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Yield Response of Bushbean (*Phaseolus vulgaris* L.) to Doses of Fertilizers and Sowing Times in Bangladesh

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ABSTRACT : The present study was initiated to explore the yield potential of bushbean by exploiting the interaction of variety, sowing time, and fertilizers containing N, P, and K Two varieties namely BARI Bushbean 1 and BARI Bushbean 2, three levels of fertilizer viz. control ($N_0P_0K_0$), medium ($N_{20}P_{30}K_{30}$), high ($N_{40}P_{60}K_{60}$) and three sowing times (November 15, December 1 and December 15) were considered as treatment variables. Among the varieties, BARI Bushbean 2 always showed better performance for most of the yield and yield attributes duly attributed by the application of fertilizers @ N: P: K = 40: 60: 60 respectively. The highest seed yield (1375.17 kg/ha) was recorded when the crop was sown on the 15th November with the supplemented soil nutrition status as above. The influence of sowing times indicate that there is a gradual trend of decreasing in seed yield and other associated parameters after first sowing (15th November). The results of this study suggest that the multi-locational trial under varied sowing times with soil nutrition might potentially increase the long-term adaptation of bushbean in Bangladesh.

Key words: variety, sowing time, NPK, yield, bushbean

Abbreviations: SAU, Sher-e-bangla Agricultural University, BARI, Bangladesh Agricultural Research Institute

Bushbean (*Phaseolus vulgaris* L.) is a one of the most important legume vegetables crops known and grown by the humankind. It is also called as Common bean or French bean. In Bangladesh, the crop is known as Farash sheem (Rashid, 1993) or Jhar sheem (Anon, 2000). It is reported to be a native crop of Central and South America (Swiader *et al.*, 1992) and is an important source of protein in human diets in many countries. The pods are nutritionally rich and used in different ways such as boiled, baked, canned in sauce, brine and syrup, soups - either alone or with other vegetables, meats and chili pepper, fresh salad or curry (Adams *et al.*, 1985). Because of its wide range of uses, the popularity of this crop is increasing day by day all over the world including Bangladesh. Bushbean is a short durated crop and its yield per day is comparatively high. Thus, it can be fit well as an inter-crop with other crops like wheat, maize, sunflower, sugarcane etc. Fortunately, these crops are grown traditionally in winter season of Bangladesh. In this context, there is an ample scope to cultivate bushbean as an additional profitable winter-crop of the country. Geographically, the winter in tropical Bangladesh normally starts on December, 01 and lasts until February, 28. However, practically, the season advents with mild cool weather by decreasing temperature as well as humidity from late October. As such, it is treated as a turning point to initiate cultivation of winter crops including the bushbean.

The average duration of flowering in bushbean was doubled when the day and night temperatures were increased from 15°C - 18°C and 12°C - 15°C respectively (Apel, 1988). So, the planting time for bushbean seems to be so critical that the seed sowing should begin with such timing as the crop could best exploit the advantages of the entire cooler period of the season for optimum growth and yield. Therefore, it is important to study the effect of sowing time to achieve the optimum growth and yield of bushbean. It is reported that depletion of soil moisture during later growth stage especially reproductive stage and low fertility status of the soils are the two major causes of low yield of food crops in the tropics (Anon, 1993). Nutrient requirements for different cultivars usually similar except in poor soils. Application of nitrogen, phosphorous and potassium before planting followed by top dressing of potash or nitrogen stimulate the early growth in cow-pea (Adams, 1984). Chandra *et al.* (1987) reported that plant growth and yield of frenchbean increases with the increasing nitrogen and phosphorous fertilizer. With the increases of NPK fertilizer, pod yield of bushbean was increased (Shrinivas and Naik, 1988) and increased seed yield was also reported by Hara *et al.*(1985).

Information on this regard to direct the cultivation of the crop in Bangladesh is meagre. So, as a newly introduced crop in the country, such information as on the agronomy of bushbean would have been of substantial practical value. Therefore, the present investigation was undertaken to elucidate the role of NPK fertilizer on bushbean variety as affected by various sowing times.

