Impact of Different Levels of Fertilizers on Growth Components of Two *Vigna* Species

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Abstract Fertilizers are widely used by farmers in agricultural practices in form of chemical fertilizer, organic fertilizer and biofertilizer, supplying plants with nutrients for their optimal growth and production. In the beginning, farmers were delighted to get improved yield in agriculture, but gradually, chemical fertilizers began to show their ill impacts such as polluting water basins and leaching out, killing microorganisms and helpful insects, and also decreasing soil fertility. Biofertilizers, on the other hand, refer to articles containing live or latent microbes which help boost fertility of soil by either solubilizing phosphorus, fixing atmospheric nitrogen, decomposing organic waste or stimulating growth of plant through the synthesis of growth-promoting substances. A study was carried out to examine the impact of fertilizers (PSB and DAP) application on growth components of *Vigna radiata* and *V. mungo*. As a result, overall maximum value of experimental parameters such as seed germination percentage, root length, shoot length, fresh and dry weight of stem, chlorophyll content, phosphorus content, potassium content, nitrogen content as well as crude protein content were found with combined application of both fertilizers as compared to the control in both *Vigna* crops. Therefore, it was concluded that the application of biofertilizer with chemical fertilizer showed higher value for experimental parameters as compared to the control and also their single fertilizer treatments in both *Vigna* crops. The main purpose of the study was to look for the best fertilizer level either single or in combination of chemical fertilizer and biofertilizer, which could be applied to the experimental crops to obtain their enhanced growth components in addition to keeping sustainable and safe environment due to the reduction or minimize the use of

chemical fertilizers.

Keywords DAP, PSB, Growth Components, *Vigna radiata* and *V. mungo*

1. Introduction

Plants whether cultivated on the field or in a jar, utilize the inorganic minerals for their nourishment. Mineral elements as nitrogen (N), phosphorus (P) and potassium (K) are needed in large amount, which are most likely to be in short supply in agricultural soils. Besides this, both nitrogen and phosphorus are essential nutrients of nearly all the biochemical substances that make existence possible for plants. Farmers inoculate the agricultural lands with different kinds of fertilizers to secure a preferable crop yield. Fertilizers serve as catalyst for optimal growth and production of plants. The usage of chemical fertilizers with large varieties of seeds and irrigation improves the agricultural productivity and helps to achieve food grain self-sufficiency [28]. Many experiments have shown that the usage of phosphorus fertilizers typically has a significant effect on crop yield as its reduction restricts plant reaction to certain nutrients [2]. But gradually chemical fertilizers begin to show their ill impacts such as polluting water basins and leaching out, killing microorganisms and helpful insects, rendering the crop more perceptible to disease invasions and decreasing soil fertility. Apart from this, application of biofertilizers to the soil improves the biomass that makes up all sorts of beneficial bacteria and fungi. So many microorganisms

thrive in the soil, particularly in rhizosphere. A large amount of such microorganisms has a working interaction and shapes a systemic plant network. They have positive implications for plant development [36].

Biofertilizers are gaining quickness due to the increasing insistence on maintenance of soil health, reducing the environmental pollution and cut down on the use of chemicals in agriculture that will lead to sustainable agricultural production [30]. These are important components of sustainable farming which play a crucial role in maintaining long-lasting soil fertility and crop production sustainability [22]. Thus, reduce the dependency on chemical fertilizers to crop growth and yield improvement, and replace it with biofertilizers as they are comparatively low-cost inputs and eco-friendly to the sustainable agricultural system to save as well as protect the environment. In the present study, two experimental *Vigna* species were green gram (*Vigna radiata* L. Wilczek; var. sweta) also named as mung bean, and black gram (*V. mungo* L. Hepper; var. Azad-3) also known as urdbean. Both are annual herbaceous self-fertilized crops. Plants are rising to a height of 30 to 100 cm containing trifoliate leaves, along with yellow-colored flowers formed in axillary racemes. These are a good source of quickly digestible protein to the vegetarian population of the nation.

