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# Judicious Defoliation Increases the Yield of Tomato by Controlling the Morphological Characteristics

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## Abstract

Growers usually practice pruning at vegetative and reproductive stages of staked tomato. This study was conducted during November to March for two successive years of 2016 and 2017 to investigate the effect of defoliations on morphological characters, and yield of tomato. Five levels of defoliation comprising of 0 (control), 3, 6, 9 and 12 leaves from basal 17 leaves were applied at beginning of flowering phase considering two widely cultivated varieties of TM-110 and TM-135. The study was laid out in two factors split-plot design with three replicates where varieties as main plot and defoliation levels as sub-plot. Morphological traits like plant height and leaves per plant were not affected up to 6 leaves defoliation irrespective of genotypes and seasons. Fruit yield (Kg) per plant also not affected up to 6 leaves defoliation, rather increases 10.24% and 2.92% for TM-110 and 11.35% and 5.16% for TM-135 in season 2016 and 2017, respectively. However, in season 2017, TM-110 increases 5.00% yield at 3 leaf defoliation. Heavy defoliation (> 6 leaves) causes reduced plant height and smaller number of leaves per plant for all the cases. Fruit yield per plant also decreased as total sink (flower and fruits) production is hampered due to reduction of source sizes. That's why lowest fruit yield was recorded in 12 leaves defoliated plants. These results indicate that tomato plants can tolerate one-third leaf loss during reproductive stage. Implication of the results in relation to early blight disease management is also crucial.

***Keywords:*** *Tomato; Defoliation; Morphological characters; Fruit yield*

## Introduction

Traditional varieties of tomato (Lycopersicon esculentum Mill.) bears greater sources size than sink being leafy and bushy leading to poor crop performance (Heuvelink and Buiskool, 1995). It means optimum and stable but functional source size is more advantageous to realize the potential sink size under field conditions. Even increased leaf area index (LAI) is not associated with increased fruit production but reaches a plateau (Heuvelink et al., 2005). 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., 2001; Andnolo et al., 2004; Xiao et al., 2004; Heuvelink et al., 2005). That's why, for commercial purposes, leaf pruning should practice maximizing light interception and fruit yield (Andriolo et al. 2001).

Defoliation is not always advantageous, sometimes it has disadvantageous effect in crops (Board and Harville, 1998; Bhatt and Rao, 2003; Leonard et al., 2004; Mondal et al., 2011a, b). For example,

one-third leaf removal from basal portion of the canopy increased fruit yield over control and severe defoliation decreased fruit yield in tomato (Xiao et al., 2004; Heuvelink, 2005). Similarly, mild defoliations (16.6-33%) during reproductive phase do not adversely affect the seed yield in mung bean (Mondal et al., 2011a) and in soybean (Ali et al., 2013). No detail information is available about source-sink relationships in tomato during early reproductive growth stage. These aspects need investigation in tomato genotypes to develop the high yielding variety and to assist in the development of practices under Sub-tropical condition. In tropical and sub-tropical countries, loss of foliage in tomato by leaf-eating insects and diseases is common. The tomato plant can tolerate such source (leaf) damages up to a certain extent without significant yield loss (Martinez et al., 2001). Tomato crop is vulnerable to be infected by bacterial, viral, nematode and fungal diseases. Among the fungal diseases, early leaf blight of tomato caused by Alternaria solani is the worst that causes reduction in quantity and quality of the tomato (Abada et al., 2008). The pathogen causes infection first on old lower leaves, then spread on upper leaves, stem, petiole, twig and fruits leading to the defoliation, drying of twigs and premature fruit drop which ultimately reduce the yield (Gondal et al., 2012). In previous study we found that defoliation of lower leaves at flowering stage did not affect the rest leaves by A. solani. Anyway, removal of full-grown leaves from below is common practice in tomato cultivation. Old leaves are also believed not to contribute to the crop photosynthesis anymore (Hauvelink et al., 2005) but favours dry matter partitioning towards the fruits (Xiao et al., 2004). The purpose of this study was to find out the extent of leaf removal during the beginning of reproductive phase that will increase fruit yield by modifying morphological characteristics of tomato.

## Materials and Methods

### Experimental site

Two experiments were carried out in the farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during two successive seasons (November-March) of 2016-17 and 2017-18. This area is situated at 24°75′ N and 90°50′ E under subtropical climates characterized by heavy rainfall from April to September and scanty rainfall from October to March. Soil of the site was sandy loam having a total nitrogen 0.065%, organic matter 1.07%, available phosphorus 18.5 ppm, exchangeable potassium 0.30 meq 100g-1, sulphur 20 ppm and pH 6.8.

