6% in control (Khan and Mukhopadhyay 1985).

iii)Polyethylene Mulch

Cohen and Melamed-Madjar (1978) reported that soil mulching with yellow polyethylene sheets can delay the spread of TYLCV for at least 20 days. A combined treatment of mulching with yellow polyethylene sheets and 1% sprays of azinphos-methyl starting 20 days after germination was found to be most effective in preventing the spread of TYLCV of tomato.

Five mulch types, i.e. silver, black, white/black and black/white plastic and paper were evaluated in terms of their effect on growth, yield and fruit quality of tomato and incidence of *Tomato yellow leaf curl virus* (TYLCV). Silver colored mulch reduced disease incidence by 80% and increased the yield 2 times as compared to control (Suwwan *et al.* 1988).

Csizinsky *et al*. (1995) conducted field experiment on the effect of six different plastic mulches like blue, orange, red, aluminum, yellow, white/black on fruit yields and insect

vectors of tomato. Aluminum and orange mulches reduced the whitefly numbers, delayed virus infection and increased the yield. Virus symptom development was not delayed and yield did not increase in yellow mulch in spite of lower number of whiteflies. They concluded that under high insect stress, the insect repellent, soil-microclimate-modifying and biologically beneficial effects of the mulch be considered when a mulch color is selected for tomato production.

Molla (2000) worked on different mulching materials (blue, aluminum, yellow, black, transparent polyethylene, rice straw, dried natural grass) and weed control on tomato yellow leaf curl virus (TYLCV). Mulching reduced the disease incidence by 50% as compared to control. Aluminum colored mulch had the lowest disease incidence but higher yield was obtained from yellow colored mulch.

iv) Trap crop

Al-Musa (1982) studied the effect of some inter crops on TYLCV of tomato. In field trial cucumber, eggplant and corn were planted in alternate rows of tomato 30 days before the tomato seedlings were transplanted. TYLCV was effectively delayed in cucumber interplanted plots whereas; corn or eggplant was not found suitable.

El-Serwiy *et al*. (1987) studied the effect of intercropping aubergine, okra, pepper and cucumber with tomato on the incidence of TYLCV and *B. tabaci* in plastic green houses in Iraq. Adult whiteflies preferred to oviposit on aubergines than on tomato. The incidence of TYLCV was reduced by 10-26% in tomato plots intercropped with *Capsicum* during first 3 months after transplanting.

Xienqui (2000) evaluated the effect of interplanting tomato with vegetable soybean, corn, sweet potato, cucumber, okra on whitefly population and incidence of TYLCV in the field.

All the crop combination partially reduced TYLCV infection. Among the intercrops cucumber and vegetable soybean were much preferred by whiteflies as compared to others.

The impact of whitefly transmitted geminiviruses on tomato yield depends on plant age at the time of infection and is highest during the first eight weeks after germination. This is the critical period. In order to delay the *Tomato yellow mottle* geminivirus (ToYMoV) in tomato, some living ground covers were evaluated by Hilje (2000) in Costa Rica.

Chemical Control of Whiteflies

Chemical control of whiteflies is both expensive and increasingly difficult. If the rate of whitefly re-infestation is great enough, the cost of effective **insecticide** treatments may be prohibitive. Besides the cost of treatment, other factors involved in chemical control decisions are the need for thorough coverage, the risk of secondary pest outbreaks, the risk of whiteflies developing insecticide resistance, and the regulatory restrictions on the use of insecticides. These factors have to be weighed against the expected returns for a given crop at a given planting date. Many **systemic** and **contact insecticides** have been tested for control of whiteflies, but few give effective control. Currently registered systemic insecticides, such as oxamyl, have been only partially effective. Certain contact insecticide combinations, especially **pyrethroids** such as fenpropathrin or bifenthrin plus **organo-phosphates** such as acephate or metamidophos, have provided excellent control in greenhouse and field studies as long as there was thorough coverage of the foliage. However, by exposing pest populations to two types of chemicals at once, combinations may accelerate selection for resistance to both materials. Therefore, tank mixes should be resorted to only when single applications are not effective. Other products with contact activity, such as oils, soaps and K-salts of fatty acids, can be very effective with thorough coverage, but in field tests they are often less effective because of poor coverage. Good

coverage of the foliage with **contact** insecticides is essential for best results. Most whiteflies are located on the **undersides of leaves** where they are protected from overtop applications, and the immature stages (except for the **crawler**) are immobile and do not increase their exposure to **insecticides** by moving around the plant. Use drop nozzles where appropriate, adequate pressure, and calibrate and maintain equipment carefully. Specific **insecticides** should be selected according to the **stage(s) of whitefly** to be controlled. The effectiveness of the few currently registered insecticides could be lost if they are excessively and repeatedly applied. There are techniques for monitoring resistance to determine which insecticides are still active against whiteflies. Generally, if an insecticide treatment is properly made with sufficient coverage and yet is ineffective, then that whitefly population should be tested for resistance to the product. There is a possibility that treating a resistant whitefly population with certain **insecticides** could actually accelerate population growth. This could be because more eggs are laid when the insect is under biochemical stress, or because beneficial **arthropods** are eliminated. To minimize this potential problem, insecticide applications should be used judiciously and **combined with non-chemical** control tactics. Furthermore, distinct classes of chemical compounds should be rotated at least every other spray. Distinct classes of insecticide include the **pyrethroids** (Ambush, Asana, Danitol, Karate, etc.), **organo-phosphates** (Orthene, Monitor, Lorsban), **carbamates** (Vydate), **chlorinated hydrocarbons** (Thiodan), insect **growth regulators** (Applaud, fenoxicarb), oils, and soaps and detergents. Resistance to soaps and oils is unlikely to ever develop, so these materials should be used as much as possible.

The effectiveness of 19 insecticides and insecticides combinations against the Aleyrodid, *Bemisia tabaci* were evaluated in Venezuela by Marcano and Gonzalz (1993) and they observed that the most effective insecticedes against eggs and nymphs of the pest were: Imidacloprid (91.67 and 78.61 litres/ha); Mineral oil +Imidacloprid (88.85 and 71.33

litres/ha); Cyfluthrin + Methamidophos (87.85 and 69.08 litres/ha); Buprofezin (86.1 and 53.19 litres/ha); Lambda-cyhalothrin (86.1 and 47.47 liters/ha); Profnofos + Cypermethrin (85.93 and 70.18 litres/ha).

Imidacloprid (a systemic chloronicotinyl insecticide) gained major importance for control of *Bemisia tabaci* in both field and protected crops, in view of extensive resistance to Organophosphorous, Pyrethroid and Cyclodiene insecticides (Cahil *et al.* 1995).

Azam *et al.* (1997) conducted an experiment during 1993-95 with some insecticides (Carbofuran, Endosulfan, Dimethoate, Buprofezin and Triazophos) for the control of *B. tabaci* and yellow leaf curl bigeminivirus (TYLCV) and found that Endosulfan had the most affect to control *Bemisia tabaci.*

The plots treated with seed bed netting and two spray of Imidacloprid 200SL had the lowest number of Whitefly and it was statistically similar with the treatment seed bed netting with the spraying Nimbicidine and seed treatment only (Anon. 2005).

Pesticide and oil spray

Sastry (1989) reported that incidence of TYLCV can be reduced through dipping roots of tomato seedlings in a 0.1% carbofuran solution for 1hr followed by 2 foliar sprays of agricultural spray oil at 20 and 30 day after transplanting.

Butler *et al*. (1991) conducted a study to assess several plant derived oils to control sweet potato whitefly (*Bemisia tabaci*) in tomato. House hold cooking oils like corn, peanut, safflower; soybean and sunflower were used as 1% foliar spray. Oil spray significantly reduced whitefly adults and immature for 5 days following application as compared to control. For home gardeners use of on the shelf cooking oils and liquid detergents available in most homes is recommended as a safe and economic solution for the control of whitefly.

Csizinsky *et al*. (1997) evaluated various color mulches with oil sprays to control whitefly population which transmits *Tomato mottle virus* (TMoV) in Florida. Orange, yellow, black and white and aluminum mulches together with weekly application of soybean oil emulsion (93%) were used in the field. Virus symptom developed slowly in the plots where orange + oil yellow + oil and aluminum mulches were used as compared to control. Use of yellow mulch with soybean oil was suggested to manage TMoV in tomatoes.

Rao *et al*. (1999) studied the effect of recommended and sublethal doses of some insecticides on the biology and population of *Bemisia tabaci*. Results showed that synthetic pyrethroids like deltamethrin, fenvalerate, permethrin and cypermethrin popularly used on cotton have contributed to resurgence of whitefly on cotton. The failure of these insecticides to control the whitefly also suggests the development of resistance to the chemicals.

Mason *et al*. (2000) studied the effect of 'Thiamethoxam' a new neonicotinoid insecticide in preventing transmission of *Tomato yellow leaf curl virus* (TYLCV) by the whitefly *Bemisia tabaci*. Results have demonstrated that foliar and drench applications of thiamethoxam could prevent TYLCV transmission by B. *tabaci*. Thiamethoxam proved to be very effective in preventing virus acquisition because up to 8 weeks after foliar application, no whitefly survived the 24h feeding period and later on, there was a high mortality of acquiring adults. They suggested that integration of resistant variety and one or two foliar applications of thiamethoxam could be effective to reduce TYLCV damage in tomato crop.

Savary (2000) reported that Imidacloprid and Cypermethrin/ imidacloprid in rotation were effective in reducing the TYLCV disease incidence by 50%. It was suggested that these two insecticides could be used in an IPM package.

Ahmed *et al*. (2001) used 'confidor' (imidacloprid) at four rates (47.6, 71.4, 95.2 and 119 g a.i. /ha) for indirectly controlling *Tomato yellow leaf curl virus* (TYLCV) in the field plantings of tomato. IPM practices and two applications of confidor at the two highest rates immediately after planting and 6 weeks later protected tomato plants against the disease until 12 weeks after sowing. All rates of confidor reduced disease incidence as compared to standard chemical (cypermethrin) application. Confidor treated plots had higher yield than control plots. When applied immediately after planting, confidor's long lasting systemic activities protected the crop against the disease during early stages of growth. In addition it reduced the number of sprays and increased yield of tomato.

Integrated Management

Ioannou (1987) reported that TYLCV disease on tomato could be delayed by roguing the infected, overwintered tomato plants and use of virus free plants produced in covered seedbeds. The author opined that the most effective and economic method of TYLCV control is the development of resistant variety. But until such cultivars are bred or available, yield loss due to TYLCV could be minimized through integrating effective alternative cultural practices.

