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Performance of Mungbean in the South-Central Region of Bangladesh

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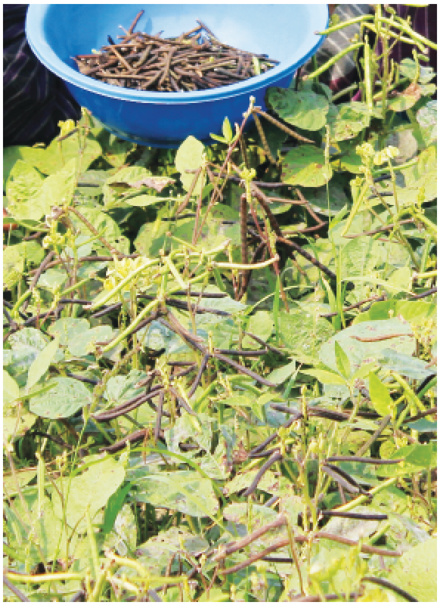
EXECUTIVE SUMMARY

Bangladesh has been experiencing shortage of land for pulses, whereas its demand is increasing day by day. Thus, increasing yield remains to be the option for elevating pulse production in the country. In this regard, Mung bean can play an important role especially in the South-Central Region of Bangladesh. This study was undertaken for scoping increased yield and profitability of the crop in the region. Field experiments were conducted using three genotypes ['G'] ('Sonamoog', a local variety, and two improved varieties, 'Binamoog-8' and 'BARI Mug-6'), four location environment ['E[L]'] (Barguna Sadar, Barisal Sadar, Bhola Sadar and Patuakhali Sadar upazilas), two seasonal environment ['E[Y]'] (years 2016 and 2017) and two management ['M'] (Farmers' management and Improved management). Results showed that the seed yield from 'Binamoog-8' (1062 kg ha^{-1}) and 'BARI Mug-6' (1069 kg ha^{-1}) was statistically similar, but significantly higher than the local variety 'Sonamoog' (733 kg ha^{-1}). Between the locations, Barguna Sadar produced significantly highest seed yield (1135 kg ha-1) and Barisal Sadar the lowest (628 kg ha^{-1}). The yield was significantly higher in 2016 (1077 kg ha^{-1}) compared to 2017 (832 kg ha^{-1}), and significantly lower (711 kg ha^{-1}) under farmers' management than improved management (1198 kg ha^{-1}). The regression analysis undertaking combination of three plant characteristics, pods $plant^{-1}$, seeds pod^{-1} and 100 seed weight, explained 83% variation in seed yield ($P \leq 0.001$). Among the three plant characteristics, pods $plant^{-1}$, largely contributed to the seed yield ($r = 0.76$). Improved management produced optimum population density (m^{-2}) which ultimately translated into larger number of pods $plant^{-1}$. The individual contribution of 'G' accounted for 12.8% seed yield variation in this study, which was much lower than management 'M' (31.0%) or 'E' (27.5%). The gross margin, 'GM', was ~46,000 (BDT ha^{-1}) from 'BARI Mug-6' in Barguna Sadar and Patuakhali Sadar, and from 'Binamoog-8' in Patuakhali Sadar – all under improved managements. The production costs under improved management (BDT 52,084 ha^{-1}) was almost double than farmers' management (BDT 26,810 ha^{-1}). The GM affected due to selling price of mungbean; this price varied by variety and location. Under current market need, adopting 'BARI Mug-6' can be a choice of the genotype in the region couple with targeted management that ensures optimum plant population. Extension and development agencies may undertake programs for diffusing of the knowledge. Side by side, research institutes make think of developing robust genotypes to suit under low management and constrained environments.

1.0 INTRODUCTION



Pulses constitute an important component of the Bangladesh diet, and have historically been a major part of the farming system. A large number of pulse crops are grown in Bangladesh, among those, mungbean (***Vigna radiata***) is the third most important pulse crop in terms of area and tonnage grasspea (***Lathyrus sativus***) and lentil (***Lens culinaris***) (Asaduzzaman ***et al***. 2008). Its importance is related to its short growing period ideal for intensive crop production, which makes it an ideal cash crop. Its role in nitrogen fixation to improve soil fertility also makes it an ideal crop to cropping patterns (Ahmed ***et al***., 1978).