There are many studies that showed the combined application of chemical fertilizers and biofertilizers significantly influenced the growth and development of many crops and improved the crop yield thus, reduced the dependency on chemical fertilizers to increase their yield. *Echinochloa frumentacea* showed increased values of morphological and yield parameters with a combination of biofertilizer and synthetic fertilizer application than using either method alone [9]. Biofertilizers with a reduced amount of chemical fertilizers were recommended for better yield of chickpea [21]. Significantly higher values of saloid-P and Ca-P observed in soil with DAP and PSB seed treatment in groundnut [3]. Thus, the present study was undertaken to identify specific level of fertilizers with a reduced or minimized dose of chemical fertilizer to obtain maximum growth components of *Vigna radiata* and *V. mungo* crops.

2. Materials and Methods

To study the impact of different levels (single and their combinations) of chemical fertilizer (DAP) and biofertilizer (PSB) on growth components of *Vigna radiata* and *V. mungo* crops, a poly pot experiment, based on randomized complete block design (RCBD) with three replicates of 10 plants per treatment was carried out during kharif season (2017) at department of Botany, D. V. College, Orai (Jalaun) in Bundelkhand region of Uttar Pradesh, India. Bundelkhand region lies in south-west corner of Uttar Pradesh (India), and is predominantly a

drought prone area which is extended 24°11' and 26°27' N latitude and 78°17' and 81°34' E longitudes with an average altitude ranging 250 to 300 m above MSL (mean sea level) [19].

Collection of materials:

For the present study purpose, black soil, locally called as 'kabar' was collected from neighboring localities of Orai. Experimental crops seed (certified) and PSB (Phosphate Solubilizing Bacteria) biofertilizer culture were obtained from kendriya krashi beej bhandar, Orai whereas, chemical fertilizer as DAP (Diammonium Phosphate) obtained from IFFCO, Orai.

Soil treatments:

There were total sixteen soil treatments (T_1 to T_{15}) prepared containing different doses of DAP (as 0.25 g, 0.50 g and 1.00 g of DAP per kg of soil) and PSB (as 2.50 g, 5.00 g and 10.00 g of PSB per kg of soil) with a control treatment (T_0) i.e. without fertilizer application (Table-1). Fixed doses of experimental fertilizers were mixed well with calculated amount of soil to prepare different fertilizer levels.

Table 1. Different levels of chemical fertilizer (DAP) and biofertilizer (PSB)

S. No.	Treatments	Doses (in per kg of soil)
1	T_0	Control (Without fertilizer)
2	T_1	0.25g of DAP
3	T_2	0.50g of DAP
4	T_3	1.00g of DAP
5	T_4	2.50g of PSB
6	T_5	5.00g of PSB
7	T_6	10.00g of PSB
8	T_7	0.25g of DAP×2.50g of PSB
9	T_8	0.25g of DAP×5.00g of PSB
10	T_9	0.25g of DAP×10.00g of PSB
11	T_{10}	0.50g of DAP×2.50g of PSB
12	T_{11}	0.50g of DAP×5.00g of PSB
13	T_{12}	0.50g of DAP×10.00g of PSB
14	T_{13}	1.00g of DAP×2.50g of PSB
15	T_{14}	1.00g of DAP×5.00g of PSB
16	T_{15}	1.00g of DAP×10.00g of PSB

Sowing of seeds:

Plants were raised in black coloured 12 inches poly flower pots with a bottom and few on the upper edge drainage holes. Before sowing, *Vigna* seed surface was sterilized with 0.1% $HgCl_2$ for two minutes and thoroughly washed with distilled water. Then, the seeds were sown in poly pots with treated soil according to the

Table-1. As many as 10 seeds were sown in each pot.

Observations and data analysis:

Experimental parameters of both species of *Vigna* crop were observed, analyzed and recorded at requisite time intervals from seed germination to harvesting. Seed germination percentage was recorded at 7 DAS (Days after sowing). Length of root and shoot was measured by using a centimeter scale and the mean value was recorded by randomly selected three normal seedlings. To measure fresh weight of stem, plant samples were cut with sharp blade and properly water washed. After that blotted with blotting paper and weighed in gram (g), whereas dry weight of the same samples was determined by drying the finally chopped and mixed sample in a forced draught oven at 70°C for 24 hours to constant weight. The samples were taken out from the oven and placed in a desiccator cooled for about an hour and weighed in gram. Chlorophyll content of fresh leaves of plant sample was determined by Petering method [27]. Phosphorus content

