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Effect of Indoleacetic Acid on Growth of Mungbean (*Vigna radiata* L.)

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Abstract: IAA at 600 ppm significantly increased plant height, number of branches/plant, number of leaves/plant, total dry matter, leaf area, leaf area index and crop growth rate. Significant varietal differences were observed in terms of the morpho-physiological characters studied. The variety BARI 4 (V_1) manifested better performance than BARI 2 (V_2). V_1 plants treated with 600 ppm of IAA had the highest plant height, number of leaves, total dry matter, crop growth rate, number of branches, leaf area, leaf area index and relative growth rate. So plants treated with IAA at 600 ppm performed better than those of control and other treatments.

Key words: Indoleacetic acid, growth characters, mungbean, *Vigna radiata* L., pulse crop

Introduction

Mungbean (*Vigna radiata* L.) is an important pulse crop commonly cultivated in Bangladesh. It is ranking fifth in acreage, sixth in production, third in protein contents and first in respect of price. It provides valuable supplement to rice based diet in this country (Tsu and Hsu, 1978). In Bangladesh its contribution is only 5% to the total pulse production (Rahman and Main, 1988; Anonymous, 1992). About 55,004 ha of land is under its cultivation with a production of about 34,405 metric tons i.e., 0.62 t ha^{-1} which contributes 6.65 % of total pulse production in the country (Anonymous, 2000). Mungbean is normally grown in summer season, which grows within a mean temperature range of about 20-40°C. Warm temperature is essential for rapid germination of mungbean seeds. Studies at AVRDC indicated that 29-31°C temperature is the optimum temperature for better germination (Simon *et al.*, 1976). In spite of its importance and well adaptability in the agroclimatic condition of Bangladesh, the acreage and production of mungbean is decreasing gradually because of mounting competition from other profitable cereals, especially irrigated boro rice in medium high land (Shaikh *et al.*, 1981; Ahmed, 1984; Anonymous, 1987). The crop has received very little attention of the researchers in comparison to other cereals and grain crops. Considering the significance of mungbean in the Bangladesh context, it is therefore, of utmost necessity to improve this pulse both in terms of its quantitative and qualitative values. Various practices may help to achieve this goal. Application of growth regulators seems to be the most significant. Indoleacetic acid (IAA) is one of such plant growth regulators, which can manipulate a variety of growth and developmental phenomena in various crops. A foliar application of IAA has been found to increase plant height, number of leaves/plant, fruit size with consequent enhancement in seed yield in different crops like groundnut (Lee, 1990), cotton (Kapgate *et al.*, 1989), cowpea (Khalil and Mandurah, 1989), bottle gourd (Gaur and Joshi, 1966) and rice (Kaur and Singh, 1987). It also increases the total dry matter of crops (Gurdev and Saxena, 1991). Very limited work has been carried out regarding the use of growth regulators especially on mungbean in our country. Although studies, in other countries of the world provided useful information those may not be applicable directly to our cultivars because of varied weather and soil conditions. Considering this view in mind, the present work was designed to study the effect of IAA on plant growth and development of mungbean.

Materials and Methods

The present experiment was conducted at the Experimental Field of the Department of Crop Botany, Bangladesh Agricultural University Mymensingh, in kharif season during the period from October to December 2000. The whole experimental land was divided into three blocks maintaining 0.5 m space between two blocks and each block was divided into eight plots maintaining 0.25 m space between them. The site of unit plot was 2.5 x 1 m^2. The plots were spaded one day before planting and the basal doses of fertilizers were incorporated thoroughly before planting. Urea, triple super phosphate (TSP) and muriate of potash (MP) were applied at the rate of 45, 100 and 58 kg ha^{-1}, respectively. Total amount of TSP, MP and urea were applied uniformly at the time of final land preparation. Two varieties of mungbean, BARI 4 $(V)_1$ and BARI 2 (V_2) were used. The seeds were sown in rows. The distance between rows and seeds were 30 and 15 cm, respectively and two seeds were placed in each point at a depth of 15 cm from the soil surface. Indoleacetic acid 300 ppm (c_1), 600 ppm (c_2) and 900 ppm (c_3) was used as spray at 20 days after sowing (DAS). Control (c_o) was also maintained. First crop sampling was done at 13 DAS and the sampling was continued at an interval of 13 to 65 DAS. At the time of each harvest, five plants were randomly selected from each plot for collecting morphophysiological data. Plant height was measured, from ground level to the top most leaf with a graduated scale. The number of leaves formed per plant during its life cycle was counted. Leaf area was measured at 13 days interval. Total leaf area of individual plant was measured by an electronic leaf area meter (LI 3000, USA). Number of branches per plant was counted at 13 days interval starting from 39 DAS. The standard growth parameters such as total dry matter (TDM) of above ground parts, leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR) were computed by the standard formulae (Radford, 1967).

