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Effect of sources of nutrient and biofertilizers on growth and yield of mungbean (*Vigna radiata* L.)

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Abstract
A field experiment was conducted during spring-summer seasons of 2017 at Tarnak Research Farm, ANASTU, Kandahar, Afghanistan to investigate the effect of sources of nutrient and biofertilizers on growth, yield and economics of Mungbean. The experiment laid out in Split Plot Design (SPD) with by assigning 4 levels of nutrients sources (control, 30:60:40 kg N:P:K ha^{-1}, 10 t FYM ha^{-1}, and 15:30:20 kg N:P:K ha^{-1} + 5t FYM ha^{-1}) in main plot and 4 levels of biofertilizers [No Biofertilizer, *Rhizobium*, Phosphate solubilizing bacteria (PSB) + Vesicular Arbuscular Mycorrhiza (VAM), and *Rhizobium* + PSB + VAM] in subplot, thus sixteen treatment combinations were tested in three replications. Results of the study revealed that significantly superior plant growth parameters like plant height, number of branches, trifoliate leaves, leaf area and dry matter accumulation were recorded from RDF 0.5+ FYM 5 t ha^{-1}. Similarly, these parameters were superior with the application of *Rhizobium*+ PSB+VAM at most of the growing stages. Among different nutrient sources and biofertilizer the interaction effect was significant at different stages and found best with the combination of RDF 0.5+ FYM 5 t ha-1 and *Rhizobium*+PSB+VAM for most of the growth parameters. Root parameters like root length and root nodules (7.7 plant^{-1}) were significantly higher with the application of RDF0.5+FYM 5 t ha^{-1} and *Rhizobium*+PSB+VAM over control at 25, 50 and at harvest stages. Highest growth and yield can be obtained with the application of 15:30:20 kg N: P: K ha^{-1}+ 5 t FYM ha^{-1} along with *Rhizobium* + PSB + VAM in the Kandahar province of Afghanistan.

Keywords: Nutrients, biofertilizer, growth, yield and mungbean

Introduction

Mungbean is an annual crop and cultivated mostly in rotation with cereals. It is an erect plant which is highly branched and is about 60 to 76 cm tall Oplinger *et al.* (1990). Productivity of mungbean is very low in Afghanistan. To maintain the level of pulses consumption in balanced diet the people the Government of Afghanistan has to spend huge amount of foreign currency for importing pulses, therefore, it is necessary to put efforts to improve and enhance production of mungbean in the country. The climate of Afghanistan is more suitable for mungbean cultivation however, in general the productivity of most of the pulse crops is quite low. The main reason of low productivity of pulse crop and specially mungbean is due to its cultivation on marginal lands with meager irrigation facilities and low soil fertility. Although, it is essential to apply nitrogen and phosphorus fertilizers to the pulses but only few farmers prefer to apply fertilizers in mungbean. The cultivation of mungbean is less remunerative in Afghanistan and therefore farmers do not apply the needed amount of fertilizers. Being a leguminous plant mungbean has ability to fix atmospheric nitrogen in association with a *Rhizobium* through the processes of symbiosis. Thus, the biofertilizers, which are cost effective, can be used in the mungbean cultivation to supplement the major nutrients N and P. Apart from biofertilizers, locally available organic manures can also fulfill the nutritional demand to some extent.

The efficient plant nutrition management should ensure both enhanced and sustainable agricultural production and safeguard the environment. Chemical, organic or microbial fertilizer has its advantages and disadvantages in terms of nutrient supply, soil quality and crop growth and yield (Chen *et al.* (2008) [1].