Green and Kalloo (1994) reviewed various aspects of TYLCV including control options. Several options are available to reduce TYLCV incidence in the field. These are use of insecticides, mineral oils, reflective mulches, mixed cropping or trap crop, elimination of weed host, adjustment of date of planting to avoid high insect density and cultivation of tolerant lines. These approaches alone or in combination have been found to be effective in reducing TYLCV menace in many situations.

Traboulsi (1994) reviewed many aspects of whitefly (*Bemisia tabaci*). One study report in the article suggested that B. *tabaci* is not a single species but a species complex, mostly in

tropical and subtropical regions but also in temperate regions. About 40 virus diseases transmitted by *B. tabaci* are mentioned worldwide. In many parts of the world *B. tabaci* is a striking example of how a secondary pest can rise to the rank of a major one over a short period of time as a result of excessive use of insecticide.

For the management of TYLCV, use of insect proof netting, sticky traps, intercropping, various planting date, drip irrigation or colored plastic mulches are suggested. Insect proof netting permanently affixed to greenhouse doors and windows is widely used and is the only preventive control measure feasible in many situations. Coarse mesh net can be used with frequent insecticide application. Rouging is also a good practice for reducing the source of primary infection. *Lycopersicon chilense* is a promising potential source for breeding tomatoes resistant to TYLCV.

Ramappa *et al*. (1998) suggested some control measures, which delay the *Tomato leaf curl virus* (ToLCV) infection in tomato. The techniques include use of nylon net to protect the seedling, intercropping, use of barrier crops, crop rotation, siting new tomato fields away from obvious sources of infection and use of resistant / tolerant cultivars. Applications of these measures have already proved successful in reducing yield loss due to TYLCV of tomato in Israel and Tobacco leaf curl in Karnataka, India.

Schuster and Polston (1999) suggested a number of practices for the management of TYLCV through reduction of whitefly population. Practices include destruction of crop residue after harvest, use of virus free transplants, aluminum polyethylene as soil mulch, use of admire at transplanting, spraying of crop oil (0.25-0.5 percent) as whitefly repellent and rouging.

Jiang *et al*. (2000) reported that whitefly transmitted viruses are very difficult to control with chemical insecticide alone, because single viruliferous adult is able to transmit TYLCV with Phloem contact lasting less than 2 minutes. Therefore modern control methods must be developed to interfere with the acquisition and transmission cycle and several pest management tactics should be integrated for efficient whitefly transmitted virus disease control.

Hilje *et al*. (2001) reviewed cultural practices for the management of *Bemisia tabaci* and associated viral diseases. Practices include manipulation of planting date, removal of weed, netting, trap crop, living and inert mulches.

Number of vector and virus inoculum can often be avoided by planting early or late. Eradicating one weed species (*Cynanchum acutum*) in Jordan Valley of Israel controlled spread of TYLCV. Growing of seedlings in insect proof net (variety of mesh size) house or cultivation of plants in enclosed greenhouse or under an insect proof structure have been found effective in delaying TYLCV spread. Various intercropping or trap cropping have been suggested like cucumber, green beans, squash, eggplant in tomato crop. But use of trap crop sometimes can aggravate the disease situation i.e. instead of reducing it can lead to increased disease situation. Colored plastic mulches including aluminum, silver, transparent, white and yellow have been proven to be effective in reducing incidence of whitefly transmitted viruses. The report suggested that a wide variety of cultural practices are available for the management of *B. tabaci* worldwide, although great variations are found with respect to different crop situations and geographic locations.

Kalb (2004) suggested few measures for the management of TYLCV of tomato. These include growing seedlings in an insect proof net house (50 meshes or fine), spraying infected plants with imidacloprid before rouging, interplanting tomato with bait plants like

cucumber, application of systemic insecticides as soil drenches during seedling stage. Rotation of insecticides is necessary otherwise resistance may develop in the vector. Chemical control is ineffective when disease incidence is high. Other methods suggested include spraying of soap solution (1%) or oil but there is a risk of phytotoxicity. Few resistant or tolerant commercial varieties are also available against some strains of TYLCV in Taiwan.

Works done in Bangladesh

Alam (1995) reported 7 virus diseases on tomato in Bangladesh. The viruses are *Cucumber mosaic virus* (CMV), *Tomato yellow leaf curl virus* (TYLCV), *Tomato leaf curl virus* (TLCV), *Tomato mosaic virus* (TMV), *Tomato purple vein virus* (TPVV), *Potato leaf roll virus* (PLRV) and *Tomato spotted wilt virus* (TSWV). Among these TYLCV and TPVV were found to be most damaging and widely distributed.

Gupta (2000) worked on identification, symptom expression and yield loss due to TYLCV in Bangladesh. Identification by DNA hybridization proved the presence of TYLCV in the field. Symptoms include yellowing and upward curling of leaves and stunting of the tomato plants. Due to TYLCV infection all the growth parameters were found to be reduced. Yield reduction varied from 63-95% depending on variety. Positive and significant correlation was found between number of whitefly and spread of TYLCV.

Rashid *et al*. (2001) reported that *Tomato yellow leaf curl virus* (TYLCV) is one of the most damaging diseases of tomato in 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. Wild tomato accession ATY-10, 11 and 22 were found to be resistant.

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.

Akhter (2003) reported that incidence of TYLCV on tomato varies with respect to time of planting. Planting of tomato in the first, third week of December and first week of January caused 62-66, 72-75 and 75-80% disease incidence respectively. Yield reduction varied from 19-74% depending on variety and sowing time. Growth parameters like plant height shoot weight, root length and yield contributing characters like fruits/plant, fruit length were significantly reduced in diseased plant as compared to healthy.

CHAPTER III

MATERIALS AND METHODS

The present study regarding management of whitefly (*Bemisia tabaci)* in Tomato has been conducted during October 2006 to March 2007 at the experimental fields of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. Laboratory studies were done in the laboratory of Entomology department, Sher-e-Bangla Agricultural University. Required materials and methodology are described below under the following heading.

Location of the Experimental Field

The experimental site was situated at latitude 23°46´ N and longitude 90˚23´E with an elevation of 8.45 meter from the sea level.

Climate of the Experimental Area

The experimental area is characterized by subtropical rainfall during the month of May to September and scattered rainfall during the rest of the year. Monthly maximum and minimum temperature, relative humidity and total rainfall recorded during the period of the present study at the SAU experimental farm have been presented in (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.

Treatments of the Experiment

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval

T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 days interval at vegetative stage and 10 day interval at fruiting stage

T_3: Actara 25WG @ 0.4 gm/ litre of water at7 dayinterval

T_4: Silver color strips as visual repellents

T_5: Marshal 20 EC + Ripcord 10 EC (2 ml + 1 ml)/1 litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage

T_6: Neem Seed Kernel Extract@ 2 gm / litre of water at 7 day interval

T_7: Neem oil @ 3 ml + 10 ml Trix / litre of water at 7 day interval

T_8: Untreated control

Land Preparation

The soil was well prepared and good tilth was ensured for commercial crop production. 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. The target land was divided into 24 equal plots (3m×1.5m) with plot to plot distance of 1.0 m and block to block distance is 1.0 m.

Manure and Fertilizer

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

Collection of seed, seedling raising and transplanting

The tomato seeds of 'Raton' variety were collect from Bangladesh Agricultural Research Institute (BARI). Seeds were then directly sown in the middle of October, 2006 in seedbed containing a mixture of equal proportion well decomposed cowdung and loam soil. Seeds were sown in seedbed and irrigated regularly. After germination the seedling were sprayed with water by a hand sprayer. Watering was done 3 or 4 day for a week. Seedlings were placed in a shady place for transplanting in the main field. Thirty days old healthy seedlings were transplanted on November 18th 2006 in the pits of the main field. Other intercultural operations were done as mentioned earlier.

Design of Experiment

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 8 unit plots. The size of the unit plot was 3m×1.5m. Block to block and plot-to-plot distance was 1m and 1m.

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 1m 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 five plants per plot were randomly selected and tagged. Data collection was started at 15 days after transplanting (15 DAT) the seedlings and continued up to fruit set. All the data were collected once in a week. The data were collected on number of whitefly per plant; tomato yellow leaf curl infected plant per plot, Tomato purple vein virus infected plant per plot, mixed infestation plant per plot, number of flower bunches per plant, fruit bearing capacity per plot, total weight of healthy fruit per plot (kg), total weight of deformed fruit per plot (kg), total number of healthy and deformed fruit per plot, percent fruit deformation, total weight of fruit per plot (kg), yield per hectare (ton).

Efficacy of Treatments for the Virus- Transmitting Whitefly

The sampling on the incidence of whitefly and the occurrence of TYLCV, and TPVV diseases were done by direct visual method (Hirano *et al*., 1993). The sampling of the incidence of whitefly was taken at vegetative, early flowering, early fruiting and fruit ripening stages at 15 days interval. The plants were carefully checked visually for the presence of whitefly. Sometimes plants were shaken gently to observe their presence and count their number accurately. As the population of whitefly was very low the number was recorded per 5 plants. Sampling on whitefly incidence was taken at both pre and post application of treatments. Two post treatment counts were taken at each vegetative, early flowering, early fruiting and at fruit ripening stages.

The effectiveness of each treatment in reducing the infestation of whitefly and suppressing the infection of virus diseases was evaluated on the basis of some preselected parameters. The parameters are described below:

Number and Weight of Healthy and Deformed Fruits

Data were collected on the number and weight of healthy fruits (HF) and deformed fruits (DF) harvested at early, mid and late fruiting stages. At early fruiting stage 4-5 harvests were made. During the mid fruiting stage 8-9 harvests were undertaken. On the other hand, only 2-3 harvests were carried out at late fruiting stage.

Fruit Deformation Percent

Extent of deformation of fruit was calculated in percent at each reproductive stage using the following procedures:

$$\% \text{ fruit deformation (by number)} = \frac{\text{Number of deformed fruits}}{\text{Total number of fruits}} \times 100$$

$$\% \text{ fruit deformation (by weight)} = \frac{\text{Weight of deformed fruits}}{\text{Total weight of fruits}} \times 100$$

The total percent of fruit deformation was calculated on the basis of the deformation occurred at each fruiting stage of the crop.

Fruit Bearing Capability of a Plant at Different Treatments

The total number and weight of fruit for each treatment at early, mid and late fruiting stages were recorded. Number and weight of fruits at early, mid and late stages were recorded as percent of the total fruits produced by the plants under different treatments.

$$\% \text{ fruit bearing ability At any fruiting stage} = \frac{\text{Number of fruit bearing ability at any fruiting stage}}{\text{Total number of fruits in that treatment}} \times 100$$

Similar procedure was followed incase of weight of fruit at any fruiting stage for a treatment.

Percent TYLCV and TPVV infected plant in number

Identification of the virus disease was done mainly through visual observation of typical symptoms of TYLCV infection like upward curling, cupping, with or without marginal chlorosis, smaller leaflets and stunting of the plant (Green and Kalloo 1994 and Sinistera *et al*. 2000).

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

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

Yield per hectare

The total yield of tomato per hectare for each treatment was calculated in tons from cumulative fruit production in a plot. Effect of different treatments on the increase and decrease of tomato yield over control was also calculated in case as follows:

$$\% \text{ increase or decrease of yield over control} = \frac{\text{Yield of treated plot - Yield of control plot}}{\text{Yield of control plot}} \times 100$$

Statistical analysis

The data obtained for different characters were statistically analyzed to find out the incidence of whitefly, diseases severity and affect on the yield of tomato. The mean values of all the characters were calculated and analysis of variance was performed by using the 'F' (variance ratio) test. The significance of the difference among the treatment combinations means ware determined by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to study the management of whitefly in Tomato. The analysis of variance (ANOVA) of the data on fruit infestation and different yield contributing characters are given in Appendix I-X. The results have been presented and discussed, and possible interpretations have been given under the following headings:

Number of white fly per plant

At vegetative stage statistically significant variation was found in number of whitefly per plant in tomato under the present trial (Appendix II). At vegetative stage minimum number of whitefly per plant (2.80) was recorded in T_5 and T_3 treatments and the maximum (23.20) number of whitefly per plant was recorded in T_8 treatment.

Statistically significant variation was recorded in number of whitefly per plant in tomato at early and late flowering stage. At early flowering stage minimum number of whitefly per plant (4.00) was recorded in T_5 and T_3 treatment consisting of Marshal 20 EC + Ripcord 10 EC (2 ml +1 ml)/1 litre of water at 7 days interval and Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval (Table 1). On the other hand the maximum (26.34) number of whitefly per plant was recorded in T_8 treatment (Untreated control). At early fruiting stage a statistically significant variation was recorded in number of whitefly per plant in tomato. At early fruiting stage minimum number of whitefly per plant (2.00) was recorded in T_5 treatment. (Table 1). On the other hand the maximum (18.20) number of whitefly per plant was recorded in T_8 treatment (Untreated control).

Table 1. Incidence of whitefly at different growth stages of tomato as affected by various treatments

Treatment	Number of whitefly/plant			
	Vegetative stage	Early Flowering stage	Early Fruiting stage	Fruit Ripening stage
T_1	5.60 bc	5.00 bc	5.00 bc	3.80 c
T_2	5.60 bc	5.33 bc	5.00 bc	5.20 bc
T_3	2.80 d	4.00 c	4.00 c	1.60 d
T_4	4.20 cd	5.99 b	6.40 b	6.20 b
T_5	2.80 d	4.00 c	2.00 d	1.60 d
T_6	4.20 cd	4.33 bc	4.20 c	3.60 c
T_7	6.40 b	5.67 bc	5.20 bc	5.40 bc
T_8	23.20 a	26.34 a	18.20 a	24.00 a
$LSD_{(0.05)}$	1.857	1.759	1.535	1.964
CV (%)	15.48	13.25	14.03	17.46

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

At ripening stage statistically significant variation was recorded in number of whitefly per plant. Minimum number of whitefly per plant (1.60) was recorded in T_5 and T_3 treatment consisting of Marshal 20 EC + Ripcord 10 EC (2 ml +1 ml)/1 litre of water at 7 days interval and Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval (Table 1). On the

other hand the maximum (24.00) number of white fly per plot was recorded in T_8 treatment (Untreated control).

From the results it was found that the number of whitefly per plant was higher in early flowering stage. At ripening stage this counted number followed a decreasing trend. Chemical control was more effective than other control measures. The systemic action and quick knockdown properties of chemicals might have helped in reducing whitefly population in the entire cultivation period. At early flowering stage of tomato similar results were also obtained by Alam *et al*. (1994).

Some variables of weather such as temperature, rainfall and humidity influenced the number of whitefly and found a relationship (Figure 1). Increasing trend of temperature increased the activity of whitefly and increased infestation. Rainfall and humidity also enhanced the activity of whitefly which also reduced the yield. 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).

Fruit bearing capacity per plot

At early fruiting stage statistically significant variation was recorded in number and weight of tomato fruit per plot (Appendix III). Highest (57.25) number of fruits per plot was recorded in T_5 treatment (Table 2). On the other hand the lowest (39.33) number of fruits

per plot was recorded in T_8 treatment (Untreated control). Again highest (4.39 kg) weight of fruits per plot was recorded in T_5 treatment and the lowest (2.08 kg) weight of fruits per plot was recorded in T_8 treatment.

At mid fruiting stage statistically significant variation was recorded in number and weight of tomato fruit per plot. Highest (414.75) number of fruits per plot was recorded in T_5 treatment (Table 2). On the other hand the lowest (310.00) number of fruits per plot was recorded in T_8 treatment. The highest (20.80 kg) weight of fruits per plot was recorded in T_5 treatment and the lowest (15.50 kg) weight of fruits per plot was recorded in T_8 treatment.

At late fruiting stage statistically significant variation was recorded in number and weight of tomato fruit per plot. Highest (214.25) number of fruits per plot was recorded in T_5 treatment (Table 2). On the other hand the lowest (118.50) number of fruits per plot was recorded in T_8 treatment (Untreated control). The highest (9.45 kg) weight of fruits per plot was recorded in T_5 treatment and the lowest (4.66 kg) weight of fruits per plot was recorded in T_8 treatment.

Table 2. Fruit bearing capacity per plot at different stages of tomato as affected by various treatments

Treatments	Fruiting Stages					
	Early		Mid		Late	
	Number	Weight (kg)	Number	Weight (kg)	Number	Weight (kg)
T_1	51.45 abc	2.79 c	351.65 c	18.73 ab	177.00 b	7.98 c
T_2	50.00 abc	2.70 c	351.00 c	18.42 ab	163.34 bc	7.34 d
T_3	55.85 a	3.24 b	384.67 b	20.54 a	200.55 a	8.68 b
T_4	45.00 cd	2.49 c	342.00 c	17.37 bc	146.75 c	5.95 f
T_5	57.25 a	4.39 a	414.75 a	20.80 a	214.25 a	9.45 a
T_6	53.50 ab	2.80 c	353.75 c	19.12 ab	181.42 b	8.39 bc
T_7	46.50 bc	2.58 c	347.00 c	18.02 abc	163.34 bc	6.59 e
T_8	39.33 d	2.08 d	310.00 d	15.50 c	118.50 d	4.66 g
$LSD_{(0.05)}$	6.687	0.384	23.11	2.527	18.77	0.551
CV (%)	7.66	7.61	3.70	7.77	6.28	4.26

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Effect of different treatments on number of Healthy and Deformed fruit per plot:

At early fruiting stage statistically significant variation was recorded in percentage of deformed fruit per plot under the present trial (Appendix III). The lowest (0.52%) of deformed fruits per plot was recorded in T_5 treatment consisting of Marshal 20 EC+ Ripcord 10 EC (2 ml +1 ml)/1 litre of water at 7 days interval (Table 3). On the other hand the highest (30.46%) of deformed fruits per plot was recorded in T_8 treatment (Untreated control). The highest number of healthy fruit increase over control was recorded from plots having Marshal 20 EC+ Ripcord 10 EC (T_5) (108.27) followed by treatment with Actara 25WG (T_3) (93.38) (Table 3.).

At mid fruiting stage statistically significant variation was recorded in percentage of deformed fruit per plot under the present trial (Appendix IV). The lowest (3.75%) of deformed fruits per plot was recorded in T_5 treatment (Table 4). On the other hand the highest (18.88%) of deformed fruits per plot was recorded in T_8 treatment. The highest number of healthy fruit increase over control was recorded from plots having Marshal 20EC + Ripcord 10 EC (T_5) (58.75) followed by treatment with Actara 25WG (T_3) (42.91)

At late fruiting stage statistically significant variation was recorded in percentage of deformed fruit per plot under the present trial (Appendix V). The lowest (4.32%) of deformed fruits per plot was recorded in T_5 treatment (Table 5). On the other hand the highest (22.99%) of deformed fruits per plot was recorded in T_8 treatment. The highest number of healthy fruit increase over control was recorded from plots having Marshal 20 EC + Ripcord 10 EC (T_5) (124.72%) and Actara 25WG (T_3) (105.62%) followed by treatment with NSKE (T_6) (82.63%)

Table 3. Effect of different treatments applied against tomato whitefly on healthy and deformed fruits at early fruiting

Treatments	No. of fruit/plot		% Deformed	% Increase healthy fruit over control
	Healthy	Deformed		

T_1	46.95 bcd	4.50 cd	8.75 cd	71.79
T_2	44.50 cde	5.50 bc	11.04 bc	62.82
T_3	52.85 ab	3.00 d	5.38 d	93.38
T_4	38.75 e	6.25 b	13.96 b	41.79
T_5	56.92 a	0.33 e	0.52 e	108.27
T_6	50.00 bc	3.50 d	6.59 d	82.95
T_7	40.65 de	5.85 bc	12.59 b	48.74
T_8	27.33 f	12.00 a	30.46 a	--
$LSD_{(0.05)}$	6.564	1.499	3.455	--
CV (%)	8.38	16.73	17.68	

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Table 4. Effect of different treatments applied against tomato Whitefly on healthy and deformed fruit at mid fruiting stage

Treatments	No. of fruit/plot		% Deformed	% Increase healthy fruit over control
	Healthy	Deformed		
T_1	311.65 c	40.00 c	11.37 c	23.92

T_2	307.75 c	43.25 bc	12.32 bc	22.37
T_3	359.42 b	25.25 d	6.56 d	42.91
T_4	296.00 c	46.00 b	13.49 b	17.69
T_5	399.25 a	15.50 e	3.75 e	58.75
T_6	314.75 c	39.00 c	11.03 c	25.15
T_7	301.50 c	45.50 b	13.12 b	19.88
T_8	251.50 d	58.50 a	18.88 a	--
$LSD_{(0.05)}$	23.96	5.218	1.652	--
CV (%)	4.31	7.62	8.34	--

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Table 5. Effect of different treatments applied against tomato Whitefly on healthy and deformed fruit at late fruiting stage

Treatment	No. fruit/plot		% Deformed	% Increase healthy fruit over control
	Healthy	Deformed		
T_1	161.12 bc	15.88 de	9.00 d	76.55
T_2	146.04 c	17.30 cd	10.59 c	60.03
T_3	187.65 a	12.90 f	6.43 e	105.62

T_4	125.22 d	21.53 b	14.67 b	37.21
T_5	205.08 a	9.17 g	4.32 f	124.72
T_6	166.67 b	14.75 ef	8.12 d	82.63
T_7	144.52 c	18.82 c	11.54 c	58.36
T_8	91.26 e	27.24 a	22.99 a	--
$LSD_{(0.05)}$	18.64	2.275	1.261	--
CV (%)	6.94	7.55	6.57	--

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Extent of fruit deformation

Statistically significant variation was recorded in percent fruit deformation per plot in managing whitefly in tomato (Appendix VI). Among the eight treatments the lowest percent of deformed fruit per plot (6.97%) was recorded in (T_5) treatment which was closely followed (8.72%) by (T_3) (Table 6). The highest (22.04%) weight of deformed fruit per plot was recorded in T_8 treatment. Similarly, Alam *et al.* (1994) found the lowest number of brinjal shoot and fruit borer infested deformed fruits in grafted eggplant in their preliminary study.

