Influence of Auxin on flowering, fruit set and yield performance of Yard Long Bean (*Vignaunguiculata*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 was laid out in a randomized complete block design (RCBD) consisted with two factors. Factor A: four levels of nutrient management; i) N_0: control (N_0, P_0, K_0) Kg/ha; ii) N_1: (N_{12} P_{18} K_{22}) Kg/ha; iii) N_2: (N_{18} P_{27} K_{33}) Kg/ha; iv) N_3: (N_{24} P_{36} K_{44}) Kg/ha. Factor B: three levels of auxin (indole acetic acid); i) I_0: control (0 ppm); ii) I_1: 20 ppm; iii) I_2: 40 ppm. The variety of yardlong bean was BARI borboti-1. The All treatments were replicated three times. 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 maximum yield (14.5 t/ha) was observed in the N_2 treatment, and the minimumyield (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 minimum 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 maximumyield (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, Nutrient management, Yield, Bean

Introduction

Yard long bean, scientifically known as *Vignaunguiculata* sub spsesquipedalis L., originates from East and Southeast Asia. With a chromosomal number of 2n = 22, this important legume vegetablecrop 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 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 Rabi season i.e. October to March.

Planting materials

“BARI Borboti-1” has been used as planting materials. The seeds were procured 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 plotwas 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 ploughed with a power tiller on 15^{th} 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 muriate of potash (MOP) was applied and mixed with the soil during land preparation. Urea was applied as a source of Nitrogen, during final land preparation $1/3^{rd}$ amount of the urea was applied and the rest amount was applied in two installments on the 15^{th} and 30^{th} 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 fungaldiseases. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The seed sowing was done on 15^{th} 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

Theresults 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 incomparison 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}

Results revealed that the highest number of branches plant^{-1} (1.83, 4.43, 8.21, and 12.20 at 30, 60, 90, and 120 DAS, respectively) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) kg/ha which was statistically identical with N_3 (N_{24} P_{36} K_{44})kg/ha at whole crop duration whereas the lowest number of branches plant^{-1} (0.87, 2.67, 6.37 and 8.09 at 30, 60, 90 and 120 DAS, respectively) was recorded from the control treatment N_0 (N_0 P_0 K_0)(**Fig. 1**).

It was observed that the highest number of branches plant^{-1} (1.61, 4.01, 7.87, and 11.16 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) which was statistically identical with I_1 (20 ppm IAA) at all growth stages whereas the lowest number of branches plant^{-1} (1.19, 3.16, 6.84 and 9.46 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment I_0 (0 ppm IAA)(**Fig. 2**).

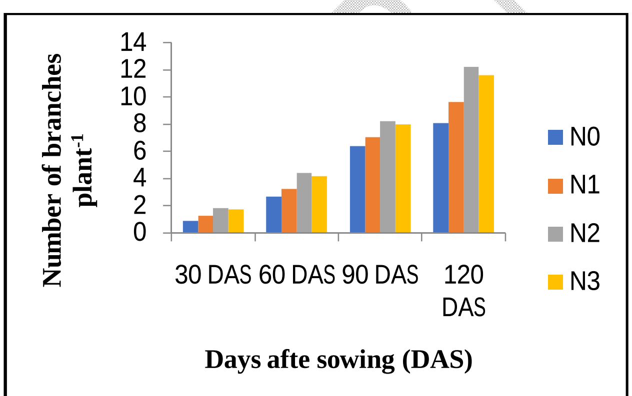


Fig. 1. Number of branches plant^{-1} of yard long bean as influenced by nutrient management
N_0 = control (N_0 P_0 K_0) kg/ha, N_1 = (N_{12} P_{18} K_{22})kg/ha, N_2 = (N_{18} P_{27} K_{33}) kg/ha, N_3= (N_{24} P_{36} K_{44}) kg/ha

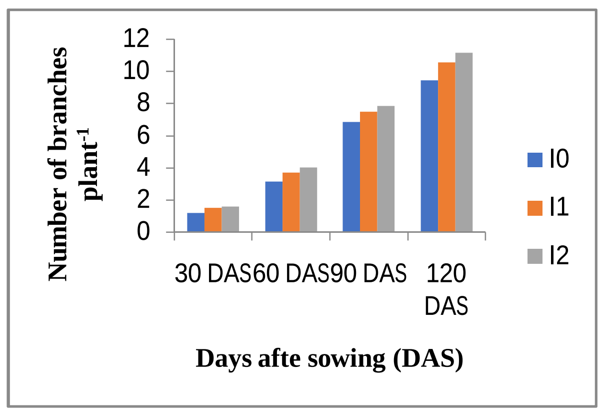


Fig. 2. Number of branches plant^{-1} of yard long bean as influenced by auxin (IAA)
I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