### Treatments and experimental design

The experiment comprised of two factors: five defoliation levels of 0 (control), 3, 6, 9 and 12 leaves removal from base of the plant out of 16 or 17 leaves at the beginning of flowering. Two recently released tomato cultivars (TM-110 and TM-135) were used as planting material. The experimental design was split plot with three replicates where varieties as main plot and defoliation levels as sub-plot. The sub-plot consisted of 6 rows including two borderlines on either side. The unit plot size was 3m × 4m.

### Management practices

For the first experiment, seeds were sown in seedbed on 29 October 2016 and 27-day old seedlings were transplanted in the experimental field with spacing of 50 cm × 50 cm. In the second experiment, seeds were sown in seedbed on 26 October 2017 and 25-day old seedlings were transplanted in the experimental field with same spacing. Urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and cow dung were applied at the rate of 280, 250, 180, 80 and 10000 kg/ha, respectively (BARC, 2012). Total amount of TSP, gypsum and cow dung; half of MP were applied as basal dose during final land preparation. The remaining half of MP was applied as top dress at 45 days after transplanting (DAT). Half of urea was applied as top dress at 21 days after transplanting and remaining half was applied at 45 days after transplanting. Irrigation, weeding, pruning, stalking, pesticides spray and other intercultural operations were done when required.

### Parameters measured

To study growth characteristics, a total of two harvests were made. The second rows from the border of each plot were used for sampling. The first and second crop sampling was done at 40 and 60 DAT. Five plants were randomly selected from each plot during each sampling date and uprooted for collecting necessary parameters. At harvest, ten plants from each plot were selected randomly for data recording on morphological, yield and yield related traits. Fruit yield was collected from each plot excluding border line and converted into tonnes per hectare. Harvesting was done at different dates depending on fruit ripening.

### Statistical analysis

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

### Defoliation and Variety for Morphological Characters

Defoliation and Variety significantly influenced the morphological traits including plant height and number of leaves per plant (Table 1). Defoliation up to six leaves out of 17 showed similar or sometimes greater plant height and leaves per plant with that of control in both growing seasons. This means that 36% leaf removal from bottom of the canopy does not affect plant height and number of leaves per plant, even increase in some cases. In contrast, defoliation beyond 36% or more than 6 leaves per plant out of 17 leaves caused significant reduction in plant height and leaves per plant with being the lowest in 12 leaves removal. Anyway, removal up to 6 leaves (36% of control) compensated the loss fully at harvest, even sometimes 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 starting of flowering phase. Between the two varieties, plant height, leaf number per plant and percent leaf compensation were greater in TM-135 than in TM-110.

| Treatments | Plant height (cm) | | Leaves no. per plant at first fruit harvest | | Leaves no. per plant at treatment impose | | Compensation of leaf loss over control (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Defoliation | | | | | | | | |
| Control | 89.0 a | 78.8 ab | 56.93 a | 36.4 a | 16.50 a | 16.8 a | --- | --- |
| 3 | 89.0 a | 79.5 a | 56.75 a | 37.6 a | 13.50 b (18.2) | 13.8 b (17.9) | 100.0 a | 100.0 a |
| 6 | 85.2 ab | 80.0 a | 53.42 ab | 38.3 a | 10.50 c (36.4) | 10.8 c (35.7) | 94.06 b | 100.0 a |
| 9 | 79.6 cd | 73.9 c | 47.25 c | 32.5 b | 7.50 d (54.5) | 7.75 d (53.6) | 81.87 c | 89.8 b |
| 12 | 76.3 d | 67.7 d | 43.05 d | 30.0 c | 4.50 e (72.7) | 4.75 e (71.4) | 74.96 d | 82.4 c |
| Level of significance | ** | ** | ** | ** | ** | ** | ** | ** |
| Variety | | | | | | | | |
| TM-110 | 80.2 b | 66.3 b | 43.33 b | 33.3 b | 10.00 b | 10.0 b | 67.71 b | 73.9 |
| TM-135 | 87.5 a | 85.7 a | 59.63 a | 36.7 a | 11.00 a | 11.5 a | 72.65 a | 75.0 |
| Level of significance | ** | ** | ** | * | ** | ** | ** | NS |

In column, within treatment, figures with same letter (s) do not differ significantly at P ≤ 0.05 by DMRT; *and **indicate significance at 5% and 1% level of probability, respectively; NS, not significant; The figures in parenthesis indicate percent leaf loss over control.