The experiment has two factors. The concentration of IAA was considered as factor A and two varieties as factor B. The experiment was laid out in randomized complete block design (RCBD). There were three replications. Each treatment was randomly accommodated once in each block. The data collected were analyzed using the MSTAT. The difference between pairs of means were compared by least significant difference test (LSD) and Duncan's multiple range test (DMRT).

Results and Discussion

Effect of IAA on morphological characters of mungbean:

Plant height: The growth regulator (IAA) had stimulatory effect on plant height as was recorded at 26, 39 , 52 and 65 DAS (Table 1). Plant height gradually increased with the advancement of crop growth and maximized at 52 DAS followed by a slight decrease at 65 DAS in all concentrations of IAA. C_2 (600 ppm IAA) produced the tallest plants at all growth stages. In the highest concentration (900 ppm), the plant height was shorter than the control in some stages indicating that 900 ppm was a supra-optimal concentration. (Table 1). Significant variation in plant height was found between the two varieties of mungbean at all growth stages except at 13 and 65 DAS (Table 2). V_1 (BARI 4) always had a higher plant height than V_2 (BARI 2). The tallest plant (34.29 cm) was found in V_1 at 52 DAS (Table 2). The interaction effect of growth regulator and variety (C_2x V_1) on plant height was significant at 26 and 39 DAS only (Table 3). The tallest plant (25.61 cm) was found in C_2 x V_1

Table 1: Effect of various concentrations of IAA on morphological characters of mungbean at different growth stages

	Plant height (cm)					Number of branches/plant			Number of leaves/plant					Leaf area/plant (cm^2)				
Conc.	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
C_0	11.72	22.40b	26.90bc	31.74b	28.82b	2.32ab	2.75b	2.17	3.41a	5.40	5.75	8.00	6.83ab	13.37b	72.00c	123.10c	314.30b	269.20ab
C_1	11.74	23.50ab	28.50ab	32.98b	29.40b	2.42a	3.00ab	2.41	3.49a	5.74	6.00	8.25	7.33a	13.90ab	90.00b	141.50b	345.20ab	304.20ab
C_2	11.98	24.98a	30.13a	37.49a	32.50a	2.67a	3.67a	2.75	3.66a	5.91	6.33	9.33	7.92a	15.31a	108.30a	156.10a	466.40a	369.60a
C_3	11.62	21.25b	25.08c	30.89b	28.25b	1.92b	2.67b	2.08	3.00b	5.17	5.53	7.84	5.75b	12.52b	62.67d	106.60d	298.80b	206.10b
Level of sig.	NS	5%	1%	1%	5%	5%	5%	NS	5%	NS	NS	NS	5%	5%	1%	1%	1%	5%
$S\bar{x}$	0.52	0.85	0.82	0.81	0.85	0.19	0.27	0.20	0.23	0.42	0.50	0.65	0.57	0.57	0.87	0.89	30.80	35.60
CV%	8.88	6.04	4.23	5.99	7.00	15.83	15.61	20.60	7.65	18.67	16.78	18.93	14.07	10.05	2.56	2.60	14.16	13.90

Table 2: Difference of mungbean varieties on morphological characters at different growth stages

