J. Sci. Technol. Environ. Inform. 05(01): 336-346 | Afreen et al. (2017)
EISSN: 2409-7632, Journal home: www.journalbinet.com
Crossref: https://doi.org/10.18801/jstei.050117.36

JSTEI ONLINE JOURNAL
Journal of Science, Technology & Environment Informatics
Journal BiNET Scientific Publication

Received: 11.03.2017, Revised: 30.04.2017, Available online: 14 May 2017.
Volume 05, Issue 01, pp. 336-346
Original research paper, Article page: journalbinet.com/jstei-050117-36.html

Management of insect pests in tomato (*Solanum lycopersicum* L.) under different planting dates and mechanical support

Sultana Afreen[1], Md. Mizanur Rahman[1], Md. Mizan Ul Islam[2], Monjur Hasan[3] and A. K. M. Sajjadul Islam[4]

[1]Dept. of Entomology, Sher-e-Bangla Agricultural University, Dhaka-1207
[2]Genetics & Plant Breeding, BRAC Agricultural Research and Development Centre, Gazipur-1701
[3]Vegetable Division, BRAC Agricultural Research and Development Centre, Gazipur-1701
[4]Hybrid Rice Division, BRAC Agricultural Research and Development Centre, Gazipur-1701, Bangladesh

Article info.

Key Words:
Tomato, Fruit borer, Infestation, White fly, Yield

For any information:
ask.author@journalbinet.com

ABSTRACT

The experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka during the Rabi Season 2013-14 to study the effects of different planting dates and mechanical support for the management of insect pests in tomato. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications consisted of nine treatments. Significant variations were found among the treatment. At early fruiting stage of tomato in number and weight basis, the highest percentage of infested fruit (10.65% and 10.99%) was recorded in T_7 treatment, while the lowest (2.67% and 4.35%) in T_5 treatment. At mid fruiting stage of tomato in number and weight basis, the highest percentage of infested fruit (11.92% and 12.62%) was recorded in T_7 treatment, while the lowest (3.13% and 4.50%) in T_5 treatment. At late fruiting stage of tomato in number and weight basis, the highest percentage of infested fruit (10.15% and 10.66%) was recorded in T_7 treatment, whereas the lowest (2.22% and 4.21%) in T_5 treatment. At total fruiting stage of tomato in number and weight basis, the highest percentage of infested fruit (10.93% and 11.43%) was recorded in T_7 treatment, whereas the lowest (2.66% and 4.35%) in T_5 treatment. The highest fruit yield (55.91 t ha^{-1}) was recorded in T_5, whereas the lowest yield (45.39 t ha^{-1}) in T_7 treatment. Planting at 10 December with the method of Horizontal mechanical support was more effective for reduction of insect pest of tomato and also for highest yield.

Citation: Afreen, S., Rahman, M. M., Islam, M. M. U., Hasan, M. and Islam, A. K. M. S. (2017). Management of insect pests in tomato (*Solanum lycopersicum* L.) under different planting dates and mechanical support. Journal of Science, Technology and Environment Informatics, 05(01), 336-346.
Crossref: https://doi.org/10.18801/jstei.050117.36

I. Introduction

Tomato (*Solanum lycopersicum* L.) botanically referred to the family *Solanaceae* is one of the most important and popular vegetable crop. Food value of tomato is very rich because of higher contents of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). Tomato contains 94 g water, 0.5 g minerals, 0.8 g fibre, 0.9 g protein, 0.2 g fat and 3.6 g carbohydrate and other elements like 48 mg calcium, 0.4 mg iron, 356 mg carotene, 0.12 mg vitamin B-1, 0.06 mg vitamin B-2 and 27 mg vitamin C in each 100 g edible ripen tomato (BARI, 2010). Bangladesh is producing a good amount of tomatoes and it is cultivated in almost all home gardens and also in the field due to its adaptability to wide range of soil and climate (Bose and Som, 1990). In Bangladesh it is mainly cultivated as winter vegetable, which occupies an area of 58,854 acres in 2011-12 with the total production of tomato was 190 thousand metric tons (BBS, 2013). Due to increasing consumption of tomato products, the crop is becoming promising. In Bangladesh, the yield of tomato is not enough satisfactory in comparison with other tomato growing countries of the World (Aditya et al., 1997). Tomato is susceptible to insect pests and all parts of the plant including leaves, stems, flowers and fruits are subjected to attack. This crop is mainly attacked by Tomato Fruit worm, Potato Aphid, Stink Bugs and Leaf footed Bugs, Hornworms, Silver leaf, Whitefly etc. Among them tomato fruit borer *Heliothis armigera* (Hub.) is one of the major pests of tomato and damage by this pest may be up to 85-93.7% (Haque, 1995). With the increasing threat of resistance in *H. armigera* towards a wide range of pesticides, the necessity to design future pest management strategies to control this pest becomes more apparent. In Bangladesh, very few research works have been done mainly on cultural, mechanical, biological control by parasitoid and pathogens, development of resistant varieties sex pheromone, and use of botanical insecticides etc. Chemical control is generally being practiced for the management of insect pests. It has many limitations and side effects; it is not only expensive but also exerts some hazards to environment and human health. The indiscriminate use of pesticides causes phytotoxicity and destruction of beneficial organisms such as predators, parasitoids, microorganisms and pollinators (Berlinger et al., 1988). Over the years, the entomologists are working to find ecologically sound and environmentally safe method for pest control (Bari and Sardar, 1998). Management of tomato pests by adopting chemical, biological and mechanical is difficult, uneconomic and hazardous to environment (Berlinger et al., 1988). Breeding plants, which are resistant to the insect vector, although they may be susceptible to the virus can restrict virus damage (Berlinger and Dahan, 1988). Economically viable management has not been achieved regularly in most areas where Gemini viruses infect tomato. Many workers explored the prospect of minimizing viral diseases by manipulating planting dates (Shaheen, 1983; Ioannou and Iordanou, 1995). The tomato fruit borer is difficult to control as it is a borer pest and has developed resistance to insecticides in many different countries. So far, very little efforts have been made to develop alternate approaches for the management of insect pests of tomato. Among available control methods, cultural method is considered to be the safest and environment friendly. Cultural control is the deliberate manipulation of the environment to make it less favorable for the pests by disrupting the reproductive cycle, eliminating their food or by making it more favorable for their natural enemies. This is a prophylactic measure of pest control. Many cultural practices can be usually employed in an IPM scheme such as sanitation or destruction of debris, destruction of alternate hosts and volunteer plants, changing dates of planting and harvesting to avoid pest attack, crop rotation to avoid building up of pests, tillage practices, habitat diversification, cropping system or intercropping, plant density, trap crops or trap logs, water management, etc. (Luckmann and Metcalf, 1975). Variation in sowing or planting date has been found to influence the incidence of many crop pests in the field (Husain and Begum, 1994). So, time of planting is a very important factor for tomato production (Haque et al., 2001) and it ensures to get optimum yield (Islam et al., 1991). Late planting reduces the number of mature fruits and reduces yield. Early harvest ensures higher income, as the market price of early crops is generally higher (Anonymous, 1989). Under the above perspective, the combination of planting dates and mechanical support has been thought to be environment friendly option for the management of insect pests of tomato and the present research work has been undertaken to find out the most suitable planting date and mechanical support for avoiding insect pest of tomato to determine the most suitable planting date and mechanical support on the growth and yield of tomato.

