Bangladesh Agron. J. 2023, 26(1): 48-55

ESCALATION OF GROWTH AND YIELD IN MUNGBEAN BY SINK MANIPULATION: AN APPROACH FOR MINIMIZING POD PICKING EPISODE

A.H.M.M.R. Talukder[1*], F. Ahmed[1], I.M. Ahmed[1], S.N. Mahfuza[1], A.F.M.S. Ahsan[1], N. Mokarraoma[1], M.K. Shahadat[2], L. Nahar[3]

[1]Plant Physiology Division, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
[2]On-Farm Research Division, BARI, Daulatpur, Khulna, Bangladesh
[3]Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
*Corresponding author, Email: motiurbari@yahoo.com

(**Received:** 14 July 2023, **Accepted:** 15 September 2023)

Keywords: Mungbean, sink manipulation, pod picking, growth, yield

Abstract

Farmers' frequently experience difficulties with their mungbean (indeterminate type) crops harvests due to continuous picking that prolong the pod-picking episode and cause an economic crisis. To solve these issues, deflowering strategies (sink manipulation) were employed in this study following the randomized complete block design. A series of deflowering strategies were started from 40 days after sowing (DAS) to 55 DAS; resulting reduced pod production as well as pod picking episode (3 to 4 times) with 6.8-36.8% seed yield compared to control. The minimum seed yield reduction was 6.8%; deflowering at 55 DAS; with the maximum gross margin Tk.112,800 ha^{-1}. Considering relative yield, yield reduction, and gross margin, 50 or 55 days produced flower (which would be matured within 60-65 DAS) could be considered for obtaining the economic seed yield.

Introduction

Growth and production of crops are closely related to the potency of sources and sinks as well as their equilibrium condition (Zhang and Flottmann, 2018, Smith and Stitt, 2007). However, to increase mungbean productivity, it is necessary to carefully study how the output is influenced by sink and how this varies during the course of development. The efficiency of individual plant parts, such as the leaves, stems, roots, and flowers, is a measure of how successfully they compete to suck in assimilates for potential growth rate (Marcelis, 1996). The amount of minerals, sugar, and amino acids available for the growth of other plant parts decreases as a result of developing blooms acting as strong sinks for these nutrients (Mossa et al., 2018). Leguminous plants have blooms that are designed to miscarry because reproductive organs compete for nutrients. Due to the mungbean's indeterminacy before it reached physiological maturity in the first flash, the second flash from fresh racemes develops from upper branches. The second flash from new racemes emerges from upper branches due to the indeterminacy of mungbean earlier than the physiological maturity of the first flash. Naturally, the mungbean crop exhibits low-high-high and low frequencies in pod formation with the first-second-third and later flash of the flower. It's interesting to note that mungbean crops, which have already completed their juvenile period, start to generate new blooms and pods after receiving new management. Hence one common method for limiting the plant's ability to reproduce and produce pod is to sink this opposition by eliminating flower buds (Kokubun *et al.,* 2009). The mungbean's consistent blooming and fruiting, which displays a weekly and erratic cycle for pod development, causes problems for farmers. In the current study, BARI Mung-6, a typical flowering and bearing kind of mungbean variety were selected, causing farmers to deal with the bother of pod selection and incur significant costs. To reduce the pod-picking event, an experiment was done in which the flowers buds^{-1} were removed on separate days following seeding while just keeping the pod.

Materials and Methods

An experiment was conducted in the pot-house of the Plant Physiology Division, BARI, during consecutive two *Kharif-I* (Mid-March to Mid-June) seasons, 2021 and 2022, to observe sink manipulation impacts on growth, yield, and the pod-picking episode of mungbean. Geographically the study area was located between 23°53' and 24°21' N latitudes and in between 90°09' and 92°39' E longitudes and 25 km north of the capital city of Bangladesh. This study was done following the randomized complete block design (RCBD) with 10 replications and each pot represented one replication. Mother seeds of trial var. BARI Mung-6 were collected from Pulse Research Centre of Bangladesh Agricultural Research Institute (BARI), Ishurdi, Pabna-6600. Five deflowering strategies were employed viz. (i) control (no deflowering) (NDF); (ii) Deflowering started at 40 days after sowing (DAS) (DF40); (iii) Deflowering started at 45 DAS (DF45); (iv) Deflowering started at 50 DAS (DF50), (v) Deflowering started at 55 DAS (DF55). A total of 50 plastic pots (26 cm top diameter, 20 cm base diameter, and 25 cm height) were organized in the pot-house of the plant physiology division of BARI, with 10 pots placed in each replicate blocks. Soil and fully decomposed farmyard manure were appropriately blended in a 4:1 volume ratio and sieved through a 2 mm sieve. The sieved soil samples were weighed and placed in pots, each holding around 12 kg of soil. Fertilizers @ 18-18-24-12-2.0-1.2 kg ha^{-1} of N-P-K-S-Zn-B were applied in the form of urea, triple super phosphate, muriate of potash, zypsum, zinc sulfate, and Boron respectively (Ahmmed *et al.,* 2018). The pots had enough perforation system at the bottom for the drainage of water. Seven to ten healthy, bigger, and equal-sized mungbean seeds were chosen and treated with Provax 200 EC @ 2.5 g kg^{-1} seeds and sown on 05 March 2021 and 01 March 2022. Finally, following uniform emergence two seedlings in each pot were maintained.

For growth data, randomly selected three pots were sampled for dry matter measurement at 35 DAS (Just before treatment application), 55 DAS, and 70 DAS (after final harvest). Sampled plants were separated into leaves, stems, and roots based on plant growth stages.

Plants were dried in an oven for 72 hours at 80° C ± 2 and calculated total dry matter weight (g plant^{-1}) from the summation of leaves, stem, and roots weights were taken in an electronic balance. Besides these, the relative yield, percent yield reduction; absolute growth rate and relative growth rate were calculated by using the following formula:

$$\text{Relative yield} = \frac{\text{Yield of deflowered (treated) plants}}{\text{Yield of control (non deflowered)plants}} \times 100$$

$$\text{Percent yield reduction} = \frac{\text{Yield of control pot} - \text{Yield of deflowering pot}}{\text{Yield of control pot}} \times 100$$

$$\text{Absolute Growth Rate (AGR)} = \frac{\Delta \text{W}}{\Delta \text{T}} = \frac{(\text{W}_2 - \text{W}_1)}{(\text{T}_2 - \text{T}_1)} \text{ (García et al., 2006)}$$

$$\text{Relative Growth Rate (RGR)} = \frac{(\overline{\ln W_2} - \overline{\ln W_1})}{(\text{T}_2 - \text{T}_1)} \text{ (Hoffmann and Poorter, 2002)}$$

Where, W and T represent weight (g) and time (day), respectively. $\overline{\ln W_2}$ and $\overline{\ln W_1}$ are the means of the natural logarithm-transformed dry weights.

At harvest, yield and yield components data were collected from three pots and analyzed using ANOVA technique Least Significant different values were calculated at 0.05 probability level wherever the F-test was significant. Data analysis was performed with the software environment R 4.2.3 using 'agricolae' package (R core team, 2023).

Results and Discussion

In the present study, mungbean crops growth and yield showed variable responses due to deflowering at different dates after sowing. The obtained response due to deflowering response and their relevant discussion has been described in this chapter.

Total dry matter

This study evaluated sink manipulation effect on total dry matter (summation of leaf, stem and root) production of mungbean. Dry matter at 3 stages of growth was collected viz. 30 DAS (before imposing deflowering treatment), 55 DAS and 70 DAS (just before harvest). In both 2021 and 2022, there were no significant differences in total dry matter production among the treatments at 35 DAS (Figure 1).