of leaves was determined by the molybdenum reduced phosphomolybdic acid blue colour method in H₂SO₄ system. The blue colour was determined in Elico-CL-20A photo-electric colorimeter using red filter. Potassium content was measured turbidimetrically. The turbidity produced at 20°C under standardized conditions was estimated in Elico-CL-20A photo-electric colorimeter using red filter. Nitrogen content of leaves was determined by semi-micro-kjeldahl method and the crude protein content of leaves was calculated by the correction factor ($N \times 6.25$) [10]. All these growth components were recorded at requisite time intervals (30 and 60 DAS) of crop growing period. Average values of the experimental parameters were shown in Table-2A, 2B, 3A and 3B. The data for the various experimental parameters in the present study were ANOVA tested and the significance of differences between control and each treatment was determined by using the value of least significant difference (L.S.D.) at P=0.05 and P=0.01 and presented within tables.

Table 2A. Effect of different levels of chemical fertilizer (DAP) and biofertilizer (PSB) on *Vigna radiata*

Fertilizer	Treatment Level (g per kg soil)	Seed germination (%)	Root length (cm)		Shoot length (cm)		Fresh weight (g) of stem		Dry weight (g) of stem	
			30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Control	T ₀	83.33	4.46	9.23	8.50	24.06	1.42	2.37	0.38	0.45
	T ₁	86.66	4.80	12.13	9.06	30.33	1.93	2.72	0.45	0.54
DAP	T ₂	83.33	4.73	10.13	8.83	28.90	1.81	2.57	0.42	0.55
	T ₃	83.33	4.60	9.30	8.73	27.73	1.54	2.41	0.51	0.65
	T ₄	83.33	4.66	9.86	9.00	27.13	1.81	2.76	0.44	0.59
PSB	T ₅	86.66	4.83	10.50	9.90	28.70	1.92	2.94	0.49	0.65
	T ₆	93.33	5.06	11.93	10.20	29.90	2.12	3.10	0.53	0.69
	T ₇	90.00	4.93	12.20	9.40	31.43	2.19	2.92	0.47	0.63
	T ₈	93.33	5.10	12.53	9.96	32.13	2.39	3.12	0.55	0.71
	T ₉	96.66	5.23	12.96	10.93	32.93	2.71	3.23	0.55	0.74
	T ₁₀	93.33	5.40	12.33	10.10	31.90	2.33	3.15	0.57	0.70
DAP×PSB	T ₁₁	96.66	5.56	13.03	10.43	32.93	2.46	3.37	0.59	0.79
	T ₁₂	100	5.83	14.83	11.00	33.56	2.79	3.78	0.59	0.83
	T ₁₃	93.33	5.63	12.60	12.10	33.70	2.62	3.45	0.53	0.67
	T ₁₄	96.66	6.13	13.36	13.50	34.20	2.73	3.77	0.57	0.76
	T ₁₅	100	6.30	15.20	15.00	34.70	2.98	3.89	0.57	0.77
L.S.D.	P=0.05 DAP	5.77	0.36	0.48	0.41	0.57	0.25	0.23	0.03	0.05
	P=0.01 DAP	7.18	0.45	0.59	0.51	0.71	0.32	0.28	0.03	0.06
	P=0.05 PSB	5.77	0.36	0.48	0.41	0.57	0.25	0.23	0.03	0.05
	P=0.01 PSB	7.18	0.45	0.59	0.51	0.71	0.32	0.28	0.03	0.06
	P=0.05 DAP×PSB	15.80	0.99	1.31	1.13	1.57	0.70	0.62	0.08	0.13
	P=0.01 DAP×PSB	18.52	1.16	1.53	1.32	1.84	0.82	0.72	0.09	0.15

Table 2B. Effect of different levels of chemical fertilizer (DAP) and biofertilizer (PSB) on *Vigna radiata*

