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EFFECT OF PLANT POPULATION AND INTEGRATED NUTRIENT MANAGEMENT ON YIELD OF YARD LONG BEAN (*Vigna unguiculata*)

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Abstract

The experiment was conducted at Agronomy Research Field of BARI, Gazipur during *Kharif-1* seasons of 2020-21 and 2021-22 to evaluate the effect of manures and fertilizers and optimum plant population for higher yield of yard long bean. Two planting geometry, viz., P_1= 45 cm × 30 cm (8 plants m^{-2}) P_2= 40 cm × 20 cm (12.5 plants m^{-2}) and three nutrient levels viz., F_1=Recommended fertilizer dose (RFD) (21-27-33-9-1.2-1.2 kg ha^{-1} NPKSZnB), F_2= IPNS (16-25-30-9-1.2-1.2 kg ha^{-1} NPKSZnB) + Poultry manure (PM) (3 t ha^{-1}) and F_3 = IPNS (16-25-30-9-1.2-1.2 kg ha^{-1} NPKSZn) + Vermicompost (VC) (3 t ha^{-1}) were used. The integrated treatment combinations involve both organic and inorganic source of nutrients which significantly influenced the growth and yield attributes. The better results in terms of vegetable fresh yield were obtained in the following order: PM > VC> NPK. Application of VC is not beneficial due to 15 times higher price than PM. The result indicated that plant spacing of 40 cm × 20 cm with PM added NPK fertilizer combination (F_2) gave the maximum pod yield (4.90 t ha^{-1} in 2020-21 and 4.83 t ha^{-1} in 2021-22) which was statistically similar to same spacing with VC added NPK fertilizer combination (F_3) but the highest benefit cost ratio (2.15) was recorded in plant spacing of 40 cm × 20 cm with PM added NPK fertilizer combination (F_2). From the result it might be could be concluded that plant spacing of 40 cm × 20 cm (1,25,000 plants ha^{-1}) with organic and inorganic source of nutrients {IPNS (16-25-30-9-1.2-1.2 kg ha^{-1} NPKSZn) with PM (3 t ha^{-1})} was found to achieve the maximum productivity of yard long bean cultivation at Gazipur.

Introduction

Vigna unguiculata (L.) commonly known as yard long bean or pole type vegetable cowpea belongs to the family Fabaceae and is one of the most popular and remunerative vegetable crop traditionally grown in Bangladesh, cultivated mainly for tender pods that are consumed both fresh and cooked. It is a rich and inexpensive source of vegetable protein and its cultivation enriches soil fertility by fixing atmospheric nitrogen. Fresh pods are used as a green vegetable. The pods are rich in calcium, phosphorus, sodium, and potassium and also fair amounts of vitamin A, thiamine and ascorbic acid are present (Piluek, 1994). It has become an essential component of sustainable agriculture in marginal lands of the tropics because of its quick growth habit. But the yield of yard long bean is quite low.

It is usually growing during February/March to May/June. Optimum plant spacing and low inputs or improper application of fertilizers resulted low yield. Nowadays, increasing cost of inorganic fertilizers and reduction in soil health with chemical fertilizers, it is essential to replace inorganic fertilizers through organic for sustainable agriculture. In Bangladesh different plant spacing of yard long bean are used by the farmers in different locations.

Moreover, organic matter content in Bangladesh soils is very low (<1.5%) and is being gradually depleted (Ullah *et al.*, 2008). Neither the chemical fertilizer nor organic manure alone can help

achieve sustainable crop production. The integrated nutrient management is the best approach to restore/ maintain soil fertility and productivity on sustainable basis. Organic manure improves soil structure through aggregation favourably influencing tillage properties, crusting, water infiltration, moisture retention, aeration and temperature. But in Bangladesh, most soils have less than 1.5%, and some even less than 1% organic matter contents (FAO, 2014). Organic fertilizers have been shown to help preserve natural resources and reduce degradation of ecosystem (Francis and Daniel, 2004). In Bangladesh, now a day, the organic fertilizers like cowdung and chicken manure are available due to increasing dairy and poultry farm. On the other hand, the price of vermicompost is very high (15 times higher) comparable to cowdung and chicken manure. Farmers of Bangladesh are mostly habituated with the use of macro-nutrients, especially N, P, K and S for crop production. Use of manures is limited. In addition, there are some reports on combined effect of NPKS (25%) and vermicompost (75%) have given higher yield of tomato, cabbage, okra compared to recommended dose of full amount NPKS and control (Islam *et al*., 2017; Akhter *et al*., 2019). However, information on the use of poultry manure and vermicompost in combination with inorganic fertilizers for yard long bean is scanty in Bangladesh. Considering the above facts, the present study was therefore under taken to investigate the effects of organic manure and inorganic fertilizer alone or in combination and appropriate plant spacing for higher yield of yard long bean.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *Kharif* seasons of 2020-21 and 2021-22. The soil of the Gazipur research area belongs to Chhihata series under AEZ-28. Initial soil nutrient status is given in Table 1. In Gazipur soil pH was (6.10 in 2020 and 6.28 2021-22) which indicated the soil was slight acidic. Organic matter percentage was low in both the years. Over the years Nitrogen percentage was very low. Phosphorus level was low. Potassium level was low. Sulphur status was low in Gazipur location. Organic matter concentration, total N, available P, exchangeable K, available S and available B was higher in poultry manure and vermicompost.

