EFFECT OF FERTILIZER ON THE INCIDENCE OF INSECT PESTS ON TOMATO

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CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF FERTILIZER ON THE INCIDENCE OF INSECT PESTS ON TOMATO"** submitted to the Faculty of **Agriculture,** Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN ENTOMOLOGY**, embodies the result of a piece of bona fide research work carried out by **MD. TANZIRUL KARIM, Registration no. 12-05240** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Date: JUNE, 2013
Place: Dhaka, Bangladesh

(Prof. Dr. Md. Abdul Latif)
Research Supervisor

DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

The present study was conducted at the field laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December 2012 to April 2013 to find out the effect of fertilizers on the incidence of insect pests on tomato. The treatments were comprised of various manure and fertilizers and these were T_1 = Recommended Dose (15 ton cow-dung + 400 kg urea + 250 kg TSP + 200 kg MP)/ha, T_2 = Recommended Dose + 400kg urea/ha, T_3 = Recommended Dose + 250kg TSP/ha, T_4 = Recommended Dose + 200 kg MP/ha, T_5 = Recommended Dose + (400 kg urea + 250 kg TSP + 200 kg MP)/ha, T_6 = Control (No fertilizer). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The highest persent increase of aphid and fruit borer infestation over control was 35.10% and 7.07%, respectively observed T_5 treated plot. Treatment T_3 gave the best result by decreasing 28.02 % aphid population. Treatment T_1, T_4 and T_2 also decreased 14.24%, 2.87% and 2.79% aphid population over control. Treatment T_4 decreased the highest per cent (35.76%) fruit borer infested fruit over control. Treatment T_1, T_2, and T_3 also reduced equal per cent of fruit infestation 28.69% over control. Considering the persent reduction of the number of whitefly over control, the best performence (43.30%) was observed in T_5 treated plot and the lowest percent of reduction 1.72% was recorded in T_2 treated plot. Treatment T_3 showed the best performance in terms of percent reduction of jassid over control, that reduced 53.75% population of jassid having no significant variation to that of T_2 (53.55%) but significantly different from others. The lowest percent reduction of jassid over control (17.34%) was recorded in T_5 treated plot. The highest vallue was obtained from T_3 which reduced 25.55% leaf miner over control that was significantly higher than all other treatments. The lowest percent reduction over control (5.03%) was recorded in T_1 treated plot. Finally, the highest per cent increase of plant height, fruit per plant and yield increase over control was achieved in T_5 treated plot resulting 15.83%, 76.40% and 62.55%, respectively. Whereas the lowest increase of plant height and fruit per plant over control showed 2.57% and 11.11% which was recorded in T_1 treated plot and the lowest yield increase was recorded in T_4 treated plot. All treatments ofdifferent doses fertilizers had great impact on major insect pests and yield of tomato.

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CHAPTER I

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.) belongs to the Solanaceae family is one of the most important and popular vegetables in Bangladesh. Both the species and its use as a food originated in Mexico, and spread around the world. Its many varieties are now widely grown, sometimes in greenhouses in cooler climates. It ranks third in the world's vegetable production and most consumable vegetable crop after potato and sweet potato occupying the top of the list of canned vegetable (Chowdhury, 1979). About 150 million tons of tomatoes were produced in the world in 2009. The largest producer China (41,864,750 tons), accounted for about one quarter of the global production followed by United States (12,902,000 tons) and India (11,979,700 tons) (FAO, 2013).

Tomato is a good source of vitamin C (31.0 mg per 100g), vitamin A, calcium, iron , minerals etc. (Matin et al., 1996)., one of the most popular and nutritious vegetables all over the world including Bangladesh. At present 6.85% area is under tomato cultivation both in winter and summer. The total production of tomato in Bangladesh was about 232000 tons from 24700 hectares of land with an average yield of 9.39 t ha^{-1} (BBS, 2011). The yield of the tomato is very low compared to those of some advanced countries (Sharfuddin and Siddique, 1985).

Tomato production in Bangladesh is affected by many factors, among them insect pest attack is the major one. There are many insect pests attacking tomato have been reported which create havoc by causing both quantitative and qualitative loss to the crop.

Aphid, *Myzus persicae* Sulzer, soft-bodied, pear-shaped insects with a pair of dark cornicles and a cauda protruding from the abdomen; yellow-green nymph, may be winged or wingless but later is most common. These are known to feed in colonies. Aphids can attain very high densities on young plant tissue, causing water stress, wilting, and reduced growth rate of the plant (Pawar*et al.* 2000). Aphids comprise a large and economically important group of phytophagous insects distributed worldwide. It damage tomatoes by sucking plant sap and excreting a sticky substance on the foliage and fruit, making the fruit unattractive (Alyokhin.2011).

Jassid, *Amrasca biguttula biguttula Ishida,* the adults are wedge shaped (2 mm) pale green with a black spot on posterior half of each of the fore wings. The female inserts about 15 yellow eggs into leaf veins on the underside. Nymphs and adults suck sap usually from the under surface of the leaves and inject toxins causing curling of leaf edges and leaves turn red or brown called as 'Hopper Burn' (Patel and Patel 1996). The leaves dry up and shed. On transformations into winged adults, they feed constantly on the plant juice.

Whitefly, *Bemisia tabaci*, Gennadius, the insect breeds throughout the year and the female lays stalked yellow spindle shaped eggs singly on the lower surface of the leaf. Nymphs and adults suck the sap usually from the under surface of the leaves and excrete honeydew. Leaves appear sickly and get coated with sooty mold (Jayaraj *et al.* 1986). The whitefly serves as the vector for the spread of yellow mosaic disease causing damage to tomato crop.

Leaf miner, *Bedellia somnulentella*, is the larva of an insect that lives in and eats the leaf tissue of plants. The larvae are small caterpillars which feed on the green tissue inside the leaf, leaving the transparent upper and lower membranes (epidermis) intact. The young larvae enter the leaf and form serpentine mines (narrow, grey-brown or silvery tracks).

As the larva matures, it consumes a broader patch of the leaf, forming blotch mines. Later holes are produced as the mined tissues are destroyed. The lower surface of the infested leaves become dirty with small grains of blackish frass and show silken webbings containing the small pupae.

Fruit borer, *Helicoverpa armigera*, is one of the most destructive pests of tomato. The adults lay majority of the eggs on the upper and lower leaf surfaces of the first four leaves in the top canopy. The larvae scrape the tomato foliage until early or late second instar stage. The larva bores into the fruit making it unfit for marketing. In severe cases of infestation, more than 70 per cent fruits get damaged.

In Bangladesh tomato insect pest severely attacked the leaves and fruit of tomato and reduced the yield of tomato. Cultural practices formed one of the accepted and well conceived approach in reducing the pest incidence in many crops and more so in tomato (Kulagod, 2009). The use of fertilizer is a burning issue in respect of agro-socio-economic and environmental aspect. At present situation in Bangladesh, there is a great need of information about appropriate effect of fertilizer to insect pests attacking tomato. There is no doubt that fertilizers increase yields of crops reported around the world. Environmentally friendly, or green, fertilizer is gaining more attention as people become more environmentally aware. The main elements of most commercial fertilizers are nitrogen, phosphate and potassium. These three elements are essential for the healthy growth in most plants. But excessive use of nitrogenous fertilizers, produce more succulent plants that are susceptible to pests than plants grown under low nutritional levels (Zuber and Dicke, 1964). Nitrogenous fertilizers also increased the population of bober (Taylor et al., 1952) and leaf aphid (Branson and Simpson, 1966). High soil fertility increased the survival of borer (Scott et al., 1996). Fertilizing with nitrogen greatly increases populations of sucking insects. Phosphorus decreased insect populations (Cregg, 2002). Use of high level of nitrogen increases leaf folder infestation (Subbaih and morachan, 1974) and potassium at enhanced doses induced resistance to some insects (Raju *et al.*, 1996).

Fertilizing on crop is going to increase insect problems one should make sure that what type of pest he is dealing with, what type of fertilizer and the current nutrient status of the soil and the plant. Therefore, the present study aimed to determine the effect of fertilizer on the incidence of insect pests attacking tomato.

Objectives

Considering the above discussion the present study was, therefore, undertaken with the following objectives:

- to know the status of insect pests infestation on tomato
- to know evaluate the effect of some fertilizer against the insect pests of tomato and
- to know the effect of fertilizers on the incidence of major insect pests attacking tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse conditions, which received much attention to the researchers throughout the world. Aphid (*Myzus persicae*), jassid (*Amrasca biguttula biguttula*), leaf miner (*Bedellia somnulentella),* whitefly (*Bemisia tabaci*) and fruit borer (*Helicoverpa armigera*) are the major insect pest of different vegetables including tomato, which causes significant damage to crop every year. The incidence of these pests occur sporadically or in epidemic throughout Bangladesh and affecting adversely the quality and yield of the crop. Numerous investigators in various parts of the world have investigated the response of tomato and its major insect pest to different fertilizer for its successful cultivation. In Bangladesh, available literature regarding effect of fertilizer on insect pest of tomato are insufficient and often conflicting. However, some of the literature relevant to fertilizer effect on insect pest attacking tomato and other crops have been furnished in this chapter under the following sub-headings:

2.1 Effect of fertilizer on incidence insect pests

Excessive use of fertilizers generally creates congenial conditions for rapid multiplication and subsequent outbreak of many insect pests (Dhaliwal and Arora, 1998). On crops, fertilizer practices can influence plant defenses. Researchers have demonstrated that high nitrogen levels

in plant tissue can decrease resistance and increase susceptibility to pest attacks.

