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Effect of Various Microbial Inoculums on the Growth, Quality and Nutrient Uptake of Mung Bean (*Vigna radiata* L.)

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ABSTRACT

A field experiment was conducted at Technology Park of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP) to study the Growth, Quality, and Nutrient Uptake of Mung Bean (*Vigna radiata* L.) as Influenced by Different Microbial Inoculums during the *kharif* season of 2020. The experiment including ten treatments was conducted in RBD design and replicated thrice. The maximum values of growth attributes viz., Root length (15.7 cm), Root weight (1.4:1.06 fresh/dry g/plant), Effective nodules (41.5 no./plant), Nodules dry weight (96.3 mg/plant) and Grain yield (1106 kg/ha), Quality i.e., Protein content (25.4%), Protein yield (279.7 kg/ha) and nutrient content and uptake viz., nitrogen, phosphorus and potassium were recorded under NPK Consortia +ZSB, each @ 20 ml/kg followed by NPK Consortia @ 20 ml/kg. This shows that NPK Consortia with ZSB have better adoptability in growth, yield and quality of mung bean.

Keywords KSB, Liquid biofertilizer, Microbial inoculum, NPK consortia, PSB, ZSB.

INTRODUCTION

Mung bean (*Vigna radiata* L.Wilczek) can be grown in both *kharif* and summer because it has a short growing season and is easy to adapt. In 2019, *kharif* mung bean was grown on a total of 3.13 mha in India with production of 1.83 m tonnes and had a productivity of 585 kg/ha (Anonymous 2020). Bio-fertilizers are very important part of making nitrogen and phosphorus more available. The yield of many crops increased when *Rhizobium*, PSB, and organic additives were added to the seeds. Inoculation of legume seeds with *Rhizobium* culture is a low-cost way to add nitrogen fertilizer. It has been found to improve soil quality by allowing more biological fixation of nitrogen from the air, which could help increase production (Pathak *et al.* 2001). For a higher yield, mung bean needs 20:40 kg NP/ha. This makes production costs higher because fertilizers prices go

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up. It also hurts the environment and makes it less efficient to use fertilizers. With all of these things in mind, liquid bio fertilizer might be the best way to replace expensive commercial fertilizers. Bio-fertilizer in liquid form helps keep organisms alive, get them where they need to go, and make them work better. Liquid bio-fertilizers are liquid mixtures that contain the microbes you want and the nutrients they need, as well as certain cell protectants or compounds that encourage the growth of dormant spores or cysts to make the mixture last longer and be more resistant to bad conditions. Chemical fertilizers have a shorter shelf life than liquid bio-fertilizers. Liquid bio-fertilizers provide nutrients like N, P and K to plants through their activities in the rhizosphere, making them easy for plants to use. Bio inoculants are becoming more important because they improve the health of the soil and cut down on pollution by reducing the use of chemical fertilizers (Roychowdhury *et al.* 2017). With all of these things in mind, this study was done on the *kharif* mung bean.

MATERIALS AND METHODS

The field experiment was conducted during the *kharif* season of 2020, at Technology Park, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP), located at a latitude of 29°4' North and longitude of 77°42' East with an elevation of 228 meter above the mean sea level. Meerut lies in the heart of Western Uttar Pradesh and has sub-tropical climate. The soil of the experimental field was well drained, sandy loam in texture and slightly alkaline in reaction. It was low in organic carbon and available nitrogen, medium in available phosphorus, potassium and zinc. The experimental site had an even topography with good drainage facilities in farm. Data showed that average maximum weekly temperature ranged between 32.1°C in August to 36.4°C in September, while average minimum weekly temperature ranged between 16.1°C to 27.1°C. The mean weekly minimum and maximum relative humidity varied between 45.1 to 84.0 % and 77.3 to 93.3%, respectively. The total amount of rainfall received during crop period was 138.5 mm. The maximum and minimum mean weekly sunshine hour during crop growth period was 1.7 and 8.8 hr, respectively. The experiment comprised with ten treatments viz., Control, RDF (20:40 kg/ha), PSB @ 20 ml/kg, KSB @ 20 ml/kg, ZSB @ 20 ml/kg, PSB+KSB, each @ 20 ml/kg, PSB+ZSB, each @ 20 ml/kg, KSB+ZSB, each @ 20 ml/kg, NPK Consortia @ 20 ml/kg and NPK Consortia + ZSB, each @ 20 ml/kg was laid out in Randomized Block Design (RBD) with 3 replications. A uniform dose of 20 kg/ha nitrogen through urea was applied to all the treatments having seed inoculation with bio-fertilizers (except control). In RDF (20:40) treatment, Urea (46% N) and SSP (16% P_2O_5) were used as sources of nitrogen and phosphorus, respectively. The entire quantity of nitrogen and phosphorus was applied as basal, at the time of sowing, 2.5 cm deep in the side of the seed rows. Mung bean (Pusa-1431) was sown in rows, 30 cm apart, using a seed rate of 18 kg/ha on 05-08-2020 and harvested on 15-10-2020. Mung bean was grown with the recommended package of practices. Observations related to Root length (cm), Root weight (g/plant), Effective nodules (no./plant), Nodules dry weight (mg/plant), Protein content (%), Protein yield (kg/ha), Grains yields (kg/ha), Nitrogen, Phosphorus, Potassium and Zinc on plant was computed as per the standard procedure. The data obtained were analyzed using statistical software package given by Sheron *et al.* (1998).

