Influence of Auxin on flowering, fruit set and yield performance of Yard Long Bean (*Vigna unguiculata* var. *sesquipedalis*)

ABSTRACT

The field experiment was conducted at the Horticultural Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, to study the effects of different levels of nutrient management and the growth regulator Auxin on the growth and yield of yard-long bean. The experiment consisted of two factors. Factor A: four levels of nutrient management; i) N0: control (N_0, P_0, K_0) Kg/ha; ii) N_1: (N_{12} P_{18} K_{22}) Kg/ha; iii) N2: (N_{18} P_{27} K_{33}) Kg/ha; iv) N3: (N_{24} P_{36} K_{44}) Kg/ha. Factor B: three levels of auxin (indole acetic acid); i) I0: control (0 ppm); ii) I1: 20 ppm; iii) I2: 40 ppm. The variety of yard-long beans was BARI borboti-1. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The results revealed that nutrient management and auxin significantly affected the plant height, number of leaves, number of branches, number of flowers, number of pods per plant, and pod yield per hectare. In the case of nutrient management, the highest yield (14.5 t/ha) was observed in the N_2 treatment, and the lowest yield (9.61 t/ha) was observed in the N_0 treatment. For auxin, the highest yield (12.57 t/ha) was observed from the I_2 treatment, and the lowest yield (9.83 t/ha) was observed from the control treatment I_0. For the combined effect, the N_2I_2 treatment combination gave the highest yield (16.64 t/ha), and the lowest yield (6.37 t/ha) was obtained from the N_0I_0 combination treatment. So, from the result, it may be concluded that applying 18 kg N/ha, 27 kg P/ha, and 33 kg K/ha with 40 ppm auxin is the best for growth and a higher yield of Yard Long Bean.

Keyword: Auxin, Flowering, Yield, Bean

Introduction

Yard long bean, scientifically known as *Vigna unguiculata* sub sp. sesquipedalis L., originates from East and Southeast Asia. With a chromosomal number of 2n = 22, this important legume vegetable crop is also known by a variety of other names, including borboti, asparagus bean, Chinese long bean, pea bean, string bean and snake bean (Bhagavati et al. 2019) It's a quick-growing annual plant and a significant summer vegetable. There are tall climbing kinds as well as a dwarf. Similar in usage to green beans, this kind of long bean is cultivated largely for its very long (35 to 75 cm) immature pods. Yard-long beans are a highly self-pollinating annual crop. Its soft green pods, popular in vegetable dishes, are the main reason for cultivation. Although yard-long beans are grown extensively throughout the tropics, they are prevalent in Bangladesh, India, Indonesia, the Philippines, and Sri Lanka, as well as in Southern Asia and Southern China (Ullah et al. 2011). Yard-long beans are vital for producing high-quality animal feed and serving as a soil's residual nitrogen source, which fixes nitrogen from the atmosphere (Leikam et al., 2007).

Yard-long beans are valued for their nutritional quantity as they are leguminous vegetables. The tender green pods of the long bean are a nutritious vegetable because they are high in dietary fiber (2g / 100g), vitamin A (941 IU / 100g), vitamin C (13 mg / 100g), phosphorus (74 mg /

100g), iron (2.5 mg / 100g) and crude protein (28%). (Singh et al. 2001). In addition, it has important micronutrients: 2.92-3.34 mg kg-1 of manganese, 0.33-0.57 mg kg-1 of cobalt, 32.58-36.66 mg kg-1 of zinc and 102.69-120.02 mg kg-1 of iron (Ano and Ubochi, 2008). Both soluble and insoluble fibers are present in large quantities in the pods. Since the entire green pod is eaten as green beans, a sufficient amount of dietary fiber is obtained. Dietary fiber protects the colon mucosa by adhering to compounds that cause cancer and shortening the time it is exposed to harmful substances.