Total weight of fruit per plant (kg)

Total weight of fruit per plant in managing whitefly in tomato under the present trial showed a statistically significant variation (Appendix VII). Highest total weight of fruit per plant (3.46 kg) was recorded in T_5 treatment consisting of Marshal 20 EC + Ripcord 10 EC (2 ml +1 ml)/1 litre of water at 7 days interval which was statically similar (3.25 kg) T_3 (Table 6). On the other hand the lowest (2.22 kg) total weight of fruit per plot was recorded in T_8 treatment (Untreated control).

Table 6. Extent of fruit deformation and total weight of fruit per plant as affected by various treatments

Treatment	Percent fruit deformation	Total weight of fruit/plant (kg)
T_1	12.86 de	2.95 cd
T_2	13.50 d	2.85 cde
T_3	8.72 f	3.25 ab
T_4	17.14 b	2.58 e
T_5	6.97 g	3.46 a

T_6	12.17 e	3.03 bc
T_7	15.07 c	2.72 de
T_8	22.04 a	2.22 f
$LSD_{(0.05)}$	1.021	0.270
CV (%)	4.30	5.35

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Number of flower bunches per plant

Statistically significant variation was recorded in number of flower bunches per plant in managing white fly in tomato under the present trial (Appendix VII). Highest number of flower bunches per plant (70.13) was recorded in T_5 treatment consisting of Marshal 20 EC+ Ripcord 10 EC (2 ml +1ml)/1 litre of water at 7 days interval which was closely followed (68.33 and 68.22) by T_1 and T_3 consisting of Admire 200SL @ 1 ml/1 litre of water at 7 days interval and Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval, respectively (Table 7). On the other hand the lowest (51.67) number of flower bunches per plant was recorded in T_8 treatment.

Total weight of healthy fruit per plot (kg)

Statistically significant variation was recorded in total weight of healthy fruit per plot in managing white fly in tomato under the present trial (Appendix VII). Highest total weight of healthy fruit per plot (32.04 kg) was recorded in T_5 treatment which was closely followed (29.36 kg) T_3 treatment (Table 6). On the other hand the lowest (15.96 kg) total weight of healthy fruit per plot was recorded in T_8 treatment (Untreated control).

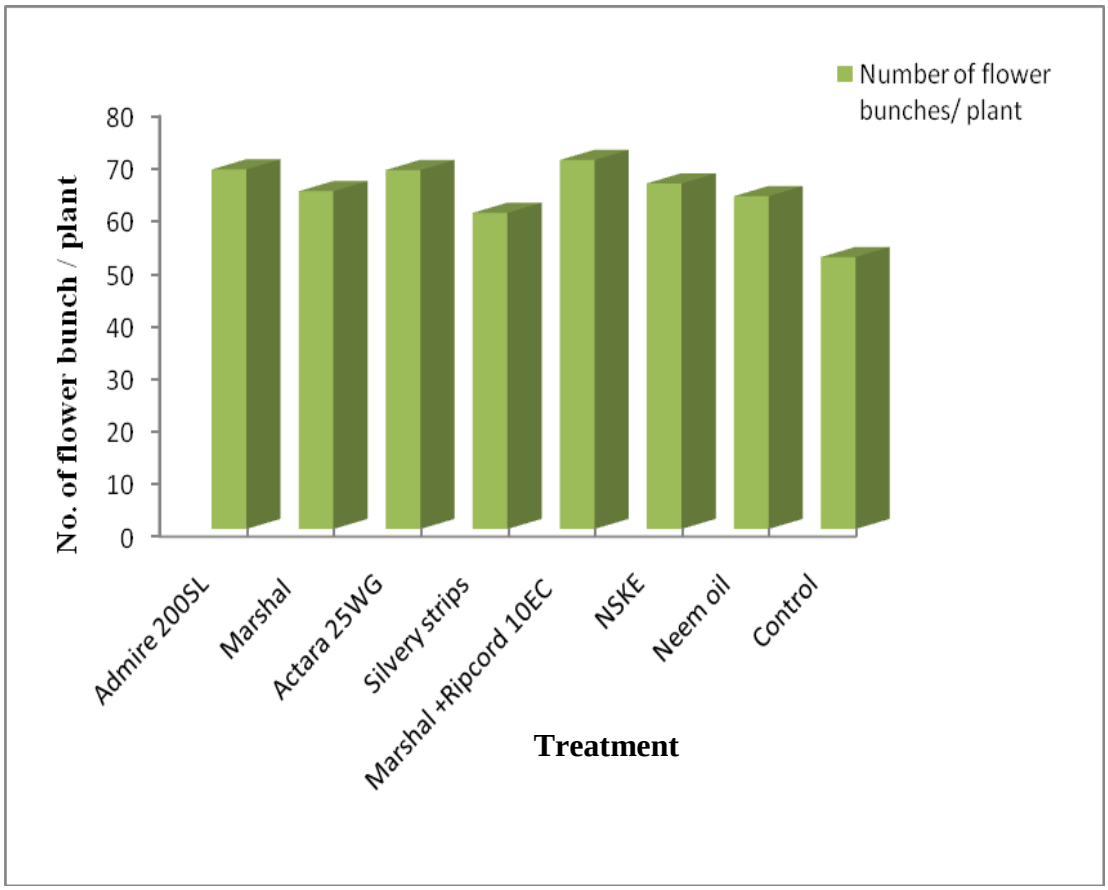

Figure 2. Effect of different treatments on the number of flower bunch of tomato plant.

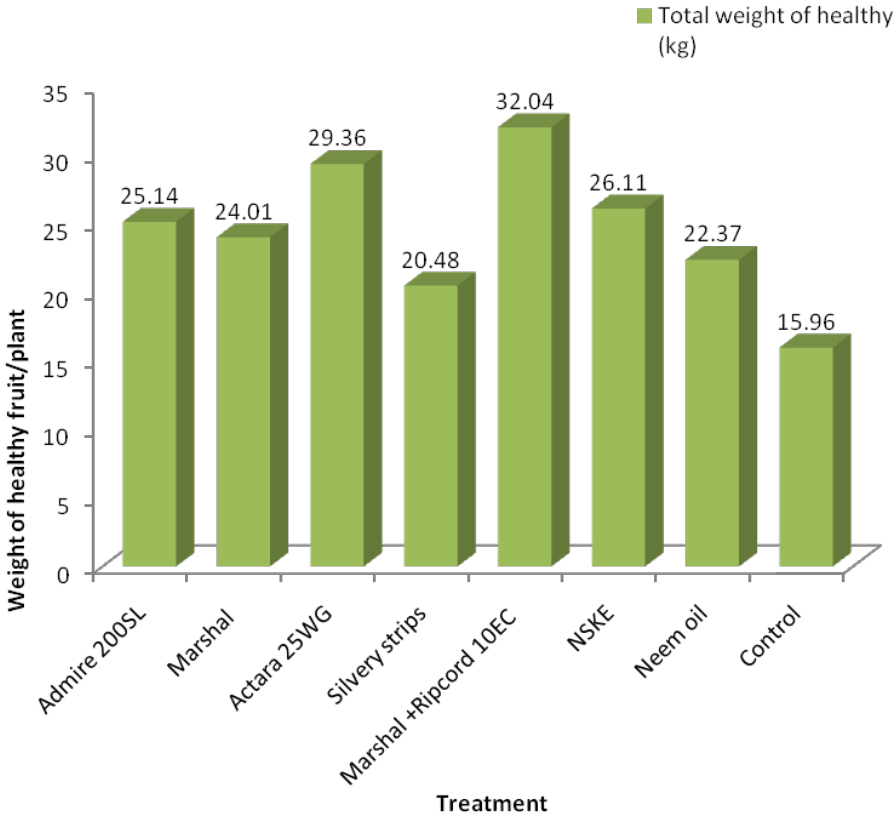

Figure 3.Effect of different treatment on healthy fruit of tomato

Total weight of deformed fruit per plot (kg)

Statistically significant variation was recorded in weight of deformed fruit per plot in managing white fly in tomato (Appendix VII). The lowest weight of deformed fruit per plot (2.60 kg) was recorded in T_5 treatment consisting of Marshal 20 EC+

Ripcord10EC (2 ml +1 ml)/1 litre of water at 7 days interval which was statistically identical (3.10 kg) T_3 consisting of Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval (Table 7). On the other hand the highest (6.28 kg) weight of deformed fruit per plot was recorded in T_8 treatment (Untreated control).

Total weight of fruit per plot (kg)

Total weight of fruit per plot in managing white fly in tomato under the present trial showed a statistically significant variation (Appendix VII). Highest total weight of fruit per plot (34.64 kg) was recorded in T_5 treatment which was statically similar (32.46 kg) T_3 (Table 7). On the other hand the lowest (22.24 kg) total weight of fruit per plot was recorded in T_8 treatment.