***Table 1:*** *Effect of different level of defoliation and variety on morphological characters in tomato.*

Interaction of variety and defoliation also have significant role to control the morphological traits (Table 2). This revealed that the reduction trend in plant height and leaves per plant due to defoliation was not similar in both the varieties. The reduction in plant height and number of leaves was greater in TM-110 than in TM-135. Similarly, percent compensation of leaves loss due to defoliation was also higher in TM-135 than in TM-110.

### Effect of variety and defoliation on yield

Defoliation has significant role to increase the fruit yield per plant (Table 3). Removal of leaves increases the yield statically for 3 and 6 leaves but decreases for 9 leaves and lowest at 12 leaves defoliation. In season 2016, 3.73% and 11.19% yield increased over control from 3 and 6 leaf defoliated plants while 2.24% and 21.64% yield decreased for 9 and 12 leaves defoliation. In season 2017, 4.91% and 4.29% yield increased over control for 3 and 6 leaves defoliation, respectively while 12.27% and 26.99% yield decreased when 9 and 12 leaves were defoliated. These results thus revealed that up to 6 leaves defoliation (36% of control) can increase the yield without interrupting plant height and leaves number per plant at harvest.

| Treatments | | Plant height (cm) | | Leaves per plant at first fruit harvest | | Leaves per plant at treatment impose | | Compensation of leaf loss over control (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Variety | Defoliation | | | | | | | | |
| TM-110 | Control | 86.0 b | 69.0 e | 49.6 cd | 34.8 cd | 16.0 b | 16.0 b | --- | --- |
| | 3 | 85.5 b | 69.2 e | 48.8 cd | 35.2 bc | 13.0 d | 13.0 d | 100.0 a | 100 a |
| | 6 | 83.8 bc | 71.8 d | 47.5 d | 37.0 ab | 10.0 f | 10.0 f | 95.8 ab | 100 a |
| | 9 | 73.8 d | 65.5 f | 36.2 e | 31.0 de | 7.0 h | 7.0 h | 73.0 e | 89.1 b |
| | 12 | 72.0 d | 55.7 g | 34.6 e | 28.0 e | 4.0 j | 4.0 j | 69.8 e | 80.5 d |
| TM-135 | Control | 92.0 a | 88.5 a | 64.2 a | 38.0 ab | 17.0 a | 17.5 a | --- | --- |
| | 3 | 92.5 a | 89.7 a | 64.8 a | 40.0 a | 14.0 c | 14.5 c | 100.0 a | 100 a |
| | 6 | 86.7 b | 88.3 a | 59.3 b | 39.7 ab | 11.0 e | 11.5 e | 92.3 bc | 100 a |
| | 9 | 85.5 b | 82.3 b | 58.3 b | 34.0 cd | 8.0 g | 8.5 g | 90.7 c | 89.5 b |
| | 12 | 80.7 c | 79.8 c | 51.5 c | 32.0 de | 5.0 i | 5.5 i | 80.2 d | 84.2 c |
| Level of significance | | * | ** | ** | * | ** | NS | ** | NS |
| CV (%) | | 3.68 | 2.42 | 4.90 | 6.40 | 4.55 | 5.29 | 4.92 | 5.64 |

In a column, within treatment, figures bearing same letter (s) do not differ significantly at P ≤ 0.05 by DMRT; * and ** indicate significance at 5% and 1% level of probability, respectively, NS, not significant.

***Table 2:*** *Interaction of different level of defoliation and variety on morphological characters of tomato.*

| Treatments | Fruit yield per plant (Kg) | | Yield change over control (%) | |
|---|---|---|---|---|
| | 2016 | 2017 | 2016 | 2017 |
| Defoliation | | | | |
| Control | 1.34 c | 1.63 a | 0.00 | 0.00 |
| 3 | 1.39 b | 1.71 a | + 3.73 | + 4.91 |
| 6 | 1.49 a | 1.70 a | + 11.19 | + 4.29 |
| 9 | 1.31 c | 1.43 b | - 2.24 | - 12.27 |
| 12 | 1.05 d | 1.19 c | - 21.64 | - 26.99 |
| Level of significance | ** | ** | | |
| Variety | | | | |
| TM-110 | 1.25 b | 1.62 | - 6.72 | - 0.61 |
| TM-135 | 1.38 a | 1.43 | + 2.99 | + 12.27 |
| Level of significance | * | NS | | |

In column, within treatment, figures with same letter (s) do not differ significantly at P ≤ 0.05 by DMRT; *and **indicate significance at 5% and 1% level of probability, respectively, NS, not significant.

