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Effect of defoliation on growth, reproductive characters and yield in mungbean [*Vigna radiata* (L.) Wilczek]

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Abstract

Loss of foliage in mungbean [*Vigna radiata* (L.) Wilczek] crop through leaf eating insects and diseases is common in tropical and sub-tropical countries where farmers do not protect their crops adequately. Experiments were carried out with eight levels of defoliations (0, 25, 50 and 75% either from top or from base of the canopy, and 100%) to investigate the growth, reproductive characters, and yield attributes in two high and two low yielding mungbean genotypes. Results revealed that degrees of defoliations parallely decreased leaf area and total dry matter (TDM) production irrespective of seasons and genotypes. Defoliation not only reduced source sizes but also decreased total sink (flower) production resulting in lower pod and seed yields. However, basal 25% defoliation did not significantly decrease TDM and seed yield plant^{-1} indicating the fact that the mungbean plant, in general, can tolerate 25% basal leaf loss of the canopy. Furthermore, the high yielding genotypes showed higher compensatory mechanism of source loss than the low yielders. Exceeding this threshold limit (> 25%) either from the base or from the top of the canopy defoliation significantly reduced TDM and seed yield. Reduction in yield was higher with top defoliation than basal defoliation. Implication of the results in relation to pest management is also discussed.

Key words: canopy structure; defoliation; dry matter production; mungbean; seed yield.
Abbreviations: DAS-days after sowing; DM-dry matter; TDM-total dry matter; HI-harvest index; LA-leaf area; LAI-leaf area index; RE-reproductive efficiency.

Introduction

Higher yield of field crops is the central objective of any crop improvement/ management programme. In tropical and sub-tropical countries, foliage loss by insects and diseases is common in mungbean yet it can sustain such source (leaf) damages up to a certain extent without significant yield loss (Mondal, 2007). Traditional varieties of pulse crop possess greater sources than sink, leads to poor crop performance especially when fertilization and 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 is advantageous to realize potential sink size under field conditions. Even increased leaf area index is not associated with increased grain production (Venkateswarlu and Visperas, 1987). 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 excessive leaves (Venkateswarlu and Visperas, 1987; Mondal, 2007). Defoliation up to certain limit may, therefore, be useful to overcome the problems with excessive vegetative growth. Greater light penetration in the canopy through defoliation have reduced the abortion of flowers and immature pods and increased seed yield in cowpea (Biswas et al., 2005; Hossain et al., 2006) and in mungbean (Mondal, 2007). The effect of manipulation of source (leaf) size in legumes have been studied and reported both advantageous and disadvantageous in many crops (Board and Harville, 1998; Bhatt and Rao, 2003; Hossain et al., 2006; Abdi et al., 2007; Barimavandi et al., 2010). 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; Gustafson et al., 2006). Likewise, mild defoliations (16.6-20%) during reproductive phase did not adversely affect seed yield in mungbean (Pandey and Singh, 1984; Begum et al., 1997) and in soybean (Board and Harvelle, 1998). Reverse results of defoliation was also reported in cowpea (Pandey 1983), in mungbean (Rao and Ghildiyal 1985) and in soybean (Verma et al. 1992, Borras et al. 2004). No detail information is available in mungbean about source-sink relationships under discriminated source levels. These aspects need investigation in mungbean genotypes to develop high yielding variety/crop management under sub-tropical condition. This study was thus carried out to investigate the magnitude and positions of leaf removal during the beginning of reproductive phase affects growth, reproductive characters and seed yield under field condition in mungbean.

Results

Growth parameters

Season, genotype and defoliation significantly influenced branch, leaf area (LA) and TDM plant^{-1} (Table 1). Results showed that number of branches plant^{-1}, LA plant^{-1} and TDM plant^{-1} were significantly higher in 2009 than in 2008 (Table 1). The two high yielding genotypes, BMX 942-8 and VC 6173, in general, produced almost three fold greater branches

Table 1. Effect of defoliations on growth and reproductive characters in four mungbean genotypes (averaged over two years)