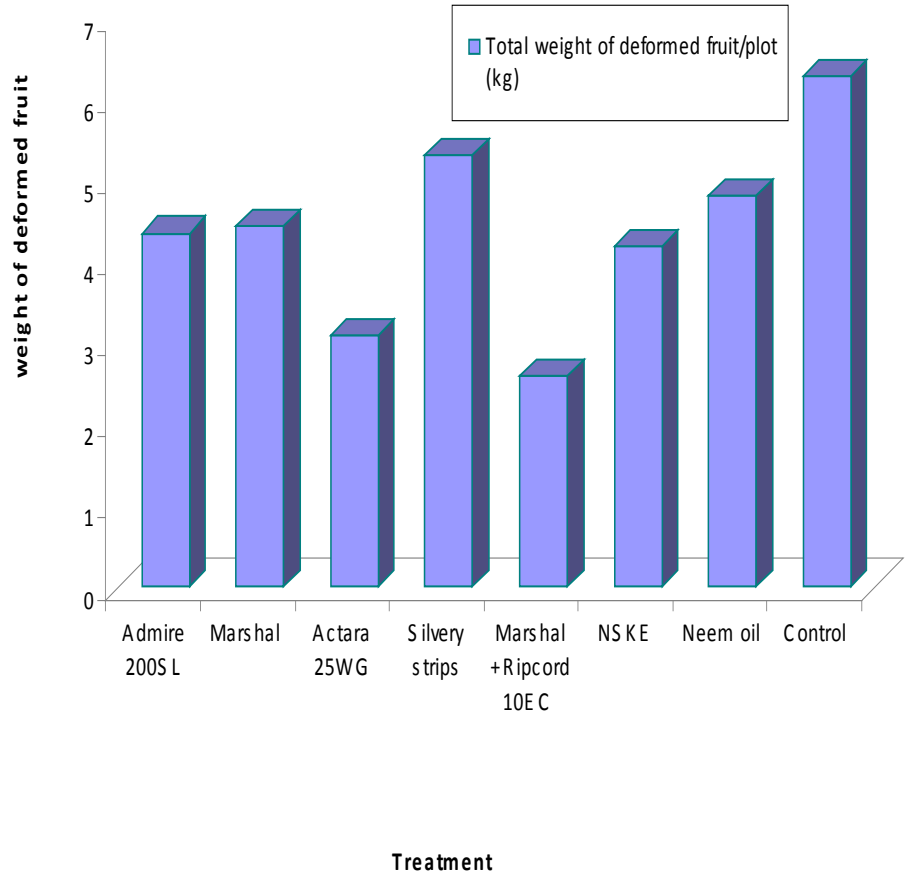

Figure 4. Effect of different treatment on deformed fruit of tomato

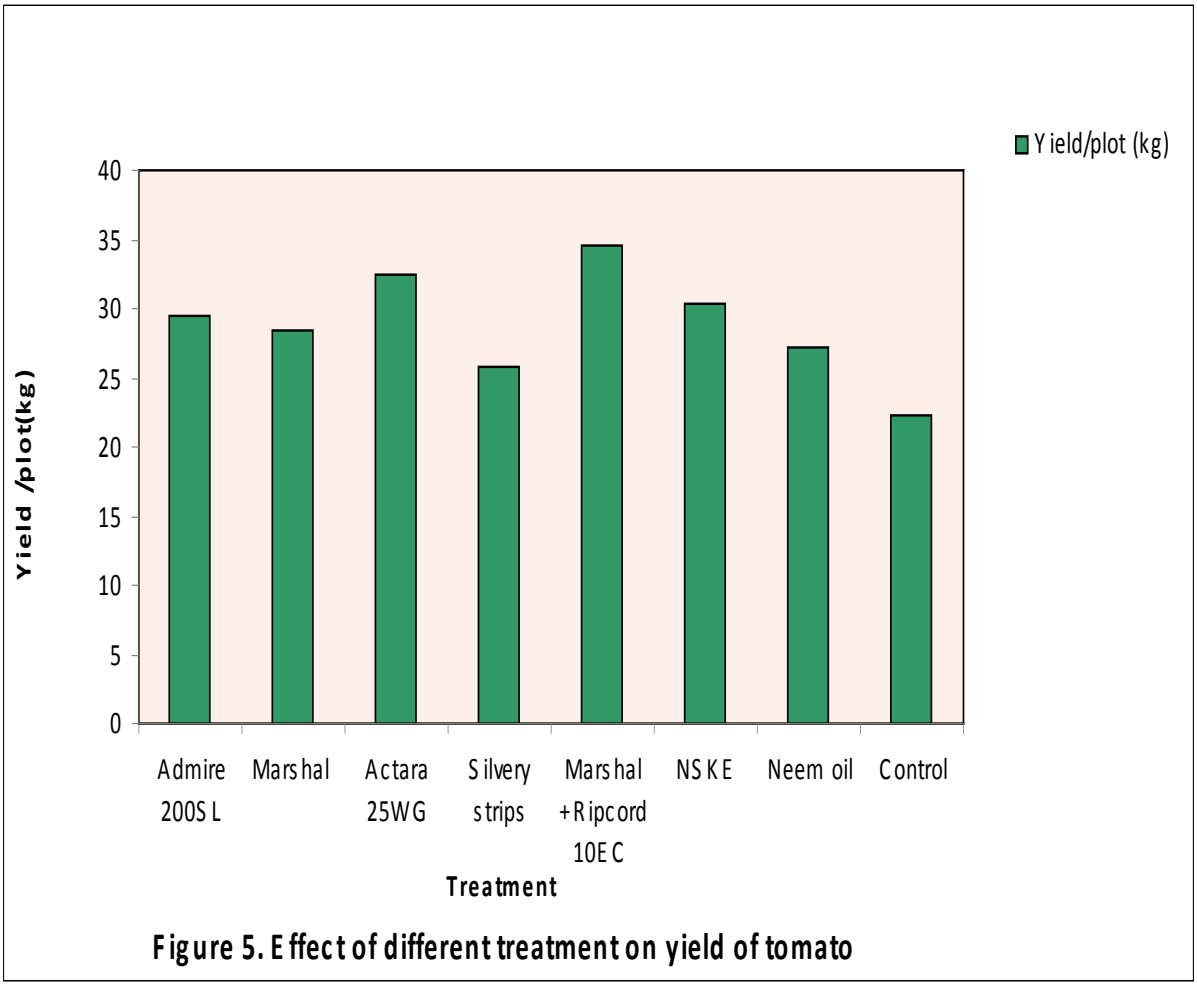

Figure 5. Effect of different treatment on yield of tomato

Yield per hectare (ton)

Total weight of fruit per hectare in managing white fly in tomato under the present trial showed a statistically significant variation (Appendix VII). Highest total weight of fruit per hectare (76.98 ton) was recorded in T_5 treatment consisting of Marshal 20 EC+ Ripcord 10 EC(2 ml +1 ml)/1 litre of water at 7 days interval which was statically similar (72.13 ton) T_3 consisting of Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval (Table 7). On the other hand the lowest (49.42 ton) weight of fruit per hectare was recorded in T_8 treatment.

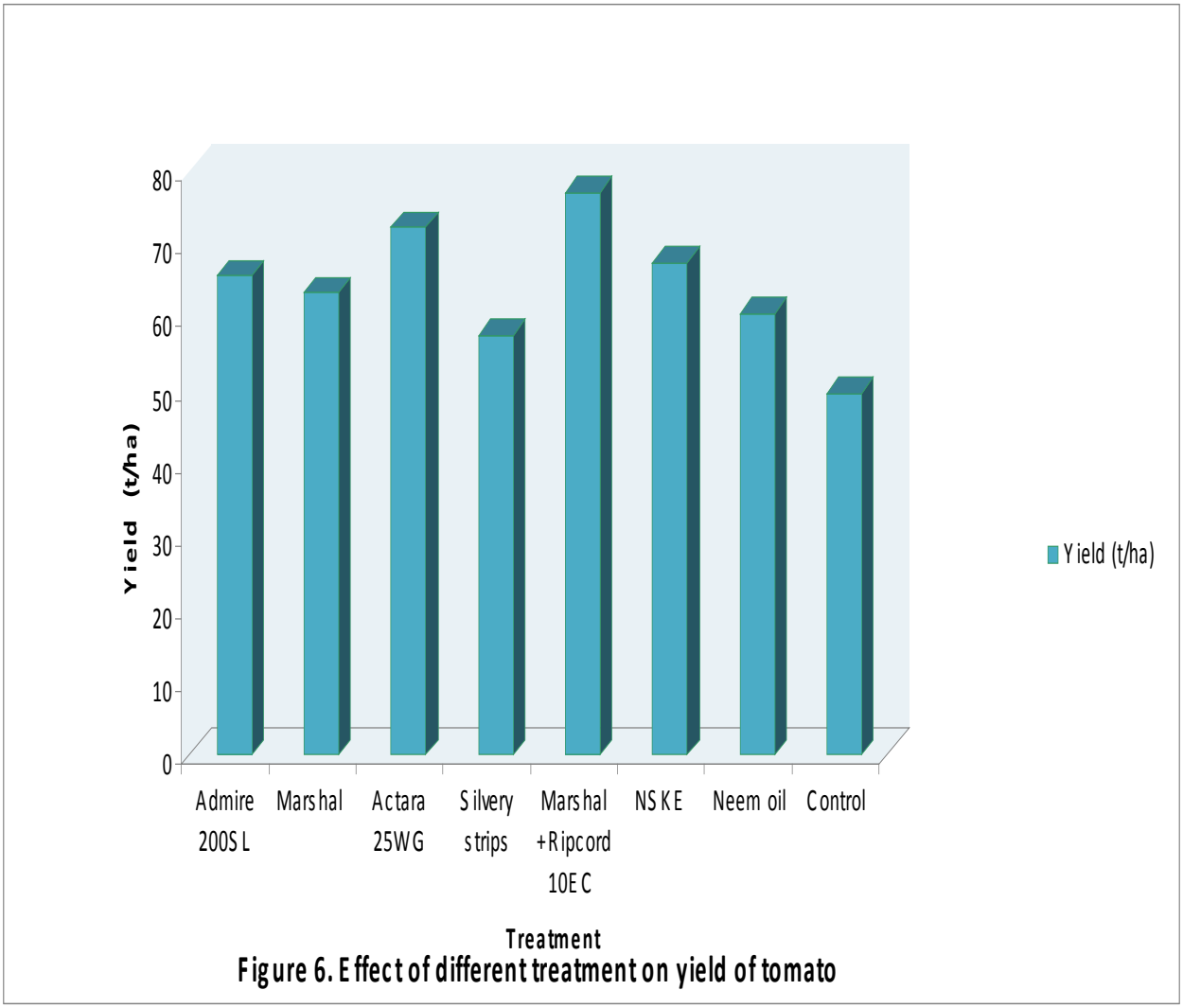

Figure 6. Effect of different treatment on yield of tomato

Tomato plants infected by yellow leaf curl virus per plot

Statistically significant variation was recorded in percentage of yellow leaf curl virus infected plants per plot in tomato under the present trial at vegetative stage (Appendix VIII). At vegetative stage no percentage of yellow leaf curl virus infected plants per plot was recorded in T_5 treatment and the maximum (16.67%) percentage of yellow leaf curl infected plants per plot was recorded in T_8 treatment. The same results was observed in case of early flowering stage.