Although yard long beans are extensively cultivated by trailing onto bowers and trellises because to their potential for continuous high production, difficulties such as delayed and inconsistent flowering and low pod set are common. Phosphorus fertilization is the key component in increasing soil productivity and maximizing yield of crops (Susila et al., 2010). Yard long bean is a nitrogen-fixing plant. It desires less nitrogen. For beans to grow and reproduce properly, potassium is a necessary plant nutrient. The optimal rate of application for growth regulators and fertilizers can guarantee improved growth and yield in yard-long beans, which will eventually encourage ordinary farmers to use these materials commercially.

Plant growth regulators, also known as plant hormones, have the potential to impact plants' metabolic and physiological responses, eventually altering their growth and development (Hayat et al. 2010). Auxin is necessary for many aspects of floral development, but the underlying mechanisms are only now becoming clear. Auxin plays a critical role in determining the fate of various flower primordial founder cells (Cheng and Zhao, 2007). Hypothetic auxin concentration variations between the founder cells and the surrounding cells, caused by polar auxin transport and/or local auxin production, may give the positional information required for primordium development. Auxins also improve quality, increase yields, minimize unwanted vegetative growth, encourage fruiting, and make harvesting easier (Sarkar et al., 2020).The current study is to determine the best combination of Auxin and nutrition for promoting flowering and fruit set in Yard Long Bean.

MATERIALS AND METHODS

Location, Characteristics of Soil and Climate

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The site's location is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level. The soil of the experiment area belongs to Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot of soil was medium-high land and the soil series was Tejgaon (FAO,1988). The characteristics of the soil used in the experiment were analyzed in the soil Testing Laboratory, Soil Resources Development Institute (SRDI). The climate of the experimental area was subtropical. It is characterized by its high temperature and heavy rainfall during the Kharif season i.e. April to September and rainfall associated with moderate temperature during the Robi season i.e. October to March.

Planting materials

"BARI Borboti-1" has been used as planting materials. The seeds were collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

Treatment, Design, and layout of the experiment

The experiment involved two factors. Factor A and Factor B

Factor A: Nutrient management – 4 levels

1. N_0: Control ($N_0P_0K_0$)
2. N_1: ($N_{12}P_{18}K_{22}$) Kg/ha
3. N_2: ($N_{18}P_{27}K_{33}$) Kg/ha
4. N_3: ($N_{24}P_{36}K_{44}$) Kg/ha

Factor B: IAA (Indole acetic acid) – 3 levels

1. I_0: control (0 ppm)
2. I_1: 20 ppm
3. I_2: 40 ppm

The two factors experiment was laid out in the Randomized Complete Block Design (RCBD) which consists of three replications. The layout of the experiment was prepared for distributing the different combinations of nutrient management and IAA levels. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot is 1.5 m × 1.2 m. All together there were 36-unit plots and required 149.25 m^2.

Land preparation and fertilizer application

Firstly, the land was plowed with a power tiller on 15th March 2019. Then the land was kept to dry sunlight. Doing ploughing and cross-ploughing the experiment plot was prepared. Laddering was done to break the clods that make the soil level. The land was cleaned by removing weeds and big clods.

In the treatment of N_1: Urea, TSP, and MoP were applied at 27 kg/ha, 86 kg/ha, and 31 kg/ha, respectively. And per block 43 g urea, 61 g TSP, and 60 g MOP were given. Per split, 1.56 g urea was given.

In the treatment of N_2: Urea, TSP, and MoP were applied at 39.130 kg/ha, 56.25 kg/ha, and 55kg/ha, respectively. 59 g Urea, 91 g TSP, and 89 g MoP were given per block. Per split, 2.34 g Urea was given.

In the treatment of N_3: 52.2 kg/ha Urea, 75 kg/ha TSP, and 73.3 kg/ha MoP were given. 85 g Urea, 121 g TSP, and 118.8 g MoP were given per block. Per split, 3.13 gm Urea was given.

A total amount of well-composed cow dung, triple super phosphate (TSP), and murate of potash (MP) was applied and mixed with the soil during land preparation. Urea was applied as a source of Nitrogen, during final land preparation 1/3rd amount of the urea was applied and the rest amount was applied in two installments on the 15th and 30th days after sowing. The fertilizers that were applied were mixed in appropriate portions with the plot soil.

