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Influence of defoliation during reproductive stage on seed yield in uniculm mungbean plants

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Authors' Contribution **Rana, M. P.** has conducted the research and analyzed the data, **M. M. A. Mondal** developed the concepts, designed the experiments, and wrote up the manuscript.

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ABSTRACT

An experiment was conducted at the pot yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from February to May 2018 to investigate the effect of defoliations on morphological characters, yield attributes and yield of uniculm mungbean plant. The experiment comprised of nine levels of defoliation *viz*., control, 2, 3, 4, 5 leaves removal from base and 2, 3, 4 and 5 leaves removal from top out of 7 leaves during flowering start phase. The morpho-physiological characters such as plant height, stem diameter, leaf area and total dry mass plant^{-1} and number of racemes, reproductive characters such as rachis length and diameter, number of flowers plant^{-1} and reproductive efficiency, yield contributing characters such as number of pods plant^{-1}, pod length, number of seeds pod^{-1}, single pod and 100-seed weight and seed yield decreased with increasing defoliation both from base and top except basal 2 leaves defoliation. The above parameters increased over control in basal 2 leaves defoliation. The decrement due to defoliation was greater in top defoliated plants than the corresponding basal defoliated ones indicating upper leaves contributes more assimilate to the sink than the basal leaves. The highest morpho-physiological parameters, reproductive characters and yield contributing characters observed in basal 2 leaves defoliated plants which resulted the highest seed yield (5.75 g plant^{-1}) followed by control (5.49 g plant^{-1}). The lowest morpho-physiological parameters, reproductive and yield contributing characters recorded in top 5 defoliated plants and produced the lowest seed yield (1.21 g plant^{-1}). These results suggest that uniculm mungbean plant tolerate basal 2 leaves loss in the canopy during reproductive stage.

Keywords: Defoliation, total dry mass production, yield, mungbean.

INTRODUCTION: Higher yield and yield stability of field crops are the central objectives of any crop improvement programme. In tropical and sub-tropical countries, loss of foliage in mungbean [*Vigna radiata* (L.) Wilczek] by leaf-eating insects (Hairy caterpillar and leaf semilooper etc.) and diseases (Leaf blight and yellow mosaic virus etc.) is common. The leaf feeding insects, in general, eat leaves either top or middle position of the plant canopy. However, many workers reported that mild defoliation during reproductive stage did not adversely affect the seed yield in mungbean (Mondal *et al.*, 2011; Mondal, 2012). The mungbean plant can sustain such source (leaf) damages up to a certain extent without significant yield loss, beyond this point causes economic loss (Mondal *et al.*, 2011).

Traditional varieties of pulse crop possess greater sources than sink because they are leafy. In the course of crop improvement, leafiness is reduced and sink size is gradually increased (Mondal, 2012). Greater source capacity leads to poor crop performance as fertilization and other cultural practices result in greater foliage and poor productivity (Hossain *et al.*, 2006). 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. Even increased LAI is not associated with increased grain production but reaches a plateau (Ali *et al.*, 2013). In some situations, physical leaf area is adequate and even more than required, but the functional efficiency is far lower due to utilizing resources as a respiratory burden of those parasitic leaves (leaves in the lower canopy) on the other. 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 immature pods (Mondal, 2012) and increase seed yield. The effect of manipulation of source (leaf) size in legumes has been studied and reported both advantageous and disadvantageous effect of defoliation in many crops (Bhatt and Rao, 2003; Durli *et al.*, 2020). For example, one-third leaf removal from basal portion of the canopy in cowpea increased grain yield over control and severe defoliation decreased seed yield (Hossain *et al.*, 2006). Similarly, mild defoliations (16.6-25%) during reproductive phase do not adversely affect the seed yield in mungbean (Mondal, 2012) and in soybean (Ali *et al.*, 2013; Durli *et al.*, 2020). On the other hand, reverse results due to defoliation was also reported, in cowpea, in mungbean (Rao and Ghildiyal, 1985) and in soybean. On the other hand, asynchrony in pod maturity is a great problem for mungbean cultivation. To get synchronous maturity of pod in mungbean, the plant type should be uniculm (Mondal *et al.*, 2013) and in this regard, Bangladesh Institute of Nuclear Agriculture (BINA) has developed a uniculm plant (MB-43) which is highly synchrony in pod maturity. This genotype needs study of under different source-sink condition so that optimum source-sink ratio can be determined. 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 seed yield in uniculm mungbean genotype.