Treatment	Growth components			Reproductive characters		
	Branches plant^{-1} (no)	Leaf area plant^{-1} (cm^2) †	Total dry mass plant^{-1} (g)	Racemes plant^{-1} (no)	Opened flowers plant^{-1} (no)	Pods to opened flowers (%)
Year						
2008	1.68 b	635 b	12.70 b	9.14 b	40.80 a	41.66 b
2009	2.31 a	866 a	18.99 a	19.47 a	30.61 b	70.36 a
Genotype						
BMX 942-8	2.89 b	993 a	21.68 b	18.52 b	43.53 a	56.89 ns
VC 6173	3.24 a	---	23.03 a	23.29 a	45.42 a	54.45
MB300	0.61 d	---	6.45 d	6.75 d	16.75 c	58.22
VC3960	1.24 c	508 b	12.08 c	8.65 c	23.88 b	55.12
Degree of defoliation (%)						
Control	1.67 d	970 a	20.14 a	15.48 b	43.58 a	63.10 a
Basal 25	1.74 d	968 a	20.45 a	15.71 ab	45.75 a	63.10 a
		(*0.0*)	(*+1.49*)	(*+1.29*)	(*+4.98*)	
Basal 50	1.60 d	805 c	16.52 b	13.78 c	35.98 b	61.45 a
		(*-17.0*)	(*-17.9*)	(*-11.0*)	(*-17.40*)	
Basal 75	1.26 e	613 e	13.86 c	11.73 d	29.95 c	56.18 b
		(*-36.8*)	(*-31.2*)	(*-24.5*)	(*-31.30*)	
Top 25	2.15 c	934 ab	19.29 a	16.70 a	39.12 b	54.12 b
		(*-3.71*)	(*-3.98*)	(*+7.74*)	(*-10.20*)	
Top 50	2.59 b	819 c	16.86 b	16.01 ab	36.97 b	54.63 b
		(*-15.6*)	(*-15.9*)	(*+3.22*)	(*-15.20*)	
Top 75	2.98 a	637 d	13.31 c	16.19 ab	27.70 c	52.75 b
		(*-34.3*)	(*-33.8*)	(*+4.52*)	(*-27.70*)	
100	2.14 c	259 f	6.04 d	8.84 e	11.60 d	42.73 c
		(*-73.3*)	(*-70.0*)	(*-43.0*)	(*-73.40*)	
CV%	12.31	4.27	10.81	8.48	10.5	7.98

In a column, either within season or genotype or defoliation, the figures bearing same letter (s) do not differ significantly at $P \leq 0.05$ by DMRT; The figures in parenthesis indicate percent increase (+)/decrease (-) over control; †: Data collected from two genotypes; ---: Leaf area was not recorded in VC 6173 and MB 300.

and TDM, and almost double LA plant^{-1} compared to two low yielding genotypes (Table 1). Generally, defoliation at the top of the canopy promoted number of branches compared to defoliation at basal portion (Table 1). The highest branch number (2.98 plant^{-1}) was observed in 75% defoliation from top whilst the lowest (1.26) in 75% defoliation from bottom. With increasing degree of defoliation, LA and TDM were decreased both from base and top except basal 25% defoliation level. The 25% defoliation from both base and top had shown similar LA and TDM with that of control. This means 25% leaf removal either from bottom or top of the canopy does not affect LA and TDM production in mungbean. In contrast, defoliation beyond 25% caused significant reduction in LA and TDM. The LA and TDM plant^{-1} in control and 25% defoliated plants were similar and significantly higher (average of 957 cm^2 plant^{-1} and 20.30 g plant^{-1} for LA and TDM, respectively) than other treatments with complete defoliated plant was the lowest of all (259 cm^2 plant^{-1} and 6.04 g plant^{-1} for LA and TDM, respectively). Results of interaction of genotype and defoliation revealed that the reduction trend in LA and TDM due to defoliation both from base and top was not similar in high and low yielding genotypes (Figs. 1 and 2). The reduction in LA and TDM was greater in low yielding genotype than in high yielding one. Under basal 75% defoliation, the LA and TDM reduction was much greater in low yielding genotypes (51.6 and 31.0% for LA and TDM, respectively) than in the high yielding ones (27.5 and 29.5% for LA and TDM, respectively). In contrast, under top 75% defoliation, the LA and TDM reduction was once again much greater in the low-yielders (48.5 and 32.8 % for LA and TDM, respectively) than the high yielders (25.5 and 30.4% for LA and TDM, respectively) (Figs. 1 and 2).