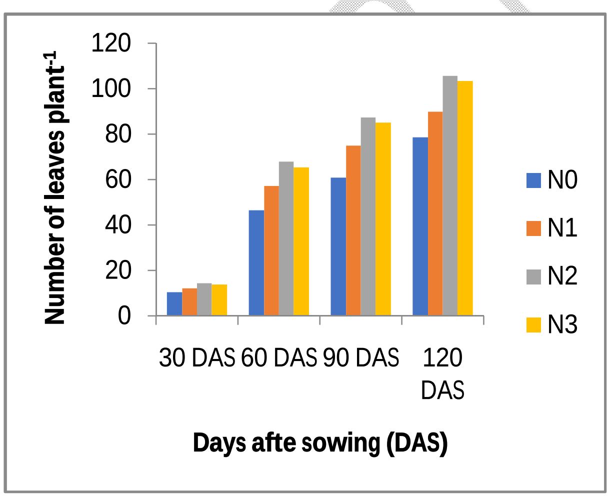
Different levels of nutrient management and auxin (IAA) had a significant impact on the numberof branches of plant^{-1} of yard-long bean, as did their interaction on different days after sowing. The treatment combination N_2I_2(N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the maximum branches $plant^{-1}$ (13.28), while the treatment N_0I_0 (N_0 P_0 K_0kg ha^{-1} with 0 ppm IAA) produced the minimum branches $plant^{-1}$ (7.72) 120 days after sowing(Table 1). 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 branches $plant^{-1}$. 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 $plant^{-1}$

The highest number of leaves $plant^{-1}$ (14.31, 67.80, 87.35, and 105.60 at 30, 60, 90, and 120 DAS, respectively) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was significantly different from all other treatments(**Fig. 3**). The lowest number of leaves $plant^{-1}$ (10.42, 46.57, 60.82, and 78.62 at 30, 60, 90 and 120 DAS, respectively) was recorded from the control treatment N_0 ($N_0P_0K_0$).

The highest number of leaves $plant^{-1}$ (13.39, 62.72, 81.40, and 98.53 at 30, 60, 90 and 120 DAS, respectively) was found from the treatment I_2 (40 ppm IAA) which was significantly different from all other treatments whereas the lowest number of leaves $plant^{-1}$ (11.98, 55.23, 71.81 and 89.12 at 30, 60, 90 and 120 DAS, respectively) was obtained from the control treatment I_0 (0 ppm IAA)(**Fig. 4**).

Meanwhile, the treatment combination of N_2I_2(N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the maximum number of leaves $plant^{-1}$(112.50), while the minimum 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 (Table 1). 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), Ullah*et al.* (2007), Thaware*et al.*(2008), and Sahu and Verma (2020).



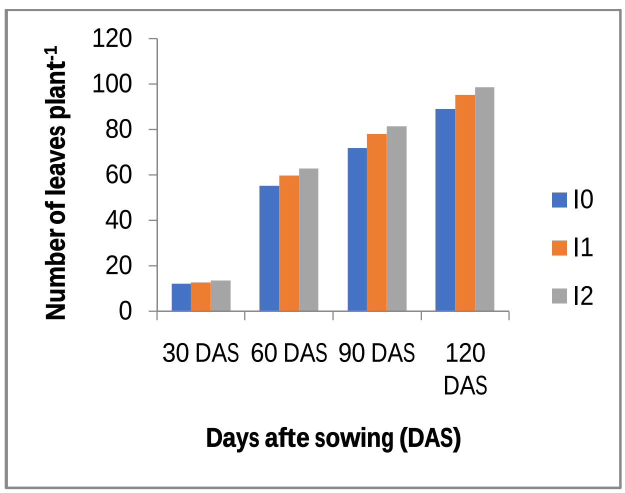


Fig. 3. Number of leaves $plant^{-1}$ of yard long bean as influenced by nutrient management
N_0 = control (N_0 P_0 K_0) kg/ha, N_1 = (N_{12} P_{18} K_{22}) kg/ha, N_2 = ($N_{18}P_{27}K_{33}$) kg/ha,
N_3= ($N_{24}P_{36}K_{44}$) kg/ha