RESULTS AND DISCUSSION

Growth attribute

Root length (cm) **:** Perusal of data given in Table 1 showed that root length varied significantly due to microbial inoculums at flowering stage in mung bean except KSB (T_4) and ZSB (T_5) @ 20 ml/kg. Maximum root length was measured with NPK Consortia+ZSB, each @ 20 ml/kg T_{10} (15.7 cm) which remained on par to treatments T_9 (15.5 cm), T_2 (15.3 cm), T_7 (15.1 cm), T_6 (14.7 cm) and T_8 (14.0 cm), while significantly superior to rest of the treatments. However, the shortest (10.7 cm) root length was measured under control.

Root weight (g/plant) **:** Perusal of data given in Table 1 revealed that mung bean inoculated with NPK Consortia+ZSB, each @ 20 ml/kg (1.4 g/plant) had highest root fresh weight, though it remained on par with treatment T_9 (1.4 g/plant), T_2 (1.3 g/plant), T_6 (1.3

Table 1. Effect of various microbial inoculums on the growth of mung bean.

Treatment	Root length (cm)	Root weight (g/plant) Fresh	Dry	Effective nodules (no./plant)	Nodules dry weight (mg/plant)
T_1 : Control	10.7	0.9	0.66	17.8	14.3
T_2 : RDF (20:40 kg/ha)	15.3	1.3	1.02	34.2	93.7
T_3 : PSB @ 20 ml/kg	13.9	1.2	0.82	28.5	37.7
T_4 : KSB @ 20 ml/kg	12.2	1.1	0.78	21.5	20.3
T_5 : ZSB @ 20 ml/kg	12.3	1.2	0.82	23.8	26.3
T_6 : PSB +KSB, each @ 20 ml/kg	14.7	1.3	0.93	31.5	66.7
T_7 : PSB + ZSB, each @ 20 ml/kg	15.1	1.3	0.96	32.0	83.7
T_8 : KSB+ ZSB, each @ 20 ml/kg	14.0	1.2	0.87	28.8	62.3
T_9 : NPK Consortia @ 20 ml/kg	15.5	1.4	1.03	40.2	94.3
T_{10} : NPK Consortia + ZSB, each @ 20 ml/kg	15.7	1.4	1.06	41.5	96.3
SEm (±)	**0.7**	**0.1**	**0.03**	**1.6**	**4.5**
CD (p=0.05)	**2.0**	**0.2**	**0.10**	**4.7**	**13.4**

g/plant) and T_7 (1.3 g/plant), while significantly superior over rest of the treatments. However the lowest root fresh weight was noticed in control (0.9 g/plant).

Root dry weight (g/plant) **:**The microbial inoculums increased significantly the root dry weight/plant Table 1. Application of NPK Consortia+ZSB, each @ 20 ml/kg (1.06 g/plant) resulted in highest root dry weight followed by T_9 (1.06 g/plant) and T_2 (1.02 g/plant), while significantly superior over rest of the treatments. Although, the lowest root dry weight was observed under control (0.66 g/plant).