Reproductive characters

The effect of season, genotype and defoliation on number of racemes plant^{-1}, number of open flowers plant^{-1} and per cent podset to opened flowers (reproductive efficiency, RE) was significant (Table 1). Results showed that the number of racemes plant^{-1} and RE were significantly greater in 2009 than in 2008 while it was reverse for flower production (Table 1). Among the genotypes, the high yielding genotypes produced higher racemes and flowers (almost three and two fold, respectively) compared to low yielding ones. Furthermore, number of racemes decreased with increasing defoliation from base (Table 1). On the other hand, defoliations up to 75% from top did not show adverse effect on raceme number and even the number of racemes was just slightly increased in 25, 50 and 75% defoliations from top compared to its non-defoliated control. The fewest racemes were observed in complete defoliated plants (8.84 plant^{-1}). Interaction effect of genotype and defoliation on racemes production in high and low yielding genotypes followed more or less a similar pattern in the two years. Thus the pooled effect for raceme production is presented in the Fig. 3. Results of interaction of genotype and defoliation indicated that the increasing magnitude in raceme number (in %) due to defoliation was greater in low yielding genotypes than in high yielding ones but fewer total number of racemes was produced in the former than the latter. Number of open flowers plant^{-1} and per cent podset to opened flowers (reproductive efficiency, RE) was decreased with increasing

Table 2. Effect of defoliations on yield components, yield and harvest index in four mungbean genotypes (averaged over two years)

Treatment	Pods plant^{-1} (no.)	Single pod weight (mg)	100-seed weight (g)	Seed yield plant^{-1} (g)	Harvest index (%)
Year					
2008	20.19 b	671 a	4.61 a	5.04 b	34.66 a
2009	22.85 a	456 b	3.83 b	6.28 a	31.27 b
Genotype					
BMX 942-8	30.01 ab	504 d	3.44 d	7.59 b	31.79 b
VC 6173	31.64 a	532 c	3.83 c	8.48 a	31.59 b
MB300	6.49 d	620 a	5.01 a	2.65 d	37.92 a
VC3960	13.93 c	596 b	4.61 b	3.93 c	30.54 b
Degree of defoliation (%)					
Control (0)	27.39 a	623 a	4.33 a	7.28 a	34.40 c
Basal 25	26.35 a (*-3.80*)	629 a	4.39 a	7.47 a (*+2.61*)	35.12 bc
Basal 50	22.31 c (*-18.5*)	618 a	4.30 ab	6.29 c (*-13.6*)	37.21 a
Basal 75	18.36 d (*-33.0*)	572 b	4.29 b	5.21 e (*-28.4*)	36.48 a
Top 25	23.91 b (*-12.7*)	590 b	4.29 b	6.87 b (*-5.63*)	33.32 c
Top 50	21.38 c (*-21.9*)	575 b	4.28 b	5.80 d (*-20.3*)	30.61 d
Top 75	18.08 d (*-34.0*)	520 c	4.13 c	4.44 f (*-39.0*)	31.11 d
100	6.36 e (*-76.8*)	389 d	3.76 d	1.74 g (*-76.1*)	25.45 e
CV%	12.64	5.45	3.78	9.10	10.37

In a column, either within season or genotype or defoliation, the figures bearing same letter (s) do not differ significantly at $P \leq 0.05$ by DMRT; The figures in parenthesis indicate per cent increased (+)/decreased (-) over control.

degree of defoliations except basal 25% defoliation (Table 1). Basal 25% defoliation and non-defoliated control significantly produced higher number of open flowers (average 44.16 flowers plant^{-1}) than the others. Likewise, reduction in RE was not significant up to 50 % defoliation from bottom. On the other hand, 100%-defoliated plant produced the fewest flowers (11.60 flowers plant^{-1}) and the lowest RE (42.73%). Flower production and RE, in general, were greater in basal defoliated plants compared to corresponding top defoliated ones. However, the number of decreased open flowers was not proportional to the degree of defoliation. For example, basal 75% leaf reduction caused only a 31.3% fewer flower production.