Fig. 4. Number of leaves $plant^{-1}$ of yard long bean as influenced by auxin (IAA)
I_0 = control (0 ppm), I_1= 20 ppm, I_2 = 40 ppm

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

Days to first Picking

The lowest days to first picking (61.22 days) were recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) which was statistically identical with N_3 ($N_{24}P_{36}K_{44}$) whereas the highest days to first picking (70.78 days) were recorded from the control treatment N_0 ($N_0P_0K_0$). Landa*et al*. (2002) showed that the application of N, P, and K significantly influenced the growth and advanced the harvesting date of green beans.The lowest days to first picking (63.92 days) were found from the treatment I_2 (40 ppm IAA) which was statistically identical to I_1 (20 ppm IAA) whereas the highest days to first picking (67.67 days) were obtained from the control treatment I_0 (0 ppm IAA)(Table 2).

N_2I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) had the shortest picking time (58.00), while the longest was 71.67 days for the controlN_0I_0 ($N_0P_0K_0$ kg ha^{-1} and 0 ppm IAA) treatment. Thus, plants treated with N_2I_2 (N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) showed early picking compared to the control N_0I_0 ($N_0P_0K_0$ kg ha^{-1} and 0 ppm IAA)treatment(Table 3). 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).

Number of flowers plant^{-1}

Results indicated that the highest number of flowers plant^{-1} (157.10) was recorded from N_2 (N_{18} P_{27} K_{33}) treatment whereas the lowest number of flowers plant^{-1} (123.50) was recorded from the

control treatment N_0 (N_0 P_0 K_0)(Table 2). Results revealed that the highest number of flowers plant^{-1} (148.60) was found from the treatment I_2 (40 ppm IAA) whereas the lowest number of flowers plant^{-1} (136.40) was obtained from the control treatment I_0 (0 ppm IAA). (Table)
For the combined effect, the treatment of N_2I_2(N_{18} P_{27} K_{33} kg ha^{-1} with 40 ppm IAA) produced the highest number of flowers plant^{-1}(164.2) which was statistically identical to the treatment combination ofN_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)(Table 3).

Number of pods plant^{-1}

The highest number of pods plant^{-1} (48.18) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$)which was statistically identical (47.49) with N_3 ($N_{24}P_{36}K_{44}$) whereas the lowest number of pods plant^{-1} (37.77) was recorded from the control treatment N_0 ($N_0P_0K_0$)(Table 2).The highest number of pods plant^{-1} (45.84) was found from treatment I_2 (40 ppm IAA) which was statistically identical (45.74) with treatment I_1 (20 ppm IAA) whereas the lowest number of pods plant^{-1} (41.29) was obtained from the control treatment control treatment I_0 (0 ppm IAA).(Table)
For varying treatment combinations, N_2I_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_2I_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(Table 3). 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 at 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)

Results revealed that the highest pod length (55.50 cm) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) whereas the lowest pod length (43.73 cm) was recorded from the control treatment N_0 ($N_0P_0K_0$). (Table 2)The finding from the experiment is more or less similar to the following research work of Begum *et al.* (2003). They conducted an experiment on yard long bean and found the highest yield by the treatment of N, P, and K followed by 90, 50, and 120. The pod length is highest (55.7cm) in this treatment.Results indicated that the highest pod length (53.10 cm) was found from the treatment I_2 (40 ppm IAA) which was statistically identical to I_1 (20 ppm IAA) whereas the lowest pod length (46.49 cm) was obtained from the control treatment control treatment I_0 (0 ppm IAA).
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(Table 3). 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 beans.

Individual pod weight (g)

The highest individual pod weight (52.51 g) was recorded from the treatment N_2 ($N_{18}P_{27}K_{33}$) whereas the lowest individual pod weight (36.44 g) was recorded from the control treatment N_0($N_0P_0K_0$)(Table 2).The highest individual pod weight (48.88 g) was found from the treatment I_2 (40 ppm IAA) which was significantly different from all other treatments followed by I_1 (20 ppm IAA) whereas the lowest individual pod weight (42.34 g) was obtained from the control treatment I_0 (0 ppm IAA.

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 N_0I_2($N_0P_0K_0$ kg ha^{-1} and 40 ppm IAA)(Table 3).

