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EFFECT OF DEFOLIATION ON GROWTH AND YIELD OF MAIZE

M.N. Jahan, M.A. Hasan and M.R. Islam

Department of Crop Physiology and Ecology, Faculty of Agriculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur–5200, Bangladesh
Corresponding E-mail: rabiulislam@hstu.ac.bd

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Abstract

The experiment was conducted to evaluate the effect of defoliation on grain and fodder yield of maize at the research field and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period of December 2018 to June 2019. The trial was carried out in a randomized completely block design with three replications. The experimental treatments were: T_1– Control (without leaf removal), T_2–Defoliating all leaves except ear and adjacent two leaves above the ear at 7 days after silking (DAS), T_3–Defoliating all leaves except ear and adjacent two leaves above the ear at 14DAS, T_4–Defoliating all leaves below the ear at 7 DAS, T_5–Defoliating all leaves below the ear at 14 DAS, T_6– Detopping except two leaves above the ear at 7 DAS and T_7–Detopping except two leaves above the ear at 14 DAS. Light intensity was increased (66.9 to 81.05%) when only lower leaves (T_5) or both upper and lower leaves (T_2) were removed, but when only the upper leaves (T_6) were removed it was not increased. SPAD value was increased (13.58 to 24.5%) but number of leaves and leaf area plant^{-1} were reduced (60.5 to 63.09% and 64.4%) due to defoliation. Substantial amount of green fodder was obtained (0.776 Kg m^{-2}) due to defoliation of maize. Grain yield of maize was reduced (5.56 to 21.83%) due to different defoliation treatments but the yield reduction was not significant when only lower (T_4) or upper (T_7) leaves were removed.

Introduction

Maize (*Zea mays* L.) belongs to the family Poaceae is the world's most widely grown cereal and global production revealed 1398.3 million metric tons in 2018–2019 (USDA, 2019), it is one of the most important crops in Bangladesh, which can be well–fitted in the cropping systems (Hashem *et al.*, 1983). Its demand is increasing day by day and becoming an important cereal crop for its high productivity and diversified use (food items for human, fodder for livestock, feeds for poultry, fuel and raw materials for industry) in Bangladesh (Islam and Kaul, 1986). Maize production in Bangladesh was 3500 thousand metric ton in the year 2018–2019 (USDA, 2019). Maize can be conserved as silage, which is a nutritious green fodder for livestock. Artificial defoliation provides lot of green fodder at the time of fodder scarcity; hence, defoliation in maize has great impact at broad spectrum for livestock production.

Location of individual leaves with respect to the ear and photosynthetic efficiency of a variety decides photosynthate translocation rate to the ear. It is estimated that the middle four leaves (2 above and 2 below the ear) approximately contributes 50 percent of the total dry matter accumulation in the ear (Allison and Watson, 1966). Defoliation of maize hybrids at later developmental stages (e.g. V11, VT, R3 and R5) reduced grain yield (Hicks *et al.*, 1977). But, when defoliation of leaves occur after ear development; plant l have the advantage of some photosynthetic activity of the leaves and therefore, produces more seeds than the leaves defoliated earlier. Proper time and level of defoliation seems to be very important for controlling lodging and obtaining enough forage without reducing grain yield (Usman *et al.*, 2007). The information on proper timing and level of defoliation in maize leaves is scarce in Bangladesh. Therefore, the present study was conducted to know the impact of different levels of defoliation on growth and yield (grain and forage) of maize.

Materials and Methods

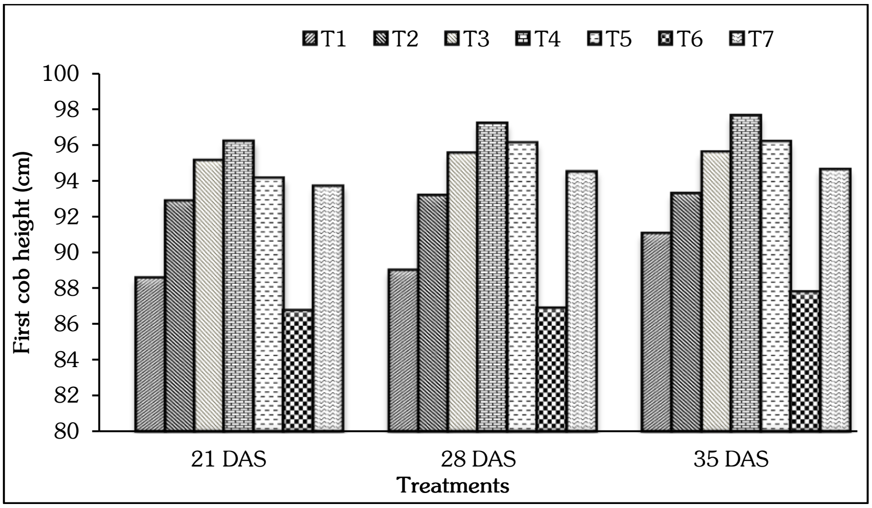
The experiment was set up at the research field (latitude, longitude and elevation were 25º39′ N, 88º41′ E and 37.58 m, respectively) of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during December 2018 to June 2019. The unit plot size (2.4 m × 2.0 m) was used for the experiment. The research was conducted following randomized completely block design (RCBD) with three replications and seven treatments. The treatments were: T_1 (Control i.e. without leaf removal), T_2 (Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS),T_3 (Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS), T_4 (Defoliating all leaves below ear at 7 DAS), T_5 (Defoliating all leaves below ear at 14 DAS), T_6 (Detopping except two leaves above the ear at 7 DAS) and T_7 (Detopping except two leaves above the ear at 14 DAS). A fertilizer dose of 86.0, 26.0, 41.0, 19.0, 6.0, 1.0 and 0.5 kg ha^{-1} N, P, K, S, Mg, Zn and B was applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, magnesium sulphate, zinc sulphate and boric acid (FRG, 2018). All fertilizers were applied as basal dose together with 1/3 urea and after irrigations 2/3 urea was top dressed. Seeds of hybrid maize PAC 293, Advanta-BRAC were sown on December 1, 2018 at a row spacing of 60 and plant spacing 20 cm. Two seeds were placed in each hole and after emergence healthy one seedling was kept. Maize cobs harvested manually at physiological maturity stage (husk has turned yellow and the seeds were hard enough), dehusked and dried separately under shade. Shelling was done with single cob maize Sheller and seeds were dried under shade till moisture content reached 12%. Five maize plants from each plot were randomly selected for data collection. The parameters first cob height, leaf number $plant^{-1}$, light intensity in crop canopy and SPAD (soil plant analyses development) values were collected at 21, 28 and 35 DAS. Light intensity in crop canopy (lux) was recorded using Light Meter (Model: LX–102, origin: China) at noon under bright sunshine and less wind conditions. The sensor of the instruments was placed on the ground level at away from the edges of four corners. SPAD value was recorded from tagged plants from each plot using self–calibrating Minolta Chlorophyll Meter (Model: SPAD–505, Minolta Co. Ltd., Japan) using the middle portion of cob bearing leaves. Leaf area (cm^2) was calculated using the formula of Kvet *et al.* (1971) as Leaf area $plant^{-1}$ = Mean leaf area 0.75 leaf number; where, 0.75 is a factor. Cob length, cob diameter, number of rows of grains cob^{-1}, number of grains row^{-1}, grain number cob^{-1}, single cob weight, weight of hundred grains, and grain, stover and green fodder yield also evaluated. The data were analyzed using Statistix 10 program and treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Results and Discussion

Growth parameters, light intensity and SPAD values of maize

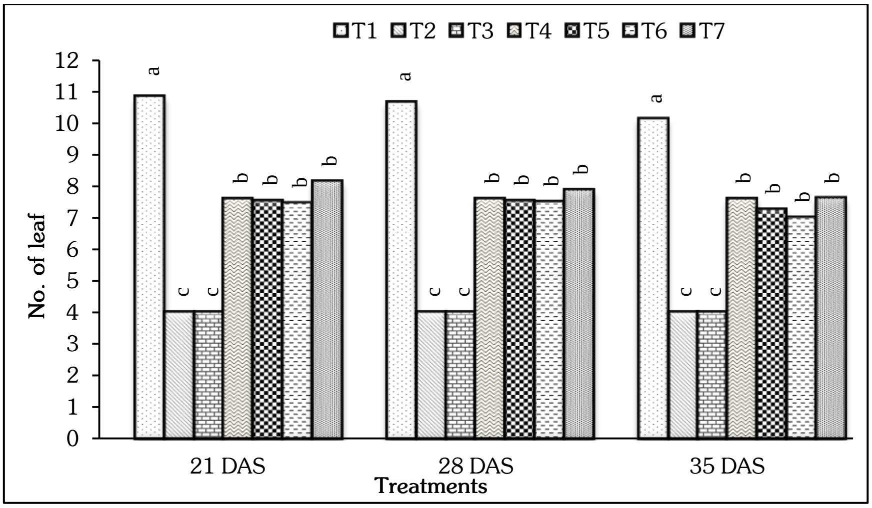
Growth attributes such as the first cob height (Figure 1) of maize plants was not significantly influenced by different defoliation treatments at 21, 28 and 35 days after silking (DAS) but number of leaves (Figure 2) and leaf area $plant^{-1}$ (Figure 3) varied significantly. The maximum number of leaves were obtained by T_1 (10.84, 10.66 and 10.13, respectively) followed by T_7,

T_6, T_5 and T_4; whereas the lowest number of leaves (4.00) in T_2 and T_3 treatments. The maximum leaf area plant^{-1} (0.749 m^2) was recorded in T_1 which was followed by T_7, T_4, T_5 and T_6 treatments and the lowest (0.2667 m^2) in T_2 which was statistically similar to T_3 treatment.



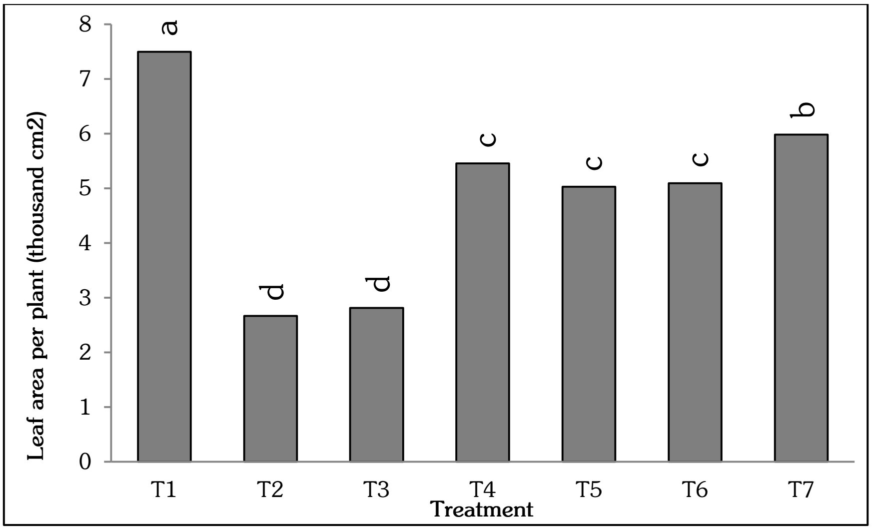
Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS, Treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Fig. 1. Effect of defoliation on first cob height of plant at 21, 28 and 35 DAS in maize.



Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS. Treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Fig. 2. Effect of defoliation on number of leaf plant^{-1}at 21, 28 and 35 DAS in maize.

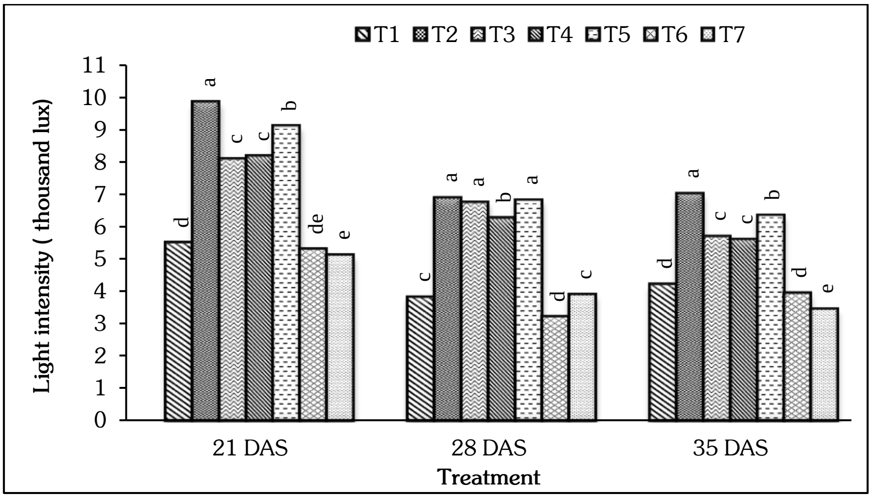


Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS. Treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Fig. 3. Effect of different levels of defoliation on leaf area plant^{-1} in maize.

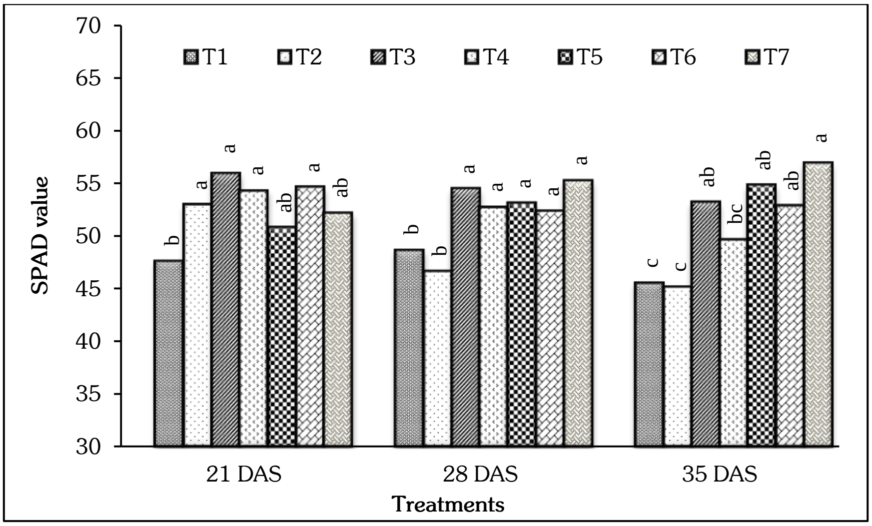
The light intensity in canopy (Figure 4) and SPAD values of leaves (Figure 5) at 21, 28 and 35 DAS were significantly influenced by different defoliation treatments of maize. The maximum light intensity in canopy (9.84 thousand lux) at 21 DAS was recorded in T_2 which was followed by T_5, T_4 and T_3 and the lowest light intensity in canopy (5.08 thousand lux) in T_6 which was statistically identical to T_7 and T_1 treatment. Similar pattern of light intensity in canopy also found at 28 and 35 DAS. The maximum SPAD value (55.86) at 21 DAS was found in T_3 which was statistically at par to T_6, T_4, T_2, T_7 and T_5 treatments. The lowest SPAD value (47.56) was recorded in T_1 treatment. The maximum SPAD value (55.2) at 28 DAS was found in T_7 which was statistically identical to those observed in T_3, T_5, T_4 and T_6 treatments. The lowest SPAD value (46.6) was recorded in T_2followed by T_1 treatment. The maize plant showed almost similar SPAD values at 35 DAS as like as 28 DAS.

The significant differences in number of leaves at 21, 28 and 35 DAS was noticed and it might be due to the obligation of defoliation treatments after 7 and 14 DAS. These findings are quite similar to those of Vasilas and Seif (1985) in corn. They revealed significant differences in number of leaves, leaf area plant^{-1} and LAI at 90 DAS and at harvest noticed among the levels of defoliation may be due to imposition of defoliation treatments after 65 DAS. Removing of leaves either 3 or 4 had a greater impact on LAI than removal of 1 and 2 leaves because of the difference in size of leaves; leaves nearest ear were larger than those further from the ear (Keating and Wafula 1992). Effects of leaf removing on LAI were different according to the intensity of defoliation and leaf position (Barimavandi *et al.*, 2010). The results of the present study revealed that when only lower leaves or both upper and lower leaves removed, the canopy density at lower portion was decreased and light intensity was increased but when only the upper leaves were removed light intensity in the canopy was not increased. Heidari (2012) also reported that the upper leaves are more efficient in absorbing light than lower leaves. The variation in SPAD value due to application of leaf clipping and density was found more conspicuously at later stage of crop growth rather than early stages. In general, the higher the level of leaf clipping, higher was the SPAD value at the later stage of crop growth except highest density of leaf clipping (D_3C_4).



Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS. Treatment means compared by Tukey's Range Test at P ≤ 5% level.

Fig. 4. Effect of defoliation on light intensity in canopy at 21, 28 and 35 DAS in maize.



Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS. Treatment means compared by Tukey's Range Test at P ≤ 5% level.

Fig. 5. Effect of defoliation on SPAD value at 21, 28 and 35 DAS in maize.

Regardless of density SPAD value in every treatment plants declined sharply from 14 DAS compared to clipping treatments. This might be due to the greater demand of cob development and its maturation along with scarcity of leaves (Emran, 2010).

Yield contributing traits

Yield contributing traits such as cob length, number of grains row^{-1}, and number of grains cob^{-1}, single cob weight, grain weight cob^{-1}, 100-grain weight were significantly influenced by different defoliation treatments but cob diameter and number of rows cob^{-1} insignificant (Table 1). The maximum cob length (17.01 cm) was found in T_7 which was followed by T_6 and T_5 and the lowest cob length (14.41 cm) in T_2 which followed by T_3. However, the cob length was reduced 8.39 percent in T_2, 3.6 percent at 14 DAS (T_3), while it was increased 5.72% in treatmentT_4, 6.48% in T_5, 6.99% at T_6 and 8.13% in treatment T_7. The percent reduction in number of grains row^{-1} were 19.78 in treatment T_2, while 3.31, 4.72, 1.05, 2.62, T_3, 3.31% reduction revealed in T_4, T_5, T_6 and T_7 treatments, respectively. The maximum number of grains cob^{-1} (573.25) was found in T_1 which was statistically identical to T_4, T_5, T_7 and T_3 treatments and the lowest number of grains cob^{-1} (472.33) in T_2. Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS (T_2) reduced the number of grains cob^{-1} compared to other treatments. The highest single cob weight (185.8 g) was found in T_1 which was statistically identical to T_4, T_7 and T_5 treatments and the lowest single cob weight (130.5 g) in T_2. However, the percent reduction in single cob weight were 29.76 percent in T_2, 13.61 percent in T_3, 5.16 percent in T_4, 6.67 percent in T_5, 10.22 percent in T_6 and 5.22 percent in T_7 treatments. The maximum grain weight cob^{-1}(156.9 g) was recorded in T_1 which was statistically similar to T_4 and T_7. The lowest grain weight cob^{-1} (112.6 g) was obtained from in T_2 treatment. However, the percent reduction in grain weight cob^{-1} were 28.23 percent in T_2, 12.81 percent in T_3, 4.39 percent in T_4, 6.30 percent in T_5, 9.24 percent in T_6 and 3.95 percent in T_7 treatments. The maximum 100–grain weight (28.93 g) was found in T_1 which was statistically identical to T_4, T_5, T_7 and T_6 treatments and the lowest 100–grain weight (25.86 g) in T_2 treatments. However, the percent reduction in 100–grain weight, were 10.61 percent in T_2, 4.59 percent in T_3, 1.97 percent in T_4, 0.95 percent in T_5, 3.45 percent in T_6 and 2.86 percent in T_7 treatment.

The intensities of defoliation and position of leaves on the plant and defoliation time are the most effective factors on the ear length (Tilahun, 1993). Emam *et al.* (2013) and Souza *et al.* (2015) revealed the artificial defoliation in reproductive stages responsible for reduction of cob length. These outputs support the present findings. Leaf situated one or two above the ear is the principle source of assimilates for the cob development. Reductions of the ear diameter in maize at vegetative and reproductive stages due to defoliation were observed by Souza *et al.* (2015), this result is in parallel with the present findings. This result are in accordance with the findings of Barimavandi *et al.* (2010), Heidari (2013) and Jalilian and Delkhoshi (2014) who reported that removing of above leaves of ear could decrease the number of grains in row. Kabiri (1996) and Echarte *et al.* (2006) stated that leaf removal at 50% silking resulted in the loss of grain number and so, less stem reserves were exploited because of the deficiency of physiological sinks. These outputs support the findings of present investigation. According to Alvim *et al.* (2011), photosynthetically active leaf area loss above the ear affects the cob mass of maize due to defoliation. Zewdu and Asregid (2001) also reported that cob weight was reduced under defoliation. Heidari (2012) who noted that cob weight was decreased with increasing defoliation intensity. Presence of two above leaves is important to form ear with thick and big skin. This skin photosynthesis and reserves had a remarkable effect on row number, length and weight of cob. These findings are in agreements with the present outputs. It seems that seed weight is more dependent on genetic factors than environmental factors (Heidari *et al.*, 2009). However, it was reported that in maize no defoliation produced the maximum seed weight cob^{-1} and minimum seed weight cob^{-1} was obtained in defoliation of all leaves below cob at two weeks after mid silking stage (Chaudhary *et al.*, 2005). The reason for decreasing grain weight cob^{-1} in D_1 might be due to lower dry matter accumulation and less translocation of assimilates to grains as affected by early stages of detopping (Maposse and Nhampalele, 2009). Assimilate availability can effect mean grain weight at early grain development stages, so that increasing availability of assimilate at later stages of grain filling would not affect mean grain weight (Lauer *et al.* 2004).

Table 1. Influence of different levels of defoliation on yield contributing traits of maize at different days after silking

Treatments	Cob length		Cob diameter		Number of rows cob^{-1}		Number of grains row^{-1}	
	cm	% change over control	cm	% Change over control	No.	% Change over control	No.	% Change over control
T_1	15.73 d	–	15.52	–	15.06	–	38.06 a	–
T_2	14.41 f	–8.39	14.54	–6.31	15.46	+2.65	30.53 b	–19.78
T_3	15.15 e	–3.60	15.17	–2.25	14.80	–1.72	36.80 a	–3.31
T_4	16.60 c	+5.72	15.37	–0.96	15.46	+2.65	36.26 a	–4.72
T_5	16.75 bc	+6.48	15.14	–2.44	14.80	–1.72	37.66 a	–1.05
T_6	16.83 b	+6.99	15.01	–3.28	14.13	–6.17	37.06 a	–2.62
T_7	17.01 a	+8.13	15.31	–1.35	14.80	–1.72	36.80 a	–3.31
CV (%)	4.35		3.29		3.11		1.42	

Table 1 Continued

Treatments	Number of grains cob^{-1}		Single cob weight		Grain weight cob^{-1}		100 -grain weight	
	No.	% Change over control	g	% Change over control	g	% Change over control	g	% Change over control
T_1	573.25 a	–	185.8 a	–	156.9 a	–	28.93 a	–
T_2	472.33 c	–17.60	130.5 d	–29.76	112.6 d	–28.23	25.86 c	–10.61
T_3	544.77 ab	–4.96	160.5 c	–13.61	136.8 cd	–12.81	27.60 b	–4.59
T_4	560.93 ab	–2.14	176.2 ab	–5.16	150.0 ab	–4.39	28.36 ab	–1.97
T_5	557.38 ab	–2.76	173.4 ab	–6.67	147.0 b	–6.30	28.66 ab	–0.95
T_6	524.00 b	–8.59	166.8 bc	–10.22	142.4 c	–9.24	27.93 ab	–3.45
T_7	545.58 ab	–4.82	176.1 ab	–5.22	150.7ab	–3.95	28.10 ab	–2.86
CV (%)	3.70		4.05		13.07		2.21%	

Here, T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS, Treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS (T_2) reduced the 100–grain weight compared to other treatments (Table 1). These results are in accordance with the findings of Emam *et al.* (2013) who reported that maximum 1000–grain weight (220 g) was obtained from control as well as 50% defoliation at 30 days after mid–silking and minimum (90 g) was obtained from 100% defoliation at mid–silking. Jalilian and Delkhoshi (2014) observed the effect of leaf clipping treatments on the 1000 -grain weight was significant.

Grain, fodder and stover yields of maize

Table 2 reveals that different yields of maize such as grain, green fodder and stover yields were significantly influenced due to various defoliation treatments. The maximum grain yield (1193 g m^{-2}) was found in T_5 which was statistically identical to T_7 and T_1 treatments and the lowest grain yield (913 g m^{-2}) in T_2 treatments. However, the percent reduction in grain yield were 21.83 percent in T_2 treatment , 11.81 percent in T_3, 5.56 percent in (T_4) and 6.25 percent in treatment T_6 and the percent increase in grain yield were 2.14 percent in T_5, and 0.06 percent when detopping done except two leaves above the ear at 14 DAS (T_7).

