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Effect of Biofertilizer and Plant Growth Regulators on Growth of Summer Mungbean

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Abstract: The experiment was carried out at the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from March 2002 to June 2002 to evaluate the effect of biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA_3 and IAA) on growth of summer mungbean (*Vigna radiata* L.). The experiment was laid out by RCBD with three replications and two factors (variety and treatment). There were altogether 12 treatment combinations. Most of the growth parameters such as number of branches plant^{-1}, number of leaves plant^{-1}, number of effective nodules plant^{-1}, number of non-effective nodules plant^{-1}, root dry weight plant^{-1}, nodule dry weight plant^{-1} was the height due to the application of biofertilizer (*Bradyrhizobium*). On the other hand, plant height, leave dry weight plant^{-1}, shoot dry weight plant^{-1} and total dry weight plant^{-1} was the height due to the application of plant growth regulators (GA_3 and IAA). However, biofertilizer (*Bradyrhizobium*) and plant growth regulators (GA_3 and IAA) showed statistically identical performance on Crop Growth Rate (CGR) and Relative Growth Rate (RGR). In addition, among the mungbean varieties, Binamoog-5 performed better than that of Binamoog-2 and Binamoog-4.

Key words: Biofertilizer, *Bradyrhizobium*, GA_3, IAA, growth, summer mungbean

INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important pulse crop of global economic importance. It ranks first position in price, fourth in acreage and sixth in production in Bangladesh (BBS, 2001). Mungbean has a special importance in intensive crop production system of the country for its short growing period (Ahmed, 1989). Mungbean covers an area of 55,100 ha and production was about 36,000 metric tons (BBS, 2001). The average yield of mungbean in Bangladesh is about 570 kg ha^{-1}, which is much lower than that of India and some other countries of the world. So use of seed inoculation with effective *Bradyrhizobium* strains and application of plant growth regulators seem to be the most effective way for the cultivation of summer mungbean. Inoculation with *Bradyrhizobium* increased 4.3 to 162% grain yield over uninoculated control in mungbean cultivation (Vaishya *et al*., 1983) *Bradyrhizobium* can also play an important role in nodule formation and nitrogen fixation. Indole Acetic Acid (IAA) and Gibberellic Acid (GA_3) are the important growth regulators. It was reported that GA_3 stimulate stem elongation and yield (Deotale *et al*., 1998), increase dry weight (Hore *et al*., 1988) as well as grain yield (Maske *et al*., 1998). Foliar application of IAA also found to be increased plant height, number of leaves plant^{-1}, fruit size with consequent enhancement in seed yield in different crops like groundnut (Lee, 1990), cowpea (Khalil and Mandurah, 1989). In view of above facts, the present research work was designed to evaluate the effect of bio-fertilizer (*Bradyrhizobium*) and plant growth regulators (IAA and GA_3) on the growth parameters of summer mungbean varieties (Barimoog-2, Barimoog-4 and Barimoog-5).

MATERIALS AND METHODS

The experiment was conducted in the field laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh in 2002. There were four treatments viz., (i) T_1 = Control (untreated), (ii) T_2 = Bio-fertilizer (*Bradyrhizobium*), (iii) T_3 = Indole acetic acid (IAA) and (iv) T_4 = Gibberellic acid (GA_3). Three mungbean varieties viz., (I) V_1= Barimoog-2, (ii) V_2 = Barimoog-4 and (iii) V_3 = Barimoog-5 were used in the experiment. The land was prepared by three ploughing