II. Materials and Methods

The experiment was conducted in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka during the period from November 2013 to April 2014. BARI Tomato 5 was used as planting material. The experiment was consisted of nine treatments, i.e., T_1: Planting at 25 November + No support, T_2: Planting at 25 November + Horizontal mechanical support, T_3: Planting at 25 November + Vertical mechanical support, T_4: Planting at 10 December + No support, T_5: Planting at 10 December + Horizontal mechanical support, T_6: Planting at 10 December + Vertical mechanical support, T_7: Planting at 25 December + No support, T_8: Planting at 25 December + Horizontal mechanical support, T_9: Planting at 25 December + Vertical mechanical support. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing all of treatments. Each experiment consists of total 27 plots of size 3.5 m × 2.0 m. The experimental field was partitioned into the unit plots in accordance with the experimental design. The sources of N, P_2O_5, K_2O and H_3BO_3 as urea, TSP, MoP and borax were applied, respectively. The entire amounts of TSP, MoP and borax were applied during the final land preparation. Urea was applied in three equal installments at 15, 30 and 45 days after seedling transplanting. Well-rotten cowdung 20 t/ha also applied during final land preparation. The amount of manures and fertilizers were used which shown as recommended by BARI (2011). Healthy and uniform tomato seedlings of 30 days old were transplanted in the experimental plots on 25 November, 10 December and 25 December, 2013 as per treatment. Seedlings were transplanted in the plot with maintaining distance between row to row 60 cm and plant to plant 40 cm. A number of seedlings were also planted in the border if the experimental plots require any gap filling. Data were recorded on the incidence of white fly and fruit borer at vegetative flowering and fruiting (early, mid, late) stage , infested and healthy fruit, plant height, number of leaves per plant, number of branches per plant, number of flower bunches per plant, number of flowers per bunch, single fruit weight and yield per hectare. Data on different parameters were compiled and tabulated in proper form for statistical analysis. "Analysis of variance" was done with the help of computer package MSTAT. The mean differences among the treatments were tested with Duncan's Multiple Range Test (Gomez and Gomez, 1984).

III. Results and Discussion

Number of white fly

At vegetative, flowering, fruiting, ripening stage and subsequently the entire growing period statistically significant variation was recorded in terms of number of whitefly and fruit borer plot^{-1} in tomato due to different planting dates and mechanical support under the present experiment. At vegetative stage, minimum number of white fly plot^{-1} (2.27) was recorded from the treatment T_5 (Planting at 10 December + Horizontal mechanical support) which was statistically similar (2.47) with T_6 (Planting at 10 December + Vertical mechanical support) and closely followed (2.80 and 3.00, respectively) by T_2 (Planting at 25 November + Horizontal mechanical support), T_3 (Planting at 25 November + Vertical mechanical support), T_1 (Planting at 25 November + No support) and T_4 (Planting at 10 December + No support), respectively (Table 01). On the other hand, the maximum (5.67) number of white fly plot^{-1} was found from T_7 (Planting at 25 December + No support) which was followed (4.40 and 3.80) by T_9 (Planting at 25 December + Vertical mechanical support) and T_8 (Planting at 25 December + Horizontal mechanical support), respectively. Brown and Bird (1992) pointed the increased prevalence as well as expanded distribution of whitefly borne viruses during the last decade and resulting devastating impact on crop growth and yield. At flowering stage, minimum number of white fly plot^{-1} (8.53) was recorded from the treatment T_5 which was statistically similar (8.73, 9.27 and 9.73, respectively) with the treatment T_6, T_2 and T_3 and closely followed (10.40 and 10.53, respectively) by T_1 and T_4, while the maximum (16.53) was recorded from the treatment T_7 which was closely followed (12.60) by T_9 treatment (Table 01). At fruiting stage, minimum number of white fly plot^{-1} (5.87) was recorded from the treatment T_5 which was statistically similar (6.00, 6.40, 6.60 and 7.20, respectively) with the treatment T_6, T_2 and T_3 and T_4 and closely followed (7.87) by T_1, whereas the maximum (11.53) number of white fly plot^{-1} was recorded from the treatment T_7 which was closely followed (8.67) by T_8 and T_9 treatment (Table 01). White flies are very small, fragile and active insects and this pest showed their existence in the tomato field from vegetative to ripening stage (Parihar et al., 1994). At entire growing season, minimum number of white fly plot^{-1} (16.67) was recorded from the