	Plant height (cm)					Number of branches/plant			Number of leaves/plant					Leaf area/plant (cm^2)				
Varieties	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
V_1	11.93	24.07a	28.51a	34.29a	30.44	2.62a	3.37a	2.58a	3.58a	5.83	6.25	8.87	7.62a	14.55a	94.12a	141.32a	402.57a	309.14a
V_2	11.60	21.96b	26.84b	32.27b	29.05	2.04b	2.67b	2.12b	3.20b	5.27	5.55	7.83	6.29b	12.99b	72.37b	122.32b	309.75b	265.42b
Level of sig.	NS	5%	5%	5%	NS	1%	5%	5%	5%	NS	NS	NS	5%	5%	1%	1%	1%	5%
$S\bar{x}$	0.37	0.60	0.58	0.57	0.60	0.13	0.19	0.14	0.16	0.30	0.35	0.46	0.40	0.40	0.62	0.63	21.66	24.80
CV(%)	8.88	6.04	4.23	5.99	7.00	15.83	15.61	20.60	7.65	18.67	16.78	18.93	14.07	10.05	2.56	2.66	14.16	13.90

Table 3: Mean interaction effect of IAA concentration and cultivars on morphological characters at different growth stages

	Plant height (cm)					Number of branches/plant			Number of leaves/plant					Leaf area/plant (cm^2)				
C x V	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
$C_0 x V_1$	11.89	23.36ab	27.50abc	32.98	29.56	2.66	3.00	2.33	3.70ab	5.66	6.00	8.50	8.00	13.90	88.70d	131.30c	332.10b	278.10ab
$C_1 x V_1$	11.91	24.56ab	30.23a	33.06	30.32	2.83	3.33	2.66	3.83a	6.00	6.33	8.50	8.16	14.80	98.30c	157.50a	367.10b	312.80ab
$C_2 x V_1$	12.07	25.61a	30.76a	39.03	32.53	3.00	4.33	3.00	3.83a	6.33	6.66	10.30	8.16	15.90	112.50a	160.20a	593.80a	434.60a
$C_3 x V_1$	11.85	22.80abc	25.54c	32.06	29.34	2.00	2.83	2.33	3.00c	5.33	6.00	8.20	6.17	13.60	77.00e	116.30cd	317.30d	211.10b
$C_0 x V_1$	11.56	21.38bc	26.32c	30.50	28.08	1.99	2.50	2.00	3.20bc	5.13	5.50	7.50	5.66	12.80	55.30f	114.90cd	296.40d	260.30b
$C_1 x V_1$	11.58	22.40abc	26.80bc	32.91	28.48	2.00	2.67	2.16	3.20bc	5.49	5.66	8.00	6.50	13.00	81.70e	125.50c	323.30d	295.70ab
$C_2 x V_1$	11.89	24.40ab	29.70ab	35.93	32.47	2.33	3.00	2.50	3.50abc	5.49	6.00	8.30	6.67	14.80	104.20b	152.00b	339.02b	304.60ab
$C_3 x V_1$	11.40	19.70c	24.60c	29.70	27.20	1.83	2.50	1.83	3.00c	5.00	5.05	7.50	5.33	11.40	48.30g	96.90d	280.30b	201.10b
Level of sig.	NS	5%	5%	NS	NS	NS	NS	NS	5%	NS	NS	NS	NS	NS	1%	5%	5%	5%
$S\bar{x}$	0.74	1.20	1.15	1.150	1.20	0.27	0.38	0.28	0.30	0.60	0.71	0.91	0.81	0.80	1.23	1.26	43.51	49.60
CV%	8.88	6.04	4.23	5.99	7.00	15.83	15.61	20.60	7.65	18.67	16.78	18.93	14.07	10.05	2.56	2.60	14.16	13.90

Figures followed by different letter(s) within a column differ significantly (DMRT)

C_0 = Control, C_1 = 300 ppm IAA, C_2 = 600ppm IAA, C_3 =900 ppm IAA, CV= Coefficient of variance,
V_1= BARI 4, V_2= BARI 2, NS= Not significant, $S\bar{x}$ = Standard deviation

Table 4: Effect of IAA concentration on dry matter production of mungbean at different growth stages