Effective nodules (no./plant) **:** Number of nodules per plant varied significantly among different microbial inoculums at all the stages of growth in mung bean. Perusal of data presented in Table 1 indicated that all the microbial inoculums exhibited significant increase in number of nodules per plant over control. Highest number of nodules/plant at flowering stage was obtained with NPK Consortia+ZSB, each @ 20 ml/kg (41.5) followed by NPK Consortia @ 20 ml/kg (40.2), while significantly superior over rest of the treatments. Although, the lowest number of nodules/plant was recorded in control (17.8).

Nodules dry weight (mg/plant) **:** Perusal of data given in Table 1 revealed that crop grown under various microbial inoculums showed an increase in nodules dry weight/plant in comparison to control. Maximum dry weight of nodules/plant was obtained with application of NPK Consortia+ZSB, each @ 20 ml/kg (96.3 mg/plant) which was significantly on par to treatments T_9 (94.3 mg/plant), T_2 (93.7 mg/plant) and T_7 (83.7 mg/plant) and superior over rest of the treatments. Although, the lowest dry weight of nodules/plant was recorded in control (14.3 mg/plant).

This might be due to higher number of bacteria present under inoculated condition which improve the soil fertility, microbial population and water holding capacity, making soil conditions more conducive for Rhizobia multiplication, ultimately leading to increase in nutrient status of soil required for vigorous root growth and nodule formation. Similar research findings were also made given by Sharma *et al.* (2006) in mung bean and Deshpande *et al.* (2015) in chick pea.

Quality

Protein content (%) **:** Perusal of data presented in Table 2 revealed that all the microbial inoculums increased the grains protein content significantly over control. Protein content of 25.4% was recorded when the crop was inoculated with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) as against 19.2 % under control. The treatments T_2, T_5, T_6 and T_9 were also statistically alike in this regard.

Protein yield (kg /ha) **:** Perusal of data presented in Table 2 showed that there was a sharp increase in

Table 2. Effect of various microbial inoculums on the quality and yield of mung bean.

Treatment			Protein content (%)	Protein yield (kg/ha)	Grains yields (kg/ha)
T_1	:	Control	19.2	134.9	701
T_2	:	RDF (20:40kg/ha)	24.4	250.2	1,024
T_3	:	PSB @ 20 ml/kg	20.9	191.0	910
T_4	:	KSB @ 20 ml/kg	21.6	177.0	821
T_5	:	ZSB @ 20 ml/kg	22.8	202.1	887
T_6	:	PSB +KSB, each @ 20 ml/kg	23.4	222.1	947
T_7	:	PSB + ZSB, each @ 20 ml/kg	21.9	212.9	970
T_8	:	KSB+ ZSB, each @ 20 ml/kg	20.5	190.3	925
T_9	:	NPK Consortia @ 20 ml/kg	24.8	260.6	1,053
T_{10}	:	NPK Consortia+ZSB, each @ 20 ml/kg	25.4	279.7	1,106
		SEm (±)	**1.0**	**15.7**	**59**
		CD (p=0.05)	**2.9**	**46.4**	**176**

protein yield among different microbial inoculums in comparison to control. Maximum protein yield of 279.1 kg/ha was recorded with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}), while lowest protein yield was recorded under control (134.9 kg/ha). Similarly, this treatment out yielded control and RDF (T_2) by 107.6 and 11.6% respectively. This may be due to higher uptake of Nitrogen, which may be easily available to plant due to higher microbial activity in soil. Similar finding supported by Bhalerao and Fernandes (2015) in mung bean and Kumawat *et al.* (2020).

Grains yields (kg/ha) **:** Perusal of data presented in Table 2 showed that maximum grain yield (1106 kg/ha) was observed with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) which remained on par with treatments T_9 (1053 kg/ha), T_2 (1024 kg/ha), T_7 (970 kg/ha) and T_6 (947 kg/ha) while significantly superior to rest of the treatments. Moreover, the increase in grain yield under T_{10}, T_9 and T_2 was 57.8, 50.2 and 46.1%, respectively over control. However, the minimum grain yield was recorded in treatment having no inoculation/fertilizer application (701 kg/ha).

Greater availability of nutrients for plant uptake along with their efficient absorption and translocation to reproductive organs of plants resulted in higher values of these yield in mung bean. Similar findings were given by Bajracharya and Rai (2009), Singh and Singh (2019) in mung bean and Ghadge *et al.* (2020) in soya been.