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followed by laddering. The stubbles were removed from the land. The land was laid out by RCBD with three replications and two factors (variety and treatment). There were altogether 12 treatment combinations. So the total numbers of plots were 36 and the size of unit plot was 2×2 m. The block-to-block and plot-to-plot distance was 1 m. The land was fertilized @ 15 kg ha^{-1} N, 13 kg ha^{-1} P and 13 kg ha^{-1} K, while bio-fertilizer plot received only PK at the same rate. The fertilizers were applied at final land preparation. Seed rate was 25 kg ha^{-1}. Seeds were sown in line sowing method maintaining 3 cm depth. Line to line distance was 25 cm. Liquid *Bradyrhizobium* mix culture were mixed thoroughly with seeds and placed in a cool dry place and sown in the fixed plots. Solution of 600 ppm IAA and 100 ppm GA_3 was sprayed by hand sprayer at 30 days after sowing. First and second weeding and thinning was done at 15 and 35 days after sowing and plant-to-plant distance was maintained 4 cm. Four plants from each plot were sampled for recording growth and dry mater production at 30, 40 and 50 days after sowing. The collected data were statistically analyzed and the treatments mean were compared by DMRT (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on growth of summer mungbean was determined at 30, 40 and 50 days after sowing (Table 1). Bio-fertilizer and plant growth regulators showed significant variation on plant height, number of branches plant^{-1} and number of leaves plant^{-1} in all counting dates. At 30 Days After Sowing (DAS), plant height varied from 24.08 to 27.76 cm, where the highest plant height was found in T_2 and the lowest plant height was found in control. But, at 40 and 50 DAS, the highest plant height was found in T_4 and the lowest plant height was found in control. This result is identical to Thakur and Panwar (1995) who found longer plant of *Vigna radiata* by the inoculation of *Bradyrhizobium* strain. Mislevy *et al.* (1989) also found increased height in soybean plant by spraying GA_3. The highest number of branches plant^{-1} and number of leaves plant^{-1} were found in T_2 and the lowest in control at 30, 40 and 50 days after sowing. Similarly, Thakur and Panwar (1995) found increased number of branches plant^{-1} in *Vigna radiate* by inoculation with *Bradyrhizobium*. Deotale *et al.* (1998) also reported that seed treatment with 100 ppm GA_3 increase number of branches and leaves.

Effect of varieties on growth of summer mungbean was determined at 30, 40 and 50 days after sowing (Table 2). Varieties showed significant variation on plant height, number of branches plant^{-1} and number of leaves plant^{-1} in all counting dates. The highest plant height, number of branches plant^{-1} and number of leaves plant^{-1} were found in Barimoog-2 variety and the lowest in Binamoog-5 at 30, 40 and 50 days after sowing. It was in agreement with the result of Thakuria and Saharia (1990) who reported that plant height differed among the varieties.

Interaction effect of varieties with bio-fertilizer and plant growth regulators (IAA and GA_3) on growth of summer mungbean was determined at 30, 40 and 50 days after sowing (Table 3). At 30 and 40 DAS, plant heights were not significant. However, at 30 and 40 DAS the highest number of plant heights was found in V_1T_2 and V_1T_4 and the lowest were found in V_3T_1, respectively. But, at 50 DAS, plant height varied significantly and ranged from 34.64 to 47.27 cm, where the highest plant height was found in V_1T_4 and the lowest in V_3T_1. On the other hand, the treatments combination showed significant influence on number of branches plant^{-1} at 30 DAS, but not in 40 and 50 DAS. At 30 DAS, the highest number of branches plant^{-1} was found in V_1T_2 and V_3T_2 (1.00), on the contrary, branches did not produce in V_1T_1, V_1T_3, V_1T_4 and V_3T_1. At 40 and 50 DAS, the highest number of branches plant^{-1} was found in V_3T_2 and the lowest in V_1T_1. Moreover, the treatments combination did not show any significant influence on number leaves plant^{-1} at 30, 40 and 50 DAS. At 30 DAS, the highest number of leaves plant^{-1} was found in V_2T_2 and the lowest in V_1T_1 and V_1T_3. At 40 and 50 DAS, the highest number of leaves plant^{-1} was found in V_3T_2 and the lowest in V_1T_1.

Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on nodule production, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) of summer

Table 1: Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on growth of summer mungbean at 30, 40 and 50 days after sowing

	Plant height (cm)			No. of branches plant^{-1}			No. of leaves plant^{-1}		
Treatments	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS
T_1	24.08b	32.35c	38.73c	0.11b	2.16c	2.89c	7.16b	10.66b	12.08b
T_2	27.76a	35.52b	43.10b	0.83a	2.55a	3.22a	7.66a	11.69a	12.97a
T_3	24.49b	36.17b	44.04b	0.11b	2.41ab	3.08ab	7.17b	11.11b	12.58a
T_4	24.53b	38.57a	45.65a	0.11b	2.33bc	3.05b	7.19b	11.08b	12.66a
CV (%)	5.72	4.92	4.43	13.09	8.07	4.76	4.95	5.18	4.58
Level of significance	**	**	**	**	**	**	**	**	*

NS = Non significant, *Significant at 5% level, **Significant at 1% level, T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3

Table 2: Effect varieties on growth of summer mungbean at 30, 40 and 50 days after sowing

	Plant height (cm)			No. of branches plant^{-1}			No. of leaves plant^{-1}		
Varieties	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS
Barimoog-2	26.12a	37.50a	44.20a	0.25c	2.20b	2.87b	7.10b	10.62b	12.31b
Barimoog-4	25.45a	36.87a	43.18b	0.29b	2.37a	3.10a	7.33ab	11.29a	12.52ab
Barimoog-5	24.07b	32.59b	41.25c	0.33a	2.52a	3.21a	7.45a	11.50a	12.89a
4.58CV (%)	5.72	4.92	4.43	12.09	8.07	4.76	4.95	5.18	4.58
Level of significance	**	**	**	**	**	**	*	**	*

NS = Non significant, *Significant at 5% level, **Significant at 1% level

Table 3: Interaction effect of varieties with bio-fertilizer and plant growth regulators (IAA and GA_3) on growth of summer mungbean at 30, 40 and 50 days after sowing

Variety	Plant height (cm)			No. of branches plant^{-1}			No. of leaves plant^{-1}		
× treatments	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS
V_1T_1	25.07	34.72	41.17d	0.00e	2.00	2.76	6.92	9.58	11.83
V_1T_2	28.26	37.17	43.72bc	1.00a	2.42	3.00	7.58	11.50	12.67
V_1T_3	25.86	37.59	44.66b	0.00e	2.25	2.92	6.92	10.75	12.08
V_1T_4	25.32	40.53	47.27a	0.00e	2.16	2.83	7.00	10.67	12.67
V_2T_1	24.64	33.47	40.39d	0.33c	2.25	2.92	7.25	11.08	12.06
V_2T_2	27.58	36.77	43.28bc	0.50b	2.50	3.25	7.65	11.67	13.00
V_2T_3	24.48	37.73	43.81bc	0.17d	2.42	3.08	7.17	11.16	12.58
V_2T_4	25.12	39.53	45.27b	0.17d	2.33	3.17	7.25	11.25	12.50
V_3T_1	22.53	28.87	34.64e	0.00e	2.25	3.00	7.33	11.33	12.42
V_3T_2	27.44	32.62	42.31cd	1.00a	2.75	3.42	7.75	11.92	13.25
V_3T_3	23.14	33.21	43.65bc	0.17d	2.58	3.25	7.42	11.42	13.08
V_3T_4	23.17	35.67	44.41b	0.17d	2.50	3.17	7.33	11.33	12.83
CV (%)	5.72	4.92	4.43	12.09	8.07	4.76	4.95	5.18	4.58
Level of significance	NS	NS	*	**	NS	NS	NS	NS	NS

NS = Non significant, *Significant at 5% level, **Significant at 1% level
T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3, V_1 = Barimoog-2, V_2 = Barimoog-4 and V_3 = Barimoog-5

Table 4: Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on nodulation, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) of summer mungbean

	No. of effective nodule plant^{-1}			No. of non-effective nodule plant^{-1}				
Treatments	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	Crop Growth Rate (CGR) (g m^{-2} d^{-1})	Relative Growth Rate (RGR) (g g^{-1}d^{-1})
T_1	2.10b	4.66b	3.99b	0.61bc	1.16b	1.31	6.95b	0.042
T_2	9.33a	11.33a	11.44a	2.88a	3.66a	2.11	8.15a	0.043
T_3	2.11b	4.21c	3.77b	0.72b	0.99b	1.30	8.74a	0.045
T_4	2.10b	4.11c	4.22b	0.33c	1.27b	1.17	8.55a	0.043
CV (%)	9.04	6.17	8.54	13.79	10.13	7.28	7.77	4.63
Level of significance	**	**	**	**	**	NS	**	NS

