ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

OPEN ACCESS
Journal of Agronomy
ISSN 1812-5379
DOI: 10.3923/ja.2016.68.75

Research Article
Effect of Defoliation on Growth and Yield Response in Two Tomato (*Solanum lycopersicum* Mill.) Varieties

[1]A.F.M. Saiful Islam, [2]Md. Monjurul Haque, [1]Rehenuma Tabassum and [1]Md. Muzahedul Islam

[1]Department of Crop Botany and Tea Production Technology, Faculty of Agriculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh
[2]Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh

Abstract
An experiment was conducted at Plant Physiology laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh to investigate the effect of defoliations on crop characters, yield attributes and yield of two tomato varieties. The experiment comprised five levels of defoliation viz., 0 (control), 3, 6, 9 and 12 leaves defoliation out of 16 leaves and two varieties viz., Binatomato-4 and Binatomato-5. The experiment was laid out in two factors completely randomized design with four replications. Results revealed that defoliation and variety had significant effect on the studied crop characters and yield except the number of effective flower clusters per plant and fruit yield for variety. Most of the parameters like plant height, number of branches and leaves per plant, straw weight per plant, number of effective and non effective flower cluster per plant, number of flowers and fruits per plant, individual fruit weight and fruit yield per plant increased with defoliations over control up to 6 leaves and produced the highest in 3 leaves defoliated plant whereas the lowest was obtained in 12 leaves defoliated plants followed by 9 leaves defoliated plants. Therefore, due to the performance of morphological and yield attributing traits especially number of fruits per plant and number of fruits per cluster were superior in Binatomato-5 but fruit yield was inferior compared to Binatomato-4 in respect of smaller fruit size.

Key words: Morphological traits, defoliation, yield, tomato verities, clusters per plant

Received: December 26, 2015 Accepted: February 10, 2016 Published: March 15, 2016

Citation: A.F.M. Saiful Islam, Md. Monjurul Haque, Rehenuma Tabassum and Md. Muzahedul Islam, 2016. Effect of defoliation on growth and yield response in two tomato (*Solanum lycopersicum* Mill.) varieties. J. Agron., 15: 68-75.

Corresponding Author: Rehenuma Tabassum, Department of Crop Botany and Tea Production Technology, Faculty of Agriculture, Sylhet Agricultural University, Sylhet-3100, Bangladesh Tel: +88-01754661778

Copyright: © 2016 A.F.M. Saiful Islam *et al.* This is an open access article distributed under the terms of the creative commons attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most important popular and nutritious vegetable crop in Bangladesh, belongs to the family Solanaceae. It is cultivated in almost all home gardens and also in the field for its adaptability to wide range of soil and climate in Bangladesh. It is the main vegetable crop in terms of volume consumed fresh worldwide, one of the major sources of natural lycopene, an important antioxidant and anticancer compound and acids (acetic, lactic and malic acids) vitamin C and traces of potassium, phosphorus and iron (Monteiro *et al*., 2008). The popularity of tomato and its product is rising day by day. It is a nutritious and delicious vegetable used in salad, soups and processed into stable products like ketchup, sauce, pickles paste, chutney and juice. Higher yield of field crops are the central objectives of any crop improvement programme. In tropical and sub-tropical countries, loss of foliage in tomato by leaf-eating insects and diseases is common. The tomato plant can sustain such source (leaf) damages up to a certain extent without significant yield loss (Martinez *et al*., 2001a).

Traditional varieties of tomato possess greater sources than sink because they are leafy. Greater source capacity leads to poor crop performance as fertilization and other cultural practices result in greater foliage and poor productivity (Heuvelink and Buiskool, 1995). It means instead of large physical dimensions of the sources, optimum and more stable functional efficiency at moderate source size are more advantageous to realize the potential sink size under field conditions. Defoliation up to certain limit may therefore, be useful to overcome this problem of excessive vegetative growth. Greater light penetration in the canopy through defoliation may reduce the abortion of flowers and increase fruit yield (Martinez *et al*., 2001b; Andriolo *et al*., 2004; Hachmann *et al*., 2014).