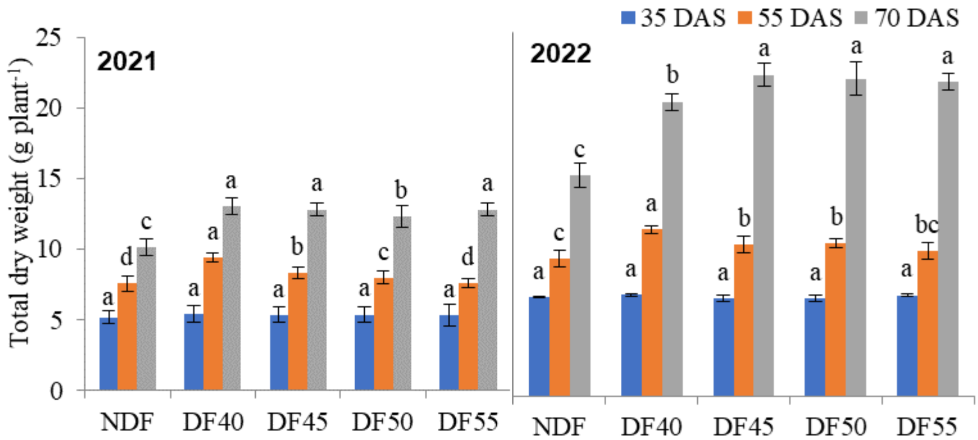

Fig. 1. Effect of deflowering treatments viz. no deflowering (NDF), deflowering at 40 days after sowing (DF40), deflowering at 45 days after sowing (DF45), deflowering at 50 days after sowing (DF50) and deflowering at 55 days after sowing (DF55) on total dry weight in mungbean during *kharif* 2021 and 2022. Data were collected at 35 days after sowing (DAS), 55 DAS and 70 DAS in 2021. Treatments with same letter did not vary significantly.

At 35 DAS, the ranges of total dry matter were 5.19 to 5.39 g plant^{-1} and 6.70 to 6.92 g plant^{-1} in 2021 and 2022, respectively. In 2021, at 55 DAS, total dry matter was recorded highest from DF40 (9.42 g plant^{-1}), whereas the lowest but statistically identical total dry weight was found from NDF (7.55 g plant^{-1}) and DF55 (7.58 g plant^{-1}). At 70 DAS, dry matter production in DF40 (13.03 g plant^{-1}) was, which was statistically identical with DF45 (12.80 g plant^{-1}) and DF55 (12.80 g plant^{-1}). Similarly in 2022, at 55 DAS, maximum total dry weight was recorded from DF40 (11.41 g plant^{-1}). However, at 70 DAS, DF45 produced maximum dry weight plant^{-1} (22.07 g plant^{-1}), which was again statistically identical to DF50 (21.80 g plant^{-1}) and DF55 (21.60 g plant^{-1}) (Figure 1). Over the growing seasons, total dry weight (g plant^{-1}) was much greater in 2022 than 2021 due to sufficient rainfall during the growth period; however, treatment effects showed almost similar pattern of response (Figure 1). In the both 2021 and 2022, there was no discernible difference in total dry weight among treatments when samples were taken at 35 days following sowing. Deflowering effects on total dry weight were noticeable when sampling was 55 DAS and 70 DAS. Overall, it appeared that deflowering at later stage increased total dry weight in all deflowering treatments in both the years and followed increasing pattern as 35 DAS< 55 DAS< 70 DAS. Deflowered sunflower plants had a larger stem and leaf dry weight, according to previous research of Ho and Below (1989). In accordance with their findings, deflowering effect in the present study showed increased total dry weight in comparison to control (NDF) (Figure 1). On an average, plant dry weight (summation of leaf, stem and root) was increased by 21.1 and 31.0%, 9.85 and 35.2%, 7.75 and 32.6%, and 2.79 and 34.6% at 55 DAS and 70 DAS sampling, respectively over the control. This could mainly be attributed to the production of new leaves and absence of potential sink in deflowered treatments. Previous study conducted by Mitra and Ghildhyal (1988) found that deflowered mungbean plants significantly increased in dry weight of leaf, stem, roots and nodules.