Sowing of seeds

Two treated seeds were sown per hill and the depth was 3.00 cm. For seed treatment, Bavistin was used to protect seeds from seed-borne diseases. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 15th March 2019 in rows and at a spacing of 60 cm×30 cm. The seeds were covered with loose soil. French bean was sown as border crops to reduce border effects.

Collection of Data

Five plants were randomly selected from the middle rows of the unit plot to avoid border effect, except yields of curds, which were recorded plot-wise. Data were recorded on the growth and yield parameters such as number of leaves per plant, number of branches per plant, number of flowers per plant, number of pods per plant, weight of green pod, and pod yield per hectare.

Statistical analysis

The recorded data on different parameters were statistically analyzed using the MSTAT computer package program. The analysis of variance for the characters under study was performed by the "F" variance test. The differences between the pairs of treatment means were compared using the least significant difference (LSD) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The research results of this study respond with firm evidence that using plant growth regulators enhanced numerous significant factors linked to plant growth and production. These parameters include number of branches per plant, number of pods per plant, average length of pods (cm), days to first picking, total pod yield per plot (g), and total pod yield per hectare (q). The results clearly show that plant growth regulators had a positive impact on these parameters when compared to the control group. Table 1 and Table 2 show detailed mean values for each growth and yield parameter in connection with specific plant growth regulators.

Number of branches plant^{-1}

Different levels of nutrient management and auxin (IAA) had a significant impact on several branches of plant^{-1} of yard-long bean, as did their interaction on different days after planting. The treatment combination N_1I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the most branches plant^{-1}(13.28), while the treatment N_0I_0 (N_0 P_0 K_0kg ha^{-1} with 0 ppm IAA) produced the fewest branches plant^{-1}(7.72) 120 days after planting. The application of IAA, which stimulates shoot development and cell elongation, is responsible for the rise in the number of branches in plant^{-1}. This is because auxin controls cell division, resulting in a synergistic effect that increases the number of plant^{-1}branches. These findings were additionally supported by the use of NAA in cowpeas by Desai and Deore (1985) and Thaware et al. (2006).

Number of leaves plant^{-1}

Meanwhile, the treatment combination of N_1I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the most number of leaves plant^{-1}(112.50), while the lowest number of leaves plant^{-1}(76.97) was observed in the treatment combination N_0I_0 (N_0 P_0 K_0 kg ha^{-1} with 0 ppm IAA) at final harvesting. The observed effects are probably due to IAA increasing cell division and stimulating cell elongation, resulting in an increased number of leaves. These experimental results align with prior research by Rai et al. (2004) [10], Ullah et al. (2007), Thaware et al. (2008), and Sahu and Verma (2020).

Days to first harvest

N_2I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) had the shortest time for maturity (69.1), while the longest was 79.8 days for the control N_0I_0 ($N_0P_0K_0$ kg ha^{-1} and 0 ppm IAA) treatment. Among the various IAA concentrations, 40 ppm IAA treated plants recorded early days to harvest (70.8), but control treatment with 0 ppm IAA resulted in delayed harvesting (78.7 days). Thus, plants treated with N_2I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) showed early harvesting (63.1 days) compared to the control N_0I_0 ($N_0P_0K_0$ kg ha^{-1} and 0 ppm IAA) treatment. The number of days to first picking was lowest in N_2I_2, which might be associated with the use of IAA to enhance ovary wall maturity and early fruiting. These findings are consistent with Sahu and Verma (2020).

Table 1. Number of branches plant-1 and number of leaves plant^{-1} of yard long bean as influenced by nutrient management and auxin (IAA)