Yield attributes and yield

The effect of defoliation on yield and yield attributes was significant (Table 2). In general, number of pods and seed yield plant^{-1} was higher in 2009 (22.85 and 6.28 g plant^{-1} for pod number and seed yield, respectively) than in 2008 (20.19 and 5.04 g plant^{-1} for pod number and seed yield, respectively). The number of pods and seed yield was higher in high yielding genotypes (30.01-31.64 plant^{-1} for pod number and 7.59-8.48 g plant^{-1} for seed yield) than in low yielding ones (6.49-13.93 plant^{-1} for pod number and 2.65-3.93 g plant^{-1} for seed yield). The number of pods and seed yield was decreased with increasing defoliation. This decrease was significant only beyond 25% basal defoliation when compared to undefoliated control. Pod number and seed yield were higher in basal defoliated plants than the corresponding top defoliated ones. Contrarily, the reduction of pod number and seed yield were greater in top defoliated plants than corresponding basal defoliated ones (Table 2). However, it was further revealed that the reduction in pod number and seed yield were not proportional to the degree of defoliation. For example, basal 50% leaf reduction caused only 18.5% pod and 13.6% seed yield reduction compared to undefoliated control. The maximum reduction in pod number and seed yield was observed in complete defoliated plants followed by top 75% defoliation. The increased number of pods and seed yield plant^{-1} was noted in control and basal 25% defoliated treatments compared to others. Interaction effects of defoliation and genotype on pod number and seed yield reduction revealed that decrement in pod number and seed yield due to defoliation was higher in low yielding genotypes than in high yielding ones (Figs. 4 and 5) indicating compensatory capacity of pod production and seed yield due to defoliation was higher in high yielders than low yielders. The higher single pod and 100-seed weight, and harvest index (HI) were recorded in 2008 than in 2009 (Table 2). Considering genotypic effect, larger pod and bolder seed was observed in low yielding genotypes compared to high yielding ones with MB 300 being the highest of all for single pod and 100-seed weight, and HI. Results revealed that single pod and 100-seed weights were decreased with increasing degree of defoliations except up to basal 50% defoliation where pod and seed size remained unaffected compared to the undefoliated control treatment. In contrast, however, pod and seed size was decreased significantly for any degree of defoliation from top. The maximum reduction in pod and seed size, and HI was recorded in 100% defoliation followed by top 75% defoliation. However, greater single pod and 100-seed weight, and HI were attended in basal defoliated plants compared to top

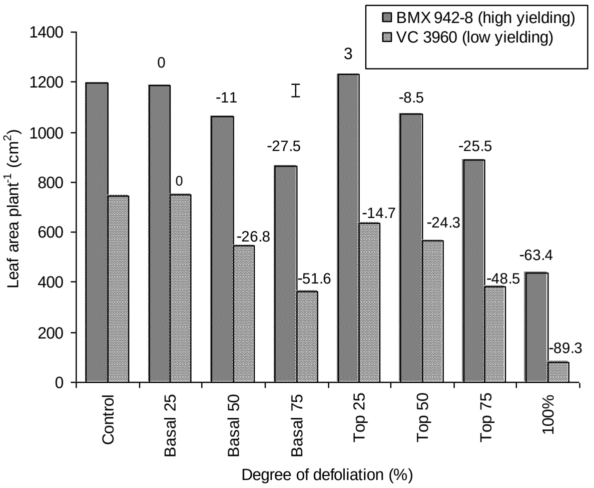

Fig 1. Interaction effect of defoliation and genotype on leaf area development in high and low yielding mungbean genotypes (mean over two years). Vertical bar represents LSD (0.05). The figures on bar indicate per cent decrease (-)/increase over control.