The effect of manipulation of source (leaf) size in field crops has been studied and reported both advantageous and disadvantageous effect of defoliation in many crops (Bhatt and Rao, 2003; Leonardi *et al*., 2004; Mondal, 2007; Da Silva *et al*., 2011). For example, one-third leaf removal from basal portion of the canopy in tomato increased fruit yield over control and severe defoliation decreased seed yield (Hachmann *et al*., 2014). Similarly, mild defoliations (16.6-33%) during reproductive phase do not adversely affect the seed yield in mungbean (Begum *et al*., 1997). On the other hand, reverse results due to defoliation was also reported in soybean (Borras *et al*., 2004). No detail information is available about source-sink relationships under discriminated levels in tomato. These aspects need investigation in tomato genotypes to develop the high yielding variety under sub-tropical condition. The purpose of this study was to investigate the extent to which and what portion of leaf removal during the beginning of reproductive phase affects fruit yield under field condition and to identify the yield components responsible for yield reduction in tomato.

MATERIALS AND METHODS

Experimental site: The field experiment was carried out at the experimental field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during November, 2012 to March, 2013. The soil of the experiment area was silty loam and belongs to the old Brahmaputra Flood Plain (AEZ-9) Alluvial Tract. The selected site was a medium high land and the pH of the soil was 6.67 with organic matter content of 1.05%. The experimental area was situated in the subtropical climatic zone, characterized by heavy rainfall, high humidity, high temperature and relatively long day during kharif season (April-September) and low rainfall, low humidity, low temperature and short day period during rabi season (October-March). Rabi season is favorable for tomato cultivation. The total rainfall of the locality was 414.7 mm during the experimental period.

Experimental materials and design: Experiment was two factorial where two tomato cultivars viz., Binatomato-4 and Binatoamto-5 were collected (Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh) and used as factor B, on the other hand five defoliations viz., 0, 3, 6, 9 and 12 leaves removal out of 16 leaves at the beginning of flowering as factor A. The experiment was laid out in pot yard in a Randomized Complete Bock Design (RCBD) with four replications. The soil in the plots were well mixing with the given amounts of urea, triple superphosphate, muriate of potash, gypsum and cowdung at the rate of 3.70, 2.15, 1.30, 0.80 and 150 g per pot corresponding to 300, 160, 140, 40 and 10000 kg ha^{-1}, respectively. Earthen pots of 30 cm diameter and 35 cm height were used for the experiment. The pots of the experiment were filled with 12 kg of soils. The seeds of each genotype were sown in the seed bed on November. Two seedlings were sown in each pot on 30 November, 2012. Finally, they were thinned to one seedling after 20 days of transplanting. The seed beds were prepared in iron sheet (50×60 cm). After sowing, the seeds were covered with light soil. Proper care was taken to raise healthy seedlings. Earthen pots of 30 cm diameter and 35 cm height were used for the experiment. The pots of the experiment were filled with 12 kg of soils. Plant protection measures were taken at 55 and

70 Days After Transplanting (DAT) against fruit and shoot borer by spraying Kormil 72 MZ WP @ 0.25%. To prevent the plants from fungal infection, Dithane M-45 was applied @ 2 g L^{-1} at 15 days interval. After 30 DAT, each plant was staked with bamboo sticks to keep them erect and to protect from damage by storm and high speedy winds.

Data collection and statistical analysis: Fruits were harvested at 5 days intervals during maturity and ripening stage. The maturity of the crop was determined on the basis of red color of fruits. At harvest, yield and plant characters like plant height (cm), number of branches per plant, number of leaves per plant, number of flowers per plant, number of flowers per cluster, number of fruits per cluster and number of fruits per plant were measured from each selected plants. Number of effective flower clusters and non-effective flower clusters per plant were counted of the sampled plant at 80 DAT. Moreover, leaf area of two plants in treatment was measured by automatic leaf area meter and average leaf area per plant and the straw yield was recorded by drying (80°C±2) for 48 h and calculated from summation of leaves, stem and roots weights were taken in an electronic balance. Besides these, few parameters were calculated by the following formula:

$$\text{Reproductive efficiency (\%)} = \frac{\text{Total No. of flowers in sample plants}}{\text{Total No. of fruits in sample plants}} \times 100$$

$$\text{Single fruit weight (g)} = \frac{\text{Total fruit weight in sample plants (g)}}{\text{Total No. of fruits in sample plants}}$$

$$\text{Fruit yield } (\text{t ha}^{-1}) = \frac{\text{Fruit weight per plot}}{\text{Area of unit plot} \times 1{,}000} \times 10{,}000$$

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

RESULTS AND DISCUSSION

Morphological characters

Plant height: The interaction effect of defoliation and variety in relation to plant height was statistically significant at $p \leq 0.05$ in tomato varieties (Table 1). Result showed that plant height increased with increasing degree of defoliation up to 6 leaves removal followed by a decline. The highest plant height was recorded in 6 leaves removal treatment (80.0 cm) followed by 3 leaves defoliation (79.5 cm) with same statistical rank. In contrast, the shortest plant was recorded in 12 leaves removal treatment (67.7 cm). The plant height increased up to 6 leaves removal because of might be due to stem height increased for producing more leaves for compensation of leaves loss. These results are in agreement with that of Heuvelink and Buiskool (1995) who reported that seed rate had significant effect on plant height of tomato. Similar result was also reported by Martinez *et al*. (2001a) in tomato who reported that plant height increased with increasing defoliation up to 50% leaf removal. The taller plant was observed in Binatomato-5 (85.7 cm) compared to Binatomato-4 (66.3 cm). Genotypic variation in plant height was also observed by Golok (2006) in tomato. Results revealed that Binatomato-5 had more compensatory capacity for plant height due to defoliation compared to Binatomato-4. The tallest plant was recorded in control, 3 and 6 leaves removal of Binatomato-5 (range 88.3-89.7 cm). The shorted plant was recorded in 12 leaves removal treatment with Binatomato-4 (55.7 cm).

Number of branches per plant: Defoliation had significant influence on branch production per plant and result indicated that all defoliated plants produced greater branches per plant than control (Table 1). The highest branches per plant was observed in 6 leaves defoliated plant (4.00) followed by 3 leaves defoliated plant (3.79) with same statistical rank. In contrast, the lowest branches per plant were recorded in control plant (3.13 per plant). Increased branch number in defoliated plant might be due to for recovery of leaf loss by producing more branches. Andriolo *et al*. (2001) reported that there was an increase in branch number with increased defoliation in tomato. In case of genotypes, the higher branches per plant were recorded in Binatomato-4 (3.80) compared to Binatomato-5 (3.32). BINA (2007) reported that among the released varieties, Binatomato-4 produced more branches per plant compared to Binatomato-5 which supported the present experimental result. In the interaction effect, results revealed that increased branches per plant were recorded in defoliated plants of Binatomato-4 compared to the control whereas, in Binatomato-5, branch number increased over control up to 6 leaves defoliation followed by a decline.

Number of leaves per plant and percent compensation of leaf loss: The effect of defoliation on leaves per plant and percent compensation of leaf loss was statistically significant and showed that leaf number increased with increased defoliation up to 6 leaves removal followed by a decline (Table 1). The leaf number increased up to 6 leaves defoliation

Table 1: Effect of different levels of defoliation and interaction of variety and defoliation on morphological characters in tomato

Treatments	Plant height (cm)	Branches per plant (No.)	Leaves per plant at fruit ripening stage (No.)	Leaves per plant after treatment imposed (No.)	Percent compensation of leaf loss at harvest	Leaf area per plant at fruit ripening stage (cm^2)
Degree of leaves removal from base (No.)						
Control	78.8^b	3.13^c	36.4^a	16.8^a	---	5394^b
3	79.5^a	3.79^a	37.6^a	13.8^b	100.0^a	5906^a
6	80.0^a	4.00^a	38.3^a	10.8^c	100.0^a	5309^b
9	73.9^c	3.38^b	32.5^b	7.75^d	89.8^b	4758^c
12	67.7^d	3.50^b	30.0^c	4.75^e	82.4^c	3403^d
Level of significance	**	**	**	**	**	**
Variety						
Binatomato-4	66.3^b	3.80^a	33.3^b	10.0^b	73.9	3584^b
Binatoamto-5	85.7^a	3.32^b	36.7^a	11.5^a	75.0	6324^a
Level of significance	**	*	*	**	NS	**
Interaction of variety and number of leaves removal						
Binatomato-4						
0	69.0^e	3.00^d	34.8^{cd}	16.0	---	4205^e
3	69.2^e	4.25^a	35.2^{bcd}	13.0 (18.8)	100^a	3932^f
6	71.8^d	4.00^{ab}	37.0^{abc}	10.0 (37.5)	100^a	3925^f
9	65.5^f	3.75^{bc}	31.0^{de}	7.0 (56.2)	89.1^{bc}	3626^g
12	55.7^g	4.00^{ab}	28.0^e	4.0 (75.0)	80.5^d	2234^h
Binatoamto-5						
0	88.5^a	3.25^d	38.0^{abc}	17.5	---	6583^b
3	89.7^a	3.33^{cd}	40.0^a	14.5 (17.3)	100^a	7880^a
6	88.3^a	4.00^{ab}	39.7^{ab}	11.5 (34.5)	100^a	6693^b
9	82.3^b	3.00^d	34.0^{cd}	8.5 (51.4)	89.5^b	5891^c
12	79.8^c	3.00^d	32.0^{de}	5.5 (68.6)	84.2^{cd}	4571^d
Level of significantce	**	**	*	NS	*	**
CV (%)	2.42	6.52	6.40	4.29	4.64	3.15