OBJECTIVES: The objectives were: (i) to investigate the effect of defoliation on leaf area and dry matter production; (ii) to assess the effect of defoliation on flower and pod production; and (iii) to study the effect of defoliation on yield and yield components in uniculm mungbean genotype.

MATERIALS AND METHODS: The experiment was conducted at the pot yard, Bangladesh Institute of Nuclear Agriculture, Mymensingh ($24^{0}75$ N $90^{0}50$ E), Bangladesh in Kharif-I (February-May), season of 2018. A completely randomized design with four replications was used in this study. A high yielding mungbean genotype *viz*., MB-43 was used for the investigation. The branches clipped off weekly so that the plant can develop as uniculm canopy structure. Planting was done on 28 February, 2018. The pots were filled with 12 kg sandy loam soil. The fertilizers were applied at the rate of 40, 80, 60 and 40 kg ha^{-1} as urea, triple superphosphate, muriate of potash and gypsum, respectively. Ten seeds were sown in a pot after 8 hours of soaking to ensure uniform germination and two weeks after germination, two plants pot^{-1} were kept for growth and development, which denotes a replication. Irrigation, weeding, spray of insecticide were used as and when needed for normal plant growth and development.

The nine defoliation treatments were employed at the beginning of opening of flowering phase (45 days after sowing). During treatment time, the plants bear seven leaves in the mainstem. The treatments were: i) Control i.e. no leaf removal; ii) removal of two leaves from base of the plant; iii) removal of three leaves from base of the plant; iv) removal of four leaves from base of the plant; v) removal of five leaves from base of the plant; vi) removal of two leaves from top of the plant; vii) removal of three leaves from top of the plant; viii) removal of four leaves from top of the plant; and ix) removal of five leaves from top of the plant.

Flower count began from the date of opening of first flower and continued at every day until flowering ceased. Total flower production and flowering duration were later calculated from the collected data. At harvest leaf area, yield and yield components, dry matter production and it's partitioning into plant parts were recorded. Harvest index was also calculated from the collected data. The total dry matter plant^{-1} was estimated by summing dry matter of leaves, stem, and roots per plant. Harvest index was determined following the method of Donald and Hamblin (1976). Reproductive efficiency was calculated from the ratio of the number of pods at maturity and the total number of opened flowers multiplied by 100. The collected data were analyzed by CRD design using the statistical computer package programme, MSTAT.

RESULTS AND DISCUSSION: The effect of different degree of defoliation on morpho-physiological characters such as plant height, stem diameter, leaf area (LA), raceme number and total dry mass (TDM) was significant at $P \leq 0.05$ (table 1). Results showed that plant height, stem diameter, LA plant^{-1}, racemes number plant^{-1} and TDM plant^{-1} decreased with increasing defoliation except basal 2 leaves defoliation. The plant parameters were greater in basal 2 leaves defoliated plants than the control. These results indicate that removal of basal 2 leaves at reproductive stage did not affect in morpho-physiological even increased over control, which further indicating that basal 2 leaves removal from bottom enhance plant growth and development. However, the decrement due to defoliation was greater from top defoliated plants than corresponding basal ones. For example, removal of basal 4 leaves reduced 19.7, 33.5, 30.4 and 33.3% while top 4 leaves removal decreased 35.4, 70.0, 64.2 and 50.0% over control for plant height, LA, TDM and number of raceme, respectively. These results are agreed with the report of Mondal (2012) in mungbean who reported that reduction in morpho-physiological (plant height, leaf area and TDM) due to defoliation was higher in top defoliated plants than basal defoliated ones. The highest plant height (38.8 cm), stem diameter (0.61 cm), leaf area (608 cm^{2})and TDM plant^{-1} (8.66 g) was observed in basal 2 leaves defoliated plants and the lowest of the above parameters (10.7 cm, 0.43 cm, 87 cm^{2} and 1.55 g, respectively) was observed in top 5 leaves defoliated plants. Leaf area plant^{-1} was observed most important source for dry matter (DM) and sink production. Removal of increasing degree of source (leaf) in the canopy decreased LAI and hence DM production. Defoliation not only decreased source size but also sink production resulting in reduction in pod and seed yield (table 3). However, such reduction in TDM and seed yield plant^{-1} was not significant between control and basal 2 leaves defoliation even TDM and seed yield increased over control in 2 leaves defoliated plant due to superiority in yield contributing characters. This indicates that uniculm mungbean plant, in general, tolerate mild basal leaves loss in the canopy during reproductive stage. The effect of defoliation on reproductive characters such as rachis length and diameter, pod bearing pod node number, flower number, reproductive efficiency (RE) and shelling percentage was statistically significant (table 2). Results revealed that rachis length and diameter, flower number plant^{-1}, RE and shelling percentage decreased with increasing defoliation except defoliation from basal 2 and 3 leaves. The above parameters increased over control in basal 2 and 3 leaves defoliated plant. Results further indicated that the decrement of flowers and RE was greater in top defoliated plants than basal defoliated ones. The highest rachis length (1.86 cm) and diameter (0.26 cm), pod bearing nodes plant^{-1} (6.0) and number of flowers plant^{-1} (35.4) was recorded in basal 2 leaves defoliated plant whereas the highest shelling percentage was recorded in basal 3 leaves defoliated plant (76.58%). The lowest rachis length (1.40 cm) and diameter (0.14 cm), pod bearing nodes plant^{-1} (3.0) and number of flowers plant^{-1} (14.8) was recorded in top 5 leaves defoliated plant. The lower reproductive characters in top defoliated plant might be due to low assimilate production by basal leaves.