Table 2. Influence of different levels of defoliation on yields of maize at different days after silking

Treatments	Grain yield		Green fodder yield	Stover yield plant^{-1}	
	g m^{-2}	% Change over control	g m^{-2}	g	% Change over control
T_1	1160 ab	–	0.00 f	209.40 a	–
T_2	910 d	–21.83	776.06 a	151.40 c	–27.69
T_3	1030 c	–11.81	758.40 a	162.90 bc	–22.20
T_4	1100 bc	–5.56	706.50 b	196.40 ab	–6.20
T_5	1193 a	+2.14	587.10 c	171.80 bc	–17.95
T_6	1090 bc	–6.25	489.10 e	192.60 ab	–8.02
T_7	1170 ab	+0.06	547.80d	220.40 a	+5.25
CV (%)	4.39		2.26	9.93	

T_1 = Control (without leaf removal), T_2 =Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS, T_3 = Defoliating all leaves except ear and adjacent two leaves above the ear at 14 DAS, T_4 = Defoliating all leaves below ear at 7 DAS, T_5 = Defoliating all leaves below ear at 14 DAS, T_6 = Detopping except two leaves above the ear at 7 DAS and T_7 = Detopping except two leaves above the ear at 14 DAS, Treatment means compared by Tukey's Range Test at $P \leq 5\%$ level.

Defoliating all leaves except ear and adjacent two leaves above the ear at 7 DAS (T_2) reduced the grain yield compared to other treatments. The maximum green fodder yield (776.06 g m^{-2}) was found in T_2 which was statistically identical to T_3 and the lowest green fodder yield (0.00 g m^{-2}) was found in T_1 which was followed by T_7 and T_6. The maximum stover yield plant^{-1} (220.4 g) was found in T_7 which was statistically identical to T_1, T_4 and T_6 treatments and the lowest stover yield plant^{-1} (151.4 g) in T_2 which was at par to T_5 and T_3 treatments. However, the percent reduction in stover yield plant^{-1} were 27.69 percent in T_2, 22.20 percent in T_3, 6.20 percent in T_4, 17.95 percent in T_5, 8.02 percent in T_6 and the percent reduction in stover yield plant^{-1} was 5.25 percent in T_7.

Grain yield is the product of number of plant m^{-2}, cobs plant^{-1}, grains cob^{-1} and individual grain weight. A change in any of these characters due to defoliation ultimately affects the grain yield. Hassen (2003) reported that the seed yield and stover yield of maize were significantly influenced by the rate of various defoliation levels (0, 25, 50, 75 and 100%). However, Adee *et al.* (2005) calculated that the upper 8 to 10 leaves contributed 88% of the grain yield. Grain yield losses associated with defoliations around tasseling/silking are mainly explained by fewer kernel number (KN) (Severini *et al.*, 2011), while losses for defoliations right before or at grain filling period (R_2, blister stage and on) are largely related to decline in kernel weight (Echarte *et al.*, 2006; Abendroth *et al.*, 2011). Reduction in yield with defoliation treatment in maize was reported by Gaias *et al.* (2017), Battaglia (2014), Heidari (2017) and Alvim *et al.* (2011). Defoliation of all leaves above ear (L_3) recorded lesser dry matter production compared to other levels of defoliation which may be due to heavy loss of foliage's and photosynthetically active leaf area and their inability to intercept the light which resulted in inadequate synthesis of food reserves. Hassen (2003) reported that the grain yield and stover yield of maize were significantly influenced by the rate of defoliation (0, 25, 50, 75 and 100%) treatments.

Conclusion

From the overall results it was concluded that light intensity in the crop canopy was increased when only lower leaves or both upper and lower leaves were removed, but when only the upper leaves were removed light intensity in the canopy was not increased. SPAD value which indicated the greenness of leaf was increased due to defoliation. Grain yield of maize was reduced due to different defoliation treatments but the yield reduction was not significant when only lower or upper leaves were removed and it was significant when both upper and lower leaves were removed. So, farmers could harvest green fodder either from lower or upper leaves to ear without significant yield reduction of maize.

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