The effectiveness of biofertilizers also depends on physico-chemical condition of soil which can be improved with the use of organic sources of nutrients. Due to its local availability, easiness in its preparation, FYM is most popular compost nowadays. Apart from improving the nutrient availability and physical condition of soil, application of FYM will also affect the microbial activity particularly of PSB and VAM. In the present circumstances where the farmers do not prefer to apply chemical fertilizer, it is an easy option to focus on locally available sources of nutrients. Currently, a real challenge of agricultural researchers is to reduce the use of expensive chemical fertilizers, which negatively affect the environment as well as human health. Chemical fertilizers are commonly used to replenish soil N, in large quantities but these are costly and contaminate environment severely. Similarly, phosphorus solubilizing bacteria (PSB) plays an important role in supplementing phosphorus to the plants. Since no study has been carried out for determining the performance of chemical fertilizers, composts prepared by different methods and their effects along with biofertilizer like *Rhizobium* and PSB on green gram. Jahish (2016) [5] reported that the application of @ 60 kg P_2O_5 ha^{-1} significantly enhanced growth parameters of mungbean. The maximum plant height 16.49, 41.22 and 51.31 cm was recorded at 30, 60 DAS and at harvest, respectively. Similarly, Hamim (2016) reported that the different potassium levels effected plant height significantly at all the growth stages. Application of 80 kg K_2O ha^{-1} gave the maximum plant height of 27.3, 50.7 and 53.7 cm at 30, 60 and 90 DAS, respectively. Prajapat (2010) [13] observed that the application of increasing levels of sulphur up to 30 kg ha^{-1} significantly increased the plant height of both the components crops (mungbean and sesame) at different growth stages.

Materials and Methods

The field experiment was conducted at Research Farm of Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan during spring and summer season of 2017. The Experiment was consisting four main-plots treatments [No nutrient (Control), 30:60:40 kg N: P: K ha^{-1} (RDF 1.0), 10 tonnes FYM ha^{-1} (FYM1.0) and 15:30:20 kg N:P:K + 5 tonnes FYM ha^{-1} (RDF0.5+FYM 0.5)] and four sub-plots treatment [No biofertilizers (No BF), *Rhizobium* (Rhi), Phosphate solubilizing bacteria and vesicular arbuscular mycorrhiza (PSB + VAM) and *Rhizobium* + Phosphate solubilizing bacteria + Vesicular arbuscular Mycorrhiza (Rhi + PSB + VAM)]. The whole set of treatments replicated three times and the total number of plots were 48. The treatments were randomly allocated to different plot. The size of each plot was 4m x 4m and seed were sown in row at 30cm apart and plant to plant spacing was maintain at 10 cm. Mungbean SML 668 variety was selected for sowing. In order to determine the physical and chemical properties of the experimental soil, the soil samples were collected randomly from whole field at 0 –15 cm depth. The samples of all the places were mixed together to form composite sample for mechanical and chemical analysis.

The collected soil sample was air-dried, ground and passed through 2mm sieve and analyzed for important physical and chemical parameters. The soil of the experimental field was sandy clay loam, well drained, and deep red grey in color. It belongs to the Desert and Oasis Agro-ecological Zone. The soil organic carbon content was 0.8% in available N (170 kg N ha^{-1}) available P (22.4 kg P2O2 ha^{-1}) available K (142.5 kg K2O ha^{-1}) and neutral to slight alkaline in reaching (pH 8.3).

Plant growth is the pre-requisite for knowing the effect of any factor on seed productivity. As growth characters are highly correlated with seed productivity, it is essential to know the trends of crop growth through growth analysis using simple primary data. Therefore, the plant growth parameters such as plant height, dry weight, leaf area, number of leaves per plant, number of branches per plant and root parameters like root length, dry weight and root nodules were studied to investigate plant growth processes.

Results and Discussion

Growth parameters

Plant height: Plant height of mungbean significantly affected by nutrient sources and biofertilizers at all the stages of growth except it was non-significant at 25 DAS due to nutrient sources and at 75 DAS duo to biofertilizers. The interaction effect of nutrient sources and Biofertilizer were also found significant for plant height at harvest stages only (Table 1 & 2). Among different nutrient sources significantly higher plant height was recorded from RDF 0.5 + FYM 5t ha^{-1} over control at all stages except 25 DAS. Biofertilizers Plant height was increased significantly due to application of *Rhizobium*+ PSB+VAM at 25, 50 and at harvest stages. The increase in plant height of peas was also observed by Bhattarai *et al*. (2003) with the application of full recