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GROWTH, YIELD AND PROFITABILITY OF SUMMER COUNTRY BEAN (*LABLAB PURPUREUS* L.) AS INFLUENCED BY EXOGENOUS APPLICATION OF PLANT GROWTH REGULATORS

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Abstract

A field experiment on summer country been (var. BARI Shim-7) was conducted at the Research Field of Plant Physiology Section of Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Gazipur, during the summer season of 2018 and 2019 to study the effect of exogenously applied plant growth regulators (PGRs) on growth, yield and profitability of the crop. The experiment was consisted *of* four levels of NAA (15, 30, 45 and 60 ppm), three of CCC (200, 300 and 400 ppm), two of GA_3 (20 and 30 ppm) and tap water as control. Average results of two years showed that all growth regulators performed better in respect of all characters studied over control. At 1st fruit set vine length (3.15 m) and number of leaves/plant (327.96), at last harvest stem girth (24.53 mm) and vine length (4.89 m), and plant dry matter (17.24%), number of pods/cluster (6.41), pod length (8.78 cm), number of pods/plant (351.30), individual pod weight (6.26 g) and pod set (38.13%) were the maximum in 60 ppm NAA followed by 45 ppm NAA and 200 ppm CCC. The maximum mean pod yield (10.65 t/ha) was obtained with the application of 60 ppm NAA closely followed by 45 ppm NAA (10.50 t/ha). Application of 200 ppm CCC also produced higher pod yield (8.75 t/ha) than that of control. Application of 60 ppm NAA also gave the maximum gross return (Tk. 532500/ha), gross margin (Tk. 3361248/ha) and BCR (3.11).

Keywords: Country bean, *Lablab purpureus,* PGRs, yield, BCR.

Introduction

Country bean or hyacinth bean [*Lablab purpureus* (L.) Sweet] belonging to the family *Fabaceae* is a tropical vine crop and one of the most important protein rich vegetables grown in Bangladesh during both summer and winter seasons. It is popularly known as 'shim' in our country. The pods (fruits) are consumed as vegetables in its immature stage. The pods and seeds contain large amount of various vitamins and minerals.

During summer season some problems such as delayed and erratic flowering and low pod set are frequent in country bean. Hazra and Som (1991) reported that 75-

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90 % flower shedding occurs in country bean. Kolle (2010) reported that country bean is faced with problem of flower shedding which is a major constraint for yield in this crop and about 10-20% of the flowers only develop into mature pods. Sometimes farmers/growers face the problems that heavy flower dropping occurs in plants of country bean var. BARI Shim-7 and pod set percent in the inflorescence is not up to the mark. BARI has developed 10 high yielding varieties (HYVs) of country bean, among which BARI Shim-7 is a popular summer country bean variety.

Application of plant growth regulators (PGRs) is known as one of the most effective tools in agriculture for increasing horticultural crop production. Moreover, PGRs are known to improve physiological efficiency including photosynthetic ability of plants and offer a significant role in realizing higher crop yield. The PGRs are also known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates, thereby increasing the productivity of the crop (Khan and Mazed, 2018).

Application of plant growth regulators has been widely recommended to overcome problems such as low flowering and poor pod set in vegetable crops (Arora *et al*., 1992; Resmi and Gopalakrishnan, 2004). Maheshbhai (2006) was obtained the highest yield of country bean with the spray of NAA @ 40 ppm. The present study was; therefore, undertaken to evaluate the effect of selected plant growth regulators on vegetative growth, fruit set, pod yield and profitability of summer country bean.

Materials and Methods

The experiment was conducted at the field of Plant Physiology Section of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during summer seasons of 2018 and 2019. The treatments consisted of four levels of NAA concentrations (15, 30, 45 and 60 ppm), three of CCC (200, 300 and 400 ppm), two of GA_3 (20 and 30 ppm) and control (where only tap water was sprayed). At first some review of literatures were collected about plant growth regulators (PGRs) (NAA, GA_3 and CCC) influence on legume crops including country bean. Based on their better results the doses of each PGR were selected (Arora *et al*., 1992; Rajani *et al.,* 2016; Noor *et al*., 2017; Rahman *et al.,* 2018; Shah and Prathapasenan, 1991; Maheshbhai, 2006; Ullah *et al*., 2007). Using electronic balance 250 mg each of gibberellic acid and naphthalene acetic acid were accurately weighed out and dissolved in a few ml of ethyl alcohol (95%) separately. The two solutions thus prepared were transferred to two 250 ml volumetric flasks. Then the volume of the solutions were made upto 250 ml with distilled water to get the 1000 ppm stock solution of GA_3 and NAA. On the other hand, 2 ml of CCC (50% aqueous solution) was accurately measured by using 5 ml pipette and dissolved in 100 ml distilled water in a 1000 ml volumetric flask and then the volume of the solution was made upto 1000 ml with distilled water to get the 1000 ppm CCC stock solution. Finally, the required lower concentrations of NAA (15, 30, 45 and 60 ppm), GA_3 (30 and 40 ppm) and CCC (200, 300 and 400 ppm) were prepared from the above three stock solutions by using the formula: V_1 x S_1 = V_2 x S_2; where, S_1: concentration of stock solution (1000 ppm) of NAA or GA_3 or CCC, V_1 = volume of stock solution NAA or GA_3 or CCC (which we have to be calculated), S_2: concentration of NAA or GA_3 or CCC needed and V_2: amount of solution of NAA or GA_3 or CCC required for spray. Then calculated amount (V_1) of NAA or GA_3 or CCC was taken from stock solution and poured into three separate volumetric flasks of known volume and then required amount of distilled water was added into these three flasks.

The experiment was laid out in a Randomized Complete Block Design with three replications. The unit plot size was 2.00 m x 1.80 m (3.6 m^2) having 2 plants. Each unit plot had single row of 2.0 m long with plant to plant space of 1.0 m. Horizontal trellises were made with bamboo separately for support of the two plants. The variety used in the experiment was BARI Shim-7. Thirteen and 12 day-old seedlings were transplanted on 19 April 2018 and 07 April 2019, respectively. Aqueous solutions of different NAA, CCC and GA_3 were prepared and sprayed as per treatment thrice on the plants i.e. 2 weeks after transplanting, at 1^{st} flowering and three weeks after 1^{st} flowering. Seedlings were raised in poly bag (6 cm x 7 cm). First flowering was appeared at 44 and 42 days after seed sowing during 2018 and 2019, respectively. Liquid soap was added in the solutions as surfactant for uniform spread of chemicals and moisture on leaves. Fertilizers were applied as recommended by Nasreen *et al.* (2015) along with cowdung @ 5 t/ha. Weeding was done when required. To control insects and diseases, protection measures were taken as necessity.

Pods were harvested during 24 June,29 August in 2018 and 25 June,16 August in 2019.The data were recorded on stem girth at last harvest (mm), vine length at 1^{st} fruit set (m) and last harvest (m), number of leaves/plant at 1^{st} suit set leaf length (cm), leaf breadth (cm), plant dry matter at last harvest % (with roots, leaves, stems and branches), soil plant analysis development (SPAD) value, number of pods/cluster, pod length (cm), pod width (cm), individual pod weight (g), number of pods/plant, pod set (%) and pod yield/plant (g). The data on SPAD value was taken at fruiting stages of each year with a SPAD meter (Brand: Minolta 502). Recorded data were statistically analyzed by MSTAT-C software and mean separation was done by LSD test at 5% level of probability. Benefit cost analysis was also done.

Results and Discussion

Growth characters and relative chlorophyll content (SPAD value)

Significant variations due to exogenously application plant growth regulators were found in respect of vine length at 1^{st} fruit set, number of leaves/plant at 1^{st} fruit set, leaf length, leaf breadth, stem girth at last harvest, vine length at last harvest, plant dry matter at last harvest, plant dry matter and SPAD value (Table 1). Application of NAA @ 60 ppm gave the maximum vine length at 1st fruit set (3.19 m in 2018 and 3.10 m in 2019) and vine length at last harvest (4.90 m in 2018 and 4.87 m in 2019) and spraying of CCC of all concentrations showed inhibitory effect on vine length. Number of leaves /plant at 1st harvest (330.92 in 2018 and 325.00 in 2019), leaf length (16.22 cm in 2018 and 15.72 cm in 2019) and leaf breadth (14.25 cm in 2018 and 13.78 cm in 2019) were found the maximum when NAA @ 60 ppm was sprayed whereas, the lowest from control. The maximum stem girth at last harvest was obtained from 60 ppm NAA (24.45 mm in 2018 and 24.61 mm in 2019) which was significantly better than other treatments followed by 45 ppm NAA (23.15 mm in 2018 and 23.40 mm in 2019). The stem girth was lowest in control (17.50 mm in 2018 and 17.46 mm in 2019). Plant dry matter at last harvest was the maximum from 60 ppm NAA (18.03% in 2018 and 16.45% in 2019) followed by 45 ppm NAA (17.41% in 2018 and 15.89% in 2019) and the minimum from 15 ppm NAA (15.14% in 2018 and 13.82% in 2019). The maximum SPAD value was recorded from CCC @ 200 ppm (38.34 in 2018 and 38.35 in 2019) followed by 300 ppm CCC (38.11 in 2018 and 38.12 in 2019) and 400 ppm CCC (38.08 in 2018 and 39.09 in 2019). Shah and Prathapasenan (1991) obtained the maximum chlorophyll content (47.18 SPAD value) over control in field pea from the foliar spray of cycocel at 500 ppm. Pramoda and Sajjan (2018) also obtained the highest plant height and SPAD value with the application of 40 ppm NAA in bushy type country bean. On contrary, Kumanan *et al.* (2020) also recorded the highest plant height from the foliar spray of 100 ppm NAA followed by 50 ppm NAA in bushy country bean.

Table 1. Effect of plant growth regulators on growth characters and leaf SPAD value of summer country bean var. BARI Shim-7 during 2018 and 2019

Treatment	Vine length at 1st fruit set (m)		Number of leaves/plant at 1st fruit set		Leaf length (cm)		Leaf breadth (cm)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	2.52	2.30e	278.94	270.50	14.26	13.82	12.51	11.97
T_1	2.57	2.46	282.85	274.32	14.61	14.17	12.61	12.15
T_2	2.70	2.60	289.53	280.51	15.35	14.88	12.78	12.27
T_3	2.88	2.80	314.09	309.58	15.40	14.94	13.87	13.23
T_4	3.19	3.10	330.92	325.00	16.22	15.72	14.25	13.78
T_5	2.49	2.35d	309.06	303.22	15.44	14.98	13.01	12.95
T_6	2.47	2.32e	305.62	301.69	15.25	14.78	13.36	12.76
T_7	2.30	2.21f	304.14	299.60	15.00	14.54	14.02	13.37
T_8	2.74	2.66	288.94	308.54	15.46	15.00	14.05	13.40
T_9	2.78	2.77	313.99	275.65	15.64	15.17	14.21	13.57
LSD (0.05)	0.11	0.13	9.51	10.20	0.68	0.57	0.15	0.16
CV (%)	3.74	3.22	4.89	5.01	3.56	3.74	2.90	2.84

T_0 = control, T_1 = 15 ppm NAA, T_2 = 30 ppm NAA, T_3 = 45 ppm NAA, T_4 = 60 ppm NAA, T_5 = 200 ppm CCC, T_6 = 300 ppm CCC, T_7 = 400 ppm CCC, T_8 = 20 ppm GA_3, T_9 = 30 ppm GA_3, Y_1 = 2018, Y_2 = 2019.

Table 1. Cont'd

Treatment	Stem girth at last harvest (mm)		Vine length at last harvest (m)		Plant dry matter (%)		SPAD value	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	17.50	17.46	4.10	4.08	15.68	14.31	33.42	33.46
T_1	17.62	17.65	4.00	4.22	15.14	13.82	33.31	33.22
T_2	18.40	18.50	4.30	4.28	15.37	14.02	34.46	34.35
T_3	23.15	23.40	4.60	4.56	17.41	15.89	35.52	35.43
T_4	24.45	24.61	4.90	4.87	18.03	16.45	35.95	35.90
T_5	17.58	17.49	3.98	3.80	16.85	15.38	38.34	38.35
T_6	17.35	17.26	3.95	3.90	15.91	14.52	38.11	38.12
T_7	17.20	17.24	3.72	3.71	16.13	14.72	38.08	38.09
T_8	17.58	17.62	4.40	4.35	16.52	15.08	34.50	34.43
T_9	17.70	17.67	4.50	4.46	16.96	15.48	34.52	34.50
LSD (0.05)	0.10	0.12	0.09	0.11	0.13	0.14	0.12	0.13
CV (%)	3.29	4.01	10.61	9.05	4.61	4.25	5.32	5.01

T_0 = control, T_1 = 15 ppm NAA, T_2 = 30 ppm NAA, T_3 = 45 ppm NAA, T_4 = 60 ppm NAA, T_5 = 200 ppm CCC, T_6 = 300 ppm CCC, T_7 = 400 ppm CCC, T_8 = 20 ppm GA_3, T_9 = 30 ppm GA_3, Y_1 = 2018, Y_2 = 2019.

Yield attributes

Application of different growth regulators showed significant influence on number of pods/cluster, pod length, pod width, individual pod weight, number of pods/plant and pod set (%) (Table 2). The maximum number of pods/cluster was harvested with the application of 60 ppm NAA (6.58 in 2018 and 6.25 in 2019) which was statistically similar to 45 ppm NAA (6.54 in 2018 and 6.21 in 2019 and the minimum number from the control (5.13 in 2018 and 4.87 in 2019) (Table 2). The maximum pod length was obtained from NAA @ 60 ppm (8.82 cm in 2018 and 8.73 cm in 2019) which was statistically identical to 45 ppm NAA (8.81 cm in 2018 and 8.72 cm in 2019). The lowest pod length was noticed from control (7.78 cm in 2018 and 7.76 cm in 2019). Application of 200 ppm CCC produced the maximum pod width (3.25 cm in 2018 and 3.18 cm in 2019) which was statistically identical to CCC @ 300 ppm (3.21 cmin 2018 and 3.14 cm in 2019) and CCC @ 400 ppm (3.20 cm in 2018 and 3.14 cm in 2019) and the lowest value with control (2.40 cm in 2018 and 2.35 cm in 2019). Application of NAA @ 60 ppm produced the maximum individual pod weight (6.42 g in 2018 and 6.10 g in 2019), which was statistically similar to NAA @ 45 ppm (6.41 g in 2018 and 6.08 g in 2019) and GA3 @ 30 ppm (6.20 g in 2018 and

5.89 g in 2019) and GA3 @ 20 ppm (6.15 g in 2018 and 5.84 g in 2019). The lowest individual pod weight was with control (5.20 g in 2018 and 4.94 g in 2019). The maximum pod set was noticed in 60 ppm NAA (39.09% in 2018 and 37.17% in 2019) followed by NAA @ 45 ppm (38.08% in 2018 and 36.21% in 2019). Application of GA_3 @ 30 ppm (38.06% in 2018 and 36.18% in 2018) gave identical pod set percentage like 45 ppm NAA. The lowest pod set was recorded in control (31.51% in 2018 and 29.97% in 2019) (Table 2). The maximum number of pods/plant was recorded with NAA @ 60 ppm (369.80 in 2018 and 332.80 in 2019) closely followed by NAA @ 45 ppm (365.80 in 2018 and 329.20 in 2018) and the lowest with control (240.90 in 2018 and 216.80 in 2019). Kumanan *et al*. (2020) also reported that maximum pod number/plant from spraying of 100 ppm NAA; whereas, Pramoda and Sajjan (2018) reported highest pod number/plant in country bean with the application of 40 ppm NAA. Shah and Prathapasenan (1991) obtained the highest pod number/plant over control in mung bean from the foliar spray of cycocel at 1000 ppm.