At early fruiting stage a statistically significant variation was recorded in percentage of yellow leaf curl virus infected plants per plot. The minimum percentage of yellow leaf curl virus infected plants per plot (6.67%) was recorded in T_3 &T_5 consisting of Actara 25 WG @ 0.4 gm/1 litre of water at 7 days interval and Marshal 20 EC + Ripcord 10 EC (2 ml +1 ml)/1 litre of water at 7 days interval (Table 7). On the other hand the maximum (20.00%) percentage yellow leaf curl virus infected plants per plot was recorded in T_8 treatment .

At ripening stage statistically significant variation was recorded in percentage of yellow leaf curl infected plants per plot in tomato. Minimum percentage of yellow leaf curl virus infected plants per plot (10.00%) was recorded in T_5 and T_3 and treatment (Table 7).On the other hand the maximum (24.00%) percentage of yellow leaf curl virus infected plants per plot was recorded in T_8 treatment.

Plate 1: Adult Whitefly

Plate 2: Whitefly on Tomato Leaf

Plate 3: Healthy Fruit of Tomato

Plate 4: Symptom of TYLCV Infected Plants in Control Plot

$T_4 R_1$
Al
Foil

Plate 5: TYLCV Infected Plants in Al-Foil Treated Plot

Plate 6: Healthy Plants in Marshal 20 EC + Ripcord 10 EC Treated Plot

Plate 7: Healthy Plants in Actara 25 WG Treated Plot

Plate 8: Healthy Plants in NSKE Treated Plot

Table 7. Incidence of tomato yellow leaf curl virus (TYLCV) at different growth stages of tomato as affected by various treatments

Treatments	Tomato yellow leaf curl virus infected plant per plot (%)			
	Vegetative stage	Early Flowering stage	Early Fruiting stage	Fruit Ripening stage
T_1	6.67 bc	6.67 bcd	10.00 bc	13.33 bc
T_2	6.67 bc	10.00 abc	13.33 abc	16.67 bc
T_3	3.33 bc	3.33 cd	6.67 c	10.00 c
T_4	10.00 ab	13.33 ab	16.67 ab	20.00 ab
T_5	0.00 c	0.00 d	6.67 c	10.00 c
T_6	3.33 bc	6.67 bcd	10.00 bc	13.33 bc
T_7	10.00 ab	13.33 ab	13.33 abc	16.67 bc
T_8	16.67 a	16.67 a	20.00a	23.33 a
$LSD_{(0.05)}$	8.437	8.437	8.107	5.571
CV (%)	68.02	55.06	38.31	22.93

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Tomato purple vein virus infected plant per plot

At vegetative stage statistically significant variation was recorded in percentage of purple vein virus infected plants per plot in tomato under the present trial (Appendix

IX). At vegetative stage no percentage of purple vein virus infected plants per plot was recorded in T_5 treatment and the maximum (16.67%) percentage of purple vein virus infected plants per plot was recorded in T_8 treatment.

Statistically significant variation was recorded in percentage of purple vein virus infected plants per plot in tomato at early flowering stage. At early flowering stage no percentage of purple vein virus infected plants per plot was recorded in T_5 treatment (Table 9). On the other hand the maximum (20.00%) percentage of purple vein virus infected plants per plot was recorded in T_8 treatment.

At early fruiting stage a statistically significant variation was recorded in percentage of purple vein virus infected plants per plot in tomato. In this stage minimum percentage of purple vein virus infected plants per plot (10.00%) was recorded in T_3, T_5 and T_6 treatment (Table 9). On the other hand the maximum (26.67%) percentage of purple vein virus infected plants per plot was recorded in T_8 treatment.

At ripening stage similar results was observed. Minimum percentage of purple vein virus infected plants per plot (10.00%) was recorded in T_3, T_5 and T_6 treatment (Table 8). On the other hand the maximum (20.00%) percentage of purple vein virus infected plants per plot was recorded in T_8 treatment.

Table 8. Incidence of tomato purple vein virus (TPVV) at different growth stages of tomato as affected by various treatments

Treatments	Tomato purple vein virus infected plant per plot (%)			
	Vegetative stage	Early Flowering stage	Early Fruiting stage	Ripening stage
T_1	6.67 bc	6.67 bc	10.00 b	10.00 d

T_2	6.67 bc	10.00 b	13.33 b	13.33 cd
T_3	3.33 bc	6.70 bc	6.67 b	10.00 d
T_4	10.00 ab	13.33 ab	13.33 b	20.00 b
T_5	0.00 c	0.00 c	6.67 b	10.00 d
T_6	3.33 bc	6.67 bc	10.00 b	10.00 d
T_7	10.00 ab	13.33 ab	13.33 b	16.67 bc
T_8	16.67 a	20.00 a	26.67 a	33.33 a
$LSD_{(0.05)}$	8.437	7.770	9.063	5.571
CV (%)	68.02	46.28	41.10	20.63

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

Mixed infected plant per plot

At vegetative stage statistically significant variation was recorded in mixed virus infected plants (tomato yellow leaf curl virus + tomato purple vein virus) per plot in tomato under the present trial (Appendix X). At vegetative stage no mixed virus infected plants per plot was recorded in T_5 treatment and the maximum (16.67%) percentage mixed virus infected plants per plot was recorded in T_8 treatment.

Statistically significant variation was recorded in mixed virus infected plants per plot in tomato at early flowering stage. At early flowering stage minimum (3.33%) mixed

virus infected plants per plot was recorded in T_5 treatment (Table 9). On the other hand the maximum (20.00%) mixed virus infected plants per plot was recorded in T_8 treatment.

At early fruiting stage a statistically significant variation was recorded in mixed virus infected plants per plot in tomato. At early fruiting stage minimum mixed virus infected plants per plot (10.00%) was recorded in T_3, T_5 and T_6 treatment (Table 10). On the other hand the maximum (30.00%) mixed virus infected plants per plot was recorded in T_8 treatment (Untreated control). At ripening stage almost same results was observed. Minimum mixed virus infected plants per plot (13.33%) was recorded in T_5 treatment (Table 10). On the other hand the maximum (36.67%) mixed virus infected plants per plot was recorded in T_8 treatment.

Table 9. Incidence of mixed infestation of virus at different growth stages of tomato as affected by various treatments

Treatment	Mixed infestation of TYLCV + TPVV plants per plot (%)			
	Vegetative stage	Early Flowering stage	Early Fruiting stage	Ripening stage
T_1	10.00 ab	10.00 bcd	13.33 cd	16.67 b
T_2	10.00 ab	10.00 bcd	16.67 bc	16.67 b
T_3	6.67 bc	6.70 cd	10.00 d	13.33 b
T_4	13.33 ab	16.67 ab	20.00 b	23.33 b
T_5	0.00 c	3.33 d	10.00 d	13.33 b

T_6	6.67 bc	6.67 cd	10.00 d	16.67 b
T_7	13.33 ab	13.33 abc	20.00 b	20.00 b
T_8	16.67 a	20.00 a	30.00 a	36.67 a
$LSD_{(0.05)}$	7.761	8.445	4.871	9.212
CV (%)	79.34	44.50	17.12	28.41

In a column, numeric data represents the mean value of 3 replications and each data is derived from the field of 5 plants .Means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of significance.

T_1: Admire 200SL @ 1 ml/ litre of water at 7 day interval
T_2: Marshal 20 EC @ 3 ml/ litre of water at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_3: Actara 25WG @ 0.4 gm/1 litre of water at 7 day interval
T_4: Silver color strips as visual repellents
T_5: Marshal 20 EC+ Ripcord 10 EC (2 ml + 1 ml)/1 litre of water used at 7 day interval at vegetative stage and 10 day interval at fruiting stage
T_6: NSKE @ 2 gm / litre of water at 7 day interval
T_7: Neem oil 3 ml + 10 ml Trix mixed with 1 litre of water at 7 day interval
T_8: Untreated control

CHAPTER V
SUMMARY AND CONCLUSION

The study was conducted during October, 2006 to March 2007 at the experimental fields of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to study the management of whitefly (*Bemisia tabaci*) in Tomato. The experiment consisted of control measures with chemical, botanical and physical methods. The experiment laid out in one factor Randomized Complete Block Design (RCBD) with three replications. Data were collected in respect of number of whitefly and virus infestation level and yield of tomato. The data obtained for different characters were statistically analyzed to find out the significance level of the treatment.

At vegetative stage the minimum number of whitefly per plant (2.80) was recorded in (T_5) and (T_3) treatment and the maximum (23.20) was recorded in (T_8) treatment. At early flowering stage minimum number of whitefly per plant (4.00) was recorded in (T_5) and T_3 treatment, while the maximum (26.34) number of whitefly per plant was recorded in T_8 treatment. At early fruiting stage minimum number of whitefly per plant (2.00) was recorded in T_5 treatment and the maximum (18.20) was recorded in T_8 treatment. At the ripening stage minimum number of whitefly per plot (1.60) was recorded in T_5 and T_3 treatment and the maximum (24.00) number was recorded in T_8 treatment.

At early fruiting stage the lowest (0.52%) of deformed fruits per plot was recorded in T_5 treatment and the highest (30.46%) of deformed fruits per plot was recorded in T_8 treatment. At mid fruiting stage the lowest (3.75%) of deformed fruits per plot was recorded in T_5 treatment. On the other hand the highest (18.88%) of deformed fruits per plot was recorded in T_8 treatment. At late fruiting stage the lowest (4.32%) of

deformed fruits per plot was recorded in T_5 treatment and the highest (22.99%) of deformed fruits per plot was recorded in T_8 treatment. The lowest percent of (6.97%) deformed fruit per plant was recorded in T_5 treatment, while the highest percent of (22.04%) deformed fruit per plant was recorded in T_8 treatment. Highest total weight of fruit per plant (3.46 kg) was recorded in T_5 treatment and the lowest (2.22 kg) total weight of fruit per plant was recorded in T_8 treatment.

Highest number of flower bunches per plant (70.13) was recorded in T_5 treatment, while the lowest (51.67) number of flower bunches per plant was recorded in T_8 treatment. Highest total weight of healthy fruit per plot (32.04 kg) was recorded in T_5 treatment and the lowest (15.96 kg) was recorded in T_8 treatment. On the other hand the highest (6.28 kg) weight of deformed fruit per plot was recorded in T_8 treatment and the lowest (2.60 kg) was recorded in T_5 treatment. Highest total weight of fruit per hectare (76.98 ton) was recorded in T_5 treatment. On the other hand the lowest (49.42 ton) weight of fruit per hectare was recorded in T_8 treatment.