treatment T_5 which was statistically similar (217.20) with the treatment T_6 and closely followed (18.47) by T_2, whereas the maximum (33.73) number of white fly plot^{-1} was recorded from the treatment T_7 which was closely followed (25.67) by T_9 treatment. During 1993-95, field experiments were carried out on the incidence of whitefly, *B. tabaci* and *Tomato leaf curl virus* (*Tomato yellow leaf curl geminivirus*) disease of tomato in Assam, India. The lowest disease incidence and whitefly population was recorded in the crop planted from October 10 to November 25. As the planting date advances the disease incidence and whitefly population increased while the fruit yield decreased (Borah and Bordoloi, 1998).

Table 01. Effect of planting dates and mechanical supports on number of white fly and fruit borer plot^{-1} in tomato at different stages of plant growth

Treatments	Number of white fly plot^{-1} at				Number of fruit borer plot^{-1} at		
	Vegetative Stage	Flowering Stage	Fruiting Stage	Total	Fruiting Stage	Ripening Stage	Total
T_1	3.00 d	10.53 cd	7.87 bc	21.40 d	8.00 cd	4.13 bc	12.13 c
T_2	2.80 de	9.27 de	6.40 d	18.47 ef	7.00 ef	2.80 e	9.80 ef
T_3	2.80 de	9.73 de	6.60 cd	19.13 e	7.40 de	3.07 de	10.47 de
T_4	3.00 d	10.40 cd	7.20 cd	20.60 d	7.53 de	3.60 cd	11.13 cd
T_5	2.27 f	8.53 e	5.87 d	16.67 g	6.40 f	2.00 f	8.40 g
T_6	2.47 ef	8.73 e	6.00 d	17.20 fg	6.87 ef	2.67 ef	9.54 fg
T_7	5.67 a	16.53 a	11.53 a	33.73 a	13.13 a	7.80 a	20.93 a
T_8	3.80 c	11.07 c	8.67 b	23.53 c	8.80 bc	4.47 b	13.27 b
T_9	4.40 b	12.60 b	8.67 b	25.67 b	9.20 b	4.80 b	14.00 b
$LSD_{(0.05)}$	*0.468*	*1.183*	*1.273*	*1.595*	*0.922*	*0.732*	*2.399*
CV (%)	*8.07*	*6.31*	*9.62*	*3.40*	*6.46*	*10.78*	*4.81*

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, T_1 = Planting at 25 November + No support , T_2 = Planting at 25 November + Horizontal mechanical support, T_3 = Planting at 25 November + Vertical mechanical support, T_4 = Planting at 10 December + No support , T_5 = Planting at 10 December + Horizontal mechanical support, T_6 = Planting at 10 December + Vertical mechanical support, T_7 = Planting at 25 December + No support, T_8 = Planting at 25 December + Horizontal mechanical support and T_9 = Planting at 25 December + Vertical mechanical support

Number of fruit borer

Significant variation was recorded for number of bruit borer plot^{-1} in tomato due to different planting dates and mechanical support at fruiting and ripening stage and also subsequently the entire growing period. At fruiting stage, minimum number of fruit borer plot^{-1} (6.40) was recorded from the treatment T_5 which was statistically similar (6.87 and 7.00, respectively) with the treatment T_6 and T_2 and closely followed (7.40 and 7.53, respectively) by T_3 and T_4, respectively, whereas the maximum (13.13) number was recorded from T_7 which was closely followed (9.20 and 8.80) by T_9 and T_8 treatment, respectively (Table 01). At ripening stage, minimum number of fruit borer plot^{-1} (2.00) was recorded from the treatment T_5 which was statistically similar (2.67) with the treatment T_6 and closely followed (2.80 and 3.07, respectively) by T_2 and T_3, while the maximum (7.80) number of fruit borer plot^{-1} was recorded from the treatment T_7 which was closely followed (4.80 and 4.47) by T_9 and T_8 treatment, respectively (Table 01). Tomato fruit borer, *H. armigera* (Hub.) is one of the serious pests attacking tomato (Singh and Singh, 1977). Parihar and Singh (1986) in India showed that, the larval population of *H. armigera* on tomato was low until the first week of February and increased rapidly thereafter, reaching a peak in the last week of March. In the last week of April, population declined to 4 larvae/10 plants. At entire growing season, minimum number of fruit borer plot^{-1} (8.40) was recorded from the treatment T_5 which was statistically similar (9.54) with the treatment T_6 and closely followed (9.80 and 10.47, respectively) by T_2 and T_3, respectively, whereas the maximum (20.93) number of fruit borer plot^{-1} was recorded from the treatment T_7 which was closely followed (14.00 and 13.27) by T_9 and T_8 treatment, respectively (Table 01).

Effect of different treatments on fruit infestation of tomato

Healthy, infested fruits and infestation percentage of tomato were recorded at early, mid, late harvesting periods and subsequently for total harvesting period and significant variation was found for different treatment.