Absolute growth rate and relative growth rate

The Figure 2 showed the variation in absolute and relative growth rate at 35 DAS, 55 DAS and 70 DAS in different deflowering treatments. In 2021, AGR decreased from 35 DAS to 55 DAS in all treatments except DF40. Those treatments showed rapid rise in AGR after 55 DAS up to 70 DAS. DF40, however, demonstrated a continuous increase in AGR from 35 to 70 DAS. In case of RGR, all treatments dropped in RGR from 35 DAS to 55 DAS. However, RGR increased in DF45, DF50 and DF55 from 55 DAS to 70 DAS. RGR, however, did not rise any further in NDF, and DF40 continued to decline. During 2022, all treatments except DF40 showed slightly downward trend for RGR from 35 DAS to 55 DAS, however, all treatments showed sharp increase up to 70 DAS. Where, RGR were higher in DF45 and DF55.

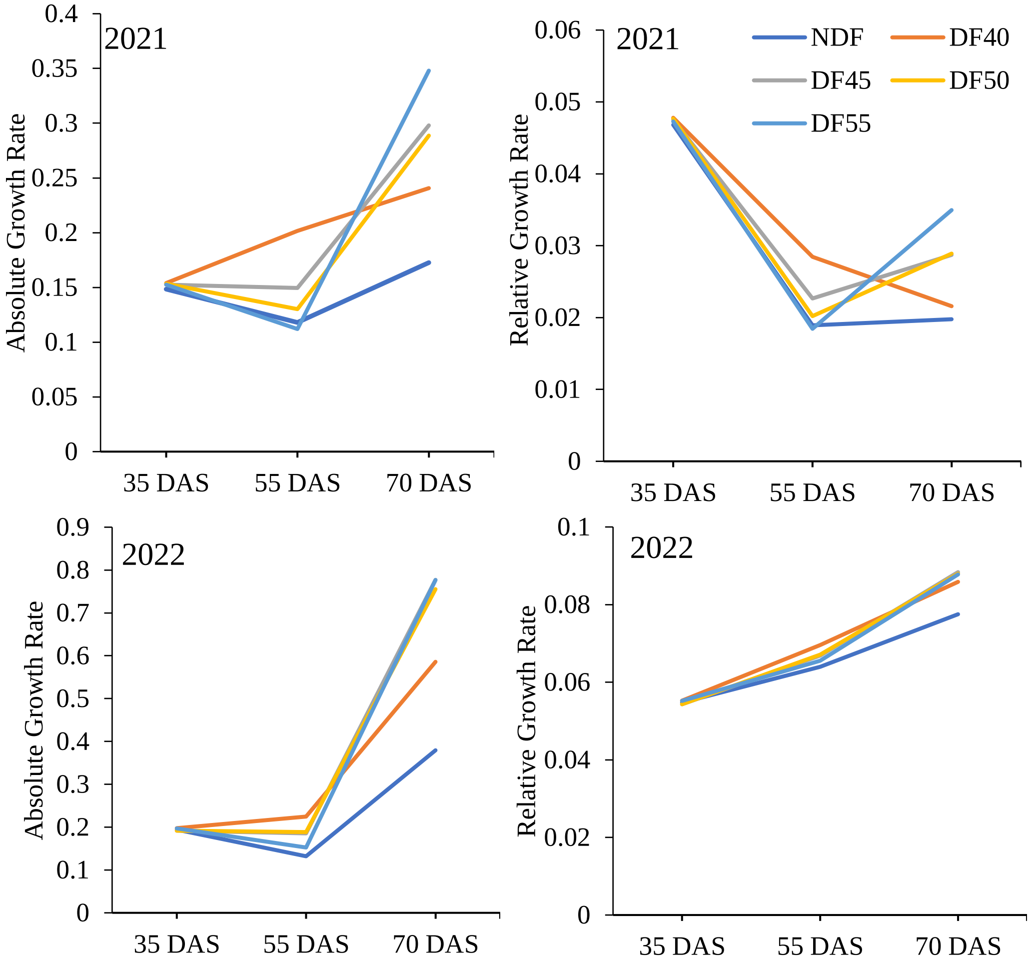

Fig. 2. Absolute growth rate and relative growth rate of mungbean as influenced by deflowering treatments during 2021 and 2022.