	Root dry wt./plant (g)					Stem dry wt./plant (g)					Leaf dry wt./plant (g)					TDM/plant (g)				
Conc.	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
C_0	0.01	0.03b	0.07b	0.24a	0.27	0.03	0.08b	0.21b	0.90b	1.18b	0.05b	0.35bc	0.73b	1.59b	5.07b	0.08b	0.48b	1.01b	2.88a	9.69b
C_1	0.01	0.03b	0.08b	0.20ab	0.30	0.03	0.09b	0.21b	0.93b	1.28ab	0.06b	0.47ab	0.76b	0.74b	6.25ab	0.99a	0.60ab	0.09b	3.08a	10.58a
C_2	0.01	0.06a	0.09a	0.24a	0.32	0.03	0.12a	0.25a	0.98a	1.46a	0.07a	0.57a	0.85a	2.30a	7.46a	0.11a	0.73a	0.39a	3.16a	11.13a
C_3	0.01	0.02b	0.05c	0.14b	0.27	0.02	0.08b	0.20b	0.90b	1.08b	0.05b	0.33c	0.59c	1.24b	5.06b	0.80b	0.43b	0.92b	2.45b	8.61c
Level of sig.	NS	1%	5%	5%	NS	5%	5%	5%	1%	5%	5%	1%	5%	1%	5%	1%	1%	1%	5%	5%
$S\bar{x}$	0.001	0.003	0.006	0.04	0.02	0.002	0.008	0.014	0.11	0.09	0.004	0.03	0.06	0.15	0.52	0.01	0.05	0.08	0.23	0.81
CV%	13.45	15.89	11.68	15.66	16.70	14.44	9.49	15.99	23.19	14.69	7.36	11.16	5.64	11.20	13.43	10.98	11.51	13.59	14.76	11.71

Table 5: Varietal difference on dry matter production of mungbean at different growth stages

	Root dry wt./plant(g)					Stem dry wt./plant(g)					Leaf dry wt./plant(g)					TDM/plant(g)				
Varieties	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
V_1	0.02a	0.04a	0.9a	0.26a	0.31	0.03a	0.10a	0.23a	1.50a	1.34a	0.07a	0.48a	0.75a	1.79a	6.61a	0.11a	0.63a	1.21a	3.14a	11.12a
V_2	0.01b	0.03b	0.06b	0.15b	0.27	0.02b	0.08b	0.21b	0.85b	1.16b	0.05b	0.38b	0.71b	1.47b	5.30b	0.08b	0.49b	0.99b	2.64b	8.89b
Level of sig.	1%	1%	1%	5%	NS	1%	5%	NS	1%	5%	1%	1%	5%	1%	5%	1%	5%	5%	5%	5%
$S\bar{x}$	0.001	0.002	0.01	0.03	0.02	0.001	0.01	0.01	0.08	0.07	0.003	0.02	0.04	0.11	0.37	0.004	0.03	0.06	0.17	0.57
CV%	13.45	15.89	11.68	15.66	16.70	14.44	9.49	15.99	23.19	14.69	7.36	11.16	5.64	11.20	13.43	10.98	11.51	13.59	14.76	11.71

Table 6: Interaction effect on dry matter production of mungbean

	Root dry wt./plant(g)					Stem dry wt./plant(g)					Leaf dry wt./plant(g)					TDM/plant(g)				
CxV	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS
C_0xV_1	0.01	0.03b	0.08b	0.35a	0.30	0.03	0.10b	0.22	0.95b	1.27	0.06b	0.44ab	0.78ab	1.90ab	5.30bc	0.10	0.60ab	1.10bc	3.07	11.10ab
C_1xV_1	0.02	0.03b	0.10a	0.21bc	0.32	0.03	0.10a	0.22	0.97b	1.37	0.06b	0.53ab	0.78ab	2.06a	7.00ab	0.12	0.66ab	1.19b	3.40	12.20a
C_2xV_1	0.02	0.08a	0.11a	0.32ab	0.32	0.03	0.10a	0.26	2.95a	1.54	0.08a	0.57a	0.85a	2.49a	8.24a	0.13	0.73a	1.62a	3.60	11.60a
C_3xV_1	0.01	0.03b	0.06c	0.15c	0.29	0.03	0.10b	0.21	1.14b	1.16	0.06b	0.39bc	0.60d	1.43c	5.90bc	0.10	0.52bc	1.00bc	2.55	9.70ab
C_0xV_1	0.01	0.03b	0.06c	0.14c	0.25	0.02	0.07b	0.20	0.85b	1.08	0.04c	0.27c	0.69c	1.28c	4.80bc	0.06	0.36c	1.00bc	2.69	8.30ab
C_1xV_1	0.01	0.03b	0.06b	0.15c	0.27	0.02	0.08b	0.20	0.90b	1.18	0.05b	0.41bc	0.73bc	1.42c	5.50bc	0.08	0.53bc	1.00bc	2.76	9.00ab
C_2xV_1	0.01	0.04b	0.07b	0.16c	0.31	0.02	0.12a	0.24	1.00b	1.39	0.06b	0.58a	0.85a	2.11a	6.70ab	0.09	0.73a	1.10bc	2.76	10.70ab
C_3xV_1	0.004	0.02c	0.05c	0.14c	0.24	0.02	0.06b	0.20	0.65b	0.99	0.04c	0.26c	0.59d	1.05c	4.25c	0.06	0.35c	0.86c	2.40	7.60b
Level of sig.	NS	1%	5%	5%	NS	NS	5%	NS	1%	NS	5%	5%	5%	5%	5%	NS	5%	5%	NS	5%
$S\bar{x}$	0.001	0.004	0.01	0.05	0.04	0.002	0.01	0.02	0.16	0.13	0.01	0.05	0.08	0.21	0.74	0.01	0.07	0.11	0.33	1.14
CV%	13.45	15.89	11.68	15.66	16.71	14.44	9.49	15.90	23.19	14.69	7.36	11.16	5.64	11.20	13.43	10.98	11.51	13.59	14.76	11.71

Figures followed by different letter(s) within a column differ significantly (DMRT)

V_1=BARI 4, V_2= BARI 2 C_0 = Control C_1 = 300 ppm IAA, C_2 = 600ppm IAA , C_3 =900 ppm IAA CV= Coefficient of variance

TDM =Total dry matter NS= Not significant $S\bar{x}$ = Standard deviation

Table 7a: Varietal difference of mungbean on growth parameters at different growth stages

	LAI					RGH/plant (g $g^{-1}day^{-1}$)				CGR/plant ($g/m^2/day$)			
Varieties	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS
V_1	0.3a	0.21a	0.31a	0.90a	0.69a	0.13	0.05	0.07	0.10	0.88a	1.01a	3.29a	13.62a
V_2	0.03b	0.16b	0.27b	0.69b	0.59b	0.14	0.06	0.08	0.01	0.71b	0.84b	1.83b	10.68b
Level of sig.	5%	1%	1%	1%	5%	NS	NS	NS	NS	5%	5%	5%	5%
$S\bar{x}$	0.001	0.001	0.001	0.05	0.06	0.01	0.01	0.01	0.01	0.05	0.10	0.28	0.89
CV%	10.13	2.59	2.63	18.16	16.88	9.16	16.78	13.05	14.53	12.06	11.88	14.49	10.40

Table 7b: Effect of IAA on growth parameters of mungbean at different growth stages

	LAI					RGH/plant (g $g^{-1}day^{-1}$)				CGR/plant ($g/m^2/day$)			
Conc.	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS
C_0	0.03b	0.16bc	0.27b	0.70a	0.60ab	0.13	0.06a	0.08a	0.09b	0.68b	0.91b	3.23a	11.61b
C_1	0.03b	0.20ab	0.31a	0.77ab	0.68ab	0.14	0.05b	0.08a	0.09b	0.85ab	0.83b	3.14a	12.83a
C_2	0.03a	0.24a	0.35a	1.04a	0.82a	0.15	0.05b	0.06b	0.10a	1.06a	0.85a	3.03a	13.63a
C_3	0.03b	0.14c	0.24b	0.66b	0.46b	0.12	0.06a	0.08a	0.10a	0.61b	1.12a	2.58b	10.53b
Level of sig.	5%	1%	1%	1%	5%	NS	5%	5%	5%	1%	5%	5%	5%
$S\bar{x}$	0.001	0.001	0.001	0.05	0.06	0.01	0.01	0.01	0.01	0.07	0.14	0.39	1.26
CV%	10.13	2.59	2.63	18.16	16.88	9.16	16.78	13.05	14.53	12.06	11.88	14.49	10.40