Fertilizer	Treatment Level	Chlorophyll (mg/100g Fresh weight of leaf)		Phosphorus content (%)		Potassium content (%)		Nitrogen content of (%)		Crude protein of (%)	
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Control	T ₀	1.22	2.75	0.18	0.33	0.41	0.81	1.79	2.91	11.21	18.22
	T ₁	1.39	3.18	0.22	0.37	0.47	0.84	1.97	3.01	12.35	18.79
DAP	T ₂	1.26	3.11	0.21	0.35	0.46	0.83	1.96	3.01	12.18	18.67
	T ₃	1.37	3.16	0.19	0.34	0.42	0.81	1.95	2.99	12.25	18.72
PSB	T ₄	1.30	3.18	0.21	0.35	0.44	0.82	1.81	3.01	11.29	18.77
	T ₅	1.54	3.14	0.21	0.37	0.45	0.85	1.83	3.06	11.48	19.15
	T ₆	1.81	3.21	0.23	0.42	0.46	0.87	1.88	3.11	11.74	19.35
	T ₇	1.69	3.13	0.24	0.38	0.47	0.86	2.05	3.04	12.81	19.02
	T ₈	1.74	3.39	0.26	0.41	0.48	0.90	2.08	3.11	13.04	19.45
	T ₉	1.93	3.45	0.28	0.43	0.52	0.92	2.11	3.15	13.21	19.71
DAP×PSB	T ₁₀	2.24	3.69	0.28	0.42	0.52	0.88	2.08	3.11	13.14	19.59
	T ₁₁	2.43	3.77	0.28	0.44	0.55	0.93	2.11	3.16	13.34	19.95
	T ₁₂	2.52	3.98	0.31	0.46	0.59	1.02	2.17	3.21	13.75	20.23
	T ₁₃	1.78	3.43	0.31	0.45	0.57	0.93	2.11	3.13	12.69	19.38
	T ₁₄	1.92	3.52	0.31	0.47	0.61	1.01	2.13	3.19	13.15	19.76
	T ₁₅	2.11	3.57	0.34	0.48	0.67	1.09	2.21	3.24	13.55	20.08
	P=0.05 DAP	0.08	0.07	0.02	0.02	0.03	0.06	0.04	0.04	0.32	0.35
	P=0.01 DAP	0.10	0.09	0.02	0.02	0.03	0.07	0.05	0.05	0.40	0.43
L.S.D.	P=0.05 PSB	0.08	0.07	0.02	0.02	0.03	0.06	0.04	0.04	0.32	0.35
	P=0.01 PSB	0.10	0.09	0.02	0.02	0.03	0.07	0.05	0.05	0.40	0.43
	P=0.05 DAP×PSB	0.23	0.19	0.05	0.05	0.08	0.16	0.11	0.12	0.88	0.95
	P=0.01 DAP×PSB	0.27	0.23	0.06	0.06	0.09	0.19	0.13	0.14	1.03	1.12

Table 3A. Effect of different levels of chemical fertilizer (DAP) and biofertilizer (PSB) on *Vigna mungo*

Fertilizer	Treatment Level (g per kg soil)	Seed germination (%)	Root length (cm)		Shoot length (cm)		Fresh weight (g) of stem		Dry weight (g) of stem	
			30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Control	T ₀	83.33	4.13	8.80	8.23	22.20	1.45	2.41	0.32	0.51
	T ₁	90.00	4.63	9.63	8.60	24.00	1.62	2.53	0.41	0.64
DAP	T ₂	86.66	4.33	9.56	8.43	22.86	1.47	2.43	0.36	0.57
	T ₃	83.33	4.23	9.10	8.46	23.83	1.53	2.46	0.41	0.61
PSB	T ₄	86.66	4.56	9.53	8.93	25.16	1.61	2.50	0.45	0.62
	T ₅	90.00	4.86	9.76	9.43	26.80	1.70	2.56	0.53	0.73
	T ₆	96.66	5.33	10.00	9.76	28.73	1.82	2.67	0.56	0.79
	T ₇	93.33	5.00	9.96	9.10	25.96	1.72	2.60	0.46	0.69
	T ₈	96.66	5.30	10.23	9.83	27.40	1.78	2.66	0.55	0.77
	T ₉	100	5.66	10.46	10.20	29.40	1.95	2.77	0.63	0.83
DAP×PSB	T ₁₀	96.66	5.53	10.56	10.06	28.13	1.93	2.76	0.64	0.75
	T ₁₁	100	5.83	10.70	10.63	29.26	2.04	2.81	0.66	0.83
	T ₁₂	100	6.23	10.86	11.06	30.40	2.19	2.93	0.71	0.86
	T ₁₃	100	5.93	11.00	9.46	27.00	1.82	2.67	0.55	0.73
	T ₁₄	100	6.20	11.43	10.23	28.46	1.93	2.74	0.65	0.81
	T ₁₅	100	6.50	11.63	10.53	29.66	2.09	2.85	0.69	0.85
	P=0.05 DAP	5.99	0.29	0.25	0.39	0.56	0.18	0.06	0.03	0.03
	P=0.01 DAP	7.45	0.37	0.31	0.49	0.70	0.22	0.07	0.03	0.03
L.S.D.	P=0.05 PSB	5.99	0.29	0.25	0.39	0.56	0.18	0.06	0.03	0.03
	P=0.01 PSB	7.45	0.37	0.31	0.49	0.70	0.22	0.07	0.03	0.03
	P=0.05 DAP×PSB	16.40	0.81	0.67	1.07	1.54	0.49	0.15	0.08	0.08
	P=0.01 DAP×PSB	19.22	0.95	0.79	1.25	1.81	0.58	0.18	0.09	0.09