Treatments	Number of branches plant^{-1}		Number of leaves plant^{-1}	
	90 DAS	120 DAS	90 DAS	120 DAS
N_0I_0	6.03 g	7.72 i	59.22 g	76.97 g
N_0I_1	6.49 f	8.10 hi	60.88 g	78.47 g
N_0I_2	6.59 ef	8.44 gh	62.37 g	80.43 fg
N_1I_0	6.70 ef	9.00 fg	70.55 f	85.31 ef
N_1I_1	6.94 e	9.40 ef	73.97 f	88.35 e
N_1I_2	7.44 cd	10.44 d	80.36 de	95.70 cd
N_2I_0	7.03 de	9.780 e	75.46 ef	93.53 d
N_2I_1	7.82 c	11.80 c	85.74 cd	103.7 b
N_2I_2	9.16 a	13.28 a	94.39 a	112.5 a
N_3I_0	7.61 c	11.32 c	81.99 d	100.7 bc
N_3I_1	8.73 ab	12.92 ab	91.57 ab	110.7 a
N_3I_2	8.29 b	12.48 b	88.50 bc	105.5 b
$LSD_{0.05}$	0.448	0.589	5.617	5.094
CV(%)	7.71	6.81	8.09	10.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability, N_0 = control ($N_0P_0K_0$), N_1 = ($N_{12}P_{18}K_{22}$) kg ha^{-1}, N_2 = ($N_{18}P_{27}K_{33}$) kg ha^{-1}, N_3= ($N_{24}P_{36}K_{44}$) kg ha^{-1}
I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

Number of flowers plant^{-1}

For the combined effect, the treatment of N_1I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the highest number of flowers plant^{-1}(164.2) and the earliest flowering (36.2 days), which was statistically identical to the treatment combination of N_3I_1(N_{24} P_{36} K_{44}kg ha^{-1}and 20 ppm IAA). The treatment combination N_0I_0 (N_0 P_0 K_0 kg ha^{-1} with 0 ppm IAA) resulted in the fewest flowers per plant (116.8).

Number of pods plant^{-1}

For varying treatment combinations, N_1I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) treated plants had a significantly earlier pod set (45.5 days) than control plants. The maximum number of pods plant-1 (51.16) was recorded in, N_1I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA), followed by N_3I_1 ($N_{24}P_{36}K_{44}$ kg ha^{-1} and 20 ppm IAA), which had a total of 50.34 green pods. In comparison, the treatment combination N_0I_0 (N_0 P_0 K_0 kg ha^{-1} with 0 ppm IAA) had the lowest number of pods plant^{-1} (32.51). The increased pod count per plant might be attributable to a greater proportion of pod development caused by the usage of IAA. These findings are consistent with those reported in earlier cowpea research by Shinde et al. (1991) and Thaware et al. (2008).

Pods length (cm)

Fruit pod lengthshowed significant differences among the treatments regarding different levels of nutrient management, auxin (IAA), and their interaction. The maximum size of the pod was reported in N_2I_2(N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA), 62.44 cm, which was comparable to N_3I_1($N_{24}P_{36}K_{44}$kg $ha^{-1}$and 20 ppm IAA), 60.48 cm. However, the length of the pod was found to be the shortest (41.30 cm) under N_0I_0 (control). The increase in average pod length might be attributed to cell elongation produced by IAA and different levels of nutrients. The experimental results are comparable to those obtained by Resmi and Gopalakrishnan (2004) and Mandal and Sanyal (2004) in French bean.

Individual pod weight (g)

The treatment combination of N_2I_2(N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the highest individual pod weight (58.64 g), which was statistically identical toN_3I_1 ($N_{24}P_{36}K_{44}$ kg ha^{-1} and 20 ppm IAA), while the treatment combination of N_0I_0 (control)produced the lowest individual pod weight (35.24 g), which was statistically identical to N_0I_1 ($N_0P_0K_0$ kg ha^{-1} and 20 ppm IAA) and similar with N_0I_2 ($N_0P_0K_0$ kg ha^{-1} and 40 ppm IAA).

Pod Yield $plot^{-1}$

In the experiment, N_2I_2 had the maximum pod yield $plot^{-1}$, or 3.00 kg, followed by N_3I_1, with a pod yield $plot^{-1}$ of 2.86 kg. However, N_0I_0 (control) showed the lowest pod yield plot-1 (1.14 kg). The treatment of IAA (Indole acetic acid) was responsible for a discernible increase in the number of branches plant-1, number of pods plant-1, and pod yield plant-1, which in turn contributed to the rise in pod yield $plot^{-1}$. These results are consistent with those of earlier research by Thaware et al. (2006) and Sahu & Verma (2020).