Table 8: Interaction effect of IAA and variety of mungbean on LAI, CGR and RGR

CxV	LAI					CGR/plant ($g/m^2/day$)				RGH/plant (g $g^{-1}day^{-1}$)			
	13 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS	26 DAS	39 DAS	52 DAS	65 DAS
C_0xV_1	0.03	0.02ab	0.29bc	0.74b	0.62ab	0.85abc	0.79b	3.49a	13.60ab	0.14	0.04a	0.08a	0.10
C_1xV_1	0.03	0.22a	0.35a	0.82b	0.70ab	0.93abc	0.91ab	3.77a	15.03a	0.13	0.05b	0.08a	0.10
C_2xV_1	0.04	0.25a	0.36a	1.32a	0.97a	1.03ab	1.50a	3.31a	13.70ab	0.13	0.06a	0.06b	0.09
C_3xV_1	0.03	0.020abc	0.26cd	0.71b	0.47b	0.73cde	0.83b	2.95b	12.18ab	0.13	0.05b	0.07a	0.10
C_0xV_2	0.03	0.12bc	0.26cd	0.66d	0.58d	0.51de	0.02ab	2.96a	9.62ab	0.13	0.08a	0.08a	0.08
C_1xV_2	0.03	0.020abc	0.28c	0.72b	0.66ab	0.77bcd	0.76b	3.06a	10.60ab	0.15	0.05b	0.08a	0.09
C_2xV_2	0.03	0.23a	0.34ab	0.75b	0.68ab	1.08a	0.72b	2.75b	13.60ab	0.16	0.35c	0.07b	0.10
C_3xV_2	0.03	0.11c	0.22b	0.62b	0.45b	0.48c	0.87b	2.57b	8.88b	0.13	0.70a	0.08a	0.09
Level of sig.	NS	1%	5%	5%	5%	5%	5%	5%	5%	NS	5%	5%	NS
$S\bar{x}$	0.002	0.002	0.003	0.097	0.11	0.10	0.20	0.56	1.79	0.007	0.01	0.01	0.01
CV%	10.13	2.59	2.63	18.16	16.88	12.06	11.88	14.49	10.40	9.16	16.78	13.05	14.53

Figures followed by different letter(s) within a column differ significantly (DMRT)

C_0 = Control, C_1 = 300 ppm IAA, C_2 = 600 ppm IAA , C_3 =900 ppm IAA, CV= Coefficient of variance, V_1= BARI 4, V_2= BARI 2, LAI= Leaf area index, CGR= Crop growth rate, RGR= Relative growth rate, NS= Not significant, $S\bar{x}$ = Standard deviation

(600 ppm IAA x V_1) and the shortest plant (19.73 cm) was found in C_3 x V_2 (900 ppm of IAA x V_2) at 26 DAS. At 39 DAS, the tallest plant (30.76 cm) was found in C_2 x V_1 and the shortest plant (24.60 cm) was recorded in C_3 x V_2. IAA induced higher plant height was reported earlier in soybean (Reena *et al.*, 1999), grasspea (Rahman *et al.*, 1989), wheat (Saha *et al.*, 1996), sesame (Sontakey *et al.*, 1991) and groundnut (Lee, 1990). The stimulatory effect of IAA on plant height in the present experiment agrees well with the above research findings. The superiority of V_1 seems to be due to its genetic character.

Number of branches per plant: Number of branches per plant was recorded at 39, 52 and 65 DAS only (Table 1). The data reveals a significant difference at 39 and 52 DAS. At 600 ppm IAA produced the highest number of 2.67 and 3.67 branches/plant at 39 and 52 DAS, respectively. The lowest number of branches was found in 900 ppm at all growth stages. A significant varietal difference in number of branches/plant at different growth stages was documented in this study (Table 2). V_1(BARI 4) produced the higher number of branches/plant at all growth stages compared with V_2 (BARI 2). It produced the maximum number of 3.37 branches/plant at 52 DAS (Table 2). The interaction effect of IAA concentration and variety was non significant (Table 3). Application of 300, 600 and 900 ppm IAA was reported to increase the number of tillers/plant in wheat (Saha *et al.*, 1996). Pre-flowering spray of sesame with 100, 250 or 500 ppm IAA increased branch number per plant and the increase was the greatest with 500 ppm. In present study 600 ppm of IAA was the most efficient in increasing the number of branches/plant.