In a column, figures bearing same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT, NS: Not significant, *,**Significant at 5 and 1% level of probability, respectiely, CV: Coefficent of variance

due to increased number of branches. The higher number of leaves per plant were recorded in control, 3 and 6 leaves per plant defoliation with being the highest in 6 leaves per plant defoliation (38.3). The lowest leaves per plant were recorded in 12 leaves defoliated plants (30.0). The result is consistent with the findings of Fukuchi *et al*. (2004) who reported that leaf number did not decreased at harvest due to partial defoliation in tomato.

For compensation of leaf loss, result revealed that losses of 3 and 6 leaves per plant at flowering stage which was equivalent to 18 and 36% leaf loss of the total, compensated the leaf loss fully even some times greater than control whereas leaves loss of 9 and 12 per plant compensated up to 90 and 82%, respectively. This result indicates that tomato plant has high compensatory capacity of leaf loss during flowering. Andriolo *et al*. (2004) reported that tomato plant had high compensatory capacity of leaf loss at early growth stages that supported the present experimental results. Mondal (2007) removed leaves at different levels of mungbean at flower initiation stage and reported that mungbean plant can compensated leaf loss fully up to 50% defoliation from basal. The leaf number per plant showed significant differences between two varieties. Binatomato-5 produced higher number of leaves per plant (11.5) compared to Binatomato-4 (10.0). Results revealed that Binatomato-5 had greater compensatory capacity of leaf loss than in Binatotomato-4.

Leaf area per plant: Result showed that defoliation had no adverse effect on leaf area development at fruit ripening stage upto 6 leaves defoliation even leaf area increased over control in 3 leaves defoliated plants and thereafter further increased number of leaf loss, the leaf area reduced significantly over control (Table 1). The result indicated that tomato plant can tolerant up to 35-40% leaf losses during flowering start phase. The highest leaf area was recorded in 3 leaves defoliated plant (5906 cm^2 per plant) and the lowest harvest index was observed in 12 leaves defoliated plant (3403 cm^2 per plant). The result was fully supported by Andriolo *et al.* (2004) and Leonardi *et al.* (2004) in tomato who observed that leaf area did not affect due to mild defoliation during flowering or before flowering stage. The higher leaf area was recorded in Binatomato-5 (6324 cm^2 per plant) than the Binatomato-4 (3584 cm^2 per plant). The leaf area was greater in Binatomato-5 than in Binatomato-4 due to production of higher number of leaves per plant in Binatomato-5 compared to Binatomato-4. Genotypic variations in leaf area production were also observed by many workers in tomato (Hossain, 2003; Golok, 2006). In the interaction effect, results revealed that leaf area decreased with increasing defoliation in Binatomato-4 whereas, in Binatomato-5, the leaf area increased compared to control up to 6 leaves defoliation followed by a decline. The highest leaf area was recorded in Binatomato-5 with 3 leaves removal treatment (7880 cm^2 per plant) and the lowest was recorded in Binatomato-4 with 12 leaves removal treatment (2234 cm^2 per plant).

Straw yield: The effect of different levels of defoliation on straw weight per plant statistically significant and showed that defoliation had no adverse effect on straw yield at fruit ripening stage up to 6 leaves defoliation even straw yield increased over control and thereafter further increased number of leaf loss, the straw yield reduced significantly over control (Table 2). The result indicated that tomato plant can tolerant up to 35-40% leaf losses during flowering start phase. The highest straw weight per plant was recorded in 3 leaves defoliated plant (29.61 g) and the lowest straw yield was observed in 12 leaves defoliated plant (22.4 g per plant). The result was fully supported by Andriolo *et al.* (2004) and Leonardi *et al.* (2004) in tomato who observed that starw yield did not affect due to mild defoliation during flowering or before flowering stage. The higher straw yield was recorded in Binatomato-5 (32.1 g per plant) than the Binatomato-4 (21.8 g per plant) due to the production of higher number of leaves per plant. A genotypic variation in leaf area production was also observed by many workers in tomato (Hossain, 2003; Golok, 2006). In the interaction effect, results revealed that straw yield reduction due to defoliation was greater in Binatoamto-4 than in Binatomato-5. The straw yield increased compared to control up to 6 leaves defoliation followed by a decline. The highest straw yield was recorded in Binatomato-5 with 3 leaves removal treatment (33.2 g per plant) and the lowest was recorded in Binatomato-4 with 12 leaves removal treatment (15.3 g per plant).