Table 2. Effect of plant growth regulators on yield and yield attributes of summer country bean var. BARI Shim-7 during 2018 and 2019

Treatment	Pods/cluster (no.)		Pod length (cm)		Pod width (cm)		Individual pod weight (g)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	5.13	4.87	7.78	7.76	2.40	2.35	5.20	4.94
T_1	5.44	5.17	7.90	7.82	2.71	2.65	6.18	5.87
T_2	5.47	5.20	8.20	8.11	2.72	2.66	6.25	5.92
T_3	6.54	6.21	8.81	8.72	2.82	2.76	6.41	6.08
T_4	6.58	6.25	8.82	8.73	2.83	2.77	6.42	6.10
T_5	6.35	6.03	8.42	8.33	3.25	3.18	5.53	5.25
T_6	6.20	5.89	7.97	7.89	3.21	3.14	5.70	5.41
T_7	5.33	5.06	7.80	7.72	3.20	3.14	5.60	5.32
T_8	5.53	5.25	8.18	8.10	2.80	2.74	6.15	5.84
T_9	5.78	5.49	8.25	8.17	2.84	2.78	6.20	5.89
LSD (0.05)	0.10	0.11	0.15	0.17	0.18	0.17	0.29	0.30
CV (%)	7.81	6.29	3.72	3.14	3.65	2.81	3.40	3.32

T_0 = control, T_1 = 15 ppm NAA, T_2 = 30 ppm NAA, T_3 = 45 ppm NAA, T_4 = 60 ppm NAA, T_5 = 200 ppm CCC, T_6 = 300 ppm CCC, T_7 = 400 ppm CCC, T_8 = 20 ppm GA_3, T_9 = 30 ppm GA_3, Y_1 = 2018, Y_2 = 2019.

Table 2. Cont'd

Treatment	Pod set (%)		Pods/plant (no.)		Pod yield/plant (g)		Pod yield (t/ha)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_0	31.51	29.97	240.90	216.80	1168.60	864.07	7.15	3.29
T_1	33.97	32.30	247.20	222.50	1437.50	1227.07	8.62	5.04
T_2	33.07	31.45	281.30	253.20	1640.20	1409.00	9.84d	5.77
T_3	38.08	36.21	365.80	329.20	2227.20	1881.40	13.36	7.64
T_4	39.09	37.17	369.80	332.80	2255.50	1908.30	13.53	7.77
T_5	36.98	35.16	347.30	312.60	1883.60	1542.60	11.3	6.20
T_6	36.30	34.52	312.50	281.30	1692.90	1430.50	10.15	5.88
T_7	33.01	31.39	218.80	196.90	1165.00	984.70	6.99	4.00
T_8	36.32	35.18	250.40	225.40	1462.50	1237.40	8.77	5.05
T_9	38.06	36.18	278.80	250.92	1642.70	1389.30	9.86	5.66
LSD (0.05)	0.71	0..73	8.85	7.98	58.45	59.32	1.21	1.25
CV (%)	4.34	4.19	3.95	5.12	4.22	4.81	6.21	5.89

T_0 = control, T_1 = 15 ppm NAA, T_2 = 30 ppm NAA, T_3 = 45 ppm NAA, T_4 = 60 ppm NAA, T_5 = 200 ppm CCC, T_6 = 300 ppm CCC, T_7 = 400 ppm CCC, T_8 = 20 ppm GA_3, T_9 = 30 ppm GA_3, Y_1 = 2018, Y_2 = 2019.

Pod yield

The maximum pod yield/plant was recorded with NAA @ 60 ppm (2255.50 g in 2018 and 1908.30 g in 2019) which was statistically similar to 45 ppm NAA (2227.20 g in 2018 and 1881.40 g in 2019) and followed by 200 ppm CCC (1883.60 g in 2018 and 1542.60 g in 2019) (Table 2). The minimum pod yield/plant was noticed in control (1168.60 g in 2018 and 864.07 g in 2019). Ullah *et al.* (2007) recorded the maximum pod yield/plant in cowpea with the application of NAA @ 50 ppm. Dahmardeh *et al.* (2010) reported that application of planofix (NAA) helped in maintaining balance of endogenous hormones within the legume plants that decreased flower dropping in beginning and thereby resulted in increasing yield of faba bean. Application of 100 ppm NAA at the beginning of flower open in the first inflorescence was reported to improve fruit set and consequently yield (Anon. (2013).