Number of leaves per plant: Number of leaves per plant was recorded from 13 to 65 DAS (Table 1). The data revealed that the influence of IAA on number of leaves/plant was significant at the final stage (65 DAS) only. At this stage, 600 ppm of IAA produced the highest number of leaves/plant (7.92) and 900 ppm of IAA produced the lowest number of leaves/plant (3.00). Between the varieties, V_1 (BARI 4) had higher number of leaves/plant at all the growth stages. However, the difference was significant only at 13 DAS and 65 DAS (Table 2). The interaction effect between growth regulator and variety on the number of leaves/plant was non-significant (Table 3). At 13 DAS maximum number of leaves/plant (3.83) was found in C_1 x V_1 (300 ppm IAA x V_1) and C_2 x V_2 (600 ppm x V_2) and the minimum number of leaves/plant (3.00) was found in the interaction between C_3 x V_1 (900 ppm IAA x V_1) and C_3 x V_2 (900 ppm x V_2). Mathur (1971) reported that IAA at 300 ppm increased number of leaves/plant in onion. In the present study, 600 ppm IAA increased the number of leaves/plant only at the final stage. Similar stimulatory effect of IAA on number of leaves/plant was also reported in cowpeas (Khalil and Mandurah, 1989) and wheat (Gurdev and Saxena, 1991)

Leaf area per plant: The effect of IAA on leaf area/plant was significant at different growth stages (Table 1). The data revealed that leaf area increased gradually with time in all the treatments. At 600 ppm IAA produced the maximum leaf area/plant at all stages of plant growth. C_1 (300 ppm) was intermediate between C_2 (600 ppm) and control, while C_3 (900 ppm) produced minimum leaf area/plant. A significant variation in leaf area/plant was observed between the cultivars (Table 2). V_1 (BARI 4) produced the higher leaf area/plant at all growth stages. It produced the maximum leaf area of 402.57 cm^2 at 52 DAS. Interaction effect of variety and growth regulator on the leaf area/plant was statistically significant (Table 3). The maximum leaf area/plant (593.8 cm^2) was found in C_2 x V_1 (600 ppm IAA x V_1) and the minimum leaf area/plant (280.30 cm^2) was found in the interaction between C_3 x V_2 (900 ppm IAA x V_2) at 52 DAS.

Effect of IAA on physiological characters of mungbean

Effect on leaf dry weight: IAA significantly influenced the leaf dry matter accumulation. Among the concentrations, 600 ppm IAA had a clear superiority over 300, 900 ppm and the control. Leaf DM increased slowly up to 52 after which it increased rapidly (Table 4). Cultivar difference in dry matter accumulation in leaves was observed at all the growth stages. V_1 (BARI 4) had significantly higher leaf dry weight throughout the growth period (Table 5). Interaction effect of IAA concentrations and varieties on leaf dry matter was significant at all the growth stages. The highest interaction effect was noticed in C_2 x V_1 throughout the entire period of growth (Table 6).

Effect on stem dry weight: Stem dry matter accumulation was significantly higher in C_2 (600 ppm) at all growth stages of mungbean (Table 4). The control and C_3 was more or less identical in accumulating stem dry matter. The cultivars manifested a significant variation in their ability to accumulate dry matter in stem. The variety BARI 4 had a clear superiority over V_2 (BARI 2) at all the growth stages (Table 5). Interaction effect of IAA and cultivars was significant at 26 and 52 DAS only. The highest interactions were found in C_2 x V_2 and C_2 x V_1 at 26 and 52 DAS, respectively (Table 6).

Effect of IAA on root dry matter (g/plant): Root dry matter(DM) varied significantly among various treatments. The highest root DM was accounted for C_2 (600 ppm) at all stages. However, the control plants had the same root DM at 13 & 52 DAS. Two cultivars had significantly different DM at all stages of plant growth (Table 5). V_1 (BARI 4) had the superiority over V_2 (BARI 2). Interaction effect of IAA and cultivars on DM was significant at 26, 39 and 52 DAS The highest effect was found with C_2 x V_1 at 26 and 39 DAS and with C_0 x V_1 at 52 DAS (Table 6). Evans (1972) stated that photosynthesis is the main contributing factor for increasing plant dry matter.