Reproductive characters

Number of effective flower clusters per plant: The effect of defoliation on effective flower clusters per plant were statistically significant at $p \leq 0.05$ (Table 2). Result revealed that the number of effective flower clusters per plant increased with increasing defoliation up to 6 leaves defoliation followed by a decline. The higher number of effective flower clusters per plant were recorded in 3 and 6 leaves defoliation treatments with being the highest in 6 leaves defoliation treatment (14.5 leaves per plant). Increased number of effective flower clusters plant under 3 and 6 leaves defoliation treated plants might be due to increased number of branches plants. In contrast, the lowest number of effective flower clusters per plant were recorded in 12 leaves defoliation treatment (11.1 per plant) followed by 9 leaves defoliation treatment (12.8 per plant). Partial defoliation increased the number of flower clusters per plant in tomato (Andriolo *et al.*, 2004; Fukuchi *et al.*, 2004). However, variety had no significant different in flower cluster numbers per plant. Similarly, the interaction effect of defoliation and variety had no significant effect on the number of effective flower clusters per plant.

Number of non-effective flower clusters per plant: The higher non-effective flower clusters per plant were observed in 3 and 6 leaves defoliated plants with being the highest in 3 leaves defoliation treatment (3.63 per plant). In contrast, the lowest number of non-effective flower clusters per plant (2.04) were recorded in 12 leaves defoliated plant. Variety had significant effect on the number of non-effective flower clusters per plant (Table 2). The non-effective flower clusters per plant were higher in Binatomato-4 (3.22 per plant) compared to Binatomato-5 (2.70 per plant). In the interaction effect, result revealed that the number of non-effective flower clusters per plant were increased with increasing defoliation up to 6 leaves defoliation followed by a decline in Binatomato-4 whereas it was decreased with increasing defoliation in Binatomato-5 except 9 leaves defoliated plants. The higher non-effective flower clusters per plant were observed in Binatomato-4 with 3 and 6 leaves defoliated plants (4.25 and 4.50 per plant, respectively) and the lowest was recorded in Binatomato-5 with 12 leaves defoliated plant (1.75 per plant). These results are corroborated by Dobromilska and Kujath (2004) and Leonardi *et al.* (2004).

Number of flowers per plant: Result revealed that the number of flowers per plant increased over control up to 9 leaves defoliation followed by a decline. The highest number of flowers per plant were recorded in 6 leaves defoliation treatments (90.0 per plant). Increased number of flowers per plant under 3 and 6 leaves defoliation treated plants might be due to increased number of flower clusters per plant. In contrast, the lowest number of flowers per plant were recorded in 12 leaves defoliation treatment (64.9 per plant) followed by control plant (74.7 per plant). Heuvelink and Buiskool (1995) reported that partial defoliation increased the number of flowers in tomato which supported the present experimental result. Variety had significant effect on the

Table 2: Effect of different levels of defoliation and interaction of variety and defoliation on straw weight and reproductive characters in tomato

Treatments	Straw weight per plant at harvest (g)	Effective clusters per plant (No.)	Non-effective clusters per plant (No.)	Flowers per plant (No.)	Reproductive efficiency (%)
Degree of leaves removal from base (No.)					
Control	28.4[a]	13.1[bc]	3.12[b]	74.7[c]	60.5[a]
3	29.6[a]	14.0[ab]	3.63[a]	78.6[b]	59.9[a]
6	28.8[a]	14.5[a]	3.50[a]	90.0[a]	51.9[b]
9	25.3[b]	12.8[c]	2.50[c]	76.1[bc]	50.3[b]
12	22.4[c]	11.1[d]	2.04[d]	64.9[d]	44.1[c]
Level of significance	**	**	**	**	**
Variety					
Binatomato-4	21.8[b]	12.9	3.22[a]	80.0[a]	50.0[b]
Binatoamto-5	32.1[a]	13.3	2.70[b]	73.8[b]	56.6[a]
Level of significance	**	NS	**	**	**
Interaction of variety and number of leaves removal					
Binatomato-4					
0	24.1[c]	12.8	2.75[cd]	72.2[f]	57.6[b]
3	26.0[c]	13.2	4.25[a]	84.2[bc]	52.4[bc]
6	24.5[c]	14.5	4.50[a]	92.5[a]	47.7[cd]
9	18.8[d]	13.0	2.25[e]	80.7[cd]	46.3[d]
12	15.3[e]	11.0	2.33[de]	70.3[f]	46.1[d]
Binatoamto-5					
0	32.8[a]	13.5	3.50[b]	77.2[de]	63.4[a]
3	33.2[a]	14.7	3.00[c]	73.0[ef]	67.4[a]
6	33.2[a]	14.5	2.50[de]	87.5[b]	56.0[b]
9	31.9[ab]	12.5	2.75[cd]	71.5[f]	54.3[b]
12	29.5[b]	11.3	1.75[f]	59.5[g]	42.1[d]
Level of significance	**	NS	**	**	**
CV (%)		6.64	7.41	3.23	5.91