Ghorbani and Khajehali **(**2013) indicated that the highest amount of nitrogen fertilizer may increase the population density of the pest.

Supriya *et al.* (2009) indicated that nitrogen plays an important role on the intensity of insect pests. Highest number of jassid/leaf, whitefly/leaf and bored fruit was found when nitrogen was applied @ 150 kg/ha. The pests populations were high at this dose as compared to those at low nitrogen doses as well as control. A positive correlation between insect pest and nitrogen was found. A direct correlation of yield and nitrogen was also found but, after a certain limit of nitrogen use the yield did not increase significantly.

According to Smith (2010) changes in the composition of a plant influence the insects that feed upon the plant. The quantitative composition of plants can be changed by the use of fertilizers and populations of insects feeding on the plants may increase or decrease. These changes in numbers of insects have been attributed to such factors as changes in nitrogen, protein, and carbohydrate content or various mineral constituents. Luong and Heong (2005) showed that organic fertilizers affected to rice plant growth and minimized the outbreak of insect pests and diseases such as brown plant hopper, stem borer, leaf folder, blast and sheath blight.

Zhong-xian *et al.* (2007) reported that nitrogen is one of the most important factors in the development of herbivore populations. The application of nitrogen fertilizer in plants can normally increase herbivore feeding preference, food consumption, survival, growth, reproduction, and population density, except few examples that nitrogen fertilizer reduces the herbivore performances. In most of the rice growing areas in Asia, the great increases in populations of major insect pests of rice, including plant hoppers (*Nilaparvata lugens* and *Sogatella furcifera*), leaffolder (*Cnaphalocrocis medinalis*), and stem borers (*Scirpophaga incertulas, Chilo suppressalis, S. innotata, C. polychrysus and Sesamia inferens*) were closely related to the long-term excessive application of nitrogen fertilizers. The optimal regime of nitrogen fertilizer in irrigated paddy fields is proposed to improve the fertilizer-nitrogen use efficiency and reduce the environmental pollution.

Ramzan *et al.* (2007) investigated that the effect of different doses of Nitrogen fertilizer on the incidence of rice insect pests conducted in six locations of Bangladesh. The lowest percent infestation of stem borers was recorded in the treatment where nitrogen was not applied at all but the yield was also adversely affected. The pest incidence in Leaf Color Chart (LCC) based N application treatment was at par with the treatments without Nitrogen with highest yield. The crop with 120 Kg/ha nitrogen application showed highest susceptibility to insect pests with the highest pest incidence. There was significant yield improvement in Leaf Color Chart (LCC) based nitrogen application (92 Kg N/ha). With further increase in N (100Kg/ha) the yield became stagnant and at 120 Kg N/ha, it start declining but remained at par with LCC based N application. The results further revealed that excessive use of N fertilizers to the crop is the wastage of resources that pose serious effects on crop health in the form of pest incidence. Optimizing the dose of nitrogen in relation to other macronutrients and its split applications are extremely essential because high nitrogen makes tissue vulnerable to pest attack.

According to Butler *et al.* (2012) the importance of a thorough understanding of the effect of synthetic fertilizer on insect population dynamics. The existing literature is conflicting and an area of intense debate. Here, a categorical random-effects meta-analysis and a vote count meta-analysis are employed to examine the effects of nitrogen (N), phosphorus (P), potassium (K) and NPK fertilizer on insect population dynamics. In agreement with the general consensus, insects were found to respond positively, overall, to fertilizers. Sucking insects showed a much stronger response to fertilizers than chewing insects. The environment in which a study is conducted can have a marked effect on insect responses to fertilizer, with natural environments showing the potential for buffering effects of nitrogen fertilizers in particular. As well as highlighting the potential shortfall in the amount of research investigating particularly the effects of potassium and phosphorus. This study provides an invaluable flag post in the ongoing research investigating fertilizer effects on ecosystems.

Altieri (1998) showed that cultural methods such as crop fertilization can affect susceptibility of plants to insect pests by altering plant tissue nutrient levels. Research shows that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical and mainly biological properties of soils. Soils with high organic matter and active soil biology generally exhibit good soil fertility. Crops grown in such soils generally exhibited lower abundance of several insect herbivores, reductions that may be attributed to lower nitrogen content in organically farmed crops. Sharon

(1987) reported that fertilization resulted in greater numbers of phloem and seed feeding insects and a concurrent increase in tending and patrolling by ants in fertilized plots. Chewing insect densities did not respond uniformly to fertilization, and no chewing species exhibited the marked increase found in all of the sucking insects. Chrysomelid beetles and beetle damage decreased significantly in fertilized plots.

Facknath and Lalljee (2005) reported thatinsects respond to very low levels of nutritional and non-nutritional compounds in plants, which influence their acceptance and colonization of the plant or plant part, and thereby their growth and development. Plant nutrient levels can vary within and between plants, and are influenced by external factors such as fertilizer treatments, irrigation regime, and light. Soil levels of nitrogen, potassium, phosphorus, calcium, and magnesium can have significant effects on the amounts of these nutrients in the plant, and thereby on pest infestation. Results showed that increases in nitrogen in the potato leaves increased larval and pupal survival, and pupal and adult body weight and length. Potassium and phosphorus, on the other hand, decreased the host suitability of potato plants to *L. trifolii*, and were detrimental to the pest.

Eigenbrode and Pimentel (1988) reported that the organic agriculture often the supply of nutrient from biological materials are more resistant to insects than those grown by using chemical fertilizer. This proposition was examined using collards grown in five treatments: two with fresh manure at two levels (12 and 220 ha^{-1}); one with 'sheet composted' manure at 220 ha^{-1}; a chemical fertilizer treatment (785 kg ha^{-1} of 13:13:13

NPK); and a control treatment with no added nutrients. Population densities of two flea beetles and two lepidopteran pests were monitored weekly during a growing season. Plant size and foliar levels of reduced nitrogen (N), nitrate nitrogen (NO_3^--N), water and total glucosinolates were also measured four times during the season. During population peaks, flea beetle densities were significantly higher on plants receiving chemical fertilizers than on plants receiving similar amounts of macronutrients from manure. Flea beetle, imported cabbage worm and diamondback moth densities were significantly higher on untreated plants than on plants receiving any added nutrients. Flea beetle densities were also significantly higher on plants grown with 'sheet composted' manure than on those grown with fres manure. The nutrient treatments affected plant size, reduced N, NO_3^--N, water and glucosinolate content. These differences were not clearly associated with differences in insect population sizes but some patterns in the data are discussed. Although the potential exists for manipulating soil amendment regimes to affect pest insect populations in collards, an understanding of the mechanisms involved will require further investigation.

2.2 Effect of Fertilizer on Incidence of some specific Insect Pests of tomato

2.2.1 Aphid

Aphid is the most destructive pest of tomato, okra, country bean, cowpea, bushbean, mungbean and other vegetables in oriental countries (Shing, 1978). Several species of aphids infect tomato plant. Both adult and nymphs cause damage to plants by sucking the plant sap from leaves, flowers and young shoots (Bari and Sarder, 1998).

A study was carrid out by Aslam *et al*. (2004) during 2002-2003 crop season at Multan, Pakistan by planting five canola varieties viz., Abaseen, Con-I, Con-III, Oscar and Shiralee in pots of 12 liter capacity. Four levels of Nitrogen, i.e. 0, 250, 500 and 1000 mg/pot were applied before planting.. Sampling for aphid, *Lipaphis erysimi Kalt*. was done weekly from early February to late March. Seasonal mean aphid population was non-significantly different among plants receiving different levels of Nitrogen, whereas population was significantly different on different varieties. Highest population (18.22 aphid/top 10 cm inflorescence) was recorded on variety Oscar. Varieties Shiralee and Abaseen had non-significant difference in population between them, having 18.8 and 13.56 aphid/ top 10 cm inflorescence. Minimum population (8.51 aphid/top 10 cm inflorescence) was found on Con-I. Based on the population recorded, variety Oscar can be classified as susceptible and Con-I as resistant to mustard aphid.

Erdal and Edwards (2003) showed that the effects of organic (composted cow manure) and synthetic (NPK) fertilizers on pests (aphids and flea beetles) and predatory arthropods (anthocorids, coccinellids and chrysopids) associated with tomatoes were evaluated in a 2-year randomized complete block field experiment. Our data suggested that the application of either organic or synthetic fertilizers could increase pest populations on tomatoes. However, there were lower populations of aphids on tomatoes grown with the organic fertilizer than on those grown with the synthetic fertilizers in the second year of the experiment, indicating that organic fertilizers may have the potential to reduce pest attacks in the long term. Anthocorid populations were larger on tomato plants with high aphid populations in the synthetic than in the organic fertilizers-treated plots.