Table 2. Yield contributing parameters of yard long bean as influenced individually by nutrient management and Auxin (IAA)

Treatments	Number of flowers plant^{-1}	Number of pods plant^{-1}	Days to first picking	Podlength (cm)	Individual pod weight (g)	Yieldplot^{-1}(kg)	Yield ha^{-1} (t)
Nutrient management							
N_0	123.50 c	37.77 c	70.78a	43.73 c	36.44 c	1.38 c	7.65 c
N_1	139.40 b	43.71 b	67.44 b	47.71 b	43.11 b	1.88 b	10.46 b
N_2	157.10 a	48.18 a	61.22c	55.50 a	52.51 a	2.53 a	14.05 a
N_3	155.30 a	47.49 a	61.56 c	55.19 a	52.22 a	2.50 a	13.87 a
$LSD_{0.05}$	3.013	2.102	1.206	1.083	1.929	0.142	1.001
CV(%)	12.54	8.63	8.11	6.19	7.28	6.97	6.99
Auxin (IAA)							
I_0	136.40 b	41.29 b	67.67 a	46.49 b	42.34 c	1.77 b	9.83 b
I_1	146.50 a	45.74 a	64.17 b	52.01 a	47.00 b	2.18 a	12.12 a
I_2	148.60 a	45.84 a	63.92 b	53.10 a	48.88 a	2.26 a	12.57 a
$LSD_{0.05}$	2.459	1.079	1.045	1.263	1.605	0.295	0.682
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

Pod Yield plot^{-1}

The highest yield plot^{-1} (2.53 kg) was recorded from the treatment N_2 (N_{18} P_{27} K_{33}) which was statistically identical to N_3 (N_{24} P_{36} K_{44}) whereas the lowest yield plot^{-1} (1.38 kg) was recorded from the control treatment N_0 (N_0 P_0 K_0)(Table 2). The highest yield plot^{-1} (2.26 kg) was found from the treatment I_2 (40 ppm IAA) which was statistically identical to I_1 (20 ppm IAA) whereas the lowest yield plot^{-1} (1.77 kg) was obtained from the control treatment control treatment I_0 (0 ppm IAA). Emonger (2007) observed that application of Auxin on Cowpea exogenously 7 days after emergence at 30, 60, and 90 mgL^{-1} significantly increased plant height, first node length, leaf area, leaf number, nodulation, pod number/plant, pod length, seed number/pod, plant dry matter accumulation, 100 seed weight.

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)(Table 3). 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 Thawaree*et al*. (2006) and Sahu&Verma (2020).

Table 3. The combined effect of different levels of nutrient management and auxin (IAA) on cropproduction of yard-long bean

Treatments	**Yield contributing parameters**						
	Number of flowers plant^{-1}	**Number of pods plant^{-1}**	**Days to first Picking**	**Pod length (cm)**	**Individual pod weight (g)**	**Yield plot^{-1} (kg)**	**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*

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 beans. 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 maximum yield ha^{-1} (14.05 t), whereas the control treatment N_0 ($N_0P_0K_0$ kg ha^{-1}) had the minimum yield ha^{-1} (7.65 t). Among factors of auxin, the maximum 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 minimum yield ha^{-1} (9.83 t) was obtained from the control treatment control treatment I_0 (0 ppm IAA)(Table 2).
However, the maximum 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 minimum 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 3).

CONCLUSION

The study found that combining two factors, management of nutrientsand Indole acetic acid (IAA), improves the growth and yield of yard-long beans. 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 shown to be extremely effective in enhancing different parameters. This included the number of branches plant^{-1}(13.28),the number of pods plant^{-1} (51.16), podlength (62.44 cm), total pod yield plot^{-1} (3.00 kg), and pod yield ha^{-1}(16.64t). In conclusion, the combined application of nutrients and IAA is advantageous in boosting the growth and yield of yard-long beans.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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Details of the AI usage are given below:

1.

2.

3.