In a column, figures bearing same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT, NS: Not significant, **Significant at 1% level of probability, CV: Coefficent of variance

number of flowers per plant (Table 2). The flowers per plant were higher in Binatomato-4 (80.0 per plant) compared to Binatomato-5 (73.8 per plant). In the interaction effect, result revealed that the number of flowers per plant were increased over control with increasing defoliation up to 9 leaves defoliation in Binatomato-4 whereas in Binatomato-5, the flower number increased up to 6 leaves defoliation. The highest number of flowers per plant was recorded in Binatomato-4 with 6 leaves defoliated plant (92.5) and the lowest was recorded in Binatomato-5 with 12 leaves defoliated plant (59.5).

Reproductive Efficiency (RE): Result revealed that RE decreased with increasing level of defoliation. The higher RE was observed in control and 3 leaves defoliation treatment with being the highest in control (60.5%) and the lowest was recorded in 12 leaves defoliated plants (44.1). Reduced RE at higher defoliated plants might be due to lower amount of assimilate translocation from leaf to flower which consequence maximum flower aborted. Hasan (2004) and Mondal (2007) observed that RE decreased for higher levels of defoliation in field crops. A significant difference in RE was also observed in two varieties of tomato (Table 2). The higher RE was recorded in Binatomato-5 (56.6%) than the Binatomato-4 (50.0%). Genotypic variation in RE was also observed by Golok (2006) in tomato that also supported the present experimental result. The interaction effect, the highest RE was recorded in Binatomato-5 with 3 leaves defoliated plant (67.4%) followed by Binatomato-5×control (63.4%) with same statistical rank. In contrast, the lowest RE observed in Binatomato-5×12 leaves defoliated plant (42.1%).

Variety and yield contributing characters

Number of fruits per plant: The effect of defoliation on fruit number per plant was statistically significant at $p \leq 0.05$ (Table 3). Result revealed that the number of fruits per plant had no negative effect in 3 and 6 leaves defoliated plant over control. The highest number of fruits per plant were observed in 3 leaves defoliated plant (47.6 per plant) followed by control (45.3 per plant) and 6 leaves defoliated plant (45.4 per plant). In contrast, the lowest number of fruits per plant were recorded in 12 leaves defoliated plant (35.2 per plant). Reduction in the number of fruits per plant under high defoliated condition might be due to lesser leaf area per plant which consequence production of lower amount of assimilate which is not sufficient for bearing maximum fruits. Similar result was also reported by many workers in tomato (Heuvelink and Buiskool, 1995; Leonardi *et al.,* 2004). They

Table 3: Effect of different levels of defoliation and interaction of variety and defoliation on yield contributing characters and yield in tomato

Treatments	Fruits per plant (No.)	Fruits per cluster (No.)	Weight per fruit (g)	Fruit yield per plant (kg)
Degree of leaves removal from base (No.)				
Control	45.3^{b}	3.45^{a}	37.6^{a}	1.63^{a}
3	47.6^{a}	3.49^{a}	37.9^{a}	1.71^{a}
6	45.4^{b}	3.13^{b}	38.2^{a}	1.70^{a}
9	41.2^{c}	3.24^{b}	33.7^{b}	1.43^{b}
12	35.2^{d}	3.12^{b}	30.9^{c}	1.19^{c}
Level of significance	**	**	**	**
Variety				
Binatomato-4	39.8^{b}	3.06^{b}	38.3^{a}	1.62
Binatoamto-5	46.2^{a}	3.51^{a}	33.0^{b}	1.43
Level of significance	**	**	**	NS
Interaction of variety and number of leaves removal				
Binatomato-4				
0	41.6^{de}	3.26^{bcd}	41.6^{a}	1.71^{a}
3	44.0^{cd}	3.32^{a-d}	41.2^{a}	1.80^{a}
6	43.8^{cd}	3.02^{de}	39.7^{ab}	1.76^{a}
9	37.2^{f}	2.86^{e}	35.8^{bc}	1.59^{a}
12	32.2^{g}	2.83^{e}	33.3^{cd}	1.28^{bc}
Binatoamto-5				
0	49.0^{ab}	3.63^{ab}	33.6^{c}	1.55^{ab}
3	51.2^{a}	3.66^{a}	34.6^{c}	1.61^{a}
6	47.0^{a-c}	3.44^{abc}	36.7^{a-c}	1.63^{a}
9	45.2^{bcd}	3.62^{ab}	31.6^{cd}	1.27^{bc}
12	38.2^{cf}	3.40^{a-c}	28.5^{d}	1.09^{c}
Level of significance	*	*	*	*
CV (%)	4.68	5.56	6.94	9.15