At vegetative stage no mixed virus infected plants per plot was recorded in T_5 treatment and the maximum (16.67%) percentage mixed virus infected plants per plot was recorded in T_8 treatment. At early flowering stage minimum (3.33%) mixed virus infected plants per plot was recorded in T_5 treatment and the maximum (20.00%) mixed virus infected plants per plot was recorded in T_8 treatment. At early fruiting stage minimum mixed virus infected plants per plot (10.00%) was recorded in T_3, T_5 and T_6 treatment. On the other hand the maximum (30.00%) mixed virus infected plants per plot was recorded in T_8 treatment. At ripening stage no significant variation was found but the maximum (36.67%) mixed virus infected plants per plot was recorded in T_8 treatment.

REFERFENCES

Aboul-Ata, A.E., Awad, M.A.E., Aziz, A.S., Peters, D., Megahed, H. and Sabik, A. (2000). Epidemiology of Tomato yellow leaf curl begomovirus in the Fayium area, Egypt. Bulletin OEPP 30: 297-300.

Ahmed, N.E., Kanan, H.O., Sugimoto, Y., Ma, Y.Q. and Inanaga, S.(2001). Effect of Imidacloprid on incidence of *Tomato yellow leaf curl virus*. Plant Disease 85: 84-87.

Akanda, A.M. (1991). Studies on the virus and mycoplasma disease of vegetable crops in Bangladesh. A PhD thesis submitted to the Plant Pathology Laboratory, Department of Agronomy, Faculty of Agriculture, Kyushu University, Fukuoka, Japan. 181p.

Akhter, K. (2003). Effect of date of sowing on the prevalence of *Tomato yellow leaf curl virus* (TYLCV) and impact of TYLCV infection on growth and yield contributing characters of tomato varieties. An MS thesis submitted to the Department of Plant Pathology, BSMRAU, Salna, Gazipur, Bangladesh. 112p.

Alam, N. (1995). Studies on the virus diseases of tomato in Bangladesh. An MS thesis submitted to the Department of Botany, Jahangirnagar University, Savar, Dhaka.

Alam, M.Z., M. Ali, A.M. Akanda, D.A.M. Choudhury, N.M.M. Haque, M.M. Hossain and K. Ohato. 1994. Grafting technology : An Integrated Pest Management Component for Eggplant and Tomato. Bull. Institute of Tropical Agriculture, Kyushu University. 17:85-91.

Al-Musa, A. (1982). Incidence, economic importance and control of tomato yellow leaf curl in Jordan. Plant Disease 66: 561-563.

Anonymous, (2005). Development of a Management Approach against Whitefly *Bemisia tabaci* attacking tomato. Annual Research Report, Entomology Division. Bangladesh Agricultural Research Institute. Gazipur, Bangladesh. Pp.46-48.

Anonymous. (1999). Monthly Statistics Bulletin of Bangladesh. Statistics Division, Ministry of Planting. Government of Peoples Republic of Bangladesh, Dhaka p54.

Anonymous. (1997). Development of Management Package for the Cotton Jassid on Brinjal. Annual research report, Entomology Division. Bangladesh Agricultural Research Institute. Gazipur, Bangladesh. Pp.18-21.

Avgelis, A.D., Roditakis, N., Dovas, C.I., Katis, N.N., Varveri, C., Vassilakos, N. and Ben, F.(2001). First report of *Tomato yellow leaf curl virus* on Tomato crops in Greece. Plant Disease 85: 678.

Avidov, Z. (1956). Bionomics of the tobacco Whitefly (*Bemisia tabaci* Gennad.) in Israel.Ktavim (English edition). 7(1): 25-41.

Azab, A.K., Megahed, M.M. and EI-Mirsawi, H.D. (1971). On the biology of *Bemisia tabaci* (Gen.) (Hemiptera-Homoptera: Aleyrodidae).

Azam, K.M., Razvil, S.A., Zouba, A. and Al-Raeesi, A.A. (1997). Management of Whitefly (*Bemisia tabaci* Gennadius) and tomato leaf curl virus in tomato crops. Arab and Near East Plant Protection Newsletter. Pp.25,27.

Basu, A.N. (1995). *Bemisia tabaci* (Gennadius): Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay, Calcutta, India. Pp. 1-183.

Bock, K.R. (1982). Geminivirus diseases in tropical crops. Plant Diseases. 66(3):226-270.

Brown, J.K. and Bird, J. (1992). Whitefly-transmitted geminiviruses and associated disorders in the Americas and the Caribbean Basin. Plant Disease. 76(3):220-225.

Brunt, A., Crabtree, L. and Gibbs, A. (Edt.) (1990). Tomato yellow leaf and geminivirus. In viruses of tropical plants. CAB International, Wallingfork, Oxon, OX-10 eight DE. UK. Pp 578-580 (Original not seen).

Butani, D.and M. Jotwani. (1984). Insects in vegetables. Periodical Expert book Agency, Vivek- Vihar, Delhi (India). Pp.29.

Butler, G.D., Jr., and Henneberry, T.J. (1991). Sweet potato whitefly control: Effect of tomato cultivars and plant derived oils. Southwestern Entomologist 16(1): 37-43.

Byrne, D.N., Bellows, T.S. and Parrella, M.P. (1991).Whiteflies in agricultural systems. *In:* whiteflies: Their Bionomics, Pest Status and Management (D. Gerling, ed.) Intercept, Wimborne, England. Pp.227-261.

Byrne,D.N. and M.A. Houck. (1990). Morphometric identification of wing polymorphism in *Bemisia tabaci* (Homoptera: Aleyrodidae).Annals of the Entomological Society of America. 83:487-493.

Cahil, M., Byrne, F.J., Gorman, K., Denholm, I. and Devonshire, A.L. (1995). Pyrethroud and Organophosphate resistance in tobacco Whitefly, *Bemisia tabaci* (Homoptera: Alerodidae). Bulletin on Entomological Research. 85:181-187.

Chenulu, V,V. and Giri, B.K. (1985). Viral and mycoplasmal disease of tomato and their management. *In:* perspectives in plant virology (B.M. Gupta, H.N. Verma and K.M. Srivastava, eds.). Print House, Lucknow, India. Pp.45-74.

Cohen, S. and Melamed-Madjar. (1978). Prevention by soil mulching of the spread of *Tomato yellow leaf curl virus* transmitted by *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) in Israel. Bull. Ent. Res. 68: 465-470.

Cohen, S. and Nitzany, F.E. (1966). Transmission and host range of tomato yellow leaf curl virus. Phytopathology 56: 1127-1131.

Cohen, S. and Harpaz, I. (1964). Periodic, rather than continual acquisition of a new tomato virus by its vector, the tobacco whitefly (*Bemisia tabaci* Gennadius). Entomol. Exp. Appl. 7: 155-166.

Csizinsky, A.A., Schuster, D.J. and Kring, J.B. (1997). Evaluation of color mulches and oil spray for yield and for the control of silver leaf whitefly, *Bemisia argentifolii* (Bellows and Perring) on tomatoes. Crop Protection 16(5): 475-481.

Csizinsky, A.A., Schuster, D.J. and Kring, J.B. (1995). Color mulches influence yield and insect pest populations in tomatoes. J. Amer. Soc. Hort. Sci. 120(5): 778-784.

Czosnek, H. and Laterrot, H. (1997). A world wide survey of *Tomato yellow leaf curl virus*. Archives of Virology 142: 1391-1406.

Duffus, J.E. (1987). Whitefly transmission of plant viruses. *In:* Current Tropics in Vector Research (K.F. harris, ed.). Springer-Verlag, New York. 4:73-91.

El-Serwiy, S.A., Ali, A.A., and Razoki, I.A. (1987). Effect of intercropping of some host plants with tomato on population density of tobacco whitefly, *Bemisia tabaci* (Genn.) and the incidence of tomato yellow leaf curl virus (TYLCV) in plastic houses. Journal of Agriculture and water resources Research, Plant Production 6(2): 79-81.

Gafni, Y. (2003). *Tomato yellow leaf curl virus*, the intracellular dynamics of a plant DNA virus. Molecular Plant Pathology 4(1): 9-15.

Gerling, D. and Horowitz, A.R. and Baumgartner, J.(1986). Autecology of *Bemisia tabaci*. Agric. Ecosys. Evniron. 17:5-9.

Ghanim, M., Morin, S., Zeidan, M. and Czosnek, H. (1998). Evidence for transovarial transmission of tomato yellow leaf curl virus by its vector, the whitefly *Bemisia tabaci*. Virology 240(2): 295-303.

Greathead, A.H. (1986). Host plants. *In: Bemisia tabaci*- a Literature Survey (M.J.W. Cock, ed.). C.A.B. international Institute of Biological Control, U.K. Pp.17-23.

Green, S.K. and Kalloo, G. (1994). Leaf curl and yellowing viruses of pepper and tomato: an overview. Technical Bulletin No. 21. Asian Vegetable Research and Development Center, Taiwan. 51p.

Gupta, N.D. (2000). Occurrence of *Tomato yellow leaf curl virus* (TYLCV) and *Tomato purple vein virus* (TPVV) and their effect on growth and yield of tomato. An MS thesis submitted to the Department of Plant Pathology, BSMRAU, Salna, Gazipur, Bangladesh. 77p.

Hilje, L., Costa, H.S. and Stansly, P.A. (2001). Cultural practices for managing *Bemisia tabaci* and associated viral diseases. Crop Protection 20: 801-812.

Hilje, L. (2000). Use of living ground covers for managing the whitefly *Bemisia tabaci* as a geminivirus vector in tomatoes. The BCPC Conference – Pests and Disease, UK, 13-16 Nov. 2000. 1:167-170.

Hinata, K. (1986). *In:* Y.P.S. Bajaj (Ed.), Biotechnology in Agriculture and Forestry, Vol. 2, Crops 1, Springer- Verlag, Berlin, Heidelberg. Pp. 363-370.

Hirano,K., E. Budiynto and S.Winarni. (1993). Biological characteristics and forecasting outbreaks of the whitefly *Bemisia tabaci*, a vector of virus diseases in soybean fields. Food and Fertilizer Technical bulletin. No.135.

Horowitz, A.R., (1986). Population dynamics of *Bemisia tabaci* (Gennadius) with special emphasis on cotton fields, Agric. Ecosys. Environ. 17:37-47.

Hussain, M.A., Trehan, K.N. (1933). Observations on the life history, bionomics and control of the whitefly of cotton (*Bemisia gossypiperda,* M and L.). Indian J. Agric. Sci. 3:710-753.

Ioannou, N. and Iordanou, N. (1985). Epidemiology of Tomato yellow leaf curl virus in relation to the population density of its whitefly vector, *Bemisia tabaci* (Genn.). Technical Bulletin 71, Agricultural Research Institute, Nicosia, Cyprus. 7p.