Effect of deflowering on plant height

Deflowering treatments showed variable response in plant height in both years. However, overall plant height was found taller in 2022 than 2021 (Figure 3). In 2021, the range of plant height was between 20.4 ± 0.83 in NDF to 22.9 ± 0.58 in DF40, which was statistically identical to DF45 (22.6 ± 0.37). In 2022, the highest plant height was recorded from DF40 (33.0 ± 0.87 cm) and DF45 (33.0 ± 1.15 cm). Whereas, NDF produced lowest plant height 26.2 ± 0.58 cm.

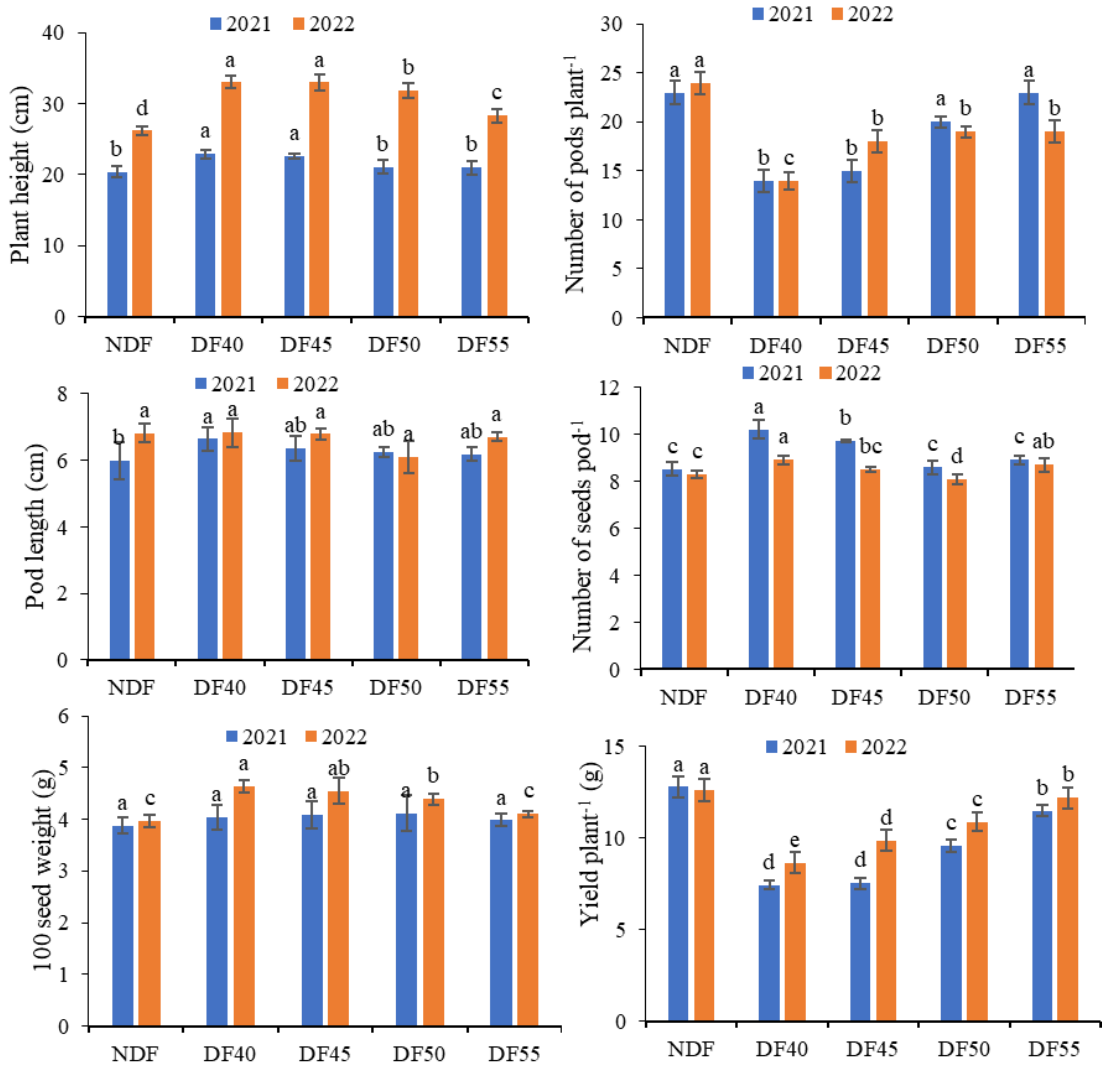

Fig. 3. Deflowering treatments effect on plant height (cm), number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1}, 100-seeds weight (g) and yield plant^{-1} (g) in mungbean during *kharif* 2021 and 2022.