Karungi *et al.* (2006) recorded variables included plant height and width, leaf area, tissue nitrogen content, nodulation; occurrence of *Aphis fabae, Maruca vitrata* and the associated natural enemies; and grain yield. Results indicated that significant differences in plant attributes and yield were only detected in the second and subsequent season of the crop or when weather conditions were stressful. For the insect pests, it was only *A. fabae* infestation that varied among treatments with Market Crop Wastes (MCW) amended plants sustaining higher infestations than NPK and the untreated control, a trend that held for all the seasons. Natural enemy occurrence followed the trend of *A. fabae* infestation. After the first and subsequent harvests, more P, K, Ca, and Mg were extracted from the soil from MCW plots than NPK plots. The study indicated that yields accruing from MCW amended plots were comparable and sometimes even higher than those from NPK despite the higher *A. fabae* infestation of the former.

2.2.2 Whitefly

Whitefly in an important pest worldwide. The whiteflies are very small, fragile and active insects, jump from plant to plant with very slight disturbance and because of this there is great difficulty in handling them during experimental work. Large population of nymphs and adult suck sap directly from plant and greatly reduce yield (Parihar*et al., 1994).* Tobacco whitefly is a serious pest of tomatoes. Whiteflies attack tomatoes from seedling to mature stage. They suck sap from the leaves, and may weaken the plants. Feeding of whiteflies cause yellowing of infested leaves. Immature stages (nymphs) produce honeydew on which sooty mould grows. Heavy honeydew or mould coating reduces plant growth and fruit quality.Tomato crop protection against whiteflies is difficult. This pest is a problem both for the direct damage it causes and for its capacity to transmit several viruses (Dalmon *et al.*,2003).

According to Zaini *et al.* (2013) Variation in nutrient levels applied to the plants could influence different physiological performance of the plants which subsequently affected whitefly population. Populations of whitefly were higher following increasing levels of nutrients in non-pre-infested (control) plants. Kathryn (2002) observations allow us to conclude that the use of this sustainable fertilizer will not cause increases in whitefly populations relative to plants fertilized with other fertilizers that deliver the same level of nitrogen to the plant. Jauset *et al.* (2000) reported that the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), was studied on tomato plants, *Lycopersicon esculentum* (Miller) treated with three different nitrogen levels [308, 140 and 84 ppm] within the normal range for tomato fertilisation in Spain. High nitrogen fertilization increased egg survival, size of pupalexuviae and female tibial length. *T. vaporariorum* populations that developed on plants fertilized with high nitrogen level showed a higher intrinsic rate of increase, making its control more difficult.

2.2.3 Jassids

Jassids damage seedlings and new growth but prefer to feed on the upper surface of mature leaves from flowering onwards. Damage appears as a pale silvery stippled effect. The stipples often occur in wiggly lines. Jassids are unlikely to reduce yield unless in very high numbers before crop cut-out (when production of new growth ceases). This would be indicated by damage to >50% of the upper leaf surface. According to Haq

(1982) Nitrogenous fertilizer (urea) increased the susceptibility of maize crop to jassid, aphid and borer, while phosphatic fertilizer (SSP) showed a tendency to reduce the susceptibility of the crop to these insects. Whitefly population remained unaffected with the application of both of these fertilizers.

2.2.4 Leaf miner

Larvae make long, slender white tunnels in the leaves. Leaf mining flies make tiny punctures on the side of tomato leaves when feeding and laying eggs. These punctures may serve as entry point for disease causing organisms such as bacteria and fungi. Leaf miners attack a wide range of cultivated vegetables. Imamsaheb *et al.* (2011) to studied the effect of different levels of fertigation (50, 75, 100 percent recommended NPK) and genotypes (PTR-4, PTR-6 and Arka Ashish) on productivity and nutrients uptakes of tomato. There was no significant difference with respective to different fertigation levels on leaf miner infestation. However higher leaf minor infestation was recorded in F3 (100% recommended NPK) with respective to number of live maggots on young leaves (13.47), mid leaves (13.81) and old leaves (13.80). The study shown that among different levels of fertigation F3 (100% recommended NPK) with genotype Arka Ashish has shown moderately susceptible (26.66), where as all other treatments has shown moderately resistant. There was no significant difference with respective to different fertigation levels on leaf miner infestation.

2.2.5 Fruit Borer

Fruit borers such as the African bollworm (*Helicoverpa armigera*) and leaf-eating caterpillars such as the cotton leaf worm (*Spodoptera littoralis*) attack the developing and mature fruit of tomato. The African bollworm, also known as the tomato fruit worm, is one of the most destructive insect pests of tomato, causing yield losses as high as 70% due to fruit boring. They usually bore into the fruit from the stem end, and feed on the inner parts of the fruits, causing extensive fruit damage and promoting decay caused by secondary infections. According to Debebe *et al.* (1995), the effect of nitrogen and phosphorous fertilizers and varietal differences on the suitability of host plants for the development of borer larvae. The stems of fertilizer-treated crops hosted more larvae than those of untreated ones and these were significantly longer and heavier. Improved varieties tended to be more suitable for *B. fusca* development. Furthermore, irrespective of the crop species, improved varieties grown with fertilizer were more suitable for the development of *B. fusca*.

Kumar and Urs (1988) reported the effect of nitrogen, phosphorus and potassium fertilizers on the incidence of the noctuid *Earias vittella* on okra was studied in the field in Karnataka, India, during the rainy seasons of 1983 and 1984. Nitrogen and potassium were applied in various proportions with a constant level of 75 kg P/ha. The greatest yields were recorded in plots treated with nitrogen and potassium at 250 and 30 or 125 and 120 kg/ha, respectively, in 1983, and 250 and 60 kg/ha in 1984. The highest infestations were recorded following treatment with 250 and 30 kg nitrogen and potassium/ha. There was a positive correlation between nitrogen uptake by the plants and infestation by *E. vittella*, while potassium uptake was negatively correlated with infestation.

Hossain et al. (2009) studied different dose of NPK fertilizer are showed both negative and positive influence on pod borer damage. In general, application of low to moderate doses of NPK reduced pod borer damage. Application of higher doses NPK increased pod borer damage compared to untreated control. Pod borer damage reduction by low to moderate doses of NPK fertilizer application ranged from 3.10 to 14.22%. The highest pod damage reduction (14.22%) was found in 20-20-20 kg NPK/ha followed by 40-20-20 kg NPK/ha (14.00%) and 20-40-20 kg NPK/ha (12.42%). While, pod borer damage was increased by higher dose levels of NPK fertilizer application which ranged from 4.34 to 15.81 %.Manuring with NPK fertilizer in chickpea increased grain yield upto 34.62%. The highest yield (1750kg/ha) was obtained from 20- 40-20 kg NPK/ha, which was statistically identical among levels of NPK application except 20-20-20 kg NPK/ha. The lowest yield (1300kg/ha) was recorded from control treatment. The highest marginal benefit cost ratio (4.35) computed from the manurial combination 40-20-20 kg NPK/ha followed by 20- 40-20 kg NPK/ha (MBCR 3.73) Manurial combination 40-20-20 kg NPK/ha was found most profitable followed by 20-40-20 kg NPK/ha in considering pod borer damage and yield in chickpea.

Ndereyimana1 *et al.* (2013) reported that shoot and fruit borer (*Leucinodesorbonalis*Guenee) is an important pest responsible for deterioration of quality and quantity of eggplant fruits. Ecofriendly practices such as adoption of proper plant spacing and fertigation level can be used in the management of this pest. For this, investigations were carried out in eggplant (*Solanum melongena* L.) grafted on *Solanum torvum* Swartz to evaluate the effect of spacing and fertigation levels on shoot and fruit borer infestation. A strip plot design was adopted with four levels of spacing (1 m x 1 m, 2 m x 1 m, 1.5 m x 1.5 m and 0.6 m x 0.6 m) and three levels of fertigation: 75, 100 and 125 % RDF (Recommended Dose of Fertilizer) replicated four times. After six months, the plants were pruned to obtain the ratoon crop which was maintained for four months. The lowest shoot borer (8.61 and 7.86 per cent) and fruit borer (9.66 and 8.20 per cent) infestations were recorded under widest plant spacing as compared to the closest; while the lowest fertigation level (75 per cent RDF) recorded the lowest shoot borer (7.74 and 7.01 per cent) and fruit borer (8.91 and 8.21 per cent) incidence in main and ratoon crops, respectively. It can be concluded that the shoot and fruit borer infestation reduces with increased spacing and with decreased nutrition level.

2.3 Effects of fertilizer on plant growth and yield

Schreiner and Nafus (1993) showed thatfertilizer increased plant size and yield. The functional analysis shows that MP and TSP had positive significant impact on yield of hybrid tomato (Karim *et al.*, 2009).

Islam *et al.* (1997) studied yield contributing characters of tomato due to the effect of planting patterns and different N levels. They reported that N at the rate of 250 kg/ha gave the highest number of flower, fruits per plant. The maximum weight of individual fruit was obtained from 250 kg/ha N application. The length and diameter of individual fruit increased with the increased N levels. Nandi *et al.* (1999) reported that NPK played important role on growth, fruit and seed yield of tomato. In respect of all, the highest level (150 kg/ha). They suggested that 90 kg P_2O_5/ha and 90 kg K_2O /ha are optimum doses for fruit and seed yield of tomato.