Although Mungbean is popularly grown on elevated land, the south-central region of Bangladesh where it is traditionally grown, is often affected by monsoon floods and submergence. Thus, to enable its production in this region, improved physical facilities such as dams have been developed. However, the area under pulses cultivation has been declining because of the growing demand of cereals, and declining cultivable land due to population and land pressures. Resulting in the production deficit of pulses of 2.55 MT as of 2014. Thus, meeting this deficit largely depends on increasing yield by improving, farmers' knowledge and experience with its production in respect to genotype, environment and agronomic practices (Islam ***et al***., 2016). Rao ***et al***. (2010) further argues that the yield gap can be bridged by improving farmers' access to quality inputs, improved technologies and information. This study is an attempt to explore the avenues through which Mungbean productivity can be increased in the south-central region of Bangladesh.

2.0 MATERIALS AND METHODS

This study was conducted in farmers' fields in the south-central region of Bangladesh. It consisted of 3 main treatments: Genotype (G), Environment (E) and Management (M) (Table 1). The 'G' comprised of 3 varieties – 1 local ('Sonamoog') and two improved ('Binamoog-8' and 'BARI Mug-6'). The 'E' had two sub-treatments – 4 locations [E(L)]: Barguna Sadar, Barisal Sadar, Bhola Sadar and Patuakhali Sadar upazilas; and two years [E(Y)]: 2016 and 2017. The 'M' treatment had 2 factors: Farmers' management and Improved management.

Table 1: Treatments and their specifications undertaken in the study.

Treatment	Treatment specification
Genotype (G)	3 varieties- Sonamoog (Local check), Binamoog-8 (Improved) and BARI Mug-6 (Improved)
Environment (E)	4 locations (E-L)- Barguna Sadar, Barisal Sadar, Bhola Sadar and Patuakhali Sadar
	2 years (E-Y)- 2016 and 2017
Management (M)	2 agronomic practice- Farmers' management and Improved management

The field trials were carried out in randomized complete block (RCB) design and replicated 4 times (each farmer's field as one replication). Altogether, there were 192 experimental units in the study (3 variety × 4 locations × 2 years × 2 agronomic practices × 4 replications).

Data were collected on seed yield, number of pods per plant, number of seeds per pod, 100 seed weight (SW) and plant density.

Results were analyzed following the principle of RCB design using CropStat for Windows, Version 7.2.2007.3 software (International Rice Research Institute). The means treatments and/or treatment combinations were compared by LSD (least significance difference). Descriptive statistics of seed yield including histogram were analyzed using 'Excel Data Analysis Tool'. The same statistical tool was also used to perform multiple regression to quantify the combined effect of pods plant^{-1}, seeds pod-1 and 100 seed weight on seed yield. The partitioning of contributions of 'G', 'E' and 'M' to seed yield was calculated according to Anderson ***et al***. (2005).

3.0 RESULTS

3.1 : Distribution of seed variety of mungbean in the study

The seed yield of mungbean across the treatments ranged from 235 to 2161 kg ha-^{1} (Fig. 1a). The mean yield was 955 kg ha-1 with a standard error of 32 kg ha-^{1}. The most frequently recorded yields (39 out of 192 data-points) observed in the range of 850 – 1050 kg ha-^{1} slightly skewed on the right (skewness = 0.53) and light-tailed (kurtosis =-0.42) (Fig. 1b). Overall, both the skewness and kurtosis was small indicating the distribution was close to normal.

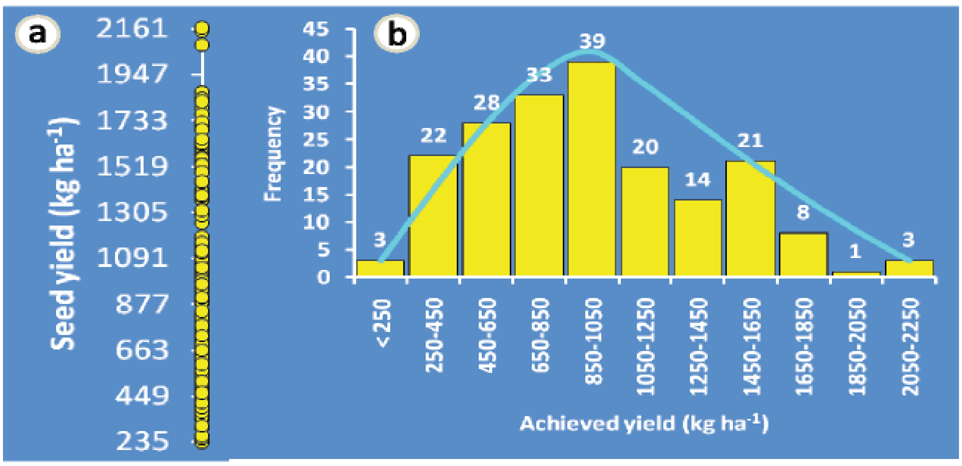


Fig. 1: The Column (a) graph and histogram (b) showing the range and distribution of grain yields of mungbean across the treatments in the experiments conducted in the South-Central Region of Bangladesh.