In a column, figures bearing same letter(s) do not differ significantly at $p \leq 0.05$ by DMRT, NS: Not significant, *,**Significant at 5 and 1% level of probability, respectively, CV: Coefficient of variance

observed that fruits per plant decreased under heavy defoliated condition in tomato. Variety had significant effect on the number of fruits per plant (Table 3). Binatomato-5 produced higher number of fruits per plant (46.2) than the Binatomato-4 (39.8). In the interaction effect, the higher fruits per plant was recorded in Binatomato-5 with control and 3 leaves defoliated plants with being the highest in 3 leaves defoliated plant (51.2 per plant) and the lowest was recorded in Binatomato-4×12 leaves defoliated plants (32.2 per plant).

Number of fruits per cluster: The higher number of fruits per cluster was observed in control and 3 leaves defoliated plants (3.45 and 3.49 per cluster). The lower number of fruits per cluster was recorded in 6, 9 and 12 leaves defoliated plants with being the lowest in 12 leaves defoliated plants (3.12 per cluster). The higher number of fruits per cluster was recorded in Binatomato-5 (3.51) than the Binatomato-4 (3.06). Genotypic variations in fruits per cluster was also observed by Golok (2006) in tomato. The interaction effect, results revealed that the number of fruits per cluster was less affected by defoliation in Binatomato-5 whereas, Binatomato-4 significantly affected by defoliation. The highest number of fruits per cluster was recorded in Binatomato-5×3 leaves defoliated plants (3.66 per cluster) and the lowest was recorded in Binatomato-4×12 leaves defoliated plants (2.83 per cluster).

Single fruit weight: Result revealed that single fruit weight decreased after 6 leaves defoliation treatment even single fruit weight increased over control in 3 and 6 leaves defoliated plants. The result indicated that assimilate partitioning towards fruits was better under partial defoliated condition in tomato. The higher single fruit weight was observed in control, 3 and 6 leaves defoliated plants with being the highest in 6 leaves defoliated plant (38.2 g). The lowest single fruit weight was recorded in 12 leaves defoliated plants (30.9 g) followed by 9 leaves defoliated plants (33.7 g). Similar result was also reported by many workers in tomato (Andriolo *et al*., 2004; Fukuchi *et al*., 2004; Dobromilska and Kujath, 2004). They observed that weight per fruit decreased only when plants were severely defoliated in tomato. The single fruit weight was greater in Binatomato-4 (38.3 g) than the Binatomato-5 (33.0 g). In the interaction effect, the higher single fruit weight was recorded in Binatomato-4 with control, 3 and 6 leaves defoliated plants with being the highest in control plant (41.6 g). In contrast, the lowest single fruit was recorded in Binatomato-5×12 leaves defoliated plants (28.5 g).

Fruit yield: Defoliations had significant effect on fruit yield per plant (Table 3). Result revealed that fruit yield increased over control up to 6 leaves defoliated plants and thereafter decreased significantly. The higher fruit yield was recorded in control, 3 and 6 leaves defoliated plants and the highest fruit weight was recorded in 3 and 6 leaves defoliated plants (1.70 kg per plant). In contrast, the lowest fruit yield was recorded in 12 leaves defoliated plants (1.19 kg per plant). The result indicates that tomato plant can tolerant up to 6 leaves loss during flowering. The fruit yield per plant increased under 3 and 6 leaves defoliated plants was due to greater number of fruits per plant and larger fruit size compared to control. Again, lower fruit yield per plant under highly defoliated condition was due to might be lesser amount of assimilate produced by the plants through lesser photosynthetic area per plant. The result is consistent with the findings of Heuvelink and Buiskool (1995) and Fukuchi *et al.* (2004) stated that fruit yield did not affect under mild or partial defoliation in tomato. In the interaction effect, result revealed that in Binatomato-4, the fruit yield was not significantly affected by up to 9 leaves defoliation whereas in Binatomato-5, the fruit yield did not affect up to 6 leaves defoliation. The result indicates that the compensation capacity of fruit yield due to leaf loss was greater in Binatomato-4 than the Binatomato-5.