References:

1. Ano AO, Ubochi CI. Nutrient composition of climbing and prostrate vegetable cowpea accessions. African Journal of Biotechnology. 2008;7(20):3795-3798.
2. Begum, A., Ahad, A., Kaisar, M.O., Islam, M.M. and Anam, M.K. 2003. Effect of sowing dates and fertilizer treatments on the reproductive variability of french bean (Phaseolus vulgaris). Pakistan Journal of Biological Sciences, 6(22):1897-1901. http://dx.doi.org/10.3923/pjbs.2003.1897.1901
3. Bhagavati PP, Kiran TSKK, Prasad NV, Reddy MLN. Correlation for growth, quality, yield, and yield components in yard long bean (*Vignaunguiculata*(L.) Walp. ssp. *sesquipedalis*Verdc.), International Journal of Current Microbiology and Applied Science. 2019;8(1):410-414.
4. Cheng, Y. and Zhao, Y. (2007), A Role for Auxin in Flower Development. Journal of Integrative Plant Biology, 49: 99-104. https://doi.org/10.1111/j.1744-7909.2006.00412.x
5. Desai SN, Deore DD. Influence of growth regulators on the seed production of cowpea. Journal of Maharashtra Agriculture University. 1985;10(1):89-90.
6. Dilip Kumar Sahu, AnnuVerma. Effect of plant growth regulators on growth and yield of

cowpea. International Journal of Chemical Studies. 2020;8(6);1736-1738.
7. Emonger, V. (2007). Gibberellic Acid (GA3) Influence on vegetative growth, nodulation and yield of cowpea (Vignaunguiculata L.) Walp. Journal of Agronomy, 6(4), 509-517.
8. HayatQ,HayatS,IrfanM,AhmadA.Effectof exogenous application of salicylic acid under changing environment. A review. Environmental and Experimental Botany. 2010;68(1):14-25.
9. Landa,R.,Rayas,A.,Gonazalez D.L and Graz J.A.(2002).Effect of NPK on the growth and yield of French bean.Centro Agricola,29 (3):26-29.
10. Mandal S, Sanyal D. Response of French bean to foliar application of NAA and CPPU. Horticulture Journal. 2004;17(3):235-240.
11. Rai N, Patel RK, Yadav DS, Asati BS. Effect of PGR on growth, flowering, and yield of pole-type French bean cv. Meghalaya local. Vegetable science. 2004;31(1):95-97.
12. Reshmi, Gopalakrishnan. Studied the effect of plant growth regulators on the performance of yard long bean (*Vignaunguiculata var. sesquipedalis*L. Verdcourt). Journal of Tropical Agriculture. 2004;42(1-2):55-57.
13. Sarkar BC, Minjee PR, Nisu ZU, Islam MJ, Ali MJ. Morpho-physiological characteristics and yield attributes of three aromatic rice cultivars in response to 6- BAP. InternationalJournalofAgricultureandMedicinalPlants. 2020;1(1):1-9.
14. Shinde AK, Jamadagni BM, Birari SP. Effect of foliar spray of growth regulators and KNO_3 on growth andyield of cowpea (*Vignaunguiculata*L.) variety VCM-8. Indian Journal of Plant Physiology. 1991;34(4):392-395.
15. Singh SP, Muñoz CG, Terán H (2001) Registration of common bacterial blight resistant dry bean germplasm VAX 1, VAX 3, and VAX 4. Crop Sci 41:275–276
16. Susila, A.D., Kartika, J.G., Prasetyo, T., &Palada, M.C. (2010). Fertilizer Recommendation: Correlation and Calibration Study of Soil P Test for Yard Long Bean (*Vignaunguilata* L) on Ultisols in Nanggung-Bogor. Indonesian Journal of Agronomy, 38. DOI:10.24831/jai.v38i3.14968
17. Thaware BG, Jadhav BB, Mahadik SG, Mane AV. Effect of foliar application of growth regulators on growth and yieldofcowpea(*Vignaunguiculata*L.).IndianJournalof Plant Physiology. 2006;18(2):135-139.
18. Thaware BG, Jadhav BB, Mahadik SG, Kandalkar MP. Effectofseedsoakingwithdifferentgrowthregulatorson growth and yield of cowpea (*Vignaunguiculata*). Journal of Eco biology. 2008;22(1):53-56.
19. Uallah J, Quazi AF, Hossian F. Response of growth,yield attributes and yield to the application of KNP and NAA in cowpea (*Vignaunguiculata*L. Walp.). Bangladesh Journal Botany. 2007;36(2);127-132.
20. Ullah MZ, Hassan MJ, Rahman AHMA, Saki AI.Genetic variability, character association and path analysis in yard long bean, SAARC Journal of Agriculture. 2011;9(2):9-16.