NS = Non significant, *Significant at 5% level, **Significant at 1% level
T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3

Table 5: Effect varieties on nodulation, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) of summer mungbean

	No. of effective nodule plant^{-1}			No. of non-effective nodule plant^{-1}				
Varieties	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	Crop Growth Rate (CGR) (g m^{-2} d^{-1})	Relative Growth Rate (RGR) (g g^{-1}d^{-1})
Barimoog-2	3.49c	5.24c	5.16c	0.70c	1.41b	1.34	7.55b	0.045a
Barimoog-4	3.83b	6.08b	5.91b	1.20b	1.70b	1.48	7.33b	0.038b
Barimoog-5	4.41a	6.91a	6.49a	1.49a	2.20a	1.59	9.41a	0.046a
CV (%)	9.04	6.17	8.54	12.79	10.13	7.28	7.77	4.63
Level of significance	**	**	**	**	**	NS	**	**

NS = Non significant, *Significant at 5% level, **Significant at 1% level

mungbean was determined (Table 4). Bio-fertilizer and plant growth regulators showed significant variation on number of effective nodules plant^{-1} and non-effective nodules plant^{-1} (except 50 DAS). The highest number of effective and non-effective nodules plant^{-1} was found in T_2. Similarly,Shangakhara and Marambe (1989) observed significantly higher nodulation in *Vigna radiata* by inoculatiing *Rhizobium*. Pandher *et al.* (1991) also observed increasing number of root nodules in *Vigna radiatai* cv. ML 131 by using *Rhizobium* strains. Besides, Kavathiya and Pandey (2000) found 69 nodules plant^{-1} by inoculating mungbean seed with *Rhizobium*. The

Table 6: Interaction effect of varieties, and bio-fertilizer and plant growth regulators (IAA and GA_3) on nodulation, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) of summer mungbean

Variety × treatment	No. of effective nodule plant^{-1} 30 DAS	40 DAS	50 DAS	No. of non-effective nodule plant^{-1} 30 DAS	40 DAS	50 DAS	Crop Growth Rate (CGR) (g m^{-2} d^{-1})	Relative Growth Rate (RGR) (g g^{-1}d^{-1})
V_1T_1	1.66e	3.66	3.00ef	0.17de	1.00e-f	1.00	6.02f	0.044bcd
V_1T_2	8.33c	10.33	10.66b	2.00b	3.00c	1.75	6.64ef	0.041cde
V_1T_3	2.00de	3.66	2.66f	0.66cd	0.66g	1.50	8.83bc	0.051a
V_1T_4	2.00de	3.33	4.33d	0.00e	1.00d-g	1.13	8.72bcd	0.048ab
V_2T_1	2.33 de	4.66	3.66de	0.66cd	0.83fg	1.45	6.16f	0.036e
V_2T_2	9.33b	11.33	11.33b	3.33a	3.66b	2.33	7.77cd	0.040cde
V_2T_3	2.00de	4.33	4.33d	0.50c-e	1.00d-g	1.15	7.83cd	0.039de
V_2T_4	1.66e	4.04	4.33d	0.33de	1.33d-f	1.00	7.55de	0.036e
V_3T_1	2.33de	5.66	5.33c	1.00c	1.66d	1.50	8.88bcd	0.046abc
V_3T_2	10.33a	12.33	12.33a	3.33a	4.33a	2.25	10.03a	0.049ab
V_3T_3	2.33de	4.66	4.33d	1.00c	1.33d-f	1.25	9.55ab	0.045bcd
V_3T_4	2.66de	5.00	4.00d	0.66cd	1.50de	1.38	9.39ab	0.043bcd
CV (%)	9.04	6.17	8.54	13.79	10.13	7.28	7.77	5.71
Level of Significance	*	NS	**	*	*	NS	**	**

NS = Non significant, *Significant at 5% level, **Significant at 1% level

T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3, V_1 = Barimoog-2, V_2 = Barimoog-4 and V_3 = Barimoog-5

Table 7: Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on dry matter production of summer mungbean at 30, 40 and 50 days after sowing

