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Effect of *Rhizobium,* PSB and P-levels on Growth, Yield Attributes and Yield of Urdbean (*Vigna mungo* L.)

Surya Kant[1], Achin Kumar[1]*, Satendra Kumar[1], Vipin Kumar[2], Yogesh Pal[2] and Anil. K. Shukla[2]

[1]Department of Soil Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut - 250 110, India.
[2]Department of Soil Science & Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221 005, India.

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A field experiment was conducted in *kharif* 2011 on urdbean genotype T-9. The experiment was laid out in randomized block design with three replication and thirteen treatments. Some microorganisms have capable to convert the insoluble phosphorous to an accessible form and increase the growth and yield attributes viz, plant height, number of branches plant^{-1}, nodulation, dry matter accumulation plant $^{-1}$, number of pods plant $^{-1}$, test weight (g), grain yield, straw yield and biological yield (qha^{-1}) of Urdbean. All these characters were recorded higher in treatment T_{13} by application of (75 kg ha^{-1} P_2O_5 + PSB + *Rhizobium*.) as compared to all other treatments. However, combination of rhizobium, PSB and P levels had proved significant influence on plant growth, yield and its attributing traits in Blackgram.

Keywords: Microbial inoculation, phosphorus, growth, yield and Urdbean.

Pulses are one of the important segments of Indian agriculture after cereals and oilseeds with 33% of the world's area and 22 % of the production. India is the largest pulse producing country. Pulses occupy nearly 26.28 million hectare of land with the production around 18.09 million tones and average productivity 6.9 q/ha In India. Due to low and unstable production and increasing the population pressure, per capita availability of pulses decreasing from 69 g in 1961 to about 31.6 g in 2010- 11, against the minimum requirement of 80 g per capita per day (Anonymous, 2011-12). To make up minimum 50 g pulses per capita per day and further demand from burgeoning population at least 23.88 m tonnes of pulses are required by 2015 which is expected to touch 29.30 million tonnes by 2020. To satisfy the demand of pulses requirement of ever increasing population, the production of pulses has to be increased only by increasing the yield/unit area/day (Anonymous, 2011).

Black gram (*Vigna mungo* L.) also known as urdbean, urd and urad, is an important pulse crop grown throughout India. The split grains of the pulses called dahl which is excellent source of high quality protein, essential amino acids, fatty acids, fibres, minerals and vitamins. Among all the pulses, blackgram (*Vigna mungo* L.) is a highly prized pulse for its biological protein value and rich in phosphoric acid. Being, a leguminous crop, black gram fulfills major part of nitrogen requirement by symbiotic nitrogen fixation with the help of bacterium called *Rhizobia* (Pareek, 1978).

Phosphorous has referred to as the *"Master key element"* in crop production. It is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby

* To whom all correspondence should be addressed.
E-mail: achinrana1@gmail.com

atmospheric nitrogen fixation. The yield and nutritional quality of pulses is greatly influenced by application of phosphorus. It plays a key role in various physiological processes like root growth, dry matter production, nodulation, nitrogen fixation and also in metabolic activities especially in protein synthesis. Phosphate deficiency in soil can severely limit plant growth, productivity of legumes, deleterious effect on nodule formation (Alikhani *et al.*, 2006).

The role of microorganisms in solubilizing inorganic phosphates in soil and making them available to plants is well known (Barroso *et al*., 2006). These microorganisms bring about solubilization by the production of organic acid and phosphate enzyme activity. As regards phosphate only about 15-20 per cent of the applied phosphorous is utilized by first crop. *Rhizobium* is the bacteria which are involve in symbiotic biological nitrogen fixation; requires phosphorus for its growth and survival in soil, *Rhizosphere* colonization, infection and nodule development and energy transformation during Nitrogen fixation in root nodules (O, Hara *et al.* 1988). The phosphate solubalising Bacteria (PSB), dissolving inter locked phosphates appear to have an important implication in Indian agriculture. Dual inoculation of *Rhizobium* and phosphate solubilizing bacteria (PSB) may help the plant to acquire both N and P. Co-inoculation of PSB with *Rhizobium* have been found to improve the nodulation and nitrogen fixation in Chickpea. Interest has been focused on the inoculation of rhizobia and PSB into the soil to increase the availability of native fixed phosphate and to reduce the use of fertilizers (Chakrabarti *et al.,* 2007).