Petrovic (1997) conducted a trial in order to determine the effect of increasing N rates (from 0 to 160 kg/ha), with constant P (100 kg P_2O_5/ha) and K (100 kg K_2O/ha) levels on the growth dynamics, yields and quality of tomato. Fertilizer increased plant height, leaf mass and number.

Nicolea and Basoccu (1994) noted that increasing N rate increased yield because of fruit number and fruit weight. Deshmukh and Takte (2007) The effects of fertigation on the performance of tomato (cv. Rajashree) were studied in Rahuri, Maharashtra, India. Water-soluble N, P and K fertilizers were applied at one-day intervals at 100, 80 or 60% of the recommended rates. The application of 80% of the recommended rate through water-soluble fertilizers was superior to the other treatments. A 16% increase in yield (85.97 t ha^{-1}) was obtained with fertigation of 80% of the recommended fertilizer rates.

Akhtar *et al.* (2010) a field experiment was conducted to evaluate comparative effects of sulphate and muriate of potash (SOP and MOP) application on yield, chemical composition and quality of tomato *Lycopersicon esculentum,* M. cultivar Romaat National Agricultural Research Centre Islamabad, Pakistan. Potassium from two sources i.e., MOP and SOP was applied @ 0, 100 and 200 kg K ha^{-1} with constant dose of 200 kg N ha^{-1} and 65 kg P ha^{-1}. A significant increase in tomato yield with K application was observed. Potassium applied @ 100 kg K ha^{-1} as MOP produced significantly higher marketable tomatoes as compared to SOP and control. Levels and sources of potassium showed no effect on acidity of tomato fruits. Potash application decreased sugar content of tomato fruits as compared to control. This effect of K on reducing sugar content was more pronounced in K treated fruits as SOP than those of MOP. Vitamin C contents in tomato fruits increased with K application in the form of MOP. The K use as MOP significantly reduced incidence of leaf.

Adebooye *et al.* (2006) conducted an experiment in the early and late seasons of 1999 and 2000 at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria, to evaluate how tomato fruit qualities were affected by phosphorus (P) nutrition. The five levels of P evaluated were 0, 13.2, 26.4, 39.6 and 52.8 kg P/ha using single superphosphate fertilizer (18% P), while the three tomato cultivars used were Ibadan Local, Roma VF and NHLe 158-13. At 26.4 kg P/ha, significantly higher fruit diameter and fruit yields were obtained. Except for the moisture content and ether extract, the P level had significant ($p<0.05$) effects on the pH, total soluble solids (TSS), lycopene, ascorbic acid, crude fibre and crude protein content of tomato fruits with the optimum values recorded at 26.4 kg P/ha. The season did not produce any significant ($p<=0.05$) effect on fruit yield and fruit diameter. The pH, moisture content and lycopene contents were significantly higher during the early season than late season while TSS, crude fibre, crude protein and ascorbic acid were significantly ($p<0.05$) higher in the late season. The season had no significant effect on either extract content. The study established that 26.4 kg P/ha was the optimum P level for the tomato cultivars used in this study.

Kuchanwar *et al.* (2005) conducted a field experiment at Horticulture Section Farm, College of Agriculture, Nagpur, Maharashtra, India, with tomato (*Lycopersicon esculentum*) as a test crop. The effects of P application at three levels (30, 60 and 90 kg

P_2O_5 ha^{-1}), two levels of S (30 and 60 kg S ha^{-1}) and two levels of Fe (20 and 40 kg Fe ha^{-1}) and their combinations were investigated. The highest content of N, P, K, S and Fe (1.34, 0.74, 1.78, 0.18, 5.89 in fruits and 0.75, 0.70, 3.61 0.32, 3.55 in plants, respectively) was recorded with the application of 60 kg P_2O_5 + 30 kg S + 40 kg Fe ha^{-1}. The highest P and S was recorded with the application of 90 kg P_2O_5+ 60 kg S + 40 kg Fe ha^{-1} and 30 kg P_2O_5 + 60 kg S + 40 kg Fe ha^{-1}, respectively. The highest removal of nutrients by tomato were N-28.85 kg ha^{-1}, P_2O_5-265.52 g ha^{-1}, K 37.18 g ha^{-1}, S-379.15 g ha-1, Fe-129.07 g ha^{-1} in fruit and 24.19, 20.96, 116.45, 10.32 kg ha-1, 114.52 g ha^{-1} in plant, respectively, with the application of 60 kg P + 30 kg S + 40 kg Fe ha-1 except S content in fruit, which was maximum under 30 kg P_2O_5 + 60 kg S + 40 Kg Fe ha^{-1}. The total uptake of N, P, K, S and Fe was maximum (53.04, 21.22, 153.63, 10.69 kg ha^{-1}, 249.59 g ha^{-1}, respectively) with the application of 60 kg P_2O_5 + 30 kg S + 40 kg Fe ha^{-1}. According to Ravinder-Singh *et al.* (2000) carried out an experiment at Solan in 1996 and 1997, eight tomato hybrids (Meenakashi, Manisha, Menka, SolanSagun, ET-5XEC-174023, EC-174023XEC-174041, Rachna and Naveen) were treated with 25 four NPK combinations (100:75:55, 150:112.5:82.5, 200:150:110 and 250:187.5:137.5 kg N: P_2O_5: K_20 /ha). The number of marketable fruits per plant and yield per plant were highest in Menka followed by Manisha of the fertilizer treatments, 200:150:110 kg N: P_2O_5: K_20 /ha produced the highest yields.

Shil *et al.* (1997) carried out a field experiment at Gazipur, Bangladesh with four levels of each of N, P, and K and a low level of S fertilizers to determine the optimum fertilizer requirement of tomato cv. TM 0126 grafted on *Solanum sisymbriifolium* root stock.

Higher number of flowers and fruits per plant, individual fruit weight and yield were obtained with 200 kg N, 120 kg P205, and 80 kg K2O through seed (0.5 kg/ha) or soil (5.0 kg/ha) and 20 kg S/ha. They also concluded that the maximum tomato yield of 65.77 t/ha with the same fertilizer combination, which was an increase of 115.64% over the control.

Rahman *et al.* (1996) evaluated the response of a year round tomato line (IPSA-1) to applied N, P, K, S, Zn, and cow dung in a shallow red brown terrace soil at Gazipur, Bangladesh. Four rates each of N and P, three rates of K, two rates each of S, Zn, and organic manure were applied using selected set of 13 treatment combinations. Each nutrient had a positive impact on vegetative growth as well as on yield and yield attributes. The highest yield of 45.1 t/ha was obtained from the treatment combination of 200 kg N, 100 kg P205, 150 kg K20, 20 kg S, 5 kg Zn, and 5 ton cow dung/ha. Topcuoglu and Yalcin (1994) concluded that increasing rates of phosphorus increased vegetative growth and fruit yields. Somos *et al.* (1964) reported that the higher application of phosphorus reproduced toxic effect and so reduced the fruit yield. Felipe and Casanova (2000) investigated the effects of N (0, 90, 180 and 270 kg/ha), P (P_2O_5, 0, 135, 270 and 405 kg/ha), and K (K_2O, 0, 90, 180 and 270 kg/ha) on the yield and number of fruits of tomato in Venezuela. The best treatment, with the highest yield and number of fruits per plant, was 180 kg N, 270 kg P_2O_5, and 180 kg K_2O/ha. It was possible to decrease the application of nutrients, particularly P. The increased yield was not due to larger fruits, but to an increase in the number of fruits. N had a profound effect on the number of fruits.

Chandra *et al.* (2003) concluded the effects of N: P: K rate (200:100:150, 350:200:250 or 500:300:350 kg/ha) on the performance of 4 indeterminate tomato hybrids (Rakshita, Karnataka, Naveen and Sun 7611) in a multi-span greenhouse during 2000-2001 and 2001-2002. In both years, Karnataka registered the greatest fruit diameter (6.97 and 6.98 cm), average fruit weight (83.28 and 83.88 g), fruit yield (2.85 and 3.07 kg/plant), calculated yield (8.55 and 9.21 kg/m2), juice content (58.84 and 62.43%), gross income (94.05 and 101.31 rupees/m2), net income (17.38 and 24.64 rupees/m2) and benefit:cost ratio (1.23 and 1.32), and the lowest cost of cultivation (76.67 rupees/m2 in each year). Rakshita exhibited the greatest pulp content (77.46 and 78.73%), total soluble solids (6.07 and 6.27%) and shelf life (6.40 and 6.50 days). Among the fertilizer levels, N:P:K at 350:200:250 kg/ha was superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit:cost ratio. The number of fruits per plant increased with the increase in the rate of NPK. The quality parameters were not significantly affected by the NPK level in both years.

Gupta *et al.* (1978) evaluated the effects of NPK on plant height, earliness, fruit size, TSS (Total Soluble Solids) and acidity contents. They concluded that tomato cvs H. S.101 and Sioun responded best in respect of yield to 75 kg N/ha and the cv. Pusa Ruby to 150 kg N/ha. All three cultivars responded to 60 kg P_20_5/ha compare with nil P (control) but in the case of K only Pusa Ruby responded to 60 kg K_20/ha; in the other two cvs, the yield was depressed by the application of K. Dhinakaran and Savithri (1997) reported the effect of phosphorus applied at 100 kg P_2O_5/ha significantly increased the yield of tomatoes.