Jiang, Y.X., DeBlas, C., Barrios, L. and Fereres, A. (2000). Correlation between whitefly (Homoptera: Aleyrodidae) feeding behavior and transmission of *Tomato yellow leaf curl virus*. Annals of the Entom. Soc. America 93(3): 573-579.

Kajita, H. and Alam, M.Z. (1996). Whitefliess on Guava and Vegetables in Bangladesh and their Aphelinid parasitoids. Appl. Entomol. Zool. 31(1):159-162.

Kalb, T. (2004). Fact Sheet on *Tomato yellow leaf curl virus* (TYLCV). AVRDC Publication 04-608. http: www.avrdc.org.

Khalifa, A. and El-Khidir, E. (1964). Biological study on *Trialeurodes lubia* and *Bemisia tabaci* (Aleyrodidae). Bull. Soc. Entomol. d`Egypte. 48:115-129.

Khan, M.A. and Mukhopadhyay, S. (1985). Studies on the effect of some alternative control methods on the incidence of yellow vein mosain virus disease of Okra (*Abelmoschus esculentus*). Indian J. Virol. 1:69-72.

Kranz, J., Schmutterer, H. and Koch, W. (1977). Diseases, pests and weeds in tropical crops. John Wiley and Sons Ltd. Chichester, New York, Brisbane, Toronto. Pp. 27-35.

Kung, S. (1999). Effect of net protected nursery on *Tomato yellow leaf curl virus* incidence and severity. ARC-AVRDC Training Report 1999. 250p. (http:www.arc-avrdc.org/pdf_files/kung (17-N)pdf).

Lapidot, M. Friedmann, M., Pilowsky, M., Ben-Joseph, R. and Cohen, S.(2001). Effect of host plant resistance to *Tomato yellow leaf curl virus* (TYLCV) on virus acquisition and transmission by its whitefly vector. Phytopathology 91: 1209-1213.

Lopez-Avila, A. (1986). Taxonomy and biology. *In: Bemisia tabaci*: A Literature Survey of the Cotton Whitefly with an Annotated Bibliography (M.Z.W. Cock, ed.). C.A.B. International Institute of Biological Control, U.K. pp.27-35.

Mason, G., Rancati, M. and Bosco, D. (2000). The effect of Thiamethoxam, a second generation neonicotinoid insecticide in preventing transmission of Tomato yellow leaf curl geminivirus (TYLCV) by the whitefly *Bemisia tabaci* (Gennadius). Crop Protection 19: 473-479

Marcano, R. and Gonzalez, E. (1993). Evaluation of insecticides for the control of the whitefly *Bemisia tabaci* (Gennadius) in tomato. Boletin de Entomologia Venezolana. 8(2): 121-132.

Molla, M.M.H. (2000). Effect of mulching and weed control on the incidence of yellow leaf curl virus. ARC-AVRDC Training Report 2000. 205p. (http:www.arc-avrdc.org/pdf_files/021-Molla-18th.pdf).

Monsef, A.A. and Kashkooli, A. (1978). Die Baumvollveissfliege *Bemisia tabaci* (Genn.) in der provinz Fars und die kontrolle. Entomologie *et* phytopathologie Appliquees 46(1\2):66-77(impersian, German Summary pp.4-5).

Mound, L.A. (1983). Biology and identity of whitefly vectors of plant pathogens. *In:* Plant Virus Epidemiology. The Spread and Control of Insect-Borne Viruses (R.T. Plumb and J.M. Thresh, eds.). Blackwell Scientific Publications, U.K. pp.305-313.

Mound, L.A. and Hasley, S.H. (1978). Whitefly of the world. A Systematic Catalogue of the Aleyrodidae (Homoptera) with Host Plant and Natural Enemy Data. British Museum (Natural History). John Willey and Sons, London. 340 pp.

Mound, L.A. (1963). Host-correlated variation in *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae). Proc. Royal Entomological Society, London (A) 38:171-180.

Musuna, A.C.Z. (1985). A technique for monitoring whitefly, *Bemisia tabaci* (Genn.), in cotton in Zimbabwe. Agric. Ecosys. Environ. 17:29-35.

Nitzany, F.E., Geisenberg, H. and Koch, B. (1964). Tests for the protection of cucumbers from a whitefly- borne virus. Phytopathology. 54:1059-1061.

Ohnesorge, B., Sharaf, N. and Allawi, T. (1981). Population studies on the tobacco whitefly *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae) during the winter season. II some mortality factors of the immature stages. Zeitschrift fur 92:127-136.

Opena, R.T., Luo, C.G. and Yoon, J.Y. (1987). Breeding for stress tolerance under tropical conditions in tomato and heading Chinese cabbage. ASPAC-FFTC. Taipei, Taiwan (ROC). Pp.88-109 (Original not seen Appeared in CAB Pest Abstract).

Pico, B., Diez, M.J. and Nuez, F. 1998. Evaluation of whitefly-mediated inoculation techniques to screen *Lycopersicon esculentum* and wild relatives for resistance to *Tomato yellow leaf curl virus*. Euphytica 101: 259-271.

Polizzi, G., Asero, C., Cockshull, K.E., and Tuzel, Y. (1994). Epidemiology and incidence of tomato yellow leaf curl virus (TYLCV) in green house protected by screens in Italy. Acta-Horticulturae 366: 345-352.

Polston, J.E., McGovern, R.J., Sherwood, T. and Kelly, R. (2005). New Developments in *Tomato yellow leaf curl virus in Florida*. Southwest Florida Research & Education Center. www.imok.ufl.edu /veghort/pubs orkshop/Polston_99.htm.

Pruthi, H.S. and Samuel, C.K. (1942). Entomological investigation on the leaf curl disease of tobacco in Northern India. V. Biology and population of the whitefly vector (*Bemisia tabaci* Genn.) in relation to the incidence of the disease. Indian J. Agric. Sci. 12:35-57.

Rahman, A.H.M.A. (2003). Growth and yield performance of eight tomato varieties infected with tomato yellow leaf curl virus (TYLCV) under field condition. An MS thesis submitted to the Department of Plant Pathology, BSMRAU, Salna, Gazipur, Bangladesh. 140p.

Ramappa, H.K., Muniyappa, V. and Colvin, J. (1998). The contribution of tomato alternative host plants to *Tomato leaf curl virus* inoculum pressure in different areas of South India. Ann. Appl. Biol. 133: 187-198.

Rao, N.N., Reddy, A.S. and Reddy, D.D.R. (1990). Impact of some insecticides on *Bemisia tabaci* on cotton. Journal of Plant Protection in the Tropics 7(2): 77-86.

Rashid, M.A., Hossain, M.M., Rahman, M.A., Rahman, M.M., Rashid, M.H., Nahar, M.S., Alam, S.N., Faruk, I., Jasmine, H.S., **Alam,** S., Bashet, A., Black, L., Wang, J.F., Talekar, N.S., Luther, G. and Miller, S. (2002). Varietal screening of egg plant for resistance to bacterial wilt, fruit and shoot borer, leaf hopper and root-knot nematode and tomato for resistance to bacterial wilt, virus disease and root-knot nematode. IPMCRSP eighth annual report 2000-2001. pp 77-81.

Rashid, M.H., Hossain, M.M., Yasmin, L., Hossain, S.M.M. and Rahman, A.K.M.M. (2001). Leaf curl and other virus resistance in tomato and chilli. Proceedings of SAVERNET-II Final workshop, 3-8 June, Bangkok, Thailand.

Sanchez-Campos, S., Navas-Castillo, J., Camero, R., Soria, C., Diaz, J.A. and Moriones, E. (1999). Displacement of *Tomato yellow leaf curl virus* (TYLCV)-sr by TYLCV-is in tomato epidemiology in Spain. Phytopathology 89: 1083-1043.

Sastry, K.S. 1989. Tomato leaf curl virus management by carbofuran plus oil combination. Journal of Turkish Phytopathology 18(1-2): 11-16.

Sastry, K.S.M. and Singh, S.J. (1973). Assessment of losses in tomato leaf- curl virus. Indian J. Mycol. Plant Pathol. 3:50-54.

Savary, P. (2000). Effect of whitefly control on *Tomato yellow leaf curl virus* incidence for fresh market tomato. ARC-AVRDC Training Report 2000. 205p. (http: www.arc-avrdc.org/ pdf_files/027-savary-18th. Pdf).

Schuster, D. and Polston, J. (1999). Whitefly management guide: *Tomato yellow leaf curl virus*. Citrus and Vegetable Summer 1999: A6-A7.

Sharaf, N.S. and Batta, Y. 1985. Effect of some factors on the relationship between the whitefly *Bemisia tabaci* Genn. (Homopt., Aleyrodidae) and the parasitoid *Eretmocerus mundus* Mercet (Hymenopt., aphelinidae). Zeitschrift fu¨r Angewandte Entomologie. 99:267-276.

Sharaf, N.S., Al-Musa, A.M. and Nazar, I.K. (1984). Control of tomato yellow leaf curl virus in Jordan. I. Effect of two irrigation regimes alone or in combination with primiphos methyl on whitefly (*Bemisia tabaci* Genn.) population and the incidence of *Tomato yellow leaf curl virus*. Z.Pflanzenkr. Pflanzenschutz (Journal of Plant Diseases and Protection) 91(4): 404-410.

Sinistera, X., Patte, C.P., Siewnath, S. and Polston, J.E. (2000). Identification of *Tomato yellow leaf curl virus*-Is in the Bahamas. Plant Disease 84(5): 592.

Suwwan, M.A., Akkawi, M., Al-Musa, A.M. and Mansour, A. (1988). Total performance and incidence of tomato yellow leaf curl virus (TYLCV) as affected by type of mulch. Scientia Horticulturae 37: 39-45.

Thanapase, W., Polpol, P., Sutabutra, T. and Alathaom, S. (1983). Causal agent and some important characters of tomato leaf curl disease. Kasetsart J.17:80-90.

Traboulsi, R. (1994). *Bemisia tabaci*: a report on its pest status with particular reference to the Near East. FAO Plant Protection Bulletin 42(1-2): 33-58.

Xienqui, Y. 2000. Effect of intercropping on *Tomato yellow leaf curl virus* incidence. ARC-AVRDC Training Report 2000. 205p. (http://www. arc-avrdc.org/pdf_ files/023-yin-18th.pdf).

Yassin, A.M. (1978). Whitefly-borne virus diseases of important crop plants in the Sudan. *In:* Proc. Fourth Conf. Pest. Control. September 30-October 3, 1978. Acad. Sci. Tech. Natl. Res. Centre, Cairo, Egypt, pt. 1. Pp.107-114.