3.2 : The analysis of variance and treatment effects

Table 2 shows the analysis of variance (ANOVA) of seed yield and yield contributing characters of mungbean. Significant variation (P≤0.05) in seed yield occurred to variety, location, year and management; in pods per plant due to location, year and management; in seeds per pod due to location and management; in 100 seed weight due to variety, location, year and management; and in plant density due to variety, location and year. The interaction of some treatments also varied the yield and yield attributes of mungbean in this study. For example, the seed yield was significantly affected by the interactions of variety × location, variety × management, location × year, location × management, year × management and location × year × management. On the other hand, the seeds per pod varied due to interactions of variety × location and location × management (Table 2).

Table 2: Probability (P) of variation in seed yield and yield contributing characters within a treatment or treatment interaction. DF and SW denote for degrees of freedom and seed weight, respectively. Bold figures indicate statistical significance at P≤0.05.

Source of variation	DF	Yield and yield contributing characters				
		Seed yield	Pods per plant	Seeds per pod	1000 SW	Plant density
		Probability of statistical significance				
Variety	2	**0.00**	0.65	0.09	**0.00**	**0.02**
Location	3	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Year	1	**0.00**	**0.05**	0.97	**0.02**	**0.00**
Management	1	**0.00**	**0.00**	**0.00**	**0.00**	0.10
Rep	3	**0.01**	0.10	**0.00**	0.49	**0.01**
Variety*Location	6	**0.02**	0.15	**0.01**	**0.00**	**0.01**
Variety*Year	2	0.38	**0.00**	0.61	**0.02**	0.77
Variety*Management	2	**0.00**	0.67	0.75	**0.00**	0.93
Location*Year	3	**0.00**	**0.00**	0.24	0.13	**0.00**
Location*Management	3	**0.01**	**0.00**	**0.00**	**0.02**	**0.00**
Year*Management	1	**0.04**	0.82	**0.05**	0.14	**0.00**
Variety*Location*Year	6	0.78	**0.00**	0.75	0.26	0.65
Variety*Location*Management	6	0.89	0.76	0.73	0.91	0.72
Variety*Year*Management	2	0.95	0.45	0.98	0.33	0.27
Location*Year*Management	3	**0.00**	**0.04**	0.06	0.70	**0.00**
Location*Year*Variety*Management	6	0.99	0.51	1.00	0.78	0.78

Table 3 shows that across the locations, years and management, seed yield from 'Binamoog-8' (1062 kg ha^{-1}) and 'BARI Mug-6' (1069 kg ha^{-1}) was statistically similar, but significantly higher than the local variety 'Sonamoog' (733 kg ha^{-1}). Between the locations, Barguna Sadar produced the highest seed yield (1135 kg ha^{-1}) and Barisal Sadar significantly (P≤0.05) lowest (628 kg ha^{-1}); the yield resulted from Bhola Sadar (1043 kg ha^{-1}) and Patuakhali Sadar (1013 kg ha^{-1}) was statistically similar but significantly lower than Barguna Sadar. Across the locations, varieties and management, seed yield was significantly higher in 2016 (1077 kg ha^{-1}) compared to 2017 (832 kg ha^{-1}). The yields under farmers' management was significantly lower (711 kg ha^{-1}) than improved management (1198 kg ha^{-1}).

Table 3: Seed yield and yield contributing characters of mungbean as affected by treatments. LSD denotes for least significance difference at P≤0.05. Figures in a column having common letters are not statistically significance at P≤0.05.