Phosphorus content and phosphorus uptake of tomato fruit increased with increased with increased application of phosphorus.

CHAPTER III

METERIELS AND METHODS

This chapter deals with the materials and methods that were used in conducting the experiment.It consists of a short description of location of' the experimental plot, characteristics of soil, climate, material used, treatments, Layout and design of experiment, land preparation , transplanting and gap filling, staking and pruning, after cares, harvesting, and collection of data. These are described below under following sub-heading:

3.1 Location of the experimental plot

The experiment was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2012 to April 2013. The site is 22^0 $46^'$ N and $90^022^'$ E Latitude and at Altitude of 9 m from the sea level.

3.2 Characteristics of soil

The soil of the experimental site is a medium high land belonging to the Modhupur Tract under the Agro Ecological Zone (AEZ) 28. The soil texture was silty loam with a pH 6.7. Soil samples of the experimental plot was collected from a depth of 0 to 30 cm before conducting the experiment and analyzed in the Soil Resources Development Institute (SRDI), Farmgate, Dhaka. Details of the mechanical analysis of soil sample are shown in Appendix I. The experimental site was a medium high land. The morphological characters of soil of the experimental plots as indicated by UNDP (United Nations Development Programme) and FAO (Food and Agriculture Organization) (1998).

3.3 Climate

The weather condition of the experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during kharif season (April to September) and in the Rabi season (October to March)low rainfall associated with moderately low temperature, low humidity and short day. There was no rain fall during the month of December, January and February, little rain in March. Rabi is the more favorable for vegetable production. The average maximum temperature during the period of experiment was33.8°C and the average minimum temperature was 13°C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the study period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka- 1207, Dhaka and have been presented in (Appendix II).

3.4 Planting materials used for experiment

The tomato variety “BARI Tomato-15’’was used in this study .It was an open pollinated high yield indeterminate type variety developed by the Vegetable Division of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in two seedbeds situated on a relatively high land adjacent to the central farm office. The size of each seed bed was 3 m x l m. A distance of 50 cm in the form of drain was maintained between the beds. The area was well prepared with spade and made into loose, friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and the soil was mixed with well decomposed cow dung at the rate of 5 kg/bed. Sevin 85 SP was applied around each seedbed as precautionary measure against ants and cutworms. Ten grams of seeds were sown in each seedbed on 15th December 2012. After sowing, the seeds were covered with light soil to a depth of about 0.6 cm. Complete germination of the seeds took place within 4-6 days of' sowing. Necessary shading by bamboo mat (chatai) was provided over the seedbed to protect the young seedlings from the scorching sunshine or heavy rain. Dithane M-45 was sprayed on the seedbeds at the rate of 2g/l to protect the seedlings from damping-off and other diseases. Weeding, mulching, and irrigation were done from time to time as and when needed. No chemical fertilizer was used in the seedbed.

3.6 Layout and design of experiment

The experiment comprised 6 treatments combination and laid out in Randomized Complete Block Design (RCBD) with three replications (plate 1). The whole field was divided into three blocks and each block consisted of 6 plots. Altogether there were 18 unit plots in a 300 m^2 land. Each plot was $10m^2$ (4m × 2.5m) in size. The distance between plots was 1.0 m, distance between plants was 60 cm and that of row was 40 cm.

3.7 Recommended manure/fertilizer dose:

Manure/fertilizer	**Dose/ha**	**Dose/unit plot** **$10m^2$ (4m × 2.5m)**
Cow-dung	15 ton	15 kg
Urea	400 kg	0.4 kg
TSP	250 kg	0.25 kg
MP	200 kg	0.20 kg

3.8 Treatments of the Experiment

Six (6) treatments were considered in this experiment. These are as follows:

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea + 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.4kg urea + 0.25 kg TSP + 0.20 kg MP) / plot
T_6 = Control (No fertilizer)

3.9 Cultivation of tomato

The seedlings were always kept under close observation. Necessary intercultural operations were done throughout the cropping season to obtain proper growth and development of the plants.

3.9.1 Land preparation

The selected land for the experiment was first opened on 8 January, 2013 by power tiller and expose to the sun for a week. After one week the land was ploughed and cross-ploughed several times with a power tiller and laddering was done to obtain good tilth. Weeds and stubble’s were removed and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. After removal of the weeds, stubbles and dead roots, the land was leveled and the experimental plot was separated in to the unit plots and were prepared as 10 cm raised beds. Thirty five pits were made in each plot in row-to-row and plant-to-plant maintaining a spacing of 40 cm and 60 cm, respectively (plate 2).

3.9.2 Transplanting of seedlings

Healthy and uniform sized 37 days old seedlings were uprooted separately from the seedbeds. The seedbeds were watered before uprooting the seedlings so as to minimize the root injury. The seedlings were transplanted in the pits of the experimental plots in the afternoon of 22 January, 2013 maintaining a spacing of 40 cm and 60 cm between the rows and plants, respectively. Light irrigation was given immediately after transplanting by using a watering cane. In order to gap filling and to check the border effect, some extra seedlings were also transplanted around the border area of the experimental field (plate 3).

3.9.3. Intercultural operations

The following intercultural operations were done for better growth and development of the plants during the period of the experiment.

3.9.3.1 Gap filling

Gap filling was done in place of dead or wilted seedlings in the field using healthy seedlings of the same stock previously planted in the border area.

3.9.3.2 Weeding and mulching

Weeding and mulching were accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the soil crust. It also helps in conservation of soil moisture. Four weeding were done manually at 15, 30, 45 and 55 DAS to keep the plots free from weeds.

3.9.3.3 Staking and pruning

When the plants were well established, staking was given to each plant by Dhaincha*(Sesbaniasp) and Bamboo* sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were lightly pruned (plate 3).

3.9.3.4 Drainage

Stagnant water effectively drained out at the time of heavy rains.

3.9.3.5 Irrigation

Four irrigations were given throughout the growing season. The first irrigation was applied at 7 days after planting followed by irrigation 15 days after the first irrigation and the other was done in the same way. Mulching was also done by breaking the soil crust after irrigation properly.

3.10 Harvesting

As the seedling were transplanted in the field at a time but, the crops were harvested at different times. Fruits were harvested at early ripening stage when they attained slightly red color. The harvesting was started from 2 April and completed by 20 April, 2013.

3.11 Collection of data

Five plants were selected randomly from each unit plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of study.

Data recorded: The data on the following parameters were recorded at different time intervals as given below:

3.11.1 Number of aphid Whiteflies jassids per plant per plot at different time of crop growth

For recording data on aphid , whitefly and jassid , five (5) plants from each plot were randomly selected. Two fully expanded compound leaves from top and bottom of each plot wear checked silently without jerking the plant insito at an interval of 12 days commencing from first incidence and counted the number of aphid, whitefly and jassid up to the last harvesting of the fruit (plate 4).

3.11.2 Number of Leaf miner per plant at different time of crop growth

For recording leaf miner, five (5) plants from each plot were selected randomly .Selected two fully expanded compound leaves from top and bottom of each plot checked up to the last harvesting of the fruit at 15 days interval (plate 5) .

3.11.3 Number of fruit borer per 20 fruit per plot

For recording fruit borer twenty (20) fruit from each plot were selected randomly and counted carefully where they are affected by fruit borer larvae at every harvesting time (plate 6).

3.11.4 Number of mature fruits per plant

For recording number of mature fruits per plant ten (10) plants from each plot were selected randomly and counted carefully (plate 7). Then the number of mature fruits per plant was calculated.

3.11.5 Plant height

Plant height was measured from the sample plants from the ground level to the tip of the top canopy and mean was calculated. Data were recorded at 15 days interval starting from 35 days of planting and it was recorded up to final harvest.