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MATERIALS AND METHODS

The experiment was carried out at the Agronomy research field of Sher-e-Bangla Agricultural University Farm, Dhaka in the *Rabi* (winter) season of 2003-2004. Two varieties of bushbean, (BARI Bushbean 1 and BARI Bushbean 2 designated as of V_1 and V_2 respectively), three levels of N, P, and K fertilizers, namely control ($N_0P_0K_0$ = no fertilizers), medium ($N_{20}P_{30}K_{30}$: N, P, and K @ 20, 30 and 30 kg/ha respectively), high ($N_{20}P_{60}K_{60}$: N, P, and K @ 20, 30 and 30 kg/ha respectively) with three sowing dates (November 15, December 1, and December 15) were considered as treatment variables.

The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 5m X 4m. The land was opened by using a tractor with disc plough. It was then finally prepared by three subsequent ploughing with a country plough followed by laddering. At the final land preparation, nitrogen, phosphorus, and potassium were used as per the treatment variables from urea, triple super phosphate, and muriate of potash respectively. Boron, sulphur, and zinc at the rate of 0.60 kg B/ha, 18.0 S kg/ha and 2 kg Zn/ha were applied from borax , gypsum, and Zinc sulphate fertilizers respectively. Seeds were sown as per the treatment variables maintaining row to row distance and plant to plant distances of 40cm and 20 cm respectively. The depth of sowing was 2-3 cm.

Ten plants from each plot were randomly demarcated and data on number of flowers/ plant, number of pods/plant, number of seeds/pod, seed dry matter (g/plant) were taken. Seed dry matter (kg/ha) and 100-seed weight (g) were taken from a pre demarcated area of one square meter at the centre of each plot. Seed yield (kg/ha) was estimated from the sun dried harvest of one square meter area of the each plot before drying in an oven to take data on the seed dry matter (kg/ha). Data were statistically analyzed and means were compared by DMRT and studentized t- test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of variety

Variety had a significant influence on yield and yield attributes of bushbean (Table 1). All the yield and yield contributing characters influenced significantly at 1% levels of probability. Among the varieties V_2 always produced highest number of pods per plant (10.96), seed dry matter per plant (9.44 g),seed dry matter per hectare (1139.25 kg), 100 seed weight (19.38 g) and finally seed yield (1266.72 kg). Where as V_1 produced maximum number of flowers per plant (15.73) and number of seeds per pod (5.00). Although maximum number of flowers per plant was recorded from variety V_1, the pod setting capacity wasfound lower in V_1 compared to V_2. Flower and pod formation of legumes are the major sinks during the reproductive phase and the demand of nitrogen for grain development is met mostly through remobilization. These events enhance early senescence and reduce grain growth duration, the phenomenon which Sinclair and Dewit (1978) referred to as "self destruction" of legumes.

Effect of sowing time

Sowing time exhibit significant influence on number of flowers plant^{-1}, number of pods plant^{-1}, seeds pod^{-1}, seed dry

Table 1. Yield and yield attributes of bushbean as influenced by variety (V).

Variety	Number of flowers/ plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/ plant)	Seed dry matter (kg /ha)	100-seed weight (g)	Seed yield (kg/ha)
V_1	15.73	9.36	5.00	7.80	975.89	16.53	1047.62
V_2	11.66	10.96	4.32	9.44	1139.25	19.38	1266.72
"t" test	*	*	*	*	*	*	*

*Indicates significant at 5% levels of probability
V_1: BARI Bushbean 1, V_2: BARI Bushbean 2

Table 2. Yield and yield attributes of bushbean as influenced by sowing time (T).