***Table 3:*** *Effect of different level of defoliation and variety on yield of tomato.*

Variety and defoliation interaction also has significant role to increase the fruit yield per plant (Table 4). In this context, both the varieties increase the yield for removal of 3 and 6 leaves but decreases for 9 leaves and lowest at 12 leaves defoliation. TM-110 variety increased 4.72% and 10.24% yield over control for 3 and 6 leaf defoliation, respectively in season 2016 while 2.84% and 11.35% yield increased for the same in case of TM-135 in season 2016 but decreased 5.67% and 19.86% for 9 and 12 leaves defoliation. In season 2017, 5.0% and 2.92% yield increased over control for 3 and 6 leaves defoliation, respectively for TM-110 while 7.02% and 25.15% yield decreased for 9 and 12 leaves defoliation. In contrast, 3.87% and 5.16% yield increased over control when 3 and 6 leaves defoliated, respectively in TM-135 while 18.06% and 29.68% decreased on 9 and 12 leaves defoliation, respectively. These results thus revealed both the varieties increases yield up to 6 leaves defoliation (36% of control) but decreased for 9 leaf defoliation and lowest at 12 leaf defoliation.

## Discussion

Results indicated that at harvest, tomato plant compensated its leaf loss. Losses of 3 and 6 leaves plant$^{-1}$ at flowering stage, which was equivalent to 18 and 36% leaf loss of the total, compensated the leaf loss fully even sometimes greater that control, whereas leaves

| Treatments | | Fruit yield per plant (kg) | | Yield change over control (%) | |
|---|---|---|---|---|---|
| | | 2016 | 2017 | 2016 | 2017 |
| Variety | Defoliation | | | | |
| TM-110 | Control | 1.27 c | 1.71 a | 0.00 | 0.00 |
| | 3 | 1.33 bc | 1.80 a | + 4.72 | + 5.00 |
| | 6 | 1.40 b | 1.76 a | + 10.24 | + 2.92 |
| | 9 | 1.28 c | 1.59 | + 0.79 | - 7.02 |
| | 12 | 0.97 e | 1.28 bc | - 23.62 | - 25.15 |
| TM-135 | Control | 1.41 b | 1.55 ab | 0.00 | 0.00 |
| | 3 | 1.45 b | 1.61 a | + 2.84 | + 3.87 |
| | 6 | 1.57 a | 1.63 a | + 11.35 | + 5.16 |
| | 9 | 1.33 bc | 1.27 bc | - 5.67 | - 18.06 |
| | 12 | 1.13 d | 1.09 c | - 19.86 | - 29.68 |
| Level of significance | | NS | * | | |
| CV (%) | | 7.44 | 9.19 | | |

In a column, within treatment, figures bearing same letter (s) do not differ significantly at P ≤ 0.05 by DMRT; * and ** indicate significance at 5% and 1% level of probability, respectively, NS, not significant.

***Table 4:*** *Interaction of different level of defoliation and variety on yield of tomato.*

loss of 9 and 12 plant$^{-1}$ compensated up to 90 and 82%, respectively, due to regrowth of leaves. This result indicates that tomato plant has high compensatory capacity of leaf loss during flowering stage. The result is consistent with the findings of Fukuchi et al. (2004), who reported that leaf number did not decrease at harvest due to partial defoliation in tomato. Andnolo et al. (2004) reported that tomato plant had high compensatory capacity of leaf loss at early growth stages that supported the present results. Further, removal of 36% or less of tomato leaves at flowering start stage had no significant negative effect on morphological characters and fruit yield. Thus, up to 36% of the total leaf area in healthy tomato plants was apparently not required to supported normal fruit yield. However, fruit yield plant$^{-1}$ increased under 3 and 6 leaves defoliated plants may be due to greater number of fruits plant$^{-1}$ and larger fruit size compared to control. This result is consistent with the findings of Heuvelink and Buiskool (1995) and Fukuchi et al. (2004) in tomato. They observed that fruit yields were not affect under mild or partial defoliation in tomato. Xiao et al. (2004) found that removing one in every three young leaves did not result in any significant loss in yield of tomato. Again, lower fruit yield per plant under heavy defoliated condition was due to fewer numbers of fruit and smaller size fruits. Reduction in the number of fruits plant$^{-1}$ under high defoliated condition might be due to lesser leaf area plant$^{-1}$ which consequence production of lower amount of assimilate that is not sufficient for bearing maximum fruits. Similar result was also reported by many workers in tomato (Stary, 1983; Leonard et al., 2004). They observed that fruits plant$^{-1}$ decreased under heavy defoliated condition in tomato.