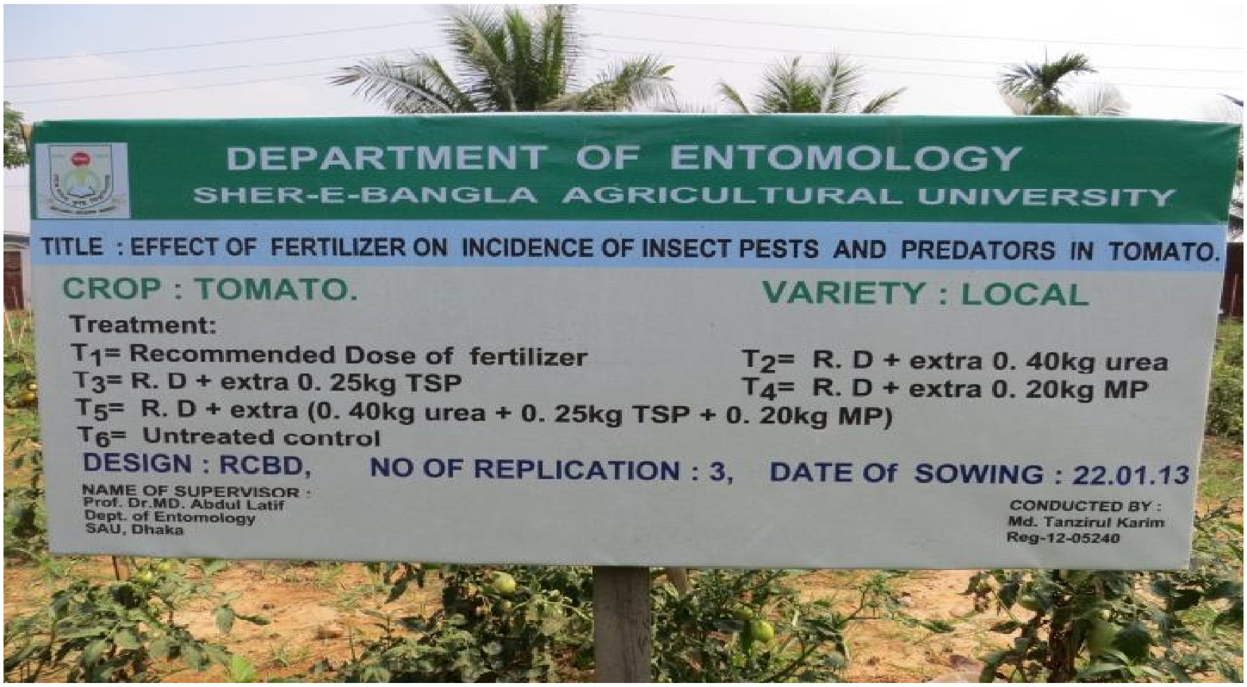

Plate 1. Showing the experimental plot

Plate 2. Transplanting of seedlings

Plate 3. Staking on to each plant by Dhaincha or Bamboo sticks

Plate 4. Aphid infestation **Plate 5**. Leaf miner infested leaf

Plate 6. Fruit borer infested fruits

Plate 7. Showing mature fruits of tomato

3.11.6 Fruit yield per plot

A top loading balance was used to take the weight of fruits per plot. It was measured by summing the fruit yield from each unit plot separately during the period from first to final harvest and was recorded in kilogram (kg).

Percent reduction of pest population over control

The percent reduction of pest population over control was calculated by using the following formula:

$$\% \text{ Reduction of population} = \frac{\text{No. in treted plot} - \text{No. in control plot}}{\text{No. in control plot}} \times 100$$

Percent increase of plant character over control

The percent reduction of pest population over control was calculated by using the following formula:

$$\% \text{ Increase of plant character} = \frac{\text{Value of treated plot} - \text{value of control plot}}{\text{Value of treated plot}} \times 100$$

3.12 Statistical analysis

The collected data on various parameters were statistically analyzed using MSTATC package program. The mean for all the treatments were calculated and analysis of variance for all the characters were performed by F-variance test. The significance of difference between the pairs of treatment mean was separated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSION

This chapter comprises the explanation and presentation of the results obtained from the experiment on the effect of fertilizers on incidence of insect pests and yield of tomato. The data have been presented and discussed and possible interpretations are made under the following sub-headings:

4.1. Effect of fertilizer on incidence of whitefly

The incidence of whitefly on infested leaf of tomato under different fertilizer treatments has been shown in Table 1. The data indicated that the significantly lowest number of whitefly (4.91/plant) was observed in T_5 treated plot followed by 8.02 and 8.27 per plant in T_1 and T_4 treated plots, respectively having no significant difference between later two treatments. On the other hand, the highest number of whitefly per infested plant (8.65/plant) was recorded in untreated control plot (T_6) which was statistically similar to that of T_2 (8.50/plant), T_3 (8.31/ plant) and T_4 (8.27/plot). In case of percent reduction of whitefly over control, significantly the highest (43.30 %) was obtained from T_5 treated plot which was significantly higher than all other treatments. On the other hand, the lowest percent of reduction over control (1.72%) was recorded in T_2 treated plot (Table 1) having no significant difference among T_3 (3.90%), T_4 (4.35%) and T_1 (7.22 %).

The above result indicated that recommended dose of manure and fertilizers in addition of 0.4kg urea + 0.25 kg TSP + 0.20 kg MP per plot reduced the population of white fly on tomato. The result contradicts with the findings of Zaini *et al.* (2013) who reported that population levels of whitefly were higher following increasing levels of nutrients in control plot. Jauset (2000) also reported that plants with high nitrogen level increased egg survival of whitefly.

Table 1. Incidence of whitefly on infested plant of tomato under different fertilization treatments during Rabi season

Treatments	Number of whitefly per plant	Percent reduction of number of whitefly over control
T_1	8.02 b	7.22 b
T_2	8.50 a	1.72 b
T_3	8.31 ab	3.90 b
T_4	8.27 ab	4.35 b
T_5	4.91 c	43.30 a
T_6	8.65 a	--
LSD	**0.37**	**5.67**
CV (%)	**2.63%**	**24.90%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.2. Effect of fertilizer on incidence of jassid

The incidence of jassid on infested leaf of tomato under different fertilization treatments has been presented in Table 2. The data indicated that the lowest number of jassid (0.96/plant) was observed in T_3 treated plot followed by 0.97 and 1.23 per plant in T_2 and T_4 treated plots, respectively having no significant difference among these three treatments. On the other hand, the highest number of jassid per infested plant (2.10) was recorded in untreated control plot which was statistically different from all other treatments (Table 2). However, no significant difference was observed among T_5 (1.73/plant) and T_1 (1.57/plant) which were significantly lower than control plot but higher than those of T_3, T_2 and T_4 treated plots. Similarly, T_3 showed the best performance in terms of per cent reduction of jassid over control, that reduced 53.75 % population of jassid over control having no significant variation to that of T_2 (53.55 %) but differed from others. On the other hand, the lowest percent reduction of jassid over control (17.34 %) was recorded in T_5 treated plot (Table 2) having no significant difference from that of T_1 (25.12 %) but significantly differed from that of T_4 (40.75 %). Considering the percent reduction of number of jassid over control, the best effect (53.75 %) was observed in T_3 treated plot and the lowest reduction (17.34 %) was observed in T_5 treated plot.

The above result indicated that the application of fertilizers and cow dung reduced the population of jassid over control in tomato. However, the best result was obtained from T_3 (recommended dose with 0.25 kg TSP/plot) and T_2 (recommended dose with 0.40 kg urea/plot) treated plots. This finding was almost in agreement with Haq (1982) who reported that phosphatic fertilizer showed a tendency to reduce the susceptibility of maize to jassid, aphid and borer but nitrogenous fertilizer (urea) increased the susceptibility to those insect pests.

Table 2. Incidence of jassid on infested leaf of tomato under different fertilization treatments during Rabi season

Treatments	Number of jassid per plant	Percent reduction of number of jassid over control
T_1	1.57 b	25.12 c
T_2	0.97c	53.55 a
T_3	0.96c	53.75 a
T_4	1.23c	40.75 b
T_5	1.73 b	17.34 c
T_6	2.10a	--
LSD	**0.26**	**10.48**
CV (%)	**9.96%**	**14.61%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.3. Effect of fertilizer on incidence of aphid

The incidence of aphid on infested leaf of tomato under different fertilization treatments has been shown in Table 3. It was demonstrated that significantly the lowest number of aphid (11.58/plant) was found in T_3 which was statistically different from other treatments. However, no significant variation was found among T_4 (15.63/plant), T_2 (15.72/plant) and T_6 (16.11/plant). On the other hand, the highest number of aphid (21.71/plant) was recorded in T_5 treated plot which was statistically different from all other treatments (Table 3). In case of percent reduction of aphid over control, T_3 showed decreasing of 28.02% aphid population. T_1, T_4 and T_2 treated plot also decreased 14.24%, 2.87% and 2.79% aphid population over control respectively. In contrast, only T_5 increased 35.10% aphid population over control (Table 3).

The result indicated that the application of fertilizers reduced the number of aphid over control and the best effect (28.02% reduction of aphid) was observed in T_3 treated plot. But the lowest reduction (2.79%) was observed in T_2 treated plot. However, it was also revealed that recommended dose of manures and fertilizers in addition of 0.4 kg urea + 0.25 kg TSP + 0.20 kg MP per plot increased population of aphid on tomato. This finding was almost in agreement with Erdal *et al.* (2003) who reported the effect of synthetic (NPK) fertilizers on pests (aphids and flea beetles). Moreover, it was also agreed with the findings of Butler *et al.* (2012) and Karungi (2006) who observed that higher rate of NPK fertilizer increased aphid infestation on tomatoes. Never the less, the result contradicts with the reports of Aslam *et al*. (2004) who found that the seasonal mean aphid population was not significantly varied among plants receiving different levels of nitrogen.