Table 1. Initial soil nutrient status of Gazipur location during *Kharif* season of 2020-21 and 2021-22

Location	pH	OM (%)	Total N (%)	Exchangeable K (meq 100^{-1}g soil)	Available P (µg ml^{-1})	Available S (µg ml^{-1})	Available Zn (µg ml^{-1})	Available B (µg ml^{-1})
Agronomy Field BARI, Gazipur								
2020-21	6.10	1.41	0.148	0.095	5.65	11.38	0.24	0.160
2021-22	6.28	1.41	0.11	0.161	14.31	12.37	0.24	0.160
		VL	L	L	L	L	VL	L
Poultry manure		8.1	18.7	2.13	2.55	0.87	0.90	0.11
Vermicompost		7.2	25.3	1.24	2.0	1.06	0.87	0.015

Note: H=High, M= Medium, L= Low, VL= Very low

The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 3.6 m × 3.0 m. Two planting spacing, viz., P_1= 45 cm × 30 cm (8 plants m^{-2}), P_2= 40 cm × 20cm (12 plants m^{-2}) and three fertility levels viz., F_1 = Recommended fertilizer dose RFD) (21-27-33-9-1.2-1.2 kg ha^{-1} NPKSZnB), F_2= IPNS + Poultry manure (3 t ha^{-1}) and F_3 =IPNS + Vermicompost (3 t ha^{-1}) were used. Seeds of yard long bean were sown on 1 March, 2021 and 18 March, 2022. Fertilizers were applied as per treatments in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid. One-third of urea and full amount of all other fertilizers were applied at the time of final land preparation. The remaining urea was top dressed in two equal splits at 35 and 50 DAS (Days after Sowing). A light irrigation was given after sowing of seeds uniform for germination. Three irrigations

were done at 25 and 50 DAS. Intercultural operations like thinning were done at 15 DAS and weeding was done two times at 15 and 25 DAS. For dry matter estimation, 5 plants were sampled at maturity. Yard long bean was harvested several times started on 13 May, 2021 and 17 May, 2022. For dry matter at harvest, 10 plants were randomly collected from each plot and oven dried at 80°C for 72. The yield component data was taken from 5 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically using MSTAT-C package and means were adjudged by least significant difference (LSD) test at 5% level of probability. Cost and return performance of the study was also evaluated.

Results and Discussion

Total dry matter production

Total dry matter (TDM) production of yard long bean was influenced by spacing and inorganic and organic fertilizer combination in both the years. Total dry matter reduced in plant spacing P_1 [45cm × 30cm (8 plants m^{-2})] under all fertilizer treatments. It might be due to lower population (8 plants m^{-2}) and leaf senescence caused by might reduce the photosynthetic efficiency and ultimately reduced the dry matter accumulation. Total dry matter was higher (218 g m^{-2} and 224 g m^{-2}) in P_2F_2 followed by P_2F_3 treatment. The lowest TDM was observed from P_1F_1 and P_1F_3 treatments (Fig.1A and Fig.1B). VC and poultry matter (PM) treatments had a beneficial optimistic effect on TDM production of yard long bean. Similar results were reported by Mohanty *et al*. (2017) in French bean.