Sowing time	Number of flowers/ plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/ plant)	Seed dry matter (kg /ha)	100-seed weight (g)	Seed yield (kg/ha)
T_1	14.70a†	10.86a	4.99a	10.15a	1207.74a	18.62a	1362.11a
T_2	14.62a	10.74a	4.78a	9.56a	1195.94a	18.63a	1283.84a
T_3	11.77b	8.88b	4.20b	6.15b	769.03b	16.61b	825.55b

T1: November 15; T2: December 1; T3: December 15
†Same letters in column do not differ significantly at 5% level of probability.

matter plant^{-1}, seed dry matter ha^{-1}, 100 seed weight and seed yield of bushbean. Data regarding mean separation values (Table 2) showed that seeds sowing at 15 November (T_1) produced the highest number of flowers plant^{-1} (14.70), number of pod plant^{-1} (10.86), seeds plant^{-1} (4.99), seed dry matter plant^{-1} (10.15 g) seed dry matter ha^{-1} (1207.74 kg) and seed yield (1362.11 kg), while the highest 100-seed weight (18.63 g) was recorded from December 1 sowing (T_2). However, these parameters were statistically identical with both November 15 and December 1 sowing. Seeds sowing at 15 December always produced the lowest values for all the yield and yield attributes except flower number. The highest seed yield (1362.11 kg ha^{-1}) obtained from November 15 sowing was attributed due to maximum number of flowers plant^{-1}, pods plant^{-1}, seeds pod^{-1} and seed dry matter. These results are consistent with the findings of Pande *et al.* (1978) as stated that the pod yield of French bean increased mainly due to higher pod number per plant and pod weight per plant. Pod yield was positively correlated with green shell yield at different sowing dates (Beaver and Roman Hernandez, 1994). Contrast with the result of Sreelatah *et al.* (1997) delay sowing reduced dry matter production of French bean, presumably, seeds sowing at 15 December produced poor seed yield (825.55 kg ha^{-1}) in our present study.

Effect of fertilizer levels

Fertilizer treatments significantly influenced all the yield and yield attributes of bushbean (Table 3). There is an increasing trend existed on yield parameters with the increasing levels of fertilizer treatment combinations. Although no statistically significant difference was observed compared to F_1 treatment ($N_{20}P_{30}K_{30}$); the F_2 treatment ($N_{20}P_{60}K_{60}$) appeared with highest effects on seeds per pod (4.80), seed dry matter per plant (9.37 g), seed dry matter per hectare (1172.13 kg), 100 seed weight (18.63 g) and seed yield (1258.28 kg/ha). Naturally, bushbean, a short durated legume crop, can grow with average yield potential on a wide range of soils. Probably, given the higher nodulation ability to store the symbiotically fixated atmospheric nitrogen, the significant variation on yield was not observed between the F_1 and F_2 treatment in the study. However, considering the crops symbiotic nature and cost minimizing proposition for the additional fertilizers, F_1 ($N_{20}P_{30}K_{30}$) level of fertilizer could be considered for cultivating the crop. However, Sa *et al.*(1982) reported significant differences in pod number per plant with fertilizer treatment. Our present investigation is in partially agreement with that of Cardoso *et al.*(1978), who reported seed yield of French bean showed a positive linear response to nitrogen and seed yield of French bean increased significantly by potassium fertilizer application (El-leboudi *et al.*, 1994).

Variety x Sowing time

Number of flowers per plant was significantly influenced

Table 3. Yield and yield attributes of bushbean as influenced by fertilizer levels (F).

Fertilizer levels	Number of flowers/plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/plant)	Seed dry matter (kg /ha)	100-seed weight (g)	Seed yield (kg/ha)
F_0	12.78b†	9.62b	4.48b†	7.44b	869.53b	17.10b	999.04b
F_1	14.80a	10.50a	4.69ab	9.04a	1131.06a	18.15a	1214.19a
F_2	13.50ab	10.36a	4.80a	9.37a	1172.13a	18.63a	1258.28a

F_0: $N_0P_0K_0$; F_1: $N_{20}P_{30}K_{30}$; F_3: $N_{40}P_{60}K_{60}$
†Same letters in a column do not differ significantly at 5% level of probability

Table 4. Interaction effects of variety (V) and sowing time (T) on yield and yield attributes of bushbean.