Treatment	Yield and yield contributing characters				
	Seed yield (kg ha^{-1})	Pods per plant (Number)	Seeds per pod (Number)	1000 SW (g)	Plant density (Number m^{-2})
Variety					
Sonamoog	733b	27.6a	10.5a	26.5c	33.0a
Binamoog-8	1062a	26.6a	10.6a	40.9b	33.0a
BARI Mug-6	1069a	26.9a	10.2a	43.1a	32.0a
LSD	66	2.2	0.3	1.2	2.2
Location					
Barguna Sadar	1135a	32.7a	12.1a	41.8a	32.3b
Barisal Sadar	628c	15.3c	9.8b	35.0c	42.0a
Bhola Sadar	1043b	25.6b	10.4b	37.5b	27.0c
Patuakhali Sadar	1013b	34.5a	9.5b	33.0d	29.0c
LSD	76	2.5	0.4	1.4	2.5
Year					
2016	1077a	27.9a	10.4a	37.4a	32.0a
2017	832b	26.1b	10.4a	36.3b	33.0a
LSD	54	1.8	0.3	1.0	1.8
Management					
Farmers' management	711b	20.7b	10.0b	35.8b	31.0b
Improved management	1198a	33.4a	10.9a	37.9a	35.4a
LSD	54	1.8	0.3	1.0	1.8

While the varieties produced statistically similar number of pods plant-1 and seeds pod-^{1}, the seed size (measured as 100 seed weight) was significantly bigger in 'BARI Mug-6' (43.1 g) followed by 'Binamoog-8' (40.9 g) and smallest in 'Sonamoog' (26.5 g) (Table 3). In Barguna Sadar, plants had more pods and seeds per pod and bigger seeds compared to other locations. The pod number (per plant) and seed weight increased in 2017 compared to 2016. Under farmers' management, number of pods (per plant) and seeds (per pod) and seed weight reduced than improved management (Table 3). In general, improved management significantly contributed to increased plant population (35.4 m-^{2}) than farmers' management (31.0 m-^{2}).

3.3 : Contribution of yield parameters to seed yield of Mungbean

The variation in seed yield of mungbean in this study was explained by the contribution of agronomic characteristics of the crop in the experiments. The regression analysis between three yield parameters- pods plant^{-1}, seeds pod-1 and 100 seed weight – and seed yield shows, the combined effect of the three parameters explained 83% variation in seed yield ($P \leq 0.001$) (Fig. 2).

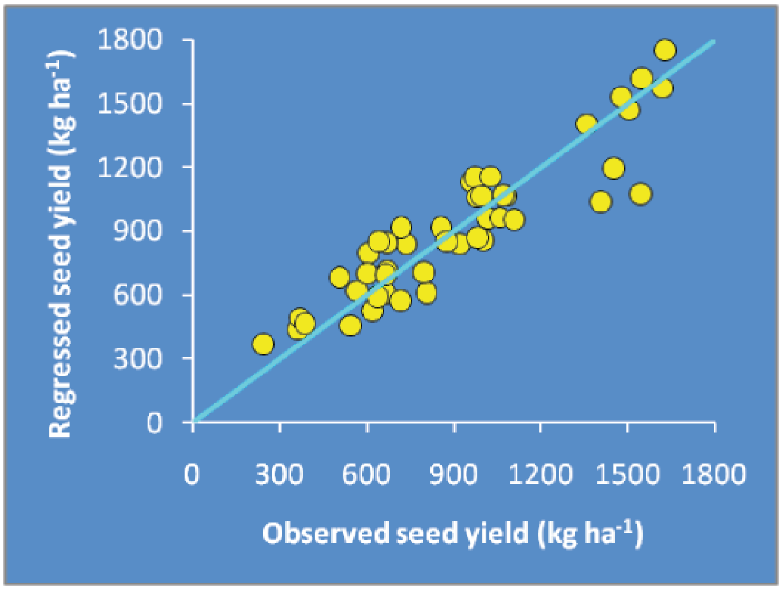


Fig. 2: Regression between observed and predicted seed yield of mungbean in the study.

The predicted yield was calculated from the regression model Y =-825.12 + 21.70 * pods plant^{-1} + 53.07 * seeds pod^{-1} + 16.79 * 100 seed weight; $R^2 = 0.83$; n = 45; $p < 0.001$.