Total dry matter (TDM): Total dry matter is the sum of dry weight of leaves, stem and roots. Dry matter production was significantly influenced by the application of IAA (Table 4). TDM was increasing slightly up to 52 DAS followed by a more than 3-fold increase during the next 13 days. The differences among growth regulator treatments in their ability to induce dry matter accumulation were lower in the early stages of crop growth but became pronounced at later stages. Data showed that the highest dry matter production was recorded in C_2 (600 ppm of IAA) at all the growth stages. However, TDM in C_2 was statistically identical with C_1 at 13 DAS, C_1 and control at 52 DAS and C_1 at 65 DAS. TDM decreased slightly with the highest concentration of IAA (900 ppm). The two varieties of mungbean differed significantly in their ability to accumulate dry matter at all the growth stages. The data revealed that V_1 (BARI 4) had superiority in accumulating dry matter over V_2 (BARI 2) throughout the entire growing season (Table 5). The interaction effect between growth regulator and variety on the dry matter production is statistically significant only at 26, 39 and 65 DAS (Table 6). At 65 DAS, the highest total dry matter (12.19 g) was found in C_1 x V_1 (300 ppm of IAA x V_1). IAA induced higher TDM was reported in wheat (Gurdev and Saxena, 1991).

Leaf area index (LAI): The effect of IAA concentrations on leaf area index was statistically significant at all the growth stages Leaf area index of mungbean plant increased gradually up to 52 DAS thereafter it decreased slightly in all treatments at the approach of crop maturity and associated leaf drying. C_2 (600 ppm IAA) increased LAI most efficient at all growth stages. However, it was statistically identical with C_1 (300 ppm) especially at 39 DAS. Between the cultivars, V_1 (BARI 4) had the higher LAI at all the growth stages (Table 7a). It revealed that V_1 (BARI 4) had the highest LAI (0.90) at 52 DAS (Table 8). The combined effect of growth regulator and variety was significant as was observed on leaf area index at different stages. C_2x V_1 interaction produced the maximum leaf area index (1.32) at 52 DAS. LAI maximized at fruiting stage and then declined with crop maturity in faba bean (Fasheun and Dennett, 1982). Similar trend was observed in the present study.

Crop growth rate (CGR): The growth regulator applied in the present study significantly regulated crop growth rate at different growth stages. The data revealed that C_2 (600 ppm) maintained a higher CGR at all stages of growth at 65 DAS, it had the highest crop growth rate (13.63 g $m^{-2}day^{-1}$). C_3 (900 ppm of IAA) had the lowest CGR (10.53 g $m^{-2}day^{-1}$) at 65 DAS. However, C_2 (600 ppm) was statistically identical with C_1(300 ppm) at this time (Table 7b). V_1 (BARI 4) had superiority in CGR over the other cultivar V_2 (BARI 2) throughout the entire growth period (Table 7a). The interaction effect of growth regulator and variety on crop growth rate was significant at different growth stages (Table 8). Highest crop growth rate (15.03 g/m^2/day) was observed in C_1 x V_1 (300 ppm of IAA x V_1) at 65 DAS and the lowest crop growth rate (8.88 g/m^2/day) was obtained in interaction between C_3 x V_2 (900 ppm of IAA x V_2) at the same DAS. CGR was reported to increase at all the treatments of IAA and GA_3 in chickpea (Khalil and Mandurah, 1989). The results of the present study are in agreement with the above information.

Relative growth rate (RGR): The effect of various concentrations of IAA on relative growth rate was significant at different growth stages except 26 DAS. The data revealed that C_2 (600 ppm of IAA) manifested the highest relative growth rate (0.1 g $g^{-1}day^{-1}$) and C_0 (control) showed the lowest relative growth rate (0.09 g $g^{-1}day^{-1}$) at 65 DAS. However, an identical result was found in treated and control plants during the early stages. Effect of varieties on relative growth rate of mungbean was found insignificant (Table 7a). But there was a significant interaction between the growth regulators and the varieties on relative growth rate at different growth stages (Table 8). The highest RGR (0.10 g g^{-1} day^{-1}), C_0 x V_1 and C_3 x V_1 was found with C_1 x V_1 (300 ppm x V_1) interactions at 65 DAS. Higher RGR of the IAA treated plant was reported in faba bean.

The results of the experiment revealed that significant variations exist among the treatments and varieties in respect of morphological characters (plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$ and leaf area $plant^{-1}$) and physiological characters (leaf area index, total dry matter, crop growth rate and relative growth). The variety BARI 4 showed better performance than BARI 2. The present study clearly showed that plants treated with IAA at 600 ppm performed better than those of control and other treatment.

Further studies are, however, necessary with some other concentrations applied at various stages of plant growth including seed treatment before making conclusion and recommendation.

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