Table 3B. Effect of different levels of chemical fertilizer (DAP) and biofertilizer (PSB) on *Vigna mungo*

Fertilizer	Treatment Level	Chlorophyll (mg/100g Fresh weight of leaf)		Phosphorus content (%)		Potassium content (%)		Nitrogen content (%)		Crude protein content (%)	
		30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Control	T ₀	1.25	2.63	0.19	0.33	0.41	0.75	1.78	2.27	11.07	14.21
	T ₁	1.37	3.08	0.27	0.39	0.49	0.83	1.84	2.51	11.49	16.01
DAP	T ₂	1.31	2.81	0.23	0.35	0.42	0.78	1.81	2.45	11.34	15.33
	T ₃	1.35	2.92	0.24	0.38	0.44	0.81	1.82	2.48	11.41	15.43
PSB	T ₄	1.28	2.71	0.22	0.35	0.44	0.81	1.80	2.55	11.30	15.93
	T ₅	1.35	2.80	0.23	0.36	0.44	0.82	1.84	2.56	11.49	15.96
	T ₆	1.43	3.07	0.24	0.38	0.49	0.84	1.86	2.59	11.63	16.18
	T ₇	1.41	3.13	0.28	0.41	0.51	0.86	1.86	2.61	11.61	16.25
	T ₈	1.49	3.21	0.32	0.44	0.53	0.89	1.87	2.63	11.72	16.43
	T ₉	1.53	3.35	0.32	0.45	0.54	0.91	1.89	2.64	11.81	16.53
DAP×PSB	T ₁₀	1.65	3.45	0.31	0.48	0.58	0.94	1.91	2.69	11.91	16.49
	T ₁₁	1.73	3.52	0.37	0.51	0.61	0.96	1.96	2.75	12.24	17.18
	T ₁₂	1.82	3.66	0.39	0.54	0.67	1.07	1.97	2.77	12.33	17.33
	T ₁₃	1.52	3.32	0.29	0.45	0.54	0.91	1.87	2.67	11.74	16.69
	T ₁₄	1.61	3.44	0.34	0.48	0.58	0.93	1.91	2.68	11.92	16.74
	T ₁₅	1.68	3.55	0.33	0.50	0.61	0.94	1.95	2.71	12.19	16.97
	P=0.05 DAP	0.05	0.11	0.03	0.02	0.03	0.05	0.03	0.03	0.13	0.43
	P=0.01 DAP	0.06	0.13	0.03	0.02	0.03	0.06	0.03	0.03	0.16	0.54
L.S.D.	P=0.05 PSB	0.05	0.11	0.03	0.02	0.03	0.05	0.03	0.03	0.13	0.43
	P=0.01 PSB	0.06	0.13	0.03	0.02	0.03	0.06	0.03	0.03	0.16	0.54
	P=0.05 DAP×PSB	0.14	0.29	0.08	0.05	0.08	0.14	0.08	0.08	0.36	1.18
	P=0.01 DAP×PSB	0.17	0.34	0.09	0.06	0.09	0.17	0.09	0.09	0.42	1.39

3. Results and Discussion

The single fertilizer application of PSB with increasing tested levels showed significantly the most favourable impact on experimental growth components as compared to the control in both experimental *Vigna* crops whereas, DAP with minimum tested level showed the most favourable impact on most of the experimental parameters. While, overall maximum values of the all experimental parameters recorded with combined application of PSB and DAP in both *Vigna* crops.