For yield and yield contributing characters, results revealed that number of pods plant^{-1}, pod length, seeds pod^{-1} and seed yield decreased with increasing degree of defoliation both from base and top except basal two leaves defoliation (table 3). But single pod and 100-seed weight did not affect up to basal 4 leaves defoliation. Result further revealed that seed yield was greater in basal defoliated plant than the corresponding top defoliated ones. However, it was further revealed that the reduction in seed yield was not proportional to the degree of defoliation. For example, basal 4 leaves defoliated plant (57% of the total leaves reduction) caused only 35.3% fewer yield production. Similarly, Pandey and Singh (1984) reported that basal 50% leaf removal caused only a 9.2% yield loss while a 50% leaf removal from top resulted in a 36.0% yield loss in mungbean. The reduction in yield was accompanied by decrease in number of pods plant^{-1}, seeds pod^{-1} and 100-seed weight (Mondal *et al.*, 2011). Rao and Ghildiyal (1985) stated that the remaining leaves of defoliated plant had high net photosynthetic rate (P_n) than intact plant and in this way remaining leaves might compensate the loss caused by defoliation. Many workers also reported similar results. The high sink-source ratio increased the photosynthetic rates in the remaining leaves by 38% in okra (Bhatt and Rao, 2003), 33-39% in mungbean (Pandey and Singh, 1984), 10-23% in soybean (Islam, 2014) and 30-40% in groundnut (Ghosh and Sengupta, 1986). This indicates involvement of an effective compensatory mechanism, which helps in production of more assimilate in the remaining leaves. That is why; seed yield does not reduce proportionally to the degree of defoliation. Results indicated that the decrement in yield contributing characters and yield due to defoliation was greater in top defoliated plants than the corresponding basal defoliated ones. For example, defoliation of basal 4 leaves caused reduction only 35.3% seed yield than control whereas top 4 leaves defoliation caused 61.6% yield reduction. These results indicate that upper leaves contributes more assimilate to the sink than the basal leaves. This is possible because of upper leaves are younger and capture more sunlight than basal ones, and produce more assimilate than basal leaves ones.

Degree of defoliation	Plant height (cm)	Stem diameter (cm)	Leaf area plant^{-1} (cm^2)	Racemes plant^{-1} (no)	Total dry mass plant^{-1} (no)
Control	38.1 a	0.56 bc	520 b	6.40 b	7.82 b
Basal 2 leaves	38.8 a	0.61 a	608 a	6.60 b	8.66 a
Basal 3 leaves	35.8 b	0.61 a	506 b	5.75 e	7.40 c
Basal 4 leaves	30.6 c	0.60 ab	346 c	6.13 cd	5.44 d
Basal 5 leaves	32.3 c	0.54 c	256 d	7.17 a	4.11 e
Top 2 leaves	30.7 c	0.63 a	362 c	5.67 e	5.70 d
Top 3 leaves	25.1 d	0.53 c	245 d	5.25 f	3.87 e
Top 4 leaves	24.6 d	0.47 d	156 e	5.50 ef	2.80 f
Top 5 leaves	10.7 e	0.43 d	87 f	5.75 de	1.55 g
CV (%)	6.32	4.41	5.94	4.10	3.72

Table 1: Effect of defoliations on morpho-physiological characters in unicum mungbean plant.
In a column, figures bearing same letter (s) do not differ significantly at P ≤ 0.05 by DMRT