Treatments	Leaf dry weight plant^{-1} 30 DAS	40 DAS	50 DAS	Root dry weight plant^{-1} 30 DAS	40 DAS	50 DAS	Shoot dry weight plant^{-1} 30 DAS	40 DAS	50 DAS	Nodule dry weight plant^{-1} 30 DAS	40 DAS	50 DAS	Total dry weight plant^{-1} 30 DAS	40 DAS	50 DAS
T_1	0.87b	2.57b	3.58c	0.06b	0.28c	0.61c	0.29b	1.13b	1.89c	4.57b	5.41b	4.22b	1.24b	4.00c	6.90b
T_2	1.29a	2.84ab	3.81bc	0.09a	0.36a	0.79a	0.38a	1.25ab	2.30b	7.00a	11.77a	12.33a	1.57a	4.46b	6.91a
T_3	0.89b	3.23a	3.99ab	0.07b	0.32b	0.68b	0.31b	1.31a	2.56ab	2.01c	4.86b	4.77b	1.28b	4.62ab	7.24a
T_4	0.88b	3.16a	4.13a	0.06b	0.32b	0.66b	0.29b	1.41a	2.66a	2.14c	4.65b	4.66b	1.25b	4.90a	7.47a
CV (%)	13.63	9.00	7.44	6.76	6.23	7.09	9.02	8.76	7.12	12.11	11.97	10.44	9.41	6.90	9.22
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*

NS = Non significant, *Significant at 5% level, **Significant at 1% level

T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3

Table 8: Effect of varieties on dry matter production of summer mungbean at 30, 40 and 50 days after sowing

Varieties	Leaf dry weight plant^{-1} (g) 30 DAS	40 DAS	50 DAS	Root dry weight plant^{-1} (g) 30 DAS	40 DAS	50 DAS	Shoot dry weight plant^{-1} (g) 30 DAS	40 DAS	50 DAS	Nodule dry weight plant^{-1} (g) 30 DAS	40 DAS	50 DAS	Total dry weight plant^{-1} (g) 30 DAS	40 DAS	50 DAS
Barimoog-2	0.83b	2.57b	3.65b	0.06b	0.27c	0.59c	0.25c	0.99b	1.87b	3.56b	5.78b	5.50b	1.18b	3.86b	6.12c
Barimoog-4	0.96ab	3.02a	3.81b	0.07b	0.32b	0.67b	0.33b	1.40a	2.45a	3.99ab	6.33b	6.75a	1.37a	4.75a	6.94b
Barimoog-5	1.15a	3.26a	4.18a	0.08a	0.36a	0.80a	0.36a	1.41a	2.73a	4.24a	7.91a	7.25a	1.45a	4.89a	7.72a
CV (%)	12.63	9.00	7.44	6.76	6.23	7.09	9.02	8.76	7.12	12.11	12.97	11.44	9.41	6.90	9.22
Level of significance	**	**	**	**	**	**	**	**	**	*	**	**	**	**	**

NS = Non significant, *Significant at 5% level, **Significant at 1% level

treatments showed significant influence on CGR but not in Relative Growth Rate (RGR). However, the highest CGR and Relative Growth Rate (RGR) was found in T_3 and the lowest in control. Sudhakar *et al.* (1989) also observed that *Rhizobium* inoculation increased crop growth rate.

Effect of varieties on nodule production, CGR and RGR of summer mungbean was determined (Table 5). The varieties showed significance influence on all these parameters. The highest number of effective and non-effective nodules plant^{-1}, CGR and RGR was found in Barimoog-5 variety and the lowest in Binamoog-2 variety at all counting dates.