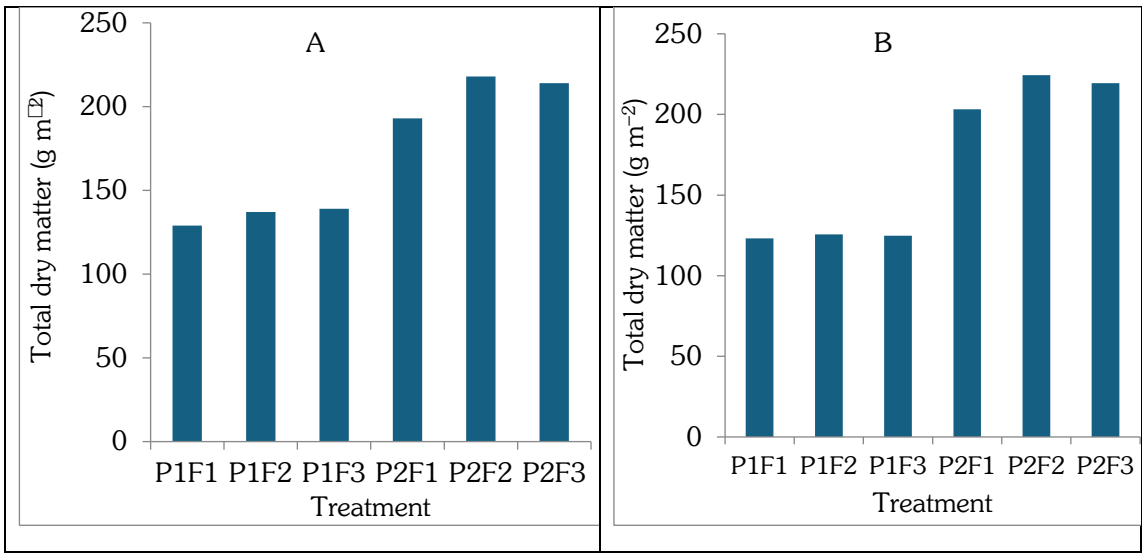

Fig. 1. Total dry matter (TDM) production of yard long bean at harvest as influenced by planting geometry and fertilizer levels during 2020-21 (A) and 2021-22 (B). Here, Two spacing: P_1=40 cm × 25 cm, P_2 = 40 cm × 20 cm and three fertilizer dose: F_1= RFD (21-27-33-9-1.2-1.2 kg ha^{-1} NPKSZnB), F_2 = IPNS + Poultry manure (3 t ha^{-1}), F_3 =IPNS + Vermicompost (3 t ha^{-1})

Plant population, plant height, yield attributes and yield

Number of plants m^{-2}, plant height at harvest, number of pods $plant^{-1}$ of yard long bean showed significant variations due to planting geometry and inorganic and organic fertilizer combination in both the years (Table 2). Number of plants m^{-2} at harvest varied widely, which ranged between 6 and 11. Plant height at maturity varied from 52.53 to 61.48 cm regardless

of treatments. The maximum plant height over the years (57.73 cm and 61.48 cm) was recorded from planting density P_2F_3 (which was followed by P_2F_2.The shortest plant over the years (52.53 cm and 53.51 cm) was in P_1F_1 treatment. The increase in height of yard long bean plants amended with organic is probably due to release of nutrients which promoted vigorous plant growth through efficient photosynthesis (Mondal *et al.*, 2019). Nitrogen fertilization had a tendency to increase plant height as nitrogen involves in cell division and cell elongation of plants (Mazumder *et al.*, 2019). The number of pods per plant increased with decrease in plant density. The number of pods plant^{-1} ranged between 9 and 17 across the fertility level and plant population. The decrease in the number of pods per plant with the increase in plant density could be due to increased intra row competition which eventually might have caused reduction in the number of pods plant^{-1} as a result of higher net assimilation rate and reduction of competition in wider spacing and also nutrient, moisture and light. The maximum number pods plant^{-1} over the years (15 and 17) was recorded with 8 plant m^{-2} when the crop was fertilized with IPNS + 3 t ha^{-1} PM which was statistically similar to IPNS + 3 t ha^{-1} VC. These results are in conformity with the findings of Sharma *et al*. (2008), Jakusko *et al*. (2009), Bakry *et al*. (2011), Almaz *et al*. (2016). Higher pod length (28.50 cm in 2020-21 and 28.77cm in 2021-22) was obtained from P_1F_2 treatment followed by P_1F_3. The lowest pod length over the years (24.77 cm and 20.63 cm) was recorded in P_2F_1 treatment. Pod yield of yard long bean was also found significantly differed due to spacing and inorganic and organic fertilizer combination (Table 2). The maximum pod yield (4.90 t ha^{-1} and 4.83 t ha^{-1}) was recorded from P_2F_2 (Planting density 12 m^{-2} under IPNS + 3 t ha^{-1} PM) treatment which was statistically similar with P_2F_3 treatment. All the yield contributing characters were higher in P_1 plant spacing but pod yield was higher in P_2 due to higher plant population. Therefore, the combined application of manures and fertilizers could supply the nutrients timely and also maintain the suitable condition for flowering, fruiting and their growth. The findings of this investigation confirm the results of earlier work Singh and Chauhan (2009) who reported that, organic and inorganic fertilizers combinations significantly increase the growth and pod yield attributes in French bean. These results are in conformity with the findings of Sharma *et al*. (2008), Jakusko *et al*. (2009), Bakry *et al*. (2011), Almaz *et al*. (2016). The lowest pod yield over the years (3.64 t ha^{-1} and 3.67 t ha^{-1}) was obtained from P_1F_1 treatment. It might be due to lower number of plant population ha^{-1} (100000 plants ha^{-1}). Addition of PM or VC greatly improved the yield of yard long bean in this study compared to NPK fertilizers and this confirms the findings of Xu *et al.* (2005) who stated that higher total yield than those grown with organic fertilizers.