At early fruiting stage

At early fruiting stage of tomato in number basis, the healthy fruit plant^{-1} was highest (9.73) in T_5 treatment which was statistically similar (9.53) with T_6 and closely followed (9.20) by T_2, while the lowest (6.67) number in T_7 which was closely followed (7.47) by T_9 treatment. The highest number of infested fruit plant^{-1} (0.80) was recorded in T_7 treatment which was statistically similar (0.60) with T_9 and closely followed (0.53 and 0.40, respectively) by T_8 and T_4, respectively, whereas the lowest number of infested fruit (0.27) in T_5 treatment which was statistically identical (0.33) with T_2, T_3 and T_6, respectively. The highest percentage of infested fruit in number (10.65%) was recorded in T_7 treatment which was followed (7.45%, 6.14% and 5.94%, respectively) by T_9, T_8 and T_1, respectively, while the lowest percentage of infested fruit in number (2.67%) was recorded in T_5 treatment which was statistically similar (3.39%, 3.50%, 3.61% and 4.42%, respectively) with T_6, T_2, T_3 and T_4, respectively (Table 02). Sutton (1991) reported aphids, whitefly, as the major pest of vegetative stages and could cause 20-40% yield loss.

Table 02. Effects of planting dates and mechanical supports in controlling tomato fruit borer at early fruiting stage by number and weight basis

Treatments	Total fruit in number plant^{-1}			Total fruits in weight (g) plant^{-1}		
	Healthy	Infested	Infestation (%)	Healthy	Infested	Infestation (%)
T_1	8.47 de	0.53 bc	5.94 bc	863.14 bc	61.85 c	6.69 c
T_2	9.20 bc	0.33 cd	3.50 d	910.64 a	45.68 ef	4.77 ef
T_3	8.87 cd	0.33 cd	3.61 d	898.02 ab	48.75 de	5.15 de
T_4	8.67 d	0.40 bcd	4.42 cd	883.82 abc	51.85 d	5.55 d
T_5	9.73 a	0.27 d	2.67 d	915.70 a	41.63 f	4.35 f
T_6	9.53 ab	0.33 cd	3.39 d	913.79 a	44.44 ef	4.64 ef
T_7	6.67 g	0.80 a	10.65 a	794.17 d	97.89 a	10.99 a
T_8	8.13 e	0.53 bc	6.14 bc	850.55 c	72.33 b	7.84 b
T_9	7.47 f	0.60 ab	7.45 b	842.66 c	75.96 b	8.29 b
$LSD_{(0.05)}$	*0.468*	*0.205*	*2.209*	*42.61*	*4.548*	*0.655*
CV (%)	*3.17*	*15.49*	*14.04*	*5.81*	*4.38*	*5.85*

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, T_1 = Planting at 25 November + No support , T_2 = Planting at 25 November + Horizontal mechanical support, T_3 = Planting at 25 November + Vertical mechanical support, T_4 = Planting at 10 December + No support , T_5 = Planting at 10 December + Horizontal mechanical support, T_6 = Planting at 10 December + Vertical mechanical support, T_7 = Planting at 25 December + No support, T_8 = Planting at 25 December + Horizontal mechanical support and T_9 = Planting at 25 December + Vertical mechanical support

At early fruiting stage of tomato in weight basis, the healthy fruit plant^{-1} was highest (915.70 g) in T_5 treatment which was statistically similar (913.79 g, 910.64 g, 898.02 g and 883.82 g, respectively) with T_6, T_2, T_3 and T_4, respectively and closely followed (863.14 g) by T_1, whereas the lowest (794.17 g) weight was recorded in T_7 which was closely followed (842.66 g and 850.55 g, respectively) by T_9 and T_8 treatment, respectively. The highest weight of infested fruit plant^{-1} (97.89 g) was recorded in T_7 treatment which was closely followed (75.96 g and 72.33 g, respectively) by T_9 and T_8, respectively, while the lowest weight of infested fruit (41.63 g) in T_5 treatment which was statistically identical (44.44 g and 45.68 g, respectively) with T_6 and T_2, respectively. The highest percentage of infested fruit in weight (10.99%) was recorded in T_7 treatment which was followed (8.29% and 7.84%, respectively) by T_9 and T_8, respectively, while the lowest percentage of infested fruit in weight (4.35%) in T_5 which was statistically similar (4.64% and 4.77%, respectively) with T_6 and T_2, respectively (Table 02).

At mid fruiting stage

At mid fruiting stage of tomato in number basis, the healthy fruit plant^{-1} was highest (10.27) in T_5 treatment which was statistically similar (10.07) with T_6 and closely followed (9.87) by T_2, while the lowest (7.40) number was recorded in T_7 treatment which was closely followed (8.20) by T_9 treatment. The highest number of infested fruit plant^{-1} (1.00) was recorded in T_7 treatment which was statistically similar (0.87) with T_9 and closely followed (0.80 and 0.73, respectively) by T_8 and T_1, respectively, whereas the lowest number of infested fruit (0.33) was recorded in T_5 treatment which was statistically identical (0.40) with T_2 and T_6, respectively. The highest percentage of infested fruit in number (11.92%) was recorded in T_7 treatment which was followed (9.57%, 8.51% and 7.67%, respectively) by T_9, T_8 and T_1, respectively, while the lowest percentage of infested fruit in number (3.13%) was recorded in T_5 treatment which was statistically similar (3.82% and 3.90%, respectively) with T_6 and T_2, respectively (Table 03). Similar result was found Khan and Griffin (1999) that whitefly, fruit borer, cutworm, leaf miner and red spider mite are most damaging at fruiting and ripening stage and could cause 25-60 per cent yield loss. At mid fruiting stage of tomato in weight basis, the healthy fruit plant^{-1} was highest (985.19 g) in T_5 treatment which was statistically similar (982.22 g, 975.30 g, 971.15 g and 947.89 g, respectively) with T_6, T_2, T_3 and T_4, respectively and closely followed (926.00 g) by T_1, while the lowest (826.40 g) weight was recorded in T_7 treatment which was followed (903.19 g and 913.29 g, respectively) by T_9 and T_8 treatment, respectively and they were statistically similar. The highest weight of infested fruit plant^{-1} (119.13 g) was recorded in T_7 treatment which was closely followed (96.47 g) by T_9, whereas the lowest weight of infested fruit (46.48 g) was recorded in T_5 treatment which was statistically identical (48.19 g and 49.40 g, respectively) with T_6 and T_2, respectively. The highest percentage of infested fruit in weight (12.62%) was recorded in T_7 treatment which was followed (9.65%) by T_9, whereas the lowest percentage of infested fruit in weight (4.50%) was recorded in T_5 treatment which was statistically similar (4.68% and 4.82%, respectively) with T_6 and T_2, respectively (Table 03).