Effect of deflowering on yield components and seed yield

Over the growing seasons, the deflowering strategies effects were noticeable in the production of the number of pod plant^{-1} which was gradually increased with the prolongation of the deflowering period, and control (NDF) treatment produced significantly maximum number of pods plant^{-1} (23.0 ± 1.15 and 24.0 ± 1.15 in 2021 and 2022, respectively). Number of pods plant^{-1} increased gradually when deflowering was delayed i.e., DF40<DF45<DF50<DF55 (Figure 3). Pod length did not differ significantly among the different deflowering strategies in 2022. However, in 2021 there was no significant difference among the deflowering treatments except control (NDF). Numerically the highest pod length was found at DF40 in both the seasons (Figure 3). The number of seeds pod^{-1} obtained from different deflowering strategies over control had a significant effect. On an average over two growing seasons, the number of seeds pod^{-1} ranged from 8 to 10 (Figure 3). The highest number seeds pod^{-1} were recorded from DF40 in both the seasons (10.2 ± 0.40 and 8.90 ± 0.17, respectively). However, delay in deflowering reduced the number of seeds pod^{-1} (Figure 3).

Deflowering strategies did not influence on 100-seed weight in 2021. However, in 2022, 100 -seed weight was maximum at DF40 (4.64 ± 0.12 g), which was statistically similar to DF45 (4.55 ± 0.26 g).

There were no significant differences between control (NDF) and DF55 (Figure 3). The seed yield of mungbean was significantly influenced by different deflowering strategies. Among the deflowering treatments, yield (g plant^{-1}) was increased with prolongations of deflowering but decreased compared to the control. The maximum (12.8 g plant^{-1}) and minimum yield (7.43 g plant^{-1}) were found in control (NDF) and DF40, respectively in 2021. In a similar fashion, highest seed yield (12.63 g plant^{-1}) was recorded from control (NDF) and lowest yield (8.65 g plant^{-1}) from DF40 in 2022 (Figure 3). Naturally, flower blooming in mungbean crops starts at the base of the inflorescence and continues up to the top, known as the "first flush," and after the first flash pod reaches physiological maturity, flower blooming begins again at the trailing edge of the same inflorescence, known as the "second flash"(Mondal et al., 2011).

However, in our current study, the results of deflowering found a significant effect on yield-contributing traits and seed yield of mungbean crops. Over the growing seasons, the deflowering strategies effects were noticeable in the production of the number of pod plant^{-1} and were gradually increased with the prolongation of the deflowering period, and control (no deflowering) treatment produced the significant maximum number of pods plant^{-1}. The number of pods plant^{-1} was increased chronologically retaining the onset flower 40<45<50<55 days over control (Figure 2). Pod set percentage was decreased by 40.4%, 29.80%, 17.0%, and 10.6% in response to deflowering at 40, 45, 50, and 55 DAS, respectively than control. Results suggested that earlier deflowering treated plants retained fewer flowers than the later deflowering and consequently decreased the number of pods plant^{-1}. Pod length (size) was less responsive due to deflowering. Though number of pods plant^{-1} was higher in NDF, however number of seeds pod^{-1} was lower in NDF along with DF50. On the average growing seasons, the number of seeds pod^{-1} ranged from 8 to 10. The percentage of seed set pod^{-1} was increased by 25.0% and 12.5% at earlier deflowering strategies *viz.* 40 and 45 DAS over control, but at later deflowering strategies was almost similar to control. As a result, 100-seeds weight was highest in DF40 and DF50 only in 2022.