CONCLUSION

Based on the experimental results, it may be concluded that the defoliation of up to 6 leaves from base had no significant negative influence on plant characters and fruit yield of tomato even increased yield over control in 3 and 6 leaves defoliated plants. Binatomato-5 performed superiority in morphological and growth characters over Binatoamto-4 but Binatomato-4 performed superiority in fruit size and yield compared to Binatomato-5.

REFERENCES

Andriolo, J.L., L.L. Falcao, T.S. Duarte and E.C. Skrebsky, 2001. Defoliation of greenhouse tomato plants and its effects on dry matter accumulation and distribution to fruits. Acta Horticulturae, 559: 123-126.

Andriolo, J.L., M.C.G. Espindola, R. Godoi, O.C. Bortolotto and G.L. da Luz, 2004. Growth and fruit yield of greenhouse tomato plants under high plant density and defoliation. Ciencia Rural, 34: 1251-1253.

BINA., 2007. A leaflet of binatomato-4 and binatomato-5. Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh.

Begum, M., A. Hamid, W. Sultana and M.R. Khan, 1997. Effect of defoliation on yield and yield contributing characters of mungbean in relation to nodal position and position of seeds in pod. Bangladesh J. Agric. Res., 22: 43-50.

Bhatt, R.M. and N.K.S. Rao, 2003. Influence of leaf excision on photosynthesis, seed setting and yield in okra. Indian J. Plant Physiol., 8: 345-348.

Borras, L., G.A. Slafer and M.E. Otegui, 2004. Seed dry weight response to source-sink manipulations in wheat, maize and soybean: A quantitative reappraisal. Field Crop Res., 86: 131-146.

Da Silva, L.J., C.D.C. Milagres, D.J.H. da Silva, C. Nick and J.P.A. de Castro, 2011. Basal defoliation and their influence in agronomic and phytopathological traits in tomato plants. Horticultura Brasileira, 29: 377-381.

Dobromilska, R. and K. Kujath, 2004. Effect of leaf cutting and use of reflection material on yield and mineral composition of two cherry tomato cultivars. J. Elementol., 9: 277-284.

Fukuchi, N., S. Motoori and Y. Udagawa, 2004. [Effects fruit thinning and training on tomato yield and fruit soluble solids content]. Hortic. Res., 3: 277-281, (In Japnese).

Golok, C.D., 2006. Evaluation of summer tomato mutants for higher yield and good keeping quality. M.S. Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hachmann, T.L., M.D.M. Echer, G.M. Dalastra, E.S. Vasconcelos and V.F. Guimaraes, 2014. Tomato cultivation under different spacing and different levels of defoliation of basal leaves. Bragantia, 73: 399-406.

Hasan, M.K., 2004. Flowering pattern and reproductive efficiencies in mungbean genotypes. M.S. Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Heuvelink, E. and R.P.M. Buiskool, 1995. Influence of sink-source interaction on dry matter production in tomato. Ann. Bot., 75: 381-389.

Hossain, M.M., 2003. Comparative morpho-physiological studies of some exotic and local genotypes of tomato. M.S. Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Leonardi, C., F. Giuffrida and V. Seiglitano, 2004. Tomato yield and fruit characteristics in relation to basal leaf removal. Acta Horticulturae, 659: 411-416.

Martinez, G., M. Garbi, F.M.J. Artuni, L.M.D. Asborno and M.I. Bulnes, 2001a. Leaf removal in inderminate tomato cultivars and yield response. Agrociencia, 17: 9-14.

Martinez, S., M.C. Grimaldi, M. Garbi and M. Artur, 2001b. Defoliation effect on three phenological stages upon tomato (*Lycopersicon esculentum* Mill.) yield under greenhouse. Agricultura Tecnica, 61: 522-526.

Mondal, M.M.A., 2007. A study of source-sink relationship in mung bean. Ph.D. Thesis, Department of Crop Botany, Bangladesh Agriculture University, Mymensingh, Bangladesh.

Monteiro, C.D., M.E. Balbi, O.G. Miguel, P.T.P.S. Hairstyle and S.M.C. Haracemiv, 2008. Nutritional quality and antioxidant the Italian style tomato. Food Nutr. Mag., 19: 25-31.

Russell, D.F., 1986. MSTAT-C Package Programme. Crop and Soil Science Department, Michigan State University, USA.