Among the three yield attributes, pods plant^{-1}, largely contributed to the seed yield (r = 0.76) compared to 100 seed weight (r = 0.60) or seeds pod^{-1} (r = 0.55). The pods plant^{-1} predominantly varied due to management factor. Fig. 3 shows in all the locations and years, improved management resulted in more number of pods plant^{-1} compared to farmers' management. Improved management produced optimum population density (measured as plant m^{-2}) which ultimately translated into larger number of pods plant-1. As shown in Fig. 5, plant population of 30 – 40 m-2 under improved management produced, on average, 56.4 pods plant-1; whereas, lower or higher population density as practiced by the farmers resulted in comparatively smaller number of pods plant-1.

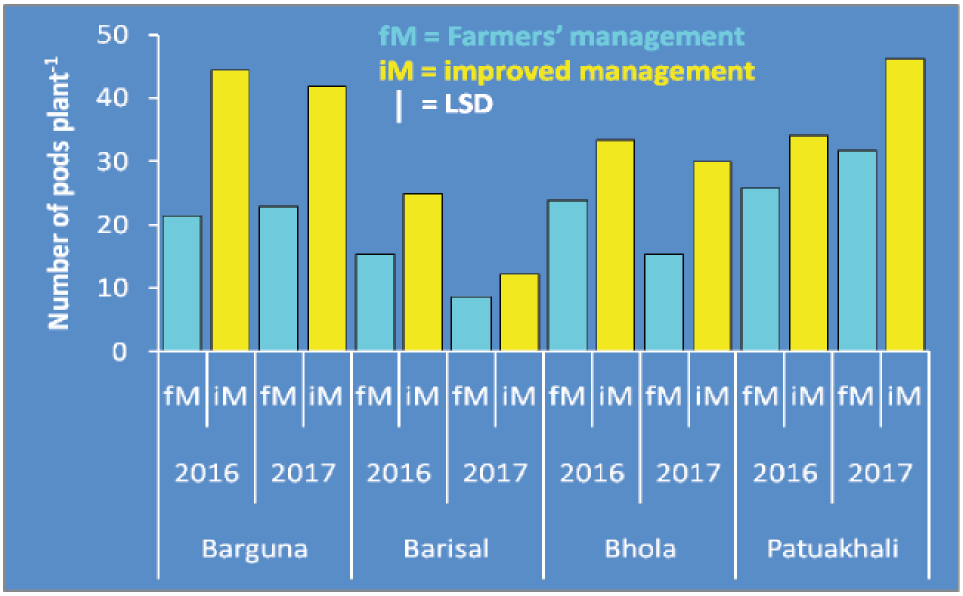


Fig. 3: Number of pods per plant across three mungbean varieties under farmers' and improved management in 2016 and 2017 seasons in four locations of the study. The variations in column height beyond the LSD (least significance difference) bar represent significance difference at P≤0.05.

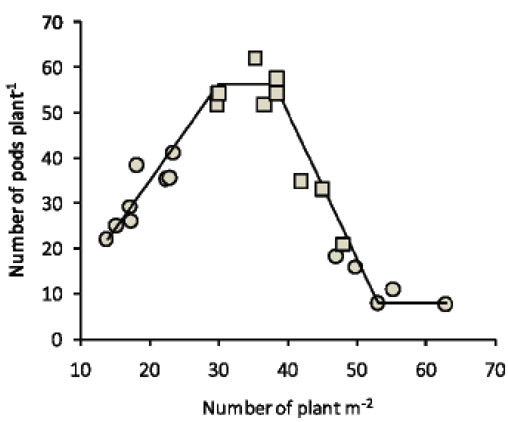
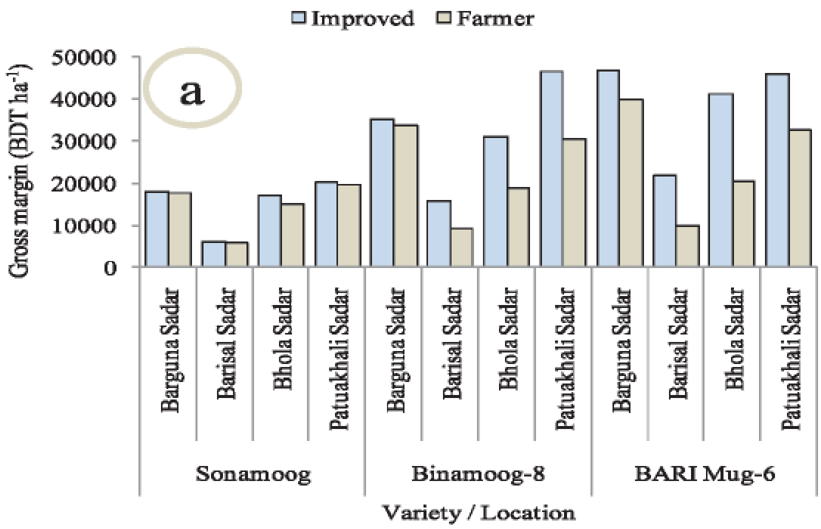


Fig. 4: Relationship between plant population m-2 and number of pods plant-1.