Variety (V) x sowing time (T)	Number of flowers/plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/plant)	Seed dry matter (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)
V_1T_1	13.76b†	9.89b	5.24a	8.67ab	1084.45ab	16.59bc	1164.16b
V_1T_2	13.59b	9.38bc	5.04ab	8.28ab	1036.13abc	17.45b	1112.29b
V_1T_3	19.84a	8.81c	4.71bc	6.45ab	807.10bc	15.55c	866.42c
V_2T_1	15.64b	11.84a	4.73bc	11.62a	1331.03a	20.65a	1560.07a
V_2T_2	15.64b	12.09a	4.52c	10.84ab	1355.75a	19.81a	1455.40a
V_2T_3	13.69c	8.95bc	3.69d	5.84b	730.96c	17.68b	784.68c

V_1: BARI Bushbean 1, V_2: BARI Bushbean 2
T1: November 15; T2: December 1; T3: December 15
†Same letters in a column do not differ significantly at 5% level of probability.

by the interaction between sowing time and variety (Table 4). Treatment combination V_1T_3 produced highest number of flowers per plant (19.84) followed by V_2T_1 (15.64), V_2T_2 (15.64), V_1T_1 (13.76), V_1T_2 (13.59) and lowest (13.69) was recorded from V_2T_3. Data pertaining to mean values (Table 4) showed that variety V_2produced highest number of pods per plant (12.09) and seed dry matter per hectare (1355.75 kg) when sowing at December 1 but statistically identical with V_2T_1 incase of pods per plant, in access identical with V_1T_2, V_1T_1 incase of seed dry matter per hectare. Among the yield attributes, except number of pods per plant and 100 seed weight variety V_2 showed poor performance for all the parameters when sowing at December 15. This might be due to depletion of soil moisture during reproductive stage adversely affect reproductive character as result lower yield. Regardless of variety, seeds sowing on 15th November produced highest seed yield (1560.07 kg/ha) and the lowest seed yield was recorded (784.68 kg/ha) from December 15 sowing. Early sowing during 15 November facilitates available soil moisture for bushbean growth as well as enhanced production of current photosynthate for proper pod and seed development, presumably higher seed yield was obtained from November 15 sowing. Vyas *et al.* (1994) and Chages *et al.* (1982) stated that seed yield varies with sowing dates. Seed yield was observed to be higher in French bean sown at the end of October in compared to that sown in other dates.

Variety x Fertilizer doses

Data presented in Table 5 showed that in response to various levels of added fertilizer, Yield and yield attributes of bushbean was significantly and positively influenced by the interaction effect of variety and fertilizer treatment. Variety V_2 and V_1 always performed better in combination with F_2 treatment, except number of flowers plant^{-1}, number of seeds per pod incase of variety V_2, but incase of V_1 it was for number of flowers per plant. Highest seed dry matter per plant (10.24 g), seed dry matter per hectare (1281.01 kg), 100 seed weight (20.64 g) and seed yield (1375.17 kg/ha) was recorded from treatment combination V_2F_2 but variety V_1treated without fertilizer showed poor performance for all the parameters except number of flowers per plant and number of seeds per pod which was true for the treatment combination V_2F_0. Nutrient requirements for different cultivars usually similar except on poor soils (Adams, 1984). This present study reviled that variety V_2 produced highest seed yield (1375.17 g/ha) when fertilized with the combination N : P : K = 40 : 60 : 60, was attributed mainly due to production of highest seed dry matter per plant as well as per hectare and maximum 100 seed weight. Incase of application of various fertilizer doses, there were significant differences in pod number per plant in French bean (Sa *et al.*, 1982). Gonzalez *et al.*(1983) reported that seed yield of bushbean increased with increasing fertilizer doses where as, increased pod yield of French bean was also reported by Srinivas and Naik (1988) with NPK fertilization.