In case of *Vigna radiata*, the combined fertilizer application of 0.50 g DAP×10.00 g PSB (T₁₂) and 1.00 g DAP×10.00 g PSB per kg soil (T₁₅) showed the overall maximum seed germination (100 percent) at 7 DAS. Overall maximum value of root length (6.30 cm and 15.20 cm at 30 and 60 DAS respectively), shoot length (15.00 cm and 34.70 cm at 30 and 60 DAS respectively), fresh weight of stem (2.98 g and 3.89 g at 30 and 60 DAS respectively), phosphorus content (0.34 and 0.48 percent at 30 and 60 DAS respectively), potassium content (0.67 and 1.09 percent at 30 and 60 DAS respectively), and

nitrogen content (2.21 and 3.24 percent at 30 and 60 DAS respectively) of leaves found with the application of 1.00 g DAP×10.00 g PSB per kg soil (T₁₅) as compared to the control (T₀), whereas overall maximum dry weight of stem at 30 DAS (0.59 g) recorded with application of 0.50 g of DAP×5.00 g of PSB (T₁₁) and 0.50 g DAP×10.00 g PSB (T₁₂), and at 60 DAS (0.83 g) with 0.50 g DAP×10.00 g PSB (T₁₂), while chlorophyll content (2.52 mg and 3.98 mg at 30 and 60 DAS respectively) as well as crude protein content (13.75 and 20.23 percent at 30 and 60 DAS respectively) recorded also with 0.50 g DAP×10.00 g PSB (T₁₂) level (Table-2A and 2B). The similar effect of PSB was observed in green gram [37] and in other crops [17,31,34].

In case of *V. mungo*, the combined fertilizer application of 0.25 g DAP×10.00 g PSB (T₉), 0.50 g DAP×5.00 g PSB (T₁₁), 0.50 g DAP×10.00 g PSB (T₁₂), 1.00 g DAP×2.50 g PSB (T₁₃), 1.00 g DAP×5.00 g PSB (T₁₄), and 1.00 g DAP×10.00 g PSB per kg soil (T₁₅) levels showed overall maximum seed germination percentage (100) at 7 DAS, while application of 1.00 g DAP×10.00 g PSB per kg soil (T₁₅) level showed overall maximum root

length (6.50 cm and 11.63 cm at 30 and 60 DAS respectively). The application of 0.50 g DAP×10.00 g PSB per kg soil (T_{12}) level recorded overall maximum shoot length (11.06 cm and 30.40 cm at 30 and 60 DAS respectively), fresh weight of stem (2.19 g and 2.93 g at 30 and 60 DAS respectively), dry weight of stem (0.71 g and 0.86 g at 30 and 60 DAS respectively), chlorophyll content (1.82 mg and 3.66 mg at 30 and 60 DAS respectively), phosphorus content (0.39 and 0.54 percent at 30 and 60 DAS respectively), potassium content (0.67 and 1.07 percent at 30 and 60 DAS respectively), nitrogen content (1.97 and 2.77 percent at 30 and 60 DAS respectively), and crude protein content (12.33 and 17.33 percent at 30 and 60 DAS respectively) of leaves as compared to the control (Table-3A and 3B). More or less similar findings were observed in black gram [29,33].

Biofertilizers with fixative bacteria increased the absorption potential of plant and dry material in plant [32]. Phosphorus solubilizing bacteria supported the phosphorus solubilization process in the soil to increase the phosphorus availability to plants [18]. Various growth parameters of cereals are found significantly changed with the *Azospirillum* inoculation [7,8].