Table 3. Incidence of aphid on infested leaf of tomato under different fertilizer treatments during Rabi season

Treatments	Number of aphid per plant	Percent decrease (-) or increase (+) of aphid over control
T_1	13.78 c	- 14.24
T_2	15.72 b	- 2.79
T_3	11.58 d	- 28.02
T_4	15.63 b	- 2.87
T_5	21.71 a	+ 35.10
T_6	16.11 b	--
LSD	**1.27**	**--**
CV (%)	**4.43%**	**--**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.4. Effect of fertilizer on incidence of leaf miners

The incidence of leaf miners on infested leaf of tomato plants under different fertilizer treatments has been shown in Table 4. The data indicated that significantly the lowest number of leaf miners infested leaf (2.87/plant) was observed in T_3 treated plot which was significantly different from those of other treatments. However, no significant variation was observed in case the incidence of leaf minors recorded from T_5 (3.30), T_4 (3.47) and T_2 (3.53) treated plot. On the other hand, the highest number of leaf miners (3.87/plant) was recorded in untreated plot (T_6) which was statistically similar to that of T_1 (3.67/plant). It was also observed that fertilizer treatment decreased leaf miner population in tomato. The best result was obtained from T_3 treated plot which reduced 25.55% leaf miner over control that was significantly higher than all other treatments. On the other hand, the lowest percent reduction over control (5.03%) was recorded in T_1 treated plot (Table 4) having no significant difference with those of T_2 (8.55%) and T_4 (9.99%) but significantly varied from that of T_5 (14.14%).

The above result indicated that the application of fertilizer decreased leaf miner population in tomato and T_3 gave the best result in terms of per cent reduction of the pest. Although other treatments also reduced the population of leaf miner but their effect was negligible. The order of effectiveness of different treatments was $T_3 > T_5 > T_4 > T_2 > T_1$. The result contradicts with the findings of Imamsaheb *et al.* (2011) who observed that there was no significant difference with respective to different fertilizer levels on leaf miner infestation.

Table 4. Incidence of leaf miners on infested leaf of tomato under different fertilizer treatments during Rabi season

Treatments	Number of leaf miners per plant	Percent reduction of leaf miners over control
T_1	3.67 ab	5.03c
T_2	3.53 bc	8.55bc
T_3	2.87 d	25.55 a
T_4	3.47 bc	9.99bc
T_5	3.30 c	14.14 b
T_6	3.87 a	--
LSD	**0.30**	**7.09**
CV (%)	**4.85%**	**19.75%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.5. Effect of fertilizer on incidence of fruit borer

The borer infested fruit of tomato under different fertilizer treatments has been shown in Table 5. The data indicated that the lowest number of fruit borer infested fruit (3.0/20 fruit) was observed in T_4 treated plot followed by 3.33/20 fruits in T_1, T_2 and T_3 treated plots, respectively having no significant difference among them. On the other hand, the highest number borer infested fruit (5.0/20 fruit) was recorded from T_5 treated plot and it was followed by 4.67/20 fruits from T_6 treated plot having no significant difference between them. Similarly T_4 treated plot decreased the highest 35.76% fruit borer infestation of fruit over untreated control. Incidence of fruit borer of T_1, T_2, and T_3 treated plot reduced equal percent fruit infestation 28.69% over untreated control. Only T_5 increased 7.07% fruit borer infestation over control.

The above result indicated that different doses of NPK fertilizer had decreased or increased fruit borer infestation of tomato. Higher dose of NPK fertilizer (T_5) increased fruit infestation by borer compared to control. The result could not compared with others due to lack of exact reference. However, effect of fertilizers on borer may support the result. Hossain (2009) reported that different dose of NPK fertilizer had shown both negative and positive effect of pod borer damage. Application of higher dose of NPK fertilizer increased pod borer (*Helicverpa armigera*) damage in gram compared to control. Moreover, Ndereyimanal *et al*. (2013) recorded the lowest brinjal shoot and fruit borer (*Leucinodes orbonalis*) from lowest fertilizer level in egg plant.

Table 5. Effect of different fertilizer treatments on fruit borer infestation in tomato during Rabi season

Treatments	Number of fruit borer infested fruit per 20 fruit	Percent decrease (-) or increase (+) fruit borer infestation over control
T_1	3.33b	- 28.69
T_2	3.33 b	- 28.69
T_3	3.33 b	- 28.69
T_4	3.00 b	- 35.76

T_5	5.00 a	+ 7.07
T_6	4.67 a	**--**
LSD	**1.14**	--
CV (%)	**16.51%**	**--**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.6. Effect of fertilizers on plant height

A remarkable variation was observed in case of plant height of tomato under different fertilizer treatments and was shown in Table 6. The data indicated that the highest plant height (43.67cm) was observed in T_5 treated plot which was significantly different from all treatments. No significant variation was observed between plant heights recorded from T_4 (42.07 cm) and T_3 (40.90 cm) treated plot. Among the fertilizer treatments, the lowest plant height (38.67 cm) was obtained from T_1 treated plot which was higher than control plot (37.70 cm). In case of percent increase of plant height over control, 15.83 % was obtained from T_5 treated plot which was significantly higher than all other treatments. On the other hand, the lowest percent increase of over control (2.57%) was recorded in T_1 treated plot (Table 6). The plot height of T_4 (11.59%) and T_3 (8.48%) gave statistically similar results in terms of percent increase over untreated control.

The above result indicated that the application of fertilizer increased plant height of tomato compared to untreated control. However, the optimum result was found from T_5 and T_4 treated plot. Although T_1 increased the height of tomato plant but its effect was not satisfactory.

The result contradicts with the findings of Schreiner *et al.* (2003) who reported that fertilizer increased plant height and yield. The result also in agreement with Petrovic (1997) who noted that fertilizer increased plant height, leaf mass and fruit number.

Table 6. Effect of different fertilizer treatments on plant height of tomato against pest infestation

Treatments	Plant height (cm)	Percent increase of plant height over control
T_1	38.67 d	2.57 d
T_2	40.57 c	7.61 c
T_3	40.90 bc	8.48 bc
T_4	42.07 b	11.59 b
T_5	43.67 a	15.83 a
T_6	37.70 d	--
LSD	**1.45**	**3.68**
CV (%)	**1.97%**	**23.17%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.7. Effect of fertilizer on production of fruits per plant

The number of fruit per plant was significantly influenced by the application of different fertilizer treatments (Table 7). Table 7 revealed that the highest number of fruit (15.40/plant) was obtained in T_5 treated plot which was significantly different from all other treatments. However, no significant difference was observed between the number of fruits per plant of T_4 (12.60/plant) and T_3 (11.93/plant) treated plants which was significantly higher than that of T_1 (9.70/plant), T_2 (9.73/plant) and T_6 (8.73/plant) treated plots. Moreover, no significant variation was found among the number of fruits per plant harvested from T_1 (9.70/plant), T_2 (9.73/plant) and T_6 (8.73/plant) treated plots. Similarly, T_5 treated plot increased the highest per cent of fruits per plant over control that was significantly different from all other fertilizer treatments. Fruit per plant of T_3 (36.66%) and T_4 (44.33%) treated plot gave the similar results but significantly lower than T_5 (76.40) and higher than T_1 (11.11%) and T_2 (11.45%) (Table 6).

The result indicated that application of fertilizer increased the number of fruits per plant in tomato. The best result was obtained by application T_5 and intermediate result was obtained from T_3 and T_4. Although T_1 and T_2 increased the number of fruits per plant in tomato but their effectiveness was not satisfactory. The result almost agreed with the finding Adebooye *et al.* (2006) who reported that application of phosphorous significantly increased fruit yield of tomato. Moreover, Islam *et al.* (1997) reported that increasing nitrogen rate increased tomato fruit yield by increasing number and fruit weight. Nicolea and Basoccu (1994) also obtained the same result by applying nitrogen fertilizer.

Table 7. Effect of different fertilizer treatments on number of fruits per plant in tomato against pest infestation

Treatments	Number of fruits per plant	Percent increase of fruit per plant over control
T_1	9.70c	11.11 c
T_2	9.73c	11.45 c
T_3	11.93 b	36.66 b
T_4	12.60 b	44.33 b
T_5	15.40 a	76.40 a
T_6	8.73c	--
LSD	**1.47**	**16.03**
CV (%)	**7.10%**	**13.48%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

4.8. Effect of fertilizers on fruit yield of tomato against pest infestation

The fruit yield per plot of tomato was significantly influenced by the application of different fertilizer treatments. The data indicated (Table 8) that the highest yield per plot (4.47 kg) was recorded in T_5 treated plot followed by T_4 (4.27 kg), T_3 treated plot (4.22 kg) having no statistical difference among them but significantly higher than others treatments. On the other hand, significantly the lowest yield (2.75 kg) per plot was recorded from control plot (T_6), which was significantly different from all other treatments (Table 8). Fruit yield of T_2 and T_1 were 3.95 kg and 3.40 kg with no significant difference between them. Considering percent increase of yield per plot over control, all treatments increased by considerable quantity of fruit yield. The best result (62.55% increase of fruit yield) was recorded in T_5 treated plot followed by 55.27% and 53.45% in T_4 and T_3 treated plot, respectively having no significant difference among them. Fruit yield of T_2 increased 43.63% over control which statistically similar with T_4 and T_3 treated plot. On the other hand, the lowest percent increase of fruit yield over control (23.64%) was recorded from T_1 which was significantly different from others (Table 8).

The above result indicated that the application of manure and fertilizer increased fruit yield of tomato compared to control. However, the best result was obtained from T_5 (Recommended dose + 0.40 kg urea + 0.25 kg TSP + 0.20 kg MP per plot), T_4 (Recommended dose + 0.20 kg MP) and T_3 treated plot gave the similar results. This result supports the findings of Deshmukh (2007) who noted that NPK fertilizers increased 16% yield of tomato. Moreover, higher yield was obtained by application of phosphorus fertilizer in tomato (Dhinakaran *et al.*, 1997; Topcuoglu and Yalcin, 1994).