## Conclusion

Leaf loss through insect attack, disease and other environmental hazards at bud initiation stage up to 36% may not affect fruit yield in tomato as was investigated in this study. This suggests that removal of lower leaves up to 36% check early leaf blight which other ways save environmental hazards by avoiding fungicide spray. Therefore, it may not be advisable to spray pesticide for controlling pests in tomato variety at one-third loss of leaf surface to save environment from pollution.

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## References

1. Heuvelink E, Buiskool RPM. (1995). Influence of sink-source interaction on dry matter production in tomato. Annals of Botany 75: 381-389.
2. Heuvelink E, Bakker MJ, Elings A, Kaarsemaker R, Marcelis LFM. (2005). Effect of leaf area on tomato yield. Acta Horticulturae 691: 43-50.
3. Martinez GSB, Garbi LM, Artuni FMJ, Asborno LMD, Bulnes MI. (2001). Leaf removal in indeterminate tomato cultivars and yield response. Agro-Ciencia 17: 9-14.
4. Andriolo JL, Espindola MCG, Godoi R, Bortolotto OC, da Luz GL. (2004). Growth and fruit yield of greenhouse tomato plants under high plant density and defoliation. Ciencia Rural 34(4): 1251-1253.
5. Xiao S, van der Ploeg A, Bakker MJ, Heuvelink E. (2004). Two instead of three leaves between tomato trusses: measured and simulated effects on partitioning and yield. Acta Horticulturae 654: 303-308.

6. Andnolo JL, Falcao LL, Duarte TS. (2001). Defoliation of greenhouse tomato plants and its effects on dry matter accumulation and distribution to fruits. Acta Horticulturae 59: 123-126.
7. Board JE, Harville BG. (1998). Late planted soybean yield response to reproductive source/sink stress. Crop Science 38: 763-771.
8. Bhatt RM, Rao NKS. (2003). Influence of leaf excision on photosynthesis, seed setting and yield in okra. Indian Journal Plant Physiology 8(4): 345-348.
9. Leonardi C, Giuffrida F, Sciglitano V. (2004). Tomato yield and fruit characteristics in relation to basal leaf removal. Acta Horticulturae 659: 411-416.
10. Mondal MMA, Fakir MSA, Ismail MR, Ashrafuzzaman M. (2011a). Effect of defoliation on growth, reproductive characters and yield in mungbean [Vigna radiata (L) Wilczek]. Australian Journal of Crop Science 5(8): 987-992.
11. Mondal MMA, Rahman MA, Akter MB, Fakir MSA. (2011b). Effect of defoliation during reproductive stage on yield in mungbean [Vigna radiata Wilczek]. Legume Research-An International Journal 34(3): 222-225.
12. Heuvelink E. (2005). Tomatoes. Crop production science in Horticulture 13. Edited by E. Heuvelink, Wallingford, UK: CABI publishing, pp. 339.
13. Ali MR, Ashrafuzzaman M, Malek MA, Mondal MMA, Rafii MY, Puteh A. (2013). Defoliation and its effect on morphology, biochemical parameters, yield and yield attributes of soybean. Research on Crops 14(2): 500-506.
14. Abada KA, Mostafa SH, Mervat R. (2008). Effect of some chemical salts on suppressing the infection by early blight disease of tomato. Egyptian Journal of Applied Science 23: 47-58.
15. Gondal AS, Ijaz M, Riaz K, Khan AR. (2012). Effect of different doses of fungicide (Mancozeb) against Alternaria leaf blight of tomato in Tunnel. Journal of Plant Pathology and Microbiology 3: 125-128.
16. BARC, (2012). Fertilizer Recommendation guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. p. 54.
17. Russell DF. (1986). MSTAT-C Package Programme. Crop and Soil Science Department, Michigan Univ, USA.
18. Fukuchi N, Motoori S, Udagawa Y. (2004). Effect of fruit thinning and defoliations on tomato yield and fruit soluble solid content. Hort. Res. Japan 3: 277-281.
19. Stary DL. (1983). The effect of artificial defoliation on the yield of tomato plants. Journal of Horticultural Science 58: 117-120.