Table 2. Plant population, plant height at harvest, yield attributes and yield of yard long bean as influenced by planting geometry and integrated nutrient management

Interaction (Spacing × fertility level)	Population m^{-2} (no.)	Plant height (cm)		Pod plant^{-1} (no.)		Pod length (cm)		Pod yield (t ha^{-1})	
	2020-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
$P_1 \times F_1$	6	52.53	53.51	12	15	26.83	25.31	3.64	3.67
$P_1 \times F_2$	7	54.83	55.50	15	17	28.50	28.77	3.84	4.02
$P_1 \times F_3$	7	51.60	54.37	14	16	25.97	27.10	3.80	4.09
$P_2 \times F_1$	11	55.47	55.80	9	9	24.77	20.63	4.35	4.38
$P_2 \times F_2$	10	56.07	60.01	11	13	27.13	22.00	4.90	4.83
$P_2 \times F_3$	9	57.73	61.48	12	13	26.47	24.04	4.84	4.87
LSD $_{(0.05)}$	1.31	1.41	1.50	1.01	0.96	1.05	0.96	0.13	0.05
CV (%)	8.23	3.30	3.15	4.68	3.86	4.17	4.17	3.03	4.15

Two spacing: P_1=40 cm× 25 cm, P_2=40 cm × 20 cm and three fertilizer dose: F_1= RFD (21-27-33-9-1.2-1.2 kg ha^{-1} NPKSZnB), F_2= IPNS+ Poultry manure (3 t ha^{-1}), F_3 =IPNS + Vermicompost (3 t ha^{-1}), NPK = Nitrogen, Phosphorus, Potassium; PM = Poultry manure, VC=Vermicompost

Cost and return

Application of manures with NPK had positive effect on economic return over control (Table 3). In general, PM added plots had higher benefit than VC added plots. From the cost-benefit analysis it was found that the highest gross return (Tk. 1,45,876 ha^{-1}) was obtained from P_2F_2 treatment and the lowest gross return (Tk.91,073 ha^{-1}) was found in P_1F_1 treatment. The highest cost of cultivation was recorded in P_2F_3 treatment (Tk. 91,364 ha^{-1}) due to higher labour and fertilizer cost. The highest gross margin (Tk. 77,946 ha^{-1}) was obtained from P_2F_2 treatment. The highest benefit cost ratio (2.15) was obtained from P_2F_2 treatment and the lowest BCR (1.29) was recorded in P_1F_3 treatment (Table 3). Though P_2F_3 treatment produced the highest pod yield but this treatment showed the lowest BCR (1.29) due to higher labour and fertilizer cost. The results were consistent with the earlier reports of lower labour and fertilizer cost which gave the highest fruit yield and returns (Islam *et al.*, 2012 and Subrahmaniyan *et al.*, 2011).

Table 3. Cost and return of yard long bean as influenced by planting geometry and integrated nutrient management (Pooled of 2020-21 and 2021-22)

Treatment	Gross return (Tk ha^{-1})	Cost of production (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Benefit cost ratio
$P_1 \times F_1$	91364	58850	32514	1.55
$P_1 \times F_2$	117912	62970	54942	1.87
$P_1 \times F_3$	118374	91430	26944	1.29
$P_2 \times F_1$	109167	63885	45282	1.71
$P_2 \times F_2$	145876	67930	77946	2.15
$P_2 \times F_3$	145669	97630	48039	1.49

Two spacing: P_1 = 40 cm× 25 cm, P_2 = 40 cm × 20 cm and three fertilizer dose: F_1 = RFD (21-27-33-9-1.2-1.2 kg ha^{-1} NPKSZnB), F_2 = IPNS+ Poultry manure (3 t ha^{-1}), F_3 = IPNS + Vermicompost (3 t ha^{-1}); NPK = Nitrogen, Phosphorus, Potassium; PM = Poultry manure, VC=Vermicompost. The price rate of manures and fertilizers (Taka): Urea: Tk. 16.00 kg^{-1}, TSP: Tk. 11.00 kg^{-1}, MoP: Tk. 15.00 kg^{-1}, PM: Tk. 1.00 kg^{-1} and VC: Tk. 15 kg^{-1}. The fresh yard long bean rate was Tk. 25.00 kg^{-1}

Conclusion

From the result it could be concluded that plant density of 40 cm × 20 cm (1,25,000 plants ha^{-1}) with integrated nutrient management practices {Organic poultry manure (3 t ha^{-1}) and inorganic combination)} was found to achieve the maximum productivity of yardlong bean which in turn gives high returns to the farmers.

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