MATERIALS AND METHODS

The field experiment was conducted in *kharif* 2011 at Crop Research Centre, Chirori of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) India, to evaluate the effect of r*hizobium*, *PSB* and P-levels on growth, yield attributes and yield of Urdbean (*Vigna mungo* L.). The soil of the experimental field was sandy loam in texture, low in available nitrogen, available phosphorus and medium in available potassium. Thirteen treatments combinations comprising of all possible treatments of three levels of phosphorus viz., 25, 50 and 75 kg ha^{-1} P_2O_5, rhizbium and PSB, respectively (Table 1). P was applied through single super phosphate and seed was inoculated with 20 gm of r*hizobium* culture and 20 gm of PSB (*Phosphate* Solubilising *Bacteria)* culture 1 kg seed, each plot size being 3m x 4m, respectively. All the recommended cultural practices and plant protection measures were followed throughout the experimental periods. The height of plant, number of branches effective nodules, dry matter, test weight, pod $plant^{-1}$, yield and yield contributing characters were recorded from all plots at pertinent stages. All obtained data from experiment were statistically analyzed by analysis of variance (ANOVA) according to randomized block design as prescribed by (Panse and Sukhatme, 1978). Standard error of mean in each case and critical difference only for significance cases were computed at 5% levels of probability.

Critical difference= SEM±×2xt (at error degree of freedom)

RESULTS AND DISCUSSION

Growth attributes

Plant height

The plant height increased progressively at successive observations with advancement of crop age and was significantly affected by different treatments (Table 2). The highest plant height at

Table 1. Details of the pot experiment and treatment

Experimental details		
Crop	:	Urd bean (*Vigina mungo L.*) Cv T-9
Experimental design	:	Randomized Block Design (RBD)
Number of treatments	:	13
Number of replication	:	3
Number of plots	:	39 (13 × 3)
Treatment	:	P - 25, 50 &75 kg ha^{-1}, *Rhizobium* and PSB

Treatments details :

T_1 Control plot, T_2(Phosphate Solubilizing bacteria), T_3(Rhizobium), T_4(PSB + Rhizobium), T_5(25kg ha^{-1} P_2O_5 + PSB), T_6(25kg ha^{-1} P_2O_5 + Rhizobium), T_7(25kg ha^{-1} P_2O_5 + PSB + Rhizobium),T_8(50kg ha^{-1} P_2O_5 + PSB),T_9(50kg ha^{-1} P_2O_5 + Rhizobium),T_{10}(50kg ha^{-1} P_2O_5 +PSB+Rhizobium), T_{11} (75kg ha^{-1} P_2O_5 +PSB),T_{12} (75kg ha^{-1} P_2O_5 +Rhizobium) T_{13} (75kg ha^{-1} P_2O_5 +PSB+Rhizobium)

30, 60 and at harvesting was recorded 42.15, 63.70 and 64.47 cm in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while smallest plant height was recorded in T_1 (control). Plant height at pertinent stage was increased by 16.67, 19.91 and 20.25% in treatment T_{13} over control. The result is supported by Jain and Singh (2003), Gilani *et al*. (2004), Band *et al*. (2007), Dhyani *et al*. (2011).