Yield ha^{-1}

The current study found that varied levels of nutrient management, auxin (IAA), and their interaction had a significant effect on yield ha-1 of yard-long bean. The treatment N_2 (N_{18} P_{27} K_{33} kg ha^{-1}), which was statistically equivalent to N_3 (N_{18} P_{27} K_{33}), had the highest yield ha-1 (14.05 t), whereas the control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}) had the lowest yield ha^{-1} (7.65 t)**.** Among factors of auxin, the highest yield ha^{-1} (12.57 t) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) whereas the lowest yield ha^{-1} (9.83 t) was obtained from the control treatment control treatment I_0 (0 ppm IAA). However, the highest yield ha^{-1} (16.64 t) was achieved from the treatment combination of N_2I_2 which was statistically identical with N_3I_1 followed by N_2I_1. The lowest yield ha^{-1} (6.36 t) was observed from the treatment combination of N_0I_0 which was significantly different from all other treatment combinations.

Table 2. The combined effect of different levels of nutrient management and auxin (IAA) on crop duration of yard-long bean

Treatments	Yield contributing parameters						
	Number of flowers plant^{-1}	Number of pods plant^{-1}	Days to first harvest	Pod length (cm)	Individual pod weight (g)	Yield plot^{-1} (g)	Yield ha^{-1} (t)
N_0I_0	116.80 h	32.51 f	71.67 a	41.30 g	35.24 g	1.14 i	6.36 h
N_0I_1	125.40 g	39.40 e	70.67 ab	44.76 f	36.72 g	1.44 h	8.01 g
N_0I_2	128.50 g	41.41 de	70.00 bc	45.12 ef	37.36 fg	1.54 gh	8.57 g
N_1I_0	135.70 f	43.00 cde	69.33 c	45.40 ef	40.38 ef	1.73 fg	9.62 f
N_1I_1	136.90 ef	43.80 cd	67.67 d	47.00 ef	41.60 e	1.82 ef	10.12 f
N_1I_2	145.70 d	44.33 cd	65.33 e	50.72 d	47.36 cd	2.10 d	11.64 de
N_2I_0	141.80 de	43.95 cd	66.00 e	47.36 e	45.14 d	1.99 de	11.03 e
N_2I_1	160.00 ab	49.43 ab	59.67 h	55.78 b	52.88 b	2.61 b	14.48 b
N_2I_2	164.20 a	51.16 a	58.00 i	62.44 a	58.64 a	3.00 a	16.64 a
N_3I_0	151.50 c	45.69 c	63.67 f	51.88 cd	48.60 c	2.22 cd	12.32 d
N_3I_1	163.80 a	50.34 a	58.67 hi	60.48 a	56.80 a	2.86 a	15.88 a
N_3I_2	155.90 bc	46.46 bc	62.33 g	54.14 bc	52.14 b	2.42 bc	13.42 c
$LSD_{0.05}$	**5.20**	**3.61**	1.225	**2.53**	**3.34**	**0.25**	**0.84**
CV	**12.54**	**8.63**	8.11	**6.19**	**7.28**	**6.97**	**6.99**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability, N_0 = control ($N_0P_0K_0$), N_1 = ($N_{12}P_{18}K_{22}$) kg ha^{-1}, N_2 = ($N_{18}P_{27}K_{33}$) kg ha^{-1}, N_3= ($N_{24}P_{36}K_{44}$) kg ha^{-1}

I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

CONCLUSION

The study found that combining two factors, management of nutrients and Indole acetic acid (IAA), improves the growth and yield of yard-long bean. The application of these sprays has shown promising results in enhancing both the growth and yield of the yard-long bean plant. Among the treatments examined, treatment N_2I_2, which contained N_{18} P_{27} K_{33} and 40 ppm IAA, was found extremely effective in enhancing different parameters. This included the number of branches plant^{-1} (7.72), the number of pods plant^{-1} (51.16), podlengt h (60.48 cm), total pod yield plot^{-1} (3.00 kg), and pod yield ha^{-1} (14.05 t). In conclusion, the combined application of nutrients and IAA is advantageous in boosting the growth and yield of yard-long bean.

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