3.4 : The Economics of Mungbean yield

The gross margin (GM) varied according to varieties, locations and management practices. The GM was ~46,000 (BDT ha-[1]) from 'BARI Mug-6' in Barguna Sadar and Patuakhali Sadar, and from 'Binamoog-8' in Patuakhali Sadar (Fig. 6a) – all under improved managements.



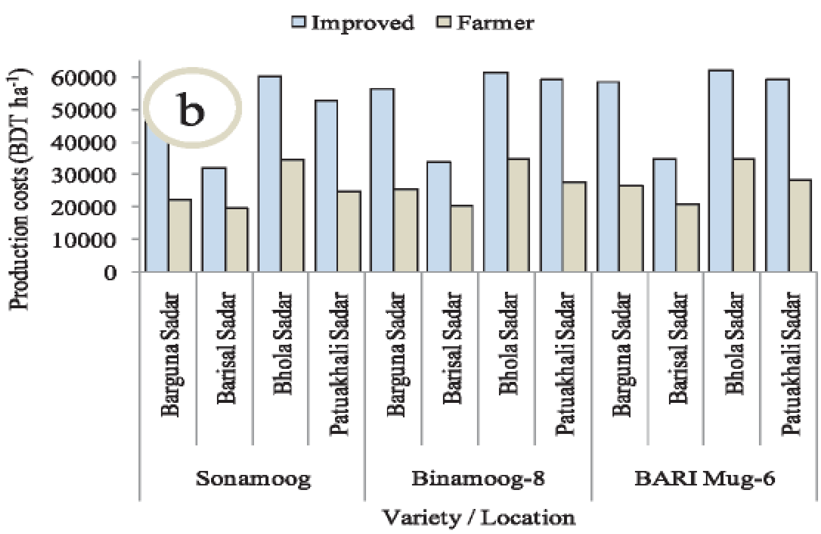


Fig. 5: Gross margin (a) and production costs (b) of three varieties of mungbean in four locations under improved and farmers' management practices.

As expected, irrespective of varieties and locations, GM under farmers' management was lower than improved management. However, in Barguna Sadar with 'Binamoog-8' GM with both managements was very close (BDT 33,909 ha^{-1} under farmers' versus BDT 35,250 ha^{-1} under improved management)

The production costs under improved management (BDT 52,084 ha^{-1}), across the varieties and locations, was almost double than farmers' management (BDT 26,810 ha^{-1}). Like GM, it varied according to varieties, locations and management practices (Fig. 6b). This cost was as low as BDT 19,982 ha^{-1}(under farmers' management) and BDT 31,904 ha^{-1} (under improved management) in Barisal Sadar, and as high as BDT 34,964 ha-1(under farmers' management) and BDT 62,184 ha^{-1}(under improved management) in Bhola Sadar.

In addition to variation in yield and production costs, the GM affected due to selling price of mungbean; this price varied by variety and location (Table 4). The average price of mungbean during the study period was BDT 67 kg^{-1} (Table 4, shaded cell). In general, Patuakhali Sadar received more price (74 kg^{-1}) than other locations (62 – 69 BDT kg^{-1}). The price of 'Sonamoog' was slightly better (71 BDT kg^{-1}) than 'BARI Mug-6' (68 BDT kg^{-1}), whereas 'Binamoog-8' was sold with lower price (63 BDT kg^{-1}).

Table 4: Selling price of mungbean (BDT kg^{-1}) received by the farmers in four locations during the study period for three varieties.