Table 03. Effects of planting dates and mechanical supports in controlling tomato fruit bore at mid fruiting stage by number and weight basis

Treatments	Total fruit in number plant^{-1}			Total fruits in weight (g) plant^{-1}		
	Healthy	Infested	Infestation (%)	Healthy	Infested	Infestation (%)
T_1	8.80 e	0.73 bc	7.67 c	926.00 bc	85.42 c	8.45 c
T_2	9.87 bc	0.40 ef	3.90 e	975.30 a	49.40 f	4.82 f
T_3	9.67 c	0.53 de	5.23 d	971.15 ab	62.52 e	6.05 e
T_4	9.20 d	0.60 cd	6.12 d	947.89 abc	69.49 d	6.85 d
T_5	10.27 a	0.33 f	3.13 e	985.19 a	46.48 f	4.50 f
T_6	10.07 ab	0.40 ef	3.82 e	982.22 a	48.19 f	4.68 f
T_7	7.40 g	1.00 a	11.92 a	826.40 d	119.13 a	12.62 a
T_8	8.60 e	0.80 b	8.51 bc	913.29 c	89.33 c	8.91 c
T_9	8.20 f	0.87 ab	9.57 b	903.19 c	96.47 b	9.65 b
$LSD_{(0.05)}$	*0.367*	*0.134*	*1.326*	*43.96*	*4.687*	*0.684*
CV (%)	*5.34*	*12.23*	*11.51*	*4.71*	*3.66*	*5.34*

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, T_1 = Planting at 25 November + No support , T_2 = Planting at 25 November + Horizontal mechanical support, T_3 = Planting at 25 November + Vertical mechanical support, T_4 = Planting at 10 December + No support , T_5 = Planting at 10 December + Horizontal mechanical support, T_6 = Planting at 10 December + Vertical mechanical support, T_7 = Planting at 25 December + No support, T_8 = Planting at 25 December + Horizontal mechanical support and T_9 = Planting at 25 December + Vertical mechanical support

At late fruiting stage

At late fruiting stage of tomato in number basis, the healthy fruit plant^{-1} was highest (11.67) in T_5 treatment which was statistically similar (11.47) with T_6 and closely followed (11.07) by T_2, while the lowest (7.67) number was recorded in T_7 treatment which was closely followed (8.33) by T_9 treatment. The highest number of infested fruit plant^{-1} (0.87) was recorded in T_7 treatment which was statistically similar (0.80 and 0.73, respectively) with T_9 and T_8, respectively and closely followed (0.60) by T_1, whereas the lowest number of infested fruit (0.27) was recorded in T_5 treatment which was statistically

identical (0.33 and 0.40, respectively) with T_6 and T_2, respectively. The highest percentage of infested fruit in number (10.15%) was recorded in T_7 treatment which was statistically similar (8.77%) with T_9 and followed (7.31%) by T_8, whereas the lowest percentage of infested fruit in number (2.22%) was recorded in T_5 treatment which was statistically similar (2.82% and 3.49%, respectively) with T_6 and T_2, respectively (Table 04). At late fruiting stage of tomato in weight basis, the healthy fruit plant^{-1} was highest (951.25 g) in T_5 treatment which was statistically similar (947.91 g, 940.15 g, 924.37 g, 914.85 g and 902.83 g, respectively) with T_6, T_2, T_3, T_4 and T_1, respectively and closely followed (895.22 g) by T_8, while the lowest (823.53 g) weight was recorded in T_7 treatment which was followed (885.35 g) by T_9. The highest weight of infested fruit plant^{-1} (98.27 g) was recorded in T_7 treatment which was closely followed (88.57 g) by T_9, whereas the lowest weight of infested fruit (41.67 g) was recorded in T_5 treatment which was statistically identical (43.43 g and 45.77 g, respectively) with T_6 and T_2, respectively. The highest percentage of infested fruit in weight (10.66%) was recorded in T_7 treatment which was followed (9.08%) by T_9, whereas the lowest percentage of infested fruit in weight (4.21%) was recorded in T_5 treatment which was statistically similar (4.39% and 4.65%, respectively) with T_6 and T_2, respectively (Table 04). Jitender et al. (1999) conducted the estimation of avoidable yield loss due to fruit borer, *H. armigera*, in tomato (cv. Roma) planted at three dates (first week each of April, May and June), during 1993 and 1994, in Kullu valley, Himachal Pradesh, India, showed that in crop transplanted in the first week of April yield loss to the extent of 105.29, 76.02 and 57.02% could be avoided by giving three sprays of acephate (0.05%), fenvalerate (0.01%) and endosulfan (0.05%), respectively.