Nutrient content and uptake

N content (%), N uptake (kg/ha) **:** Perusal of data presented in Table 3 revealed that there was an increase in nitrogen content in grains and straw among various microbial inoculums in comparison to control. Crop supplied with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) resulted in maximum nitrogen content in grains (4.06%) and straw (1.99%), while minimum was recorded in control i.e., 3.07 and 1.31 %, respectively. Microbial inoculums exhibited significant effect on nitrogen uptake grains, straw and total in mung bean. Nitrogen uptake in grains, straw and total ranged from 21.59 to 44.65, 21.09 to 42.72 and 42.68 to 87.37, respectively among different treatments. In general, the nitrogen uptake by grains was higher than straw. All the microbial inoculums increased nitrogen uptake in grains and straw over control. Maximum nitrogen uptake (44.65 kg/ha) in grains was recorded with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) followed by T_9 (41.70 kg/ha) and T_2 (40.03 kg/ha) which were statistically superior to control. However, higher uptake in straw was recorded with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) followed by T_9 (39.81 kg/ha) and T_2 (38.21 kg/ha) which were statistically superior to control. Though, the minimum nitrogen uptake in grains, straw and total was recorded under control. Moreover, the mung bean grown with NPK Consortia and ZSB+NPK Consortia accumulated 90.9, 104.7 and 4.1 and 11.7% more total nitrogen than control and RDF (T_2), respectively.

Table 3. Effect of various microbial inoculums on nutrient content and uptake of mung bean.

Treatment	N content (%)		N uptake (kg/ha)		P content (%)		P uptake (kg/ha)	
	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw
T_1 : Control	3.07	1.31	21.59	21.09	0.28	0.14	1.97	2.28
T_2 : RDF (20:40 kg/ha)	3.90	1.87	40.03	38.21	0.48	0.35	4.93	7.15
T_3 : PSB @ 20 ml/kg	3.35	1.52	30.57	29.47	0.37	0.26	3.38	5.05
T_4 : KSB @ 20 ml/kg	3.46	1.51	28.32	27.94	0.41	0.28	3.36	5.16
T_5 : ZSB @ 20 ml/kg	3.64	1.60	32.34	31.32	0.45	0.30	4.00	5.78
T_6 : PSB +KSB, each @ 20 ml/kg	3.75	1.77	35.53	35.03	0.46	0.28	4.35	5.60
T_7 : PSB + ZSB, each @ 20 ml/kg	3.50	1.63	34.07	32.28	0.43	0.29	4.18	5.73
T_8 : KSB+ ZSB, each @ 20 ml/kg	3.28	1.49	30.44	29.69	0.35	0.24	3.25	4.78
T_9 : NPK Consortia @ 20 ml/kg	3.97	1.92	41.70	39.81	0.50	0.38	5.25	7.88
T_{10} : NPK Consortia+ZSB, each @ 20 ml/kg	4.06	1.99	44.65	42.72	0.52	0.40	5.73	8.59
SEm (±)	**0.15**	**0.07**	**2.51**	**1.89**	**0.02**	**0.01**	**0.28**	**0.32**
CD (p=0.05)	**0.46**	**0.20**	**7.43**	**5.60**	**0.05**	**0.04**	**0.82**	**0.94**

Table 3. Continued.

Treatment	K content (%)		K uptake (kg/ha)		Zn content (ppm)		Zn uptake (mg/ha)	
	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw
T_1 : Control	0.38	1.15	2.67	18.65	20.4	16.1	14.3	26.1
T_2 : RDF (20:40 kg/ha)	0.52	1.32	5.34	26.97	22.7	18.1	23.3	37.0
T_3 : PSB @ 20 ml/kg	0.42	1.19	3.83	23.07	22.9	18.3	20.9	35.5
T_4 : KSB @ 20 ml/kg	0.46	1.22	3.77	22.48	23.0	18.4	18.8	33.9
T_5 : ZSB @ 20 ml/kg	0.49	1.28	4.35	25.00	24.7	19.7	21.9	38.5
T_6 : PSB +KSB, each @ 20 ml/kg	0.50	1.31	4.73	25.93	23.9	18.0	22.6	35.6
T_7 : PSB + ZSB, each @ 20 ml/kg	0.47	1.25	4.57	24.69	24.6	19.3	23.9	38.1
T_8 : KSB+ ZSB, each @ 20 ml/kg	0.40	1.17	3.71	23.32	26.8	21.9	24.9	43.6
T_9 : NPK Consortia @ 20 ml/kg	0.53	1.34	5.57	27.79	23.4	18.6	24.6	38.6
T_{10} : NPK Consortia+ZSB, each @ 20 ml/kg	0.55	1.37	6.06	29.41	27.4	22.4	30.2	48.1
SEm (±)	**0.02**	**0.04**	**0.31**	**1.35**	**0.9**	**0.7**	**1.6**	**2.1**
CD (p=0.05)	**0.05**	**0.13**	**0.91**	**3.99**	**2.6**	**2.1**	**4.7**	**6.1**