Table 8. Effect of different fertilizer treatments on yield per plot (kg) of tomato against pest infestation

Treatments	Yield per plot (kg)	Percent increase of yield per plot over control
T_1	3.40 c	23.64 c
T_2	3.95b	43.63 b
T_3	4.22ab	53.45 ab
T_4	4.27 ab	55.27 ab
T_5	4.47 a	62.55 a
T_6	2.75d	--
LSD	**0.41**	**18.18**
CV (%)	**5.94%**	**20.80%**

In a column, means followed by the same letter(s) are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT).

T_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea+ 0.25 kg TSP + 0.20 kg MP) / plot
T_2 = Recommended Dose + 0.40 kg urea / plot
T_3 = Recommended Dose + 0.25 kg TSP / plot
T_4 = Recommended Dose + 0.20 kg MP / plot
T_5 = Recommended Dose + (0.40 kg urea + 0 .25 kg TSP + 0 .20 kg MP) / plot
T_6 = Control (No fertilizer)

CHAPTER V

SUMMARY AND CONCLUSION

Effect of fertilizer on the incidence of insect pests on tomato was investigated at the field laboratory of the Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from December 2012 to April 2013. The treatments are comprised various manure and fertilizers and these wereT_1 = Recommended Dose (15 kg cow-dung + 0.4kg urea + 0.25 kg TSP + 0.20 kg MP) / plot, T_2 = Recommended Dose + 0.40 kg urea/plot, T_3 = Recommended Dose + 0.25 kg TSP/ plot, T_4= Recommended Dose + 0.20 kg MP/ plot, T_5 = Recommended Dose (0.4kg urea + 0.25 kg TSP + 0.20 kg MP)/ plot, T_6 = Control (No fertilizer). The experiment was laid out in single factor Randomized Complete Block Design (RCBD) with three replications.

The lowest number of whitefly was (4.91/plant) observed in T_5 treated plot followed by 8.02 and 8.27 per plant in T_1 and T_4 treated plots, respectively having no significant difference among them. The highest number of whitefly per infested plant (8.65/plant) was recorded in untreated control plot (T_6) which was statistically similar with T_2 (8.50/plant), T_3 (8.31/ plant) and T_4 (8.27/plot) treated plot. Considering the percent reduction of number of whitefly over control, the best effect (43.30%) was observed in T_5 treated plot and the lowest percent of reduction over control (1.72%) was recorded in T_2 treated plot having no significant difference with T_3 (3.90%), T_4 (4.35%) and T_1 (7.22%).

The lowest number of jassid (0.96/plant) was observed in T_3 treated plot followed by 0.97 and 1.23 per plant in T_2 and T_4 treated plots, respectively having no significant difference among them. The highest number of jassid per infested plant (2.10) was recorded in untreated control plot which was statistically different from all other treatments. However, no significance difference was observed T_5 (1.73/plant) and T_1 (1.57/plant) treated plot which were significantly lower than untreated control plot but higher than T_3 (0.96/plant), T_2 (0.97/plant) and T_4 (1.23/plant) treated plots. Considering percent reduction of jassid over control, the best result (53.75%) was obtained from T_3 treated plot followed by T_2 (53.55%) which was significantly higher than all other treatments and the lowest percent of reduction over control (17.34 %) was recorded in T_5 treated plot.

The lowest number of aphid (11.58/plant) was observed in T_3 treated plot which was significantly difference from all other treatments. The highest number of aphid (21.71/plant) was recorded in T_5 treated plot and it was followed by T_6 (16.11/plant), T_2 (15.63/plant) and T_4 (215.63/plant) treated plots having no significant difference among them. In case of percent reduction of aphid over control, T_3 gave the best result by decreasing 28.02% aphid population. Treatments T_1, T_4 and T_2 also decreased 14.24%, 2.87% and 2.79% aphid population over control. In contrast, only T_5 increased 35.10% aphid population over control.

The lowest number of leaf miners infested leaf (2.87/plant) was observed in T_3 treated plot which was significantly different from all other treatments. The highest number of leaf miners (3.87/plant) was recorded in untreated control plot T_6 which was statistically similar to that of T_1 (3.67/plant). Considering percent reduction of leaf miners infested leaf over control, the best result (25.55 %) was obtained from T_3 treated plot which was significantly higher than all other treatments. The lowest percent reduction over control

(5.03%) was recorded in T_1 treated plot having no significant difference in T_2 (8.55%), T_4 (9.99%) and T_5 (14.14%) treated plots.

The lowest number of fruit borer infested fruit (3.0/20 fruit) was observed in T_4 treated plot followed by 3.33 per 20 fruit in T_1, T_2 and T_3 treated plots, respectively having no significant difference among them. The highest number borer infested fruit (5.0/20 fruit) was recorded from T_5 treated plot and it was followed by 4.67/20 fruits from T_6 treated plot having no significant difference between them. Treatment T_4 decreased highest percent (35.76%) fruit borer infested fruit over untreated control. Treatment T_1, T_2 and T_3 also reduced equal percent fruit infestation (28.69%) over untreated control. Only T_5 treated plot increased 7.07% fruit borer infestation over control.

The highest plant height (43.67 cm) was observed in untreated control plot which was significantly different from all other treatments followed by T_4 (42.07 cm) and T_3 (40.90 cm) treated plots having no significant difference among them. The lowest plant height (38.67 cm) was obtained from T_1 which was higher than control plot (37.70 cm). In case of percent increase of plant height over control, the best result (15.83%) was obtained from T_5 treated plot which was significantly higher than all other treatments. The lowest percent increase over control (2.57%) was recorded in T_1 treated plot.

The highest number of fruit per plant (15.40/plant) was harvested from T_5 treated plot which was significantly different from all other treatments. The lowest number of fruit (8.73/plant) was observed in T_6 treated plot and it was followed by T_1 (9.70/plant) and T_2 (9.73/plant) treated plots having no significant variation among them. In case of percent increase of fruit per plant over control, the highest percent of fruit per plant (76.40%) was obtained from T_5 treated plot which was significantly higher than all other treatment. Treatment T_3 and T_4 gave the similar results but significantly lower than T_5 but higher than T_1 and T_2.

The highest yield per plot (4.47 kg) was recorded in T_5 treated plot followed by T_4 (4.27 kg), T_3 (4.22 kg) having no significant variation among them but significantly higher than others. The lowest yield (2.75 kg) per plot was recorder from untreated control plot which was significantly different from all other treatments. Considering percent increase of yield per plot over control, all treatments increased considerable amount of fruit yield. The best result (63.55% increase of fruit yield) was recorded from T_5 treated plot followed by 55.27% and 53.45% in T_4 and T_3 treated plot, respectively having no significant difference among them. The lowest percent increase of fruit yield over control (23.64%) was recorded from T_1 which was significantly different from others.

CONCLUSION

Based on the above findings it can be concluded that recommended dose of manure and fertilizers in addition of 400 kg urea + 250 kg TSP + 200 kg MP/ha increased aphid and fruit borer population, plant height, number of fruits and fruit yield of tomato but decreased the whitefly population compared to control. Recommended dose of manure and fertilizers in addition of 400 kg urea per hectare or 250 kg TSP per hectare minimized the jassid. Application of fertilizer decreased leaf minor population in tomato, recommended dose of manure and fertilizers in addition of 400 kg urea per hectare reduced the leaf minor population compared to control.

RECOMMENDATIONS

Considering the above findings of the study the following recommendations can be drawn:

1. Recommended dose of manure and fertilizers in addition of 400 kg urea + 250 kg TSP + 200 kg MP/ha increased aphid and fruit borer population and ensured number of fruit per plant, plant height and yield in tomato.
2. Recommended dose of manure and fertilizers in addition of 400 kg urea per hectare or 250 kg TSP per hectare suppressed the jassid and leaf minors population in tomato.
3. Further intensive studies based on different doses of fertilizer and manure for incidence of insect pest of tomato may be done.

CHAPTER VI

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CHAPTER VII

APPENDICES

Appendix I. Physiological properties of the initial soil

Characteristics	Value	Critical value
Partical size analysis		
% sand	25	-
% silt	45	-
% clay	30	-
Textural class	silty loam	-
Ph	6.7	Acidic
Organic carbon (%)	0.45	-
Organic matter (%)	0.78	-
Total N (%)	0.03	0.12
Available P (ppm)	20.00	27.12
Exchangeable K (me 100^{-1} g soil)	0.10	0.12
Available S (ppm)	45	-

Appendix II: Monthly record of air temperature, rainfall and relative humidity of the experimental site during the period from December 2012 to April, 2013

Date/Week	Temperature		Relative humidity (%)	Rainfall (mm) (Total)
	Maximum	Minimum		
December	25.1	15.8	73.1	5.08
January	25	13	60.7	0.25
February	28.2	18.4	60.3	0
March	33.8	22.3	52.2	2.53
April	33.8	24.3	61.5	36.58

Source: Bangladesh Meteorological Department (Climate and Weather Division), Agargoan, Dhaka- 1207