Location	Variety			Average across varieties (BDT kg^{-1})
	Sonamoog (BDT kg^{-1})	Binamoog-8 (BDT kg^{-1})	BARI Mug-6 (BDT kg^{-1})	
Barguna Sadar	68	60	65	64
Barisal Sadar	65	58	63	62
Bhola Sadar	73	65	70	69
Patuakhali Sadar	78	70	75	74
Average across locations	71	63	68	67

3.5 Comparative contribution of 'G', 'E' and 'M'

Table 5 shows that the individual contribution of genotype ('G') accounted for 12.8% seed yield variation in this study, which was much lower than management ('M', 31.0%) or environment ('E', 27.5%; [E(L)] = 19.7% + [E(Y)] = 7.9%). Even considering the co-contribution of 'G' of 3.6% (G × E(L), G × E(Y), G × M, G × E(L) × E(Y), G × E(L) × M, G × E(Y) × M and G × E(L) × E(Y) × M interactions), 'G' accounted for only 16.4% in seed yield variation.

Table 5: Average contributions of genotype (G, 'Sonamoog' (local) and 'Binamoog-8' and 'BARI Mug-6' (improved)), environment (E, Location [E(L)]- Barguna Sadar, Barisal Sadar, Bhola Sadar and Patuakhali Sadar and Year [E(Y) – 2016 and 2017), management (M, Farmers' management and Improved management) on the variation in seed yield of mungbean in the south-central region of Bangladesh.

Variance components	% of total variation	
	Individual contribution	Co-contribution
Genotype [G]	12.8	3.6
Environment - Location [E(L)]	19.7	11.8
Environment - Year [E(Y)]	7.9	9.4
Management [M]	31.0	7.4
Interactions	13.6	-
Replication	1.3	-
Error	13.6	-
Total	100.0	-

4.0 Discussion and Conclusion

This study has illustrated ample scope for increasing yield and profitability of mungbean in the south-central region of Bangladesh, a clear message to development agencies and farmers. Improved varieties, in this case both 'Binamoog-8' and 'BARI Mug-6', played the foundation role in the yield elevation. Both outperformed the local 'Sonamoog' across the locations, years and management options. When considered profitability, 'BARI Mug-6' superseded 'Binamoog-8'. This was because 'Binamoog-8' priced lower (on average 5 BDT kg^{-1}) than 'BARI Mug-6'. The lower price with 'Binamoog-8' was due to its grain size, it was smaller than 'BARI Mug-6', but bigger than 'Sonamoog'. Buyers' preference was directed either to bigger grain type ('BARI Mug-6') for commercial use (such as producing 'sprouts' for Japanese market) or fine grain type ('Sonamoog') for traditional cooking use in domestic market. Farmers' complained that they were having difficulty in selling 'Binamoog-8' in open market. From agro-ecological perspective, the 'Binamoog-8' had one advantage – its plant type was tall and it did not fully submerge in occasional tidal water; this was especially observed in Barisal Sadar location where tidal submergence is a problem. 'BARI Mug-6' encountered a problem of affected with fungal structures in the stem area which remained under water due to infrequent flooding.

Improved varieties and management had contributed to increased profitability from mungbean crop in the regions. However, it involved higher production costs, almost a double to farmers' existing costs. Further research is needed to find out cost cutting avenues such as saving labour cost through mechanized seeding for line sowing. Mechanized seeding is also warranted ensuring completion of seeding in 'narrow seeding window' constrained by moisture availability.

To conclude the overall results, it has been noted that there is enough scope of elevating farmer's yield of mungbean in the south-central region of Bangladesh. Under current market need, adopting a variety like 'BARI Mug-6' can be a choice of the genotype couple with targeted management that ensures optimum plant population could be a way forward. Extension and development agencies may undertake programs for diffusing of the knowledge. Side by side, research institutes may think of developing robust genotypes to adopt to low management and constrained environments.

The performance of the crop, irrespective of varieties, was poor in Barisal Sadar compared to other locations. This was probably due to frequent submergence from tidal water. Further research on variety development and management options are needed for better yield of mungbean in this environment.

Existing genotypes alone can contribute only to small part of yield improvements. The research organizations, that are involved in development of mungbean varieties, may take this message in order to develop robust varieties under constrained situations. Unless and until such varieties are available, this study has clearly reveled that management would be the building material for yield improvement of mungbean in the south-central region of Bangladesh.

The yield of mungbean in the region was significantly related to the pod number per plant; the pod number was related to optimum plant population in a unit area. Farmers' existing management did not provide with the optimum plant population, hence affected the pod number and ultimately to the yield. Besides, the yield also correlated with number of seeds per pod and seed weight, which was most likely related to fertilizer use. This simple but crucial knowledge on the management of the crop needs to deliver to farmers through extension and development agencies.

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