Number of branches plant^{-1}

The number of branches increased progressively at successive observations with advancement of crop age and was significantly affected by different treatments (Table 2). The maximum number of branches at 30, 60 and at harvesting was recorded 16.94, 21.65 and 22.20 cm in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to

Table 2. Effect of *Rhizobium*, PSB and P-levels on average plant height (cm) and number of branches plant^{-1} of Urdbean

Treatments	Plant height (cm.)			Number of branches plant^{-1}		
	30 DAS	60 DAS	At harvest	30 DAS	60DAS	At harvest
T1	36.13	53.12	53.61	10.76	14.75	15.50
T2	36.57	54.15	56.00	11.03	15.23	15.60
T3	37.33	56.05	57.54	11.33	15.92	15.55
T4	38.10	56.50	58.21	12.70	16.64	16.70
T5	38.18	59.54	58.91	13.60	18.03	17.90
T6	38.23	60.21	59.43	14.52	17.96	18.20
T7	38.90	60.58	60.80	15.33	19.50	19.97
T8	38.57	60.37	61.52	13.58	17.42	18.10
T9	39.23	60.87	62.23	14.66	18.69	19.45
T10	39.84	61.62	62.81	16.75	20.62	20.66
T11	39.42	62.43	63.20	14.32	19.20	20.20
T12	40.90	62.16	63.91	16.26	20.43	19.98
T13	42.15	63.70	64.47	16.94	21.65	22.20
SEm±	0.28	0.32	0.27	0.24	0.18	0.25
CD (0.05)	0.83	0.95	0.78	0.71	0.53	0.73

Table 3. Effect of *Rhizobium*, PSB and P-levels on number of nodules plant-1 and dry matter of Urdbean

Treatments	Number of nodules		Dry matter		
	30 DAS	60 DAS	30 DAS	60DAS	At harvest
T1	30.33	21.60	5.03	11.14	12.52
T2	34.76	26.69	5.37	11.37	12.80
T3	37.50	27.60	5.43	11.50	12.93
T4	38.74	28.74	5.46	11.66	12.96
T5	39.10	30.50	5.57	11.78	13.57
T6	40.37	30.93	5.76	12.20	14.78
T7	41.75	32.44	5.90	12.80	14.85
T8	42.74	33.74	6.28	13.30	15.75
T9	46.34	34.80	6.33	13.43	15.83
T10	46.78	35.70	6.39	14.56	17.40
T11	47.34	38.26	6.47	14.78	17.62
T12	52.13	39.44	6.75	14.90	17.97
T13	53.66	40.24	7.20	15.30	18.00
SEm±	0.33	0.39	0.23	0.26	0.28
CD (0.05)	0.97	1.15	0.67	0.76	0.81

rest of the treatments, while minimum number of branches was recorded in T_1 (control). Number of branches at pertinent stage was increased by 57.43, 46.78 and 43.23% in treatment T_{13} over control. The result is supported by Jain and Singh (2003), Gilani *et al.* (2004) and Singh *et al.* (2004).

Number of nodules plant^{-1}

The number of nodules decreased at successive observations with advancement of crop age and was significantly affected by different treatments (Table 3). The maximum number of nodules at 30 and 60 DAS was recorded 53.66 and 40.24 in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum number of nodules was recorded in T_1 (control). Number of nodules at pertinent stage was increased by 76.92% and 86.30% in treatment T_{13} over control. The result is supported by Khatkar *et al.* (2007), Sattar et *al.* (1994), Jain *et al.* (1999), Beerendra and Gupta (2006), Gupta *et al.* (2006) and Jain *et al.* (2006).

Dry Matter accumulation plant^{-1} (g)

The dry matter increased progressively at successive observations with advancement of crop age and was significantly affected by different treatments (Table 3). The maximum dry matter accumulation at 30, 60 and at harvesting was recorded 7.20, 15.30 and 18.00 g in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). Dry matter accumulation at pertinent stage was increased by 43.14, 37.34 and 43.76% in treatment T_{13} over control. The result is supported by Jain and Singh (2003), Band *et al.* (2007) and Hakeem *et al.* (2008).