Different growth regulators significantly influenced the pod yield/ha in both years (Table 2). In 2018, application of NAA @ 60 ppm produced the maximum pod yield (13.53 t/ha) which was statistically similar to NAA @ 45 ppm (13.36 t/ha) and the lowest in control (7.15 t/ha). In 2019, the maximum pod yield was in NAA @ 60 ppm (7.77 t/ha) which was statistically identical to NAA @ 45 ppm (7.64 t/ha). In 2018, the crop was good without any insects and diseases and 9 times pod harvest was possible; whereas, in 2019, the crop was attacked by insects and diseases which lowered pod yield/ha. Two years results indicate that pod yield/ha increased with the increasing of NAA levels. Pod yield also increased with the increase of GA_3 concentrations. Application of NAA @ 60 ppm, NAA @ 45 ppm and CCC @ 200 ppm gave 47.15, 46.48 and 36.72% higher yield over control in 2018 and 57.66, 56.94 and 44.05% higher yield over control in 2019, respectively (Table 2). Promada and Sajjan (2018) obtained the maximum pod yield /ha in bushy type hyacinth bean with the application of 100 ppm NAA followed by 45 ppm NAA, whereas Kumanan *et al*. (2020) obtained the highest pod yield/ha from the spray of 40 ppm NAA in bushy type hyacinth bean. On the other hand, Sahu and Verma (2020) obtained the highest pod yield/ha in 45 ppm NAA in yard long bean.

Economics

The maximum gross return was obtained from NAA @ 60 ppm (Tk. 5,32,500/ha) followed by NAA @ 45 ppm (Tk 5,25,000/ha) and CCC @ 200 ppm (Tk. 4,37,500.00/ha), CCC @ 300 ppm (Tk. 4,00,750/ha) and the minimum from the control (Tk. 2,61,000/ha) (Table 3). Gross margin was found the highest from NAA @ 60 ppm (Tk. 3,61,248/ha) followed by NAA @ 45 ppm (Tk. 3,53,871/ha) and CCC @ 200 ppm (Tk. 2,63,740/ha) while, the lowest in control (Tk. 90,240/ha). The maximum benefit cost ratio was obtained from NAA @ 60 ppm (3.11) followed by NAA @ 45 ppm (307) and CCC@ 200 ppm (2.52) while the minimum was in control (1.45).

Table 3. Benefit cost analysis of summer country bean production with the application NAA, CCC and GA_3 (Average of 2018 and 2019)

Treatment	Mean pod yield (t/ha)	Gross return (Tk./ha)	Cost of treatment Tk./ha)	Total cost of cultivation (Tk./ha)	Gross margin (Tk./ha)	Benefit-cost ratio (BCR)
T_0	5.22	261000	0.000	170760	90240	1.53
T_1	6.83	341500	0.123	170883	170617	2.00
T_2	7.81	390250	0.246	171006	219244	2.28
T_3	10.50	525000	0.369	171129	353871	3.07
T_4	10.65	532500	0.492	171252	361248	3.11
T_5	8.75	437500	3.000	173760	263740	2.52
T_6	8.02	400750	4.500	175260	225490	2.29
T_7	5.50	274750	4.000	174760	99990	1.57
T_8	6.91	345500	4.940	175700	169800	1.97
T_9	7.76	388000	7.410	178170	209830	2.18

T_0 = control, T_1 = 15 ppm NAA, T_2 = 30 ppm NAA, T_3 = 45 ppm NAA, T_4 = 60 ppm NAA, T_5 = 200 ppm CCC, T_6 = 300 ppm CCC, T_7 = 400 ppm CCC, T_7 = 20 ppm GA_3, T_7 = 30 ppm GA_3; Basic cost of cultivation: 170.76 thousand Tk:;1 kg produce: Tk 50.00.

Cost of PGRs;

1. Naphthalene Acetic Acid (NAA):Tk 2200.00/100 g
2. Cycocel (CCC)” Tk 2000.00/100 ml
3. Gibberellic acid: 500.00/g

Conclusion

Two years results revealed that application of growth regulators offers a scope for obtaining higher yield of summer country bean. However, spray of NAA @ 60 ppm at 2 weeks after transplanting i.e. 4 weeks after sowing, 1st flowering and 3 weeks after 1st flowering might be optimum for higher pod yield and economic return.

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