Table 04. Effects of planting dates and mechanical supports in controlling tomato fruit borer at late fruiting stage by number and weight basis

Treatments	Total fruit in number plant^{-1}			Total fruits in weight (g) plant^{-1}		
	Healthy	Infested	Infestation (%)	Healthy	Infested	Infestation (%)
T_1	9.73 e	0.60 bc	5.81 cd	902.83 abc	68.53 d	7.05 d
T_2	11.07 b	0.40 def	3.49 efg	940.15 ab	45.77 fg	4.65 fg
T_3	10.73 c	0.47 cde	4.16 ef	924.37 abc	51.62 f	5.29 f
T_4	10.27 d	0.53 cd	4.93 de	914.85 abc	60.00 e	6.15 e
T_5	11.67 a	0.27 f	2.22 g	951.25 a	41.67 g	4.21 g
T_6	11.47 a	0.33 ef	2.82 fg	947.91 a	43.43 g	4.39 g
T_7	7.67 h	0.87 a	10.15 a	823.53 d	98.27 a	10.66 a
T_8	9.27 f	0.73 ab	7.31 bc	895.22 bc	81.75 c	8.37 c
T_9	8.33 g	0.80 a	8.77 ab	885.35 c	88.57 b	9.08 b
$LSD_{(0.05)}$	*0.319*	*0.164*	*1.516*	*45.51*	*6.764*	*0.664*
CV (%)	*4.85*	*17.49*	*15.87*	*5.89*	*6.07*	*5.77*

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, T_1 = Planting at 25 November + No support , T_2 = Planting at 25 November + Horizontal mechanical support, T_3 = Planting at 25 November + Vertical mechanical support, T_4 = Planting at 10 December + No support , T_5 = Planting at 10 December + Horizontal mechanical support, T_6 = Planting at 10 December + Vertical mechanical support, T_7 = Planting at 25 December + No support, T_8 = Planting at 25 December + Horizontal mechanical support and T_9 = Planting at 25 December + Vertical mechanical support

At total fruiting stage

At total fruiting stage of tomato in number basis, the healthy fruit plant^{-1} was highest (31.67) in T_5 treatment which was statistically similar (31.07) with T_6 and closely followed (30.13 and 29.27, respectively) by T_2 and T_3, respectively, whereas the lowest (21.73) number was recorded in T_7 treatment which was closely followed (24.00) by T_9 treatment. The highest number of infested fruit plant^{-1} (2.67) was recorded in T_7 treatment which was followed (2.27 and 2.07, respectively) by T_9 and T_8, respectively, while the lowest number of infested fruit (0.87) was recorded in T_5 treatment which was statistically identical (1.07 and 1.13, respectively) with T_6 and T_2, respectively (Table 04). The highest percentage of infested fruit in number (10.93%) was recorded in T_7 treatment which was followed (8.64%) by T_9, whereas the lowest percentage of infested fruit in number (2.66%) was

recorded in T_5 treatment which was statistically similar (3.32% and 3.62%, respectively) with T_6 and T_2, respectively. At total fruiting stage of tomato in weight basis, the healthy fruit plant^{-1} was highest (2852.14 g) in T_5 treatment which was statistically similar (2843.92 g, 2826.09 g and 2793.54 g, respectively) with T_6, T_2 and T_3, respectively and closely followed (2746.56 g) by T_4, while the lowest (2444.09 g) weight was recorded in T_7 treatment which was statistically similar (2631.19 g and 2659.05 g, respectively) by T_9 and T_8, respectively. The highest weight of infested fruit plant^{-1} (315.29 g) was recorded in T_7 treatment which was closely followed (261.01 g) by T_9, whereas the lowest weight of infested fruit (129.78 g) was recorded in T_5 treatment which was statistically identical (136.06 g) with T_6. The highest percentage of infested fruit in weight (11.43%) was recorded in T_7 treatment which was followed (9.03%) by T_9, whereas the lowest percentage of infested fruit in weight (4.35%) was recorded in T_5 treatment which was statistically similar (4.57%) with T_6 (Table 04). The tomato fruit borer, *H. armigera* has been identified as a major pest of tomato in many countries of the world and cause damage to the extent of about 50-60 per cent fruits (Singh and Singh, 1977). Gupta et al. (1998) found that infestations were heaviest (17.88%) in March- April and lightest in January-February.

Yield contributing character and yield of tomato

Yield contributing characters and yield of tomato were recorded and statistically significant variation was recorded for different treatment under the present experiment in Table 05.

Plant height

Plant height of tomato showed significant differences for different planting dates and mechanical support under the present trial. The longest plant (96.33 cm) was recorded in T_5 which was statistically similar (94.44 cm, 93.82 cm, 93.22 cm, 91.70 cm and 91.47 cm, respectively) with T_6, T_2, T_3, T_4 and T_1 treatment, respectively and followed (86.60 cm) by T_8 treatment, while the shortest plant (77.71 cm) was found in T_7 treatment which was statistically similar (82.29 cm) with T_9.

Number of leaves plant^{-1}

Number of leaves plant^{-1} of tomato showed significant differences for different planting dates and mechanical support. The maximum number of leaves plant^{-1} (125.27) was recorded in T_5 treatment which was statistically similar (124.20, 122.87, 121.40, 119.27 and 118.27 and 111.47, respectively) with T_6, T_2, T_3, T_4, T_1 and T_8 treatment, respectively, whereas the minimum number (102.93) was found in T_7 treatment which was statistically similar (109.13) with T_9 treatment.

Number of branches plant^{-1}

Number of branches plant^{-1} of tomato showed significant differences for different planting dates and mechanical support under the present trial. The highest number of branches plant^{-1} (17.27) was recorded in T_5 which was statistically similar (16.67 and 16.60, respectively) with T_6 andT_2 treatment, respectively and closely followed (15.20, 15.13 and 14.60) by T_3, T_4 and T_1 treatment, respectively, whereas the lowest number (12.33) was found in T_7 treatment which was statistically similar (13.40 and 14.13, respectively) with T_9 and T_8, respectively.

Number of flower bunch plant^{-1}

Number of flower bunch plant^{-1} of tomato showed significant differences for different planting dates and mechanical support under the present trial. The maximum number of flower bunch plant^{-1} (17.27) was recorded in T_5 which was statistically similar (16.67 and 16.60, respectively) with T_6 andT_2 treatment, respectively, whereas the minimum number (12.33) in T_7 which was statistically similar (13.40 and 14.13, respectively) with T_9 and T_8 treatment, respectively.