Sowing time x Fertilizer doses

A strong significant interaction existed between sowing time and fertilizer doses on yield and yield attributes of bushbean. In response to fertilizer treatment, with the increasing fertilizer levels all the attributes increased but the effect was not conspicuous when fertilizer levels were combined with December 15 sowing (Table 6). Treatment T_1F_1 produced the highest number of flowers per plant (16.19) followed by T_2F_2 (15.51), T_2F_1 (15.42) and the lowest (11.19) was recorded from the treatment combination T_3F_2. Where as, highest number of pods per plant (11.46), seeds per pod (5.14), seed dry matter per plant (11.28 g) and seed yield per hectare (15.14 kg) was obtained from the treatment combination T_1F_2. However, number of flowers per plant, number of seeds per pod, seed dry matter per plant as well as per hectare and seed yield was not significantly influenced

Table 5. Interaction effects of variety (V) and fertilizer doses (F) on yield and yield attributes of bushbean.

Variety x Fertilizer doses	Number of flowers/ plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/plant)	Seed dry matter (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)
V_1F_0	14.63b†	8.67d	4.72c	6.71c	839.80d	16.36d	901.52c
V_1F_1	16.68a	9.77c	5.02b	8.19b	1024.64cd	16.61d	1099.95b
V_1F_2	15.88ab	9.64c	5.26a	8.50b	1063.24bc	16.62d	1141.39b
V_2F_0	10.93d	10.58b	4.24d	8.17b	899.25cd	17.84c	1096.56b
V_2F_1	12.93c	11.23a	4.36d	9.89a	1237.48ab	19.67b	1328.43a
V_2F_2	11.11d	11.08ab	4.34d	10.24a	1281.01a	20.64a	1375.17a

V_1: BARI Bushbean 1, V_2: BARI Bushbean 2
F_0: $N_0P_0K_0$; F_1: $N_{20}P_{30}K_{30}$; F_3: $N_{40}P_{60}K_{60}$
†Same letters in a column do not differ significantly at 5% level of probability.

Table 6. Interaction effects of sowing time (T) and fertilizer doses (F) on yield and yield attributes of bushbean.

Sowing time x Fertilizer doses	Number of flowers/plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/plant)	Seed dry matter (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)
T_1F_0	14.13bc†	9.79cd	4.68bc	8.33c	858.18cd	18.10cd	1118.06c
T_1F_1	16.19a	11.35a	5.14a	10.83a	1354.53a	18.58bc	1454.08a
T_1F_2	13.79bc	11.46a	5.14a	11.28a	1410.52a	19.19ab	1514.19a
T_2F_0	12.91cd	10.39bc	4.64e	8.34c	1043.21bc	17.33de	1119.89c
T_2F_1	15.42ab	11.04ab	4.76bc	9.85b	1232.37ab	18.76abc	1322.95b
T_2F_2	15.51ab	10.79ab	4.95ab	10.49ab	1312.24a	19.80a	1408.69ab
T_3F_0	11.31d	8.69e	4.13d	5.65d	707.19d	15.87f	759.16d
T_3F_1	12.80cd	9.11de	4.16d	6.45d	806.28cd	17.09de	865.54d
T_3F_2	11.19d	8.84e	4.31d	6.35d	793.62cd	16.89ef	851.95d

T1: November 15; T2: December 1; T3: December 15
F_0: $N_0P_0K_0$; F_1: $N_{20}P_{30}K_{30}$; F_3: $N_{40}P_{60}K_{60}$
†Same letters in a column do not differ significantly at 5% level of probability.

Table 7. Interaction effects of variety (V), sowing time (T) and fertilizer doses (F) on yield and yield attributes of bushbean.