Interaction effect of varieties with bio-fertilizer and plant growth regulators (IAA and GA_3) on nodule production, CGR and RGR of summer mungbean was determined (Table 6). The treatments combination showed significant influence on number of effective nodules plant^{-1} at 30 and 50 DAS, but not in 40. At 30 DAS, the highest number of effective nodules plant^{-1} was found in V_3T_2 (10.33) and the lowest in V_1T_1 and V_2T_4 (1.66). At 50 DAS, the highest number of effective nodules plant^{-1} was found in V_3T_2 (12.33) and the lowest in V_1T_3 (2.66). In case of non-effective nodules plant^{-1}, the treatment showed significant variation at 30 and 40 DAS. At 30 DAS, the highest number of non-

Table 9: Interaction effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on dry matter production of summer mungbean at 30, 40 and 50 days after sowing

Variety	Leaf dry weight plant^{-1}			Root dry weight plant^{-1}			Shoot dry weight plant^{-1}			Nodule dry weight plant^{-1}			Total dry weight plant^{-1}		
× treatment	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS	30 DAS	40 DAS	50 DAS
V_1T_1	0.77b	2.22c	3.32	0.05d	0.25	0.50h	0.22	0.82	1.28e	1.60c	4.23	3.33	1.08	3.30	5.11
V_1T_2	1.02b	2.60bc	3.51	0.08a-c	0.31	0.70cd	0.32	0.98	1.68de	8.83b	11.00	11.33	1.42	3.90	5.89
V_1T_3	0.78b	2.64bc	3.83	0.06cd	0.26	0.61ef	0.25	1.07	2.18b-d	1.90c	4.26	3.66	1.14	3.98	6.63
V_1T_4	0.77b	2.85bc	3.95	0.06cd	0.28	0.55gh	0.24	1.12	2.37a-c	1.93c	3.63	3.66	1.08	4.26	6.87
V_2T_1	0.91b	2.70bc	3.50	0.07c	0.26	0.58fg	0.30	1.25	1.98cd	2.13c	5.33	4.33	1.27	4.22	6.07
V_2T_2	1.10b	2.93bc	3.81	0.09ab	0.40	0.76b	0.40	1.37	1.45a-c	10.00a	11.00	12.33	1.59	4.69	7.02
V_2T_3	0.93b	3.14b	3.91	0.06cd	0.33	0.66de	0.32	1.43	2.66ab	1.86c	4.66	5.33	1.32	4.89	7.24
V_2T_4	0.92b	3.31ab	4.02	0.06cd	0.31	0.68d	0.32	1.55	2.73ab	1.96c	4.33	5.00	1.31	5.17	7.44
V_3T_1	0.94b	2.80bc	3.93	0.08bc	0.35	0.75bc	0.35	1.34	2.42a-c	2.16c	6.66	5.00	1.37	4.49	7.09
V_3T_2	1.75a	3.00b	4.12	0.10a	0.38	0.91a	0.42	1.42	2.78ab	10.00a	13.33	13.33	1.70	4.81	7.82
V_3T_3	0.97b	3.91a	4.24	0.08bc	0.36	0.78b	0.37	1.45	2.85a	2.26c	5.66	5.33	1.40	5.01	7.87
V_3T_4	0.95b	3.33ab	4.43	0.08bc	0.36	0.76b	0.33	1.58	2.90a	2.53c	6.00	5.33	1.36	5.28	8.10
CV (%)	12.63	9.00	7.44	6.76	6.23	7.09	9.02	8.76	7.12	13.11	12.97	11.44	9.41	6.90	9.22
Level of significance	*	*	NS	*	*	*	NS	NS	*	**	NS	NS	NS	NS	NS

NS = Non significant, *Significant at 5% level, **Significant at 1% level

T_1 = Control, T_2 = Bio-fertilizer (*Bradyrhizobium*), T_3 = IAA, T_4 = GA_3, V_1 = Barimoog-2, V_2 = Barimoog-4 and V_3 = Barimoog-5

effective nodules plant^{-1} was found in V_2T_2 and V_3T_2 (3.33) and non-effective nodules did not produce V_1T_4. At 50 DAS, the highest number of non-effective nodules plant^{-1} was found in V_3T_2 (4.33) and the lowest in V_1T_3 (0.66). Only at 30 DAS, the treatments showed significant variation on nodule dry weight plant^{-1}, where the highest was found in V_2T_2 and V_3T_2 (10.00 mg) and the lowest in V_1T_1 (1.60 mg). The treatment showed significant variation on CGR and RGR. The highest crop growth rate was found in V_3T_2 (10.03 g m^{-2}d^{-1}), which is statistically identical to V_3T_3 and V_3T_4 and the lowest in V_1T_1 (6.02 g m^{-2}d^{-1}). The highest relative growth rate was found in V_1T_3 (0.051 g m^{-2}d^{-1}), which is statistically identical to V_3T_1 and V_3T_2 and the lowest in V_2T_1 and V_2T_4 (0.036 g m^{-2}d^{-1}).