Yield attributes

Number of pods plant^{-1}

Number of pods per plant was affected by different treatments. (Table 4). The maximum number of pods 50.2 was recorded in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum number of pods was recorded in T_1 (control). The number of pods per plant was increased by 64.05% in treatment T_{13} over control. The results finding supported by the finding of Asheesh Elamathi (2007), Jain *et al.* (1999) and Meena *et al*. (2003).

Test weight (g)

Test weight was affected by different treatments (Table 4). The maximum weight 44.10 g was recorded in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). The test weight increased by 21.15% in treatment T_{13} over control. The results finding supported by the finding of Meena *et al.* (2003) and Hakeem *et al.* (2008).

YIELD (qha^{-1})

Grain yield was significantly affected by

Table 4. Effect of *Rhizobium*, PSB and P-levels on pod plant^{-1}, test weight, grain yield, stover yield and biological yield of Urdbean

Treatments	Pod plant^{-1}	1000-Seed weigh (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})
T1	30.60	36.40	6.31	21.48	27.79
T2	36.25	39.40	6.91	23.27	30.18
T3	37.70	37.60	7.05	24.27	31.81
T4	38.50	40.20	7.33	25.10	32.43
T5	42.20	41.50	6.92	24.77	31.19
T6	43.80	40.70	7.41	26.47	33.88
T7	45.10	41.84	8.02	27.07	35.09
T8	46.35	42.74	7.50	26.77	34.26
T9	47.90	42.12	8.08	28.70	36.78
T10	48.30	42.92	9.15	31.47	40.62
T11	49.10	43.70	8.86	29.40	38.26
T12	49.50	43.24	9.03	30.33	39.36
T13	50.20	44.10	9.28	31.60	40.88
SEm ±	0.38	0.38	0.25	0.34	0.34
CD (P=0.05)	1.10	1.12	0.74	1.01	0.99

different treatments (Table 4). The maximum grain yield (9.28 q ha^{-1}) was recorded in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). Grain yield was increased by 47.06% in treatment T_{13} over control.

Straw yield was significantly affected by different treatments (Table 4). The maximum grain yield (31.60 q ha^{-1}) was recorded in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). Straw yield was increased by 47.11% in treatment T_{13} over control.

Biological yield was significantly affected by different treatments (Table 4). The maximum grain yield (40.88 q ha^{-1}) was recorded in treatment T_{13} (75 kg P_2O_5 ha^{-1} + PSB + *Rhizobium)* respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). Straw yield was increased by 47.10% in treatment T_{13} over control. The result is supported by Jain *et al.* (1999), Meena *et al.* (2002), Tanwar *et al* (2002), Bhat *et al.* (2005), Band *et al.* (2007) and Rathore *et al.* (2007).

Rhizobium and PSB inoculation on urdbean was significantly increased all growth characters *viz.*, plant height, number of branches $plant^{-1}$, nodulation, dry matter accumulation $plant^{-1}$, number of pods $plant^{-1}$, test weight (g), grain yield, straw yield and biological yield (qha^{-1})as compared to without inoculation but its efficacy was significantly enhanced when inoculation was supplemented with phosphorus due to the synergistic effect of *Rhizobium* and PSB inoculation over control. Highly significant increase was observed in combined application of Co – inoculation of *Rhizobium*, PSB and 75 kg P_2O_5 ha^{-1}.

CONCLUSION

From the above study it is concluded that the combination of rhizobium, PSB and P levels were found superior than alone application of treatments in terms of growth and yield parameters of Urdbean. The application of *Rhizobium* and PSB along with 75 kg ha^{-1} P_2O_5 in treatment T_{13} gave the maximum grain yield (9.28 q ha^{-1}) respectively, which were superior to rest of the treatments, while minimum was recorded in T_1 (control). The grain yield was increased by 47.06% in treatment T_{13} over control). Inoculation of rhizobia and PSB into the soil found beneficial to increase the availability of native fixed phosphate and to reduce the use of fertilizers

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