Variety x sowing time x Fertilizer doses	Number of flowers/ plant	Number of pods/plant	Number of seeds/pod	Seed dry matter (g/plant)	Seed dry matter (kg/ha)	100-seed weight (g)	Seed yield (kg/ha)
$V_1T_1F_0$	11.87f†	8.83ef	4.84bcd	6.88e	860.40fghij	16.10ghi	923.64e
$V_1T_1F_1$	14.71de	10.39bc	5.42a	9.26cd	1157.58cdefg	16.44fgh	1242.66cd
$V_1T_1F_2$	14.71de	10.45bc	5.48a	9.88c	1235.37abcde	17.24efgh	1326.17c
$V_1T_2F_0$	12.84ef	8.84ef	4.72bcd	7.18e	897.54efghi	17.18efgh	963.51e
$V_1T_2F_1$	13.35ef	9.91bcd	5.01b	8.60d	1075.78defghi	17.31efgh	1154.85d
$V_1T_2F_2$	14.58de	9.41cde	5.41a	9.08cd	1135.08cdefgh	17.85def	1218.51cd
$V_1T_3F_0$	19.18b	8.35f	4.60cd	6.09ef	761.45ij	15.79hi	817.42ef
$V_1T_3F_1$	21.98a	9.02df	4.63bcd	6.72e	840.56jghij	16.80ghi	902.34e
$V_1T_3F_2$	18.37bc	9.06df	4.89bc	6.55e	819.28ghij	14.77I	879.50e
$V_2T_1F_0$	16.39cd	10.75b	4.53cd	9.78cd	855.96fghij	20.10bc	1312.49cd
$V_2T_1F_1$	17.66bc	12.31a	4.86bcd	12.41a	1551.47ab	20.72ab	1665.51a
$V_2T_1F_2$	12.87ef	12.46a	4.81bcd	12.68a	1585.67a	21.14ab	1702.22a
$V_2T_2F_0$	12.98ef	11.94a	4.56cd	9.51cd	1188.89bcdef	17.47efg	1276.27cd
$V_2T_2F_1$	17.50bc	12.18a	4.51cd	11.11b	1388.96abcd	20.20bc	1491.05b
$V_2T_2F_2$	16.45cd	12.17a	4.50d	11.91ab	1489.41abc	21.75a	1598.88ab
$V_2T_3F_0$	13.43ef	9.04def	3.65e	5.22f	652.92j	15.95ghi	700.91f
$V_2T_3F_1$	13.63ef	9.20def	3.70e	6.17ef	772.00hij	18.09de	828.74ef
$V_2T_3F_2$	14.02de	8.62ef	3.73e	6.14ef	767.96hij	19.01cd	824.41ef

V_1: BARI Bushbean 1, V_2: BARI Bushbean 2
T1: November 15; T2: December 1; T3: December 15
F_0: $N_0P_0K_0$; F_1: $N_{20}P_{30}K_{30}$; F_3: $N_{40}P_{60}K_{60}$
†Same letters in a column do not differ significantly at 5% level of probability.

by fertilizer levels when combination with December 15 sowing. Treatment T_3F_0 showed poor performance for yield and yield attributes except number of flowers per plant which was attributed with T_3F_2, although both the treatment combinations are statistically identical for number of flowers per plant (Table 6).

Variety x Sowing time x Fertilizer doses

Yield and yield attributes of bushbean influenced significantly by the interaction of variety, sowing time and fertilizer treatments. Irrespective of variety and sowing time, a significant increasing trend was observed among the yield

and yield attributes with the increasing fertilizer levels (Table 7). Treatment combination $V_1T_3F_1$ produced maximum number of flowers per plant (21.98) while $V_2T_1F_2$ produced maximum number of pods per plant (12.46), seed dry matter per plant (12.68 g), seed dry matter per hectare (1585.67 kg) and seed yield (1702.22 kg/ha). Among the treatment interactions $V_2T_3F_0$ showed poor performance for all the parameters except number of flowers per plant, number of pods per plant and the weight 100 seeds.

Seeds of variety V_2 sowing during 15 November when fertilized with the combination N : P : K = 40 : 60 : 60 always performed better for most of the yield attributes and yield of bushbean. However, for better clarification of the present investigation systematic long-term study in different location of the country in combination with physiological study is further needed.

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