The treatments with PSB alone or in group of compatible strains with or without external application of chemical NPK gave more germination index in rice (*Oryza sativa*) and bean seeds (*Vigna unguiculata*) [13]. Bacteria enhanced the root growth in plants which in turn improved nutrient uptake and water absorption from soil and favoured the improvement in crop yield [23]; similar findings were observed with the rice crop [12]. Higher values for growth in both root and shoot length and biomass were recorded with the application of PSB alone or in group of compatible strains with or without chemical fertilizer in *Oryza sativa* and *Vigna unguiculata* than control [13].

Significantly increased chlorophyll content in corn (*Zea mays* L.) leaves was observed with the application of biofertilizer and urea [20]. The chlorophyll content was found increased due to the increased of nitrogen content in the plants attributed to the nutrients release in available forms in the soil through the microbial action [4,5]. Similar results were recorded in *Chamaedorea elegans* with the biofertilizer application [14]. Combined application of biofertilizer and chemical fertilizer showed increased fresh and dry weights of leaves in *Spathiphyllum illusion* [1].

Biofertilizer has gigantic potential for improving plant nutrition by substituting chemical fertilizers [12]. PSB and KSB enhanced microbial count in soil which is capable for solubilizing insoluble form of nutrient and enhanced nutrient uptake and saving of 25 percent fertilizer dose of phosphorus and potash [16]. Besides the biological nitrogen fixation, root colonizing bacteria produced the plant growth promoting substances which were responsible to the increased crop yield [26].

In the present study, PSB and DAP both positively influenced the growth components of both *Vigna* crops over the control. Previous study showed that the DAP fertilization had positive effects on stem thickness of *Narcissus tazetta* [35]. Reduction in the use of chemical fertilizers up to 50 percent was noticed through the biofertilizer application in of fennel plants without any reduction in growth of plants and yield [11,15,24]. Improved soil quality along with the growth and development in maize plants was recorded with the application of PSB [25]. PSB in addition to phosphate solubilization, is also capable of producing growth hormones such as auxins, cytokinins and gibberellins, vitamins, antibiotics, siderophores etc. and due to this property, they enhance plant growth and suppress the soil bearing pathogens and also improve physico-chemical properties of the soil and sustain soil fertility [6].

4. Conclusions

It concluded from the study that the interaction level 0.50 g DAP×10.00 g PSB per kg soil (T_{12}) and 1.00 g DAP×10.00 g PSB per kg soil (T_{15}) were the most favourable to seed germination in *Vigna radiata*. The interaction level 1.00 g DAP×10.00 g PSB per kg soil (T_{15}) significantly influenced the root and shoot length, fresh weight of stem as well as phosphorus, potassium and nitrogen content of leaves, whereas interaction level 0.50 g DAP×10.00 g PSB (T_{12}) significantly influenced the chlorophyll and crude protein content of leaves, and dry weight of stem along with 0.50 g DAP×5.00 g PSB (T_{11}) in *V. radiata*.

In case of *V. mungo*, interaction level 0.25 g DAP×10.00 g PSB (T_9), 0.50 g DAP×5.00 g PSB (T_{11}), 0.50 g DAP×10.00 g PSB (T_{12}), 1.00 g DAP×2.50 g PSB (T_{13}), 1.00 g DAP×5.00 g PSB (T_{14}) and 1.00 g DAP×10.00 g PSB per kg soil (T_{15}) were the most favourable conditions to the seed germination. The interaction level 1.00 g DAP×10.00 g PSB per kg soil (T_{15}) significantly influenced the root length, whereas interaction level 0.50 g DAP×10.00 g PSB (T_{12}) significantly influenced the shoot length, fresh and dry weight of stem as well as chlorophyll, phosphorus, potassium, nitrogen and crude protein content of leaves in *V. mungo*.

The soil treatment with combined application of chemical fertilizer (DAP) and biofertilizer (PSB) was found significant on growth components of both *Vigna* crops as compared to the control. Therefore, it suggested that the combination of chemical fertilizer and biofertilizer can reduce the dependency on chemical fertilizers alone to improve crop growth and yield for sustainable agricultural system.

The present investigation is the primary stage of study to analyze the impact of combined application of chemical

fertilizer (DAP) and biofertilizer (PSB) on growth components of *Vigna radiata* and *V. mungo*. In future, studies may be conducted to examine the same on different crop growth and yield with the application of different chemical fertilizer and biofertilizer at different levels to enhance the crop production in this region.

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