The seed yield of Mungbean was significantly influenced by different deflowering strategies. Among the deflowering treatments, yield (g plant^{-1}) was increased with delay in deflowering, however deflowering did not significantly increase yield compared to the control (NDF). The maximum (12.8 g plant^{-1}) and minimum yield (7.43 g plant^{-1}) were found in control (NDF) and DF40. So, it appeared that flower retention at earlier stage increased total number of pods plant^{-1} and thereby increased yield. Seed yield decreased by 41.9%, 41.1%, 25.0%, and 10.0%, from deflowering at 40, 45, 50, and 55 DAS, respectively. In accordance with the previous study of Ojehomon (1970) on Cowpea, deflowering on mungbean at early stage of the reproductive cycle decreased grain yield and later deflowering, increased grain yield.

Relative yield and percent yield reduction over control

Deflowering at 40, 45, 50, and 55 DAS, produced 58%, 59%, 75% and 90% relative yield plant^{-1} over control in 2021, respectively. The similar trend was observed in 2022. Here deflowering treatments produced considerably higher relative yield than 2021. Delay in deflowering time steadily boosted relative yield.

The minimum relative yield of 58% and 68% in 2021 and 2022, respectively were found when all bloomed flowers were removed at 40 DAS but the maximum relative yield (90% and 97% in 2021 and 2022, respectively) were found when all bloomed flowers were removed at 55 DAS (Figure 4).

Deflowering at 40, 45, 50, and 55 DAS reduced the grain yield of mungbean by 42%, 41%, 25%, and 10%, respectively in 2021 in comparison to the control, whereas in 2022 yield reduction from deflowering at 40, 45, 50, and 55 DAS were 32%, 22%, 14% and 3%, respectively (Figure 4).

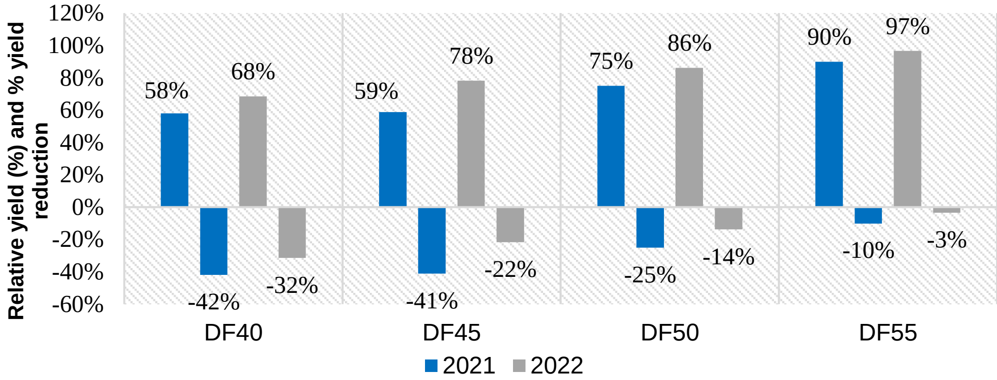

Fig. 4. Relative yield (%) and % yield reduction over control (no deflowering) at different deflowering treatments in mungbean during *kharif* 2021 and 2022.

Cost-benefit analysis

From control (NDF) pots, pods were picked maximum of five times, which produced highest seed yield (1.91 t ha^{-1}), and at the same time incurred highest pod picking cost hectare (TK. 52,500 ha^{-1}). (Table 1). Minimum one-time pod picking was done from deflowering at 40 and 45 DAS treated plants where marginal benefit cost ratio (MBCR) was 1.50 and 1.12, respectively. The maximum gross margin of Tk. 1, 12,800 ha^{-1} was obtained from deflowering at 55 DAS treated plants but gave lowest MBCR (0.43). Deflowering at 50 DAS gave gross return of TK. 116,400 and gave highest MBCR (1.60) (Table 1).