P content (%) and uptake (kg/ha) **:** Perusal of data presented in Table 3 revealed that phosphorus content in grains (0.52) and straw (0.40) was significantly highest under mung bean inoculated with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}), though it remained on par with T_9 and statistically superior over rest of the treatments, except RDF for grains. While, the lowest phosphorus content was recorded in control. Phosphorus uptake in grain and straw ranged from 1.97 to 5.73 and 2.88 to 8.59 under different microbial inoculums indicated that phosphorus uptake by grains, straw and total increased significantly among different microbial inoculums in comparison to control. Maximum phosphorus uptake in grains was recorded in T_{10} which included NPK Consortia+ZSB, each @ 20 ml/kg (5.73 kg/ha) which was statistically on par treatments T_9 (5.25 kg/ha) and T_2 (4.93 kg/ha). Almost similar trend was observed in straw and total phosphorus accumulation where T_{10} and T_9 treatments remained on par and statistically superior to rest of the treatment. Although, the minimum uptake in grains and straw as well as total was recorded in control. Further, there treatments had accumulated 10.06 and 8.88 kg/ha more total phosphorus over control, respectively.

K content (%) and uptake (kg/ha) **:** Perusal of data presented in Table 3 revealed that potassium content in grains (0.55) and straw (1.37) was significantly highest under mung bean inoculated with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}), though it remained on par with T_9, T_2 and statistically superior over rest of the treatments. While, the lowest potassium content in grain and straw was recorded in control.

Potassium uptake in grains and straw ranged from 2.67 to 6.06 and 18.65 to 29.41 under different microbial inoculums. Microbial inoculums in comparison to control, except T_4 for straw. Maximum potassium uptake in grains was recorded in T_{10} which included NPK Consortia+ZSB, each @ 20 ml/kg (6.06 kg/ha) which was statistically on par treatments T_9 (5.57 kg/ha) and T_2 (5.34 kg/ha). Almost similar trend was observed in straw and total potassium uptake where T_{10} and T_9 treatments remained on par and statistically superior to rest of the treatment. Although, the minimum uptake in both grains and straw as well as total was recorded in control. Further, these treatments had accumulated 14.14 and 12.03 kg/ha more total potassium over control, respectively.

Zn content (ppm) and zn uptake (mg/ha) **:** Crop inoculated with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) resulted in to maximum zinc content in grains (27.4 ppm) and straw (22.4 ppm), while minimum was recorded in control i.e., 20.4 and 16.1 ppm, respectively Table 3. In general, the zinc uptake by straw was higher than grains. Maximum zinc uptake (30.2 mg/ha) in grains was recorded with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) which was statistically superior to rest of the treatments. However, the highest zinc uptake (48.1 mg/ha) in straw was recorded with NPK Consortia+ZSB, each @ 20 ml/kg (T_{10}) which was on par with T_8 (43.6 mg/ha). Though, the minimum zinc uptake in grains, straw and total was recorded under control. Moreover, the mung bean grown with ZSB+NPK Consortia (T_{10}) accumulated 93.3 and 29.9 % more total zinc than control and RDF (T_2), respectively.

It might be due to acceleration of certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants which in turn improved nitrogen, phosphorus, potassium and zinc content and uptake in grain and straw of mung bean. These findings corroborate the results of Tanwar *et al.* (2003) in black gram, Bhalerao and Fernandes (2015) in mung bean and Kumawat *et al.* (2020) in chick pea.

CONCLUSION

From the above study it may be concluded that application of NPK Consortia and ZSB have better effect on growth, yield, quality and nutrient content and uptake was highest followed by NPK consortia only. However experiment was conducted only for one year to get more precise result same experiment may be conducted in same layout to get concrete result.

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