Degree of defoliation	Rachis length (cm)	Rachis diameter (cm)	Pod bearing nodes plant^{-1} (no)	Flowers plant^{-1} (no)	Reproductive efficiency (%)	Shelling percentage
Control	1.58 b	0.18 bc	6.0 a	34.9 a	49.9 a	72.1 b-e
Basal 2 leaves	1.86 a	0.26 a	6.0 a	35.4 a	48.0 ab	75.3 ab
Basal 3 leaves	1.60 b	0.19 b	5.1 b	32.2 ab	49.6 a	76.58 a
Basal 4 leaves	1.65 ab	0.18 bc	4.0 c	25.2 c	45.6 b	69.6 de
Basal 5 leaves	1.28 d	0.18 bc	4.0 c	20.2 de	44.4 bc	69.0 e
Top 2 leaves	1.50 b	0.24 a	4.0 c	30.7 b	42.4 cd	71.6 cde
Top 3 leaves	1.56 b	0.20 b	4.0 c	23.2 cd	40.3 de	69.1 e
Top 4 leaves	1.74 ab	0.20 b	3.0 d	18.8 e	40.1 de	73.1 bc
Top 5 leaves	1.40 c	0.14 d	3.0 d	14.8 f	37.3 e	72.7 bcd
CV (%)	10.70	8.43	6.88	8.06	4.58	2.85

Table 2. Effect of defoliations on reproductive characters in unicum mungbean plant
In a column, figures bearing same letter (s) do not differ significantly at P ≤ 0.05 by DMRT

Degree of defoliation	Pods plant^{-1} (no)	Pod length (cm)	Seeds pod^{-1} (no)	Single pod weight (mg)	100-seed weight (g)	Seed yield plant^{-1} (g)	Harvest index (%)
Control	17.4 a	6.93 a	8.89 b	437 b	3.72 ab	5.49 b	41.2 ab
Basal 2 leaves	17.6 a	6.90 a	9.48 a	496 a	3.96 a	5.75 a	40.0 b
Basal 3 leaves	16.0 b	6.49 b	8.79 b	438 b	3.80 ab	5.03 c	40.5 b
Basal 4 leaves	11.5 d	6.41 bc	8.11 c	430 b	3.71 abc	3.19 e	38.0 b
Basal 5 leaves	9.00 e	6.16 cd	8.13 c	342 d	3.68 abc	2.86 f	41.0 ab
Top 2 leaves	13.0 c	6.54 b	8.72 b	401 c	3.87 ab	3.97 d	41.1 ab
Top 3 leaves	9.38 e	6.25 bc	8.08 c	388 c	3.58 c	2.71 f	41.2 ab
Top 4 leaves	7.51 f	5.93 d	7.70 c	340 d	3.52 c	1.92 g	40.7 ab
Top 5 leaves	5.50 g	5.14 e	6.58 d	287 e	3.34 d	1.21 h	43.8 a
CV (%)	6.60	3.14	4.10	7.83	4.91	4.92	4.91

Table 3: Effect of defoliations on yield contributing characters and yield of unicum mungbean plant.
In a column, figures bearing same letter (s) do not differ significantly at P ≤ 0.05 by DMRT.

Seed yield did not decrease significantly over control until basal 2 leaves defoliation due to increased LA, pod and seed size with similar pod production. This result indicates that mungbean plant can tolerant up to 2 leaves loss from basal during flowering. The highest seed yield was recorded in basal 2 leaves defoliated plant (5.49 g plant^{-1}) due to production of the highest number of pods plant^{-1} (17.6), seeds pod^{-1} (9.48) and 100-seed weight (3.96 g) followed by control (5.49 g plant^{-1}) and basal 3 leaves defoliated plants (5.03g plant^{-1}). The maximum reduction in seed yield was observed in top 5 defoliated plants

(79.6%). Again, lower seed yield per plant under highly defoliated condition was due to might be lesser amount of assimilate produced by the plants through lesser photosynthetic area plant^{-1}. This result is consistent with the findings of Mondal (2012) in mungbean. They observed that pod yield did not affect under mild or partial defoliation in mungbean. The effect of defoliation on harvest index (HI) was significant but not consistent with yield and related traits. The highest HI was recorded in top 5 leaves defoliated plants (43.8%) and the lowest was recorded in basal 4 leaves defoliated plants (38.0%).

CONCLUSION: Based on the experimental results, it may be concluded that the decrement of morpho-physiological, reproductive and yield contributing characters due to defoliation was greater in top defoliated plants than the basal defoliated ones; and yield increased over control in basal 2 leaves defoliated plant and decreased over control from 3 leaves defoliated (both basal and top) plant. So, burden leaves of basal 1 and 2 may be clip off during flowering for increased seed yield in mungbean.

CONFLICT OF INTEREST: Authors have no conflict of interest.

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