Number of flower bunch $^{-1}$

Number of flower bunch $^{-1}$ of tomato varied significantly for different planting dates and mechanical support under the present trial. The maximum number of flower bunch^{-1} (7.27) was recorded in T_5 which was statistically similar (7.00) with T_6 treatment and closely followed (6.60 and 6.33, respectively) by T_2 and T_3 treatment, respectively, whereas the minimum number (5.07) in T_7 which was closely followed (5.60 and 5.87, respectively) with T_9 and T_8, respectively.

Individual fruit weight (g)

Individual fruit weight of tomato showed significant differences for different planting dates and mechanical support under the present trial. The highest single fruit weight (95.15 g) was recorded in T_5 which was statistically similar (94.89 g, 94.49 g, 93.67 g, 93.52 g, 92.57 g and 91.02 g, respectively) with T_6, T_2, T_3, T_4, T_1 and T_8 treatment, respectively, whereas the lowest weight (82.68 g) was found in T_7 treatment which was statistically similar (88.56 g) with T_9.

Table 05. Effect of planting dates and mechanical supports on yield contributing characters and yield of tomato

Treatments	Number of leaf plant^{-1}	Number of branches plant^{-1}	Number of flower bunch plant^{-1}	Number of flower bunch^{-1}	Individual fruit weight (g)	Fruit yield (t ha^{-1})
T_1	118.27 ab	14.60 bc	14.60 bc	6.00 cd	92.57 a	54.94 ab
T_2	122.87 ab	16.60 ab	16.60 ab	6.60 b	94.49 a	54.77 ab
T_3	121.40 ab	15.20 bc	15.20 bc	6.33 bc	93.67 a	54.21 ab
T_4	119.27 ab	15.13 bc	15.13 bc	6.20 cd	93.52 a	53.52 ab
T_5	125.27 a	17.27 a	17.27 a	7.27 a	95.15 a	55.91a
T_6	124.20 ab	16.67 ab	16.67 ab	7.00 a	94.89 a	55.27 ab
T_7	102.93 c	12.33 d	12.33 d	5.07 f	82.68 b	45.39 c
T_8	111.47 abc	14.13 cd	14.13 cd	5.87 de	91.02 a	51.08 abc
T_9	109.13 bc	13.40 cd	13.40 cd	5.60 e	88.56 ab	48.68 bc
$LSD_{(0.05)}$	*13.69*	*1.905*	*1.905*	*0.371*	*6.744*	*6.134*
CV (%)	*6.75*	*7.32*	*5.22*	*3.47*	*4.24*	*6.73*

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability, T_1 = Planting at 25 November + No support , T_2 = Planting at 25 November + Horizontal mechanical support, T_3 = Planting at 25 November + Vertical mechanical support, T_4 = Planting at 10 December + No support , T_5 = Planting at 10 December + Horizontal mechanical support, T_6 = Planting at 10 December + Vertical mechanical support, T_7 = Planting at 25 December + No support, T_8 = Planting at 25 December + Horizontal mechanical support and T_9 = Planting at 25 December + Vertical mechanical support

Fruit yield hectare^{-1}

Fruit yield hectare^{-1} of tomato showed significant differences for different planting dates and mechanical support under the present trial. The highest fruit yield (55.91 t ha^{-1}) was recorded in T_5 which was statistically similar (55.27 t ha^{-1}, 54.94 t ha^{-1}, 54.77 t ha^{-1}, 54.21 t ha^{-1}, 53.52 t ha^{-1} and 51.08 t ha^{-1}, respectively) with T_6, T_1, T_2, T_3, T_4 and T_8 treatment, respectively, whereas the lowest yield (45.39 t ha^{-1}) was found in T_7 treatment which was statistically similar (48.68 t ha^{-1}) with T_9. Sharma et al. (1997) reported that seedlings planted on 27 April gave highest marketable fruit yield per plant (1.205 kg) and per hectare (435.5 kg). Yield and yield components were found lowest when seedlings transplanted on 28 March or 12 April, which was primarily due to high infestation of fruit borer, *H. armigera.* Conversely, yield loss due to plant diseases was higher in crops transplanted later.

IV. Conclusion

Planting at 10 December with the method of horizontal mechanical support was more effective for reduction of insect pest of tomato and also for highest yield which was followed by planting at 10 December with the method of vertical mechanical support.

Acknowledgement

Authors are highly grateful to Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. This experiment was supported and funded by supervisors of the work.

V. References

[1]. Aditya, T. L., Rahman, L., Alam, M. S. and Ghoseh, A. K. (1997). Correlation and path co-efficient analysis in tomato. Bangladesh J. of Agri. Sci. 26(1), 119-122.

[2]. Anonymous (1989). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. p. 172.

[3]. Bangladesh Agricultural Research Institute (BARI) (2011). Krishi Projukti Hatboi. 5th edition, 1st part. December 2011. p. 484.

[4]. Bangladesh Agricultural Research Institute (BARI) (2010). Krishi Projukti Hatboi. Bangladesh Agricultural Research Institute, Joydevpur, Gazipur. p. 304.

[5]. BBS (2013). Yearbook of Agricultural Statistics of Bangladesh, 2014. Bangladesh Bureau of Statistics, Dhaka.

[6]. Bari, M. N. and Sardar, M. A. (1998). Control strategy of bean aphid with predator, *Menochilus sexmaculatus* (F.) and insecticides. Bangladesh J. of Ento. 8(1-2), 21-29.

[7]. Berlinger, M. J. and Dahan, R. (1988). Importance plant of resistance in the control of whiteflies and white fly born viruses in tomato and development of screening methods. Applied Agriculture Research, 239-248.