Effect of bio-fertilizer and plant growth regulators (IAA and GA_3) on leaf, root, shoot, nodule and total dry weight plant^{-1} of summer mungbean was determined at 30, 40 and 50 DAS (Table 7). Bio-fertilizer and plant growth regulators showed significant influence on leaf, root, shoot, nodule and total dry weight plant^{-1} in all counting dates. At 30 DAS, plant height varied from 0.87 to 1.29 g, where the highest in T_2 and the lowest in control. But, at 40 and 50 DAS, the highest leaf dry weight plant^{-1} was found in T_3 and T_4, respectively and the lowest in control. The highest root dry weight plant^{-1} was found in T_3 and the lowest in control in all counting dates. This result is identical to Begum (1989) who reported that inoculation with *Rhizobium* increased root dry weight than the control. In contrast, at 30, 40 and 50 DAS, the highest shoot dry weight plant^{-1} were found in T_2, T_3 and T_4, respectively and the lowest in control. Bhuiya *et al.* (1986) found higher shoot and nodule dry weight of mungbean by the inoculation of *Rhizobium* strains. Bhuiyan *et al.* (1998) stated that inoculation with *Rhizobium* increased nodule dry weight. On the other hand, the highest nodule and total dry weight plant^{-1} was found in T_2 and the lowest in control in all counting dates. Deotale *et al.* (1998) also observed that seed treatment with 100 ppm GA_3 increase total dry matter of soybean. Besides, Takano *et al.* (1995) reported that IAA and GA_3 increased total dry matter in faba bean.

Effect varieties on leaf, root, shoot, nodule and total dry weight plant^{-1} of summer mungbean were determined at 30, 40 and 50 DAS (Table 8). Varieties showed significant variation on leaf, root, shoot, nodule and total dry weight plant^{-1} in all counting dates. The highest leaf, root, shoot, nodule and total dry weight plant^{-1} were found in Barimoog-5 variety and the lowest in Binamoog-2 at 30, 40 and 50 DAS.

Interaction effect of varieties with bio-fertilizer and plant growth regulators (IAA and GA_3) on leaf, root, shoot and total dry weight plant^{-1} of summer mungbean was determined at 30, 40 and 50 DAS (Table 9). The treatment showed significant variation on leaf dry weight plant^{-1} at 30 and 40 DAS. At 30 DAS, the highest leaf dry weight plant^{-1} was found in V_3T_2 (1.75 mg) and the lowest in V_1T_1 and V_1T_4 (0.77 mg). At 40 DAS, the highest leaf dry weight plant^{-1} was found in V_3T_3 (3.91 mg) and the lowest in V_1T_1 (2.22 mg). The treatment showed significant variation on root dry weight plant^{-1} in all counting dates. At 30 DAS, the highest root dry weight plant^{-1} was found in V_3T_2 (0.10 mg) and the lowest in V_2T_1 (0.07 mg). At 40 and 50 DAS, the highest root dry weight plant^{-1} was found in V_3T_2 and the lowest in V_1T_1. The treatment showed significant variation on shoot dry weight plant^{-1} only at 50 DAS, where the highest shoot dry weight plant^{-1} was found in V_3T_4 (2.90 mg) and the lowest in V_1T_1 (1.28 mg). But, the treatment did not show significant variation on total dry weight plant^{-1}. However, at 30 DAS, the highest total dry weight plant^{-1} was found in V_3T_2 (1.70 mg) and the lowest in V_1T_1 and V_1T_4 (1.08 mg). At 40 and 50 DAS, the highest total dry weight plant^{-1} was found in V_3T_4 and the lowest in V_1T_1.

From the above findings, it can be concluded that bio-fertilizer was better than plant growth regulators (IAA and GA_3) for the growth of summer mungbean. However, GA_3 and IAA found better than control. Among the varieties, Binamoog-5 performed better than Binamoog-2 and Binamoog-4.

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