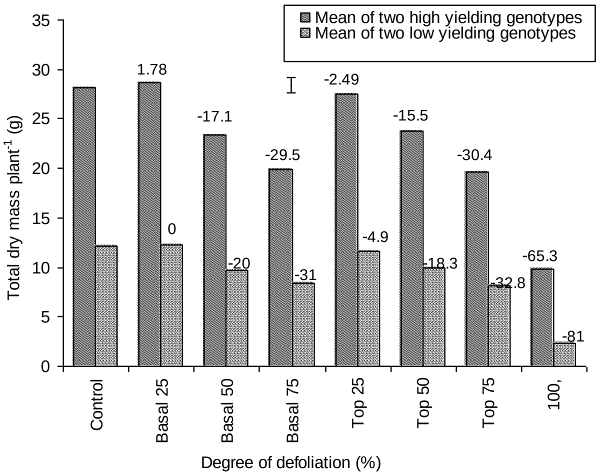

Fig 2. Interaction effect of defoliation and genotype on total dry mass ptoduction in high and low yielding mungbean genotypes (mean over two years). The vertical bars represent LSD (0.05). The figures on bar indicate per cent decrease(-)/increase over control.

defoliations. The higher HI was shown in basal 50% and 75% defoliation (average 36.85%) whilst the lowest HI was found in 100% defoliated plants (25.45%). However, defoliation from bottom did not show such significant decrease in HI over the control treatment while it was decreased with increasing defoliations from top indicating the greater importance of upper leaf for partitioning DM to the sink.

Discussion

Leaf is the major source of supplying assimilates to developing organs, young pods and seeds in crops (Abdi et al., 2007; Mondal, 2007; Barimavandi et al., 2010). Leaf removal may, therefore, influence TDM production and yield through photosynthate production and distribution into different parts depending on the magnitude of leaf removal (Chauhan and Halima, 2003; Hossain et al. 2006; Gustafson et al., 2006). In the experiment, LA and TDM were decreased with increasing defoliation, except 25% defoliation from bottom. However, the reduction in LA and TDM was not proportional to the degree of defoliation due to regrowth of leaves by producing more branches (Table 1). This result is consistent with the result of Board and Harville (1998) and Gustafson et al. (2006) in soybean who had the opinion that plant could compensate its leaf loss by leaf regrowth potentials in defoliated plants. The higher leaf loss compensation capacity in high yielding genotypes could be due to their larger initial LA and hence, the remaining leaf after defoliation along with high initials and newly emerged leaves together was capable to produce greater TDM by increasing photosynthesis (Rao and Ghildiyal 1985). With 25% defoliation (either basal or top), DM production either remained same or even increased a little compared to undefoliated control (Table 1). This indicate that physiological mechanisms might have rejuvenalized just after defoliations at this (25% defoliation) threshold level by initiating new leaves and could be one of the reason that compensated 25% leaf loss. Similar result was also reported by Mondal (2007) in mungbean and Gustafson et al. (2006) in soybean. Though branch and raceme numbers were increased in top defoliated plants yet flower and pod production, pod and seed size were higher in basal defoliated plants compared to corresponding top defoliated ones. It is in agreement with Board et al. (1997) who also observed similar affects and had the opinion that upper leaves were more active for photosynthesis than basal ones. Moreover, reduction in RE with increasing defoliation and the lowest pod set percentage in 100% defoliated plants (42.73%), could be due to lesser leaf area, unable to supply available assimilates to the sink and thereby flower abortion appeared higher in defoliated plants. Yield loss was not proportional to the degree of defoliation and yield loss compensating capacity was higher in bottom-defoliated plants than in top-defoliated ones. This is in conformity with Pandey and Singh (1984) who also reported 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. Rao and Ghildiyal (1985) stated that the remaining leaves of defoliated plant had higher net photosynthetic rate (P_n) than intact plant and in this way remaining leaves might compensate the loss caused by defoliation. 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), 20-40% in soybean (Chen and Lia 1991) 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. This could be the reason that seed yield did not reduce proportionally to the degree of defoliation. However, LA was significantly smaller in defoliated plants than in the undefoliated control during imposing treatments (defoliation). Thereafter, at pod filling and maturity stages the loss of leaf area was compensated from 77 to 100% (Table 1) due to regrowth of leaves in the defoliated plants. Again, seed yield reduction due to defoliations from top was greater in low yielding genotypes than in high yielders once again can be explained that the compensatory capacity was greater in latter than in the former. In the current result, yield was not reduced significantly up to basal 25% defoliation and even yield was slightly increased at this thresh hold level and beyond 25% defoliation yield was reduced significantly. These results are in conformity with Verma et al. (1992) and Board and Harville (1998) who observed that partial defoliation during flowering and seed filling had no adverse effects on seed yield because of $\leq$ 20-33% defoliation at flower initiation phase attains capacity to compensate leaf

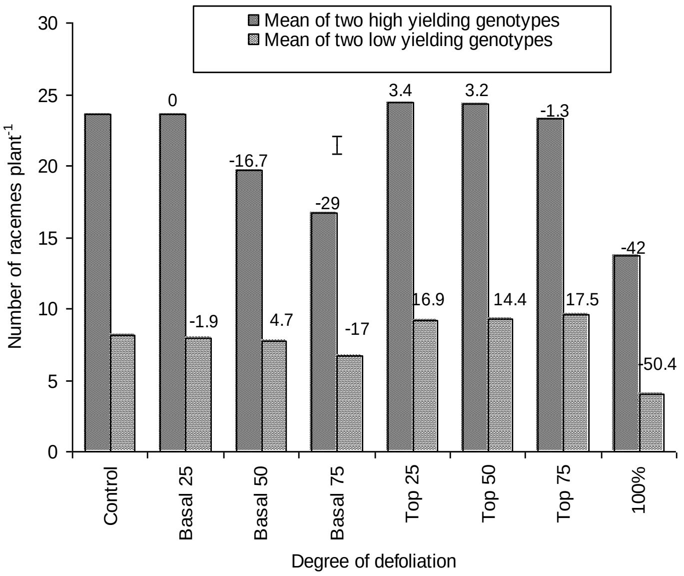

Fig 3. Interaction effect of defoliation and genotype on raceme number in high and low yielding mungbean genotypes (mean over two years). The vertical bar represents LSD (0.05). The figures on bar indicate per cent decrease (-)/ increase over control

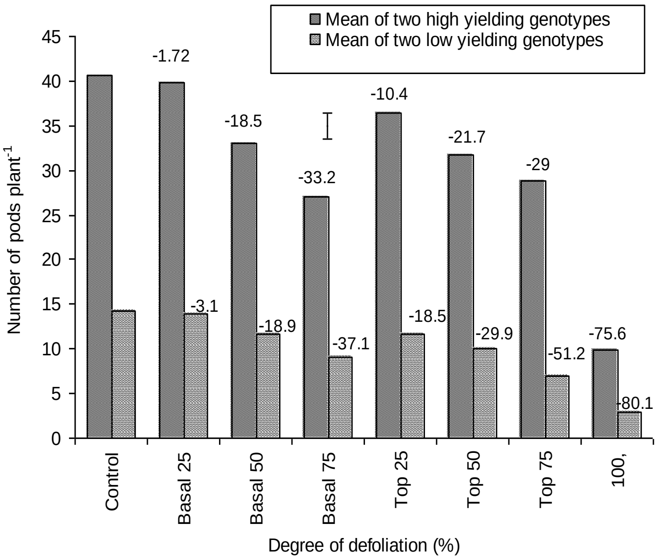

Fig 4. Interaction effect of defoliation and genotype on pod number in high and low yielding mungbean genotypes (mean over two years). The Vertical bar represents LSD (0.05). The figures on bar indicate per cent decrease (-)/increase over control.

loss and reached LAI ≥ 4 immediately after imposed treatment through regrowth of leaves in soybean. In the current investigation, basal 25% defoliation showed superiority in seed yield compared to other treatments because of higher TDM, greater number of opened flowers and increased pod and seed size. This could be argued in a way that basal leaves are aged, photosynthetically weaker and may act as a burden and compete for assimilate with growing pods (sink) while most of the assimilate transport to the pods when absence of lower leaves (basal defoliation) which resulted greater partitioning and thereby results higher yield.

Materials and methods

Site description

Experiments were conducted at the Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh ($24^0 8'$ N $90^0 0'$ E), Bangladesh in Kharif-I (February-May) season, 2008 and 2009. The soil of the experimental area of Crop Botany field laboratory, BAU is silty loam having a total nitrogen 0.06%, organic matter 1.15%, available phosphorus 18.5 ppm, exchangeable potassium 0.28 meq/100g, sulphur 18 ppm and pH 6.8.

Planting materials and experimental design

Two high yielding (BMX 942-8 and VC 6173) and two low yielding (MB 300 and VC 3960) genotypes were used. Seeds were sown in rows, 4 m long and 30 cm apart. Planting was done on 22 and 18 February for the year 2008 and 2009, respectively. The experimental design was split-split-plot with three replications i.e. the season was assigned in the main plot and four genotypes were in the sub-plot and eight defoliations were in the sub-sub-plot. The sub-plot consisted of 18 rows including two borderlines on either side. The sub-sub-plot consisted of two rows at 30 cm apart and each 4.0 m in length.

Management practices

Seeds were sown continuously in line and two weeks after germination, the plants were thinned to a density of 30 plants/m^2. Cultural practices were the same in both the seasons and locations. Uniform plant stands (30 plants/ m^2) were maintained in both the seasons. Urea, triple superphosphate, muriate of potash and gypsum were used as a source of nitrogen, phosphorus, potassium and sulphur at the rate of 40, 120, 80 and 30 kg ha^{-1}, respectively at the time of final land preparation. First weeding was done followed by thinning at about 21 days after sowing (DAS). A single irrigation was given at 25 DAS at both the seasons. Insecticide (Ripcord 50 EC at 0.025%) was sprayed at flowering and fruiting stage (55 DAS) to control shoot and fruit borer.

Treatments

The eight levels of defoliation treatments were employed at the beginning of opening of flowering stage (40 and 35 days after sowing in 2008 and 2009, respectively) were: i) control (no leaf removal), ii) 25 % leaves removed from bottom (basal 25%), iii) 25 % leaves removed from top (top 25%), iv) similarly bottom 50%, v) top 50%, vi) bottom 75%, vii) top 75% and viii) 100 % leaves removed. Total leaf area (LA) plant^{-1} from ten randomly selected plants of each sub-sub-plot was determined by measuring leaf area at individual node in the mainstem using automatic leaf area meter (Model: LI 2000). Considering total LA plant^{-1} as hundred per cent, contribution of LA at each nodal position in the mainstem was estimated. Leaf in the branches, initiated in a particular node was included in that nodal position of the mainstem. Contribution of individual nodal LA to total LA plant^{-1} was estimated. To defoliate leaf at different degrees, complete compound leaf and/ or leaves, and sometimes one or two leaflets or even a portion of a leaflet were clipped off.

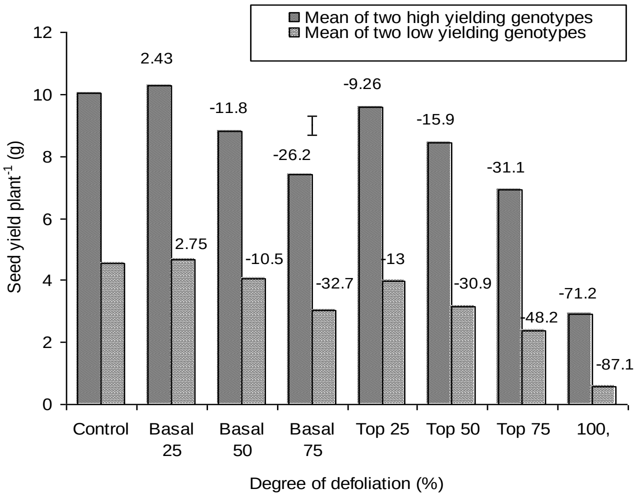

Fig 5. Interaction effect of defoliation and genotype on seed yield in high and low yielding mungbean genotypes (mean over two years). The vertical bar represents LSD (0.05). The figures on bar indicate percent decrease (-)/increase over control.

Parameters measured

A 3.0 m central section of each row was harvested to avoid border effects. The harvested plants of each sub-sub-sub plot was separately bundled and tagged. After recording some desired data, the harvested bundles were hand threshed and oven dried weights of plants parts (80 ^{0}C ± 2 for 48 hours) were recorded plot-wise. Daily flower count began from the date of opening of first flower of the randomly selected 15 plants, 5 from each replication and continued until flowering ceased in each treatment. Finally, at harvest leaf area, seed yield and yield components, dry matter production and it's partitioning into plant parts were recorded. Per cent podset to opened flower, leaf area index (LAI), total dry matter (TDM) and harvest index (HI) were calculated. The TDM plant^{-1} was estimated by summing dry matter of root, stem, leaves and pods dry weight per plant. Harvest index was determined as: (Grain yield plot^{-1} ÷ biological yield plot^{-1}) × 100. Per cent pod set to opened flowers was calculated as follows: % pod set = (Number of pods plant^{-1} ÷ Number of opened flowers plant^{-1}) × 100.

Statistical analysis

All data were analyzed statistically as per the used design following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986). Microsoft Excel was used for graphical presentation.

Conclusion

Loss of leaves through insect attack, disease and other environmental hazards reduces assimilatory surface. Such leaf loss at bud initiation stage up to 25% may not affect seed yield in mungbean as was investigated in the current experiment. Therefore, it may not advisable to spray pesticide for controlling pests in mungbean variety at one-fourth loss of leaf surface to make cost effective and to save environment from pollution.

References

Abdi S, Fayaz MA, Chadimzade M (2007) Effect of different levels of defoliation at reproductive stage on grain yield and oil percent of two hybrid sunflower. Agri Nat Res Sci Tech 11: 245-255

Barimavandi AR, Sedaghathoor S, Ansari R (2010) Effect of different defoliation treatments on yield and yield components in maize cultivation of SC704. Australian J Crop Sci 4 (1): 9-15

Begum M, Hamid A, Sultana W, Khan MR (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 RM, Rao NKS (2003) Influence of leaf excision on photosynthesis, seed setting and yield in okra. Indian J Plant Physiol 8:345-348

Biswas MI, Hossain MA, Fakir MSA (2005) Effect of defoliation at vegetative stage on dry mass production and yield in cowpea. J Bangladesh Agric Univ 3:13-20

Board JE, Harville BG (1998) Late planted soybean yield response to reproductive source-sink stress. Crop Sci 38:763-771

Board JE, Wier AT, Boethel DJ (1997) Critical light interception during seed filling for insecticide application and optimum soybean yield. Agron J 89:369-374

Borras L, Slafer GA, Otegui ME (2004) Seed dry weight response to source-sink manipulations in wheat, maize and soybean: a quantitative reappraisal. Field Crops Res 86:131-146

Chauhan SS, Halima H (2003) Effect of rate of maize leaf defoliation at various stages on grain, stover yield components of maize and undersown forage production. Indian J Agric Res 37 (2): 136-139

Chen CY, Lia WSI (1991) Effects of source-sink alteration on stomatal movement in different soybean cultivars. Photosynthetica 25:437-439

Ghosh BK, Sengupta UK (1986) Effect of source manipulation on photosynthetic activity in groundnut. Indian J Plant Physiol 29:351-356

Gustafson TC, Knezevic, SZ, Hunt TE, Lindquist JL (2006) Stimulated insect defoliation and duration of weed interference affected soybean growth. Weed Sci 54: 735-742

Hossain MA, Haque MA, Chowdhury S, Fakir MSA (2006) Effect of defoliation on morphological characters, dry mass production and seed yield in cowpea. J Bangladesh Soc Agric Sci Technol 3:197-200

Mondal MMA (2007) A study of source-sink relationship in mungbean. Ph.D Thesis, Dept. Crop Bot., Bangladesh Agric. Univ., Mymensingh, Bangladesh.

Pandey PK (1983) Influence of defoliation on seed yield in cowpea [*Vigna unguiculata* (L.) Walp.] in a sub-tropical environment. Field Crops Res 7: 249-256

Pandey RK, Singh VB (1984) Influence of source and sink size on growth and seed yield of mungbean [*Vigna radiata*]. Legume Res 7:27-36

Rao TRT, Ghildiyal MC (1985) Analysis of photosynthetic source and sink relationship in mungbean. Indian J Plant Physiol 28:135-144

Russell DF (1986) MSTAT-C Pakage Programme. Crop and Soil Science Department, Michigan Univ, USA.

Venkateswarlu B, Visperas RM (1987) Source-sink relationships in crop plants. IRRI Res paper series 125:1-19

Verma R, Awasthi AK, Chowdhary BS (1992) Effect of artificial defoliation on plant growth and seed weight of soybean. Indian J Agric Sci 62: 290-292