[8]. Berlinger, M. J., Dahan, R. and Mordechi, S. (1988). Integrated pest management of organically grown tomatoes in Israel. Applied Agriculture Research, 3(5), 233-238.

[9]. Borah, R. K. and Bordoloi, D. K. (1998). Influenced of planting time on the incidence of leaf curl virus disease and whitefly population on tomato. Indian J. of Viro. 14(1), 71-73.

[10]. Bose, T. K. and Som, M. G. (1990). Vegetable Crops in India. Naya Prokash, 206 Bidhan Sarani, Calcautta, India. p. 249.

[11]. Brown, J. K. and Bird, J. (1992). White fly-transmitted Gemini viruses and associated disorder in the Americans and the Caribbean Basin. Plant Disease, 76(3), 220-225.

[12]. Gomez, A. K. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research, Second edition. John Wiley and Sons. p. 680.

[13]. Gupta, P. R., Babu, B. R. R. M., Reddy, P. P., Kumar, N. K. K. and Verghese, A. (1998). Management of *Helicoverpa armigera* on tomato with *Trichogramma pretiosum* and *Bacillus thuringiensis* var. kurstaki. Advances in IPM for horticultural crops. Proceedings of the first national symposium on Pest management in horticultural crops: environmental implications and thrusts, Bangalore, India. p. 75-80.

[14]. Haque, M. M. (1995). Insect pest of tomato. In: Curriculum Outline and Training Support Materials, Training Manual: Winter Vegetables and Spices Production. Horticulture Research and Development Project, DAE, BADC, Dhaka. p. 180-181.

[15]. Haque, M. M., Islam, A. T. M. S., Sikder, S. and Alam, M. S. (2001). Effect of planting time and application of kinetin on yield and yield components of tomato. Bangladesh J. of Agri. Res. 26(4), 479-485.

[16]. Husain, M. and Begum, M. (1994). Incidence of jute indigo caterpillar as influenced by sowing date variation. Bangladesh J. of Nuc. Agri. 10, 81-82.

[17]. Ioannau, N. and Iordanau, N. (1995). Epidemiology of tomato leaf curl virus in relation to the population density of its whitefly vector, *Bemisi atabaci* (Gennadius). Technical Bulletin, Agriculture Research Institute, Cyprus. 71, 7.

[18]. Islam, M. S., Farooque, A. H. and Hossain, M. M. (1991). Effect of different time of planting and number of plants per hill on plant growth and yield of tomato. Annual Bangladesh Agriculture, 19(2), 109-112.

[19]. Jitender, K., Sharma, S. D., Jamwal, R. S. and Kumar, J. (1999). Estimation of avoidable yield loss due to fruit borer, *Helicoverp aarmigera* (Hubner) in tomato planted at different dates in lower Kullu valley, Himachal Pradesh. Pest Management Ecology and Zoology, 7(2), 155-159.

[20]. Khan, M. F. R. and Griffin, R. P. (1999). Efficacy of insecticides at controlling insect pests of tomato in South Carolina. Journal of Agriculture and Urban Entomology. 16(3), 165-170.

[21]. Luckmann, W. H. and Metcalf, R. L. (1975). The pest management concept. In: Introduction to insect pest management. Metecalf. R. L. and Luckman, W. H. (Eds). John Wiley and sons, N.Y. p. 3-35.

[22]. Parihar, S. B. S., Verma, K. D. and Singh, R. P. (1994). Leaf cage for the studies on cotton whitefly Bemisiatabaci. Indian Journal of Entomology, 56(2), 201-203.

[23]. Parihar, S. B. S. and Singh, B. R. (1986). Incidence of *Heliothis armigera* (Hub.) a fruit borer on tomato. India Journal of Plant Protection, 13(2), 133-136.
[24]. Shaheen, A. H. (1983). Some ecological aspects of the whitefly, *Bemisiatabaci Genn*. in tomato. Bulletin Science of Entomology, Egypt, 62, 83-87.
[25]. Sharma, D. K., Sharma, I. M. and Sharma, J. P. (1997). Effect of different dates of planting on fruit yield and losses caused by fruit borer and different diseases in tomato (*Lycopersicon esculentum* Mill.) cv. Roma. Indian Journal of Hill Farming, 10(1-2), 63-66.
[26]. Singh, H. and Singh, G. (1977). Biological studies on *Heliothis armigera* Hub. in Punjab. India Journal of Entomology, 27(2), 154-164.
[27]. Sutton, A. (1991). Tomato vegetable market development team, CIBA-GEIGY. AG 6.82 Basel. p. 6-60.

HOW TO CITE THIS ARTICLE?

Crossref: http://doi.org/10.18801/jstei.050117.36

APA (American Psychological Association)

Afreen, S., Rahman, M. M., Islam, M. M. U., Hasan, M. and Islam, A. K. M. S. (2017). Management of insect pests in tomato (*Solanum lycopersicum* L.) under different planting dates and mechanical support. Journal of Science, Technology and Environment Informatics, 05(01), 336-346.

MLA (Modern Language Association)

Afreen, S., Rahman, M. M., Islam, M. M. U., Hasan, M. and Islam, A. K. M. S. "Management of insect pests in tomato (*Solanum lycopersicum* L.) under different planting dates and mechanical support." Journal of Science, Technology and Environment Informatics, 05.01 (2017): 336-346.

Chicago and or Turabian

Afreen, S., Rahman, M. M., Islam, M. M. U., Hasan, M. and Islam, A. K. M. S. "Management of insect pests in tomato (*Solanum lycopersicum* L.) under different planting dates and mechanical support." Journal of Science, Technology and Environment Informatics, 05, no. 01 (2017): 336-346.