Table 1. Economic performances under different deflowering strategies

Treatments	Economic analysis						
	Grain Yield (g plant^{-1}) (average of two growing season)	Grain Yield (t ha^{-1})	Pod picking episode	Average pod picking cost of two season (Tk ha^{-1})	Gross return (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
NDF	12.7	1.91	05 times	52,500	1,52,400	99,900	1.00
DF40	8.0	1.20	01 times	15,000	96,000	81,000	1.50
DF45	9.2	1.38	01 times	15,000	1,10,400	95,400	1.12
DF50	9.7	1.46	02 times	30,000	1,16,400	86,400	1.60
DF55	11.9	1.79	02 times	30,000	1,42,800	1,12800	0.43

One hectare areas pod picking need 30 labors and per labor cost is Tk. 500 day^{-1}.

Where, NDF- no deflowering (control), DF40- deflowering at 40 days after sowing (DAS), DF45- deflowering at 40 DAS, DF50- deflowering at 50 DAS and DF55- deflowering at 55 DAS. MBCR=marginal benefit cost ratio

In terms of economic analysis, DF40 and DF45 facilitate only a single pod picking episode. However, based on the overall cost benefit analysis, DF50 and DF55 required a couple times of pod picking, where DF50 gave higher MBCR (1.60) than any other treatments.

Conclusion

The study showed that mungbean yield varied depending on the sink size (deflowering) at various periods of the reproductive phase. So, it is important to consider potential sink sizes throughout the reproductive phase in order to obtain economic yield. 50 or 55 days produced flower (which would be matured within 60-65 DAS) could be considered for obtaining the economic seed yield by sacrificing minimum seed yield (6.8%). So, farmers should complete pod picking within 65 DAS without waiting for the maturity of the remaining pods.

Acknowledgments

This research was funded by climate change project (phase-II), implemented by KGF, Farmgate, Dhaka, Bangladesh.

References

Ahmmed, S. and M. Jahiruddin. 2018. Fertilizer Recommendation Guide-2018. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215, Bangladesh. pp. 223.

García, A.L., J.A. Franco, N. Nicolás and R.M. Vicente. 2006. Influence of amino acids in the hydrophonic medium on the growth of tomato plants. J. Plant Nutr. 29: 2093-2104

Ho, L. and F.E. Below. 1989. Whole plant senescence of sunflower following seed head removal. Plant Physiol. 91: 85-90.

Hoffmann, W.A. and H. Poorter. 2002. Avoiding bias in calculations of relative growth rate. Ann. Bot. 80: 37-42.

Kokubun, M., K. Nonokawa, A. Kaihattttsu and Y. Yashima. 2009. Mechanisms controlling flower abortion in soybean. Tohoku J. Agric. Res. 60: 23-26.

Marcelis, L.F. 1996. Sink strength as a determinant of dry matte partitioning in the whole plant. J. Exp. Bot. 47: 1281-1291.

Mitra, S., and M.C. Ghildhyal. 1988. Photosynthesis and assimilate partitioning in Mungbean in response to source-sink alteration. J. Agron. Crop Sci. 160: 303-308.

Mondal, M.M.A., M.S.A. Fakir, A.K.M.A. Prodhan, M.R. Ismail and M. Ashrafuzzaman. 2011. Deflowering effect on vasculature and yield attributes in raceme of Mungbean (*Vigna radiata* L. Wilczek). Aust. J. Crop Sci. 5: 1339-1344.

Mossa, H.Y, A. Mohammed and D. Fekadu. 2018. Effect of flower bud removal on root quality of Anchote (*Coccinia abyssinica* L. Cogn.) accessions at Bishoftu, Ethiopia. Asian J. Plant Sci. Res. 8(4): 18-23.

Ojehomon, O.O. 1970. Effect of continuous removal of open flowers on the seed yield of two varieties of cowpea (*Vigna unguiculata* L. walp). J. Agric. Sci.74: 375-381.

R Core Team 2023. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Smith, A.M. and M. Stitt. 2007. Coordination of carbon supply and plant growth. Plant Cell Environ. 30: 1126-1149.

Zhang, H and S. Flottmann. 2018. Source-sink manipulations indicate seed yield in canola is limited by source availability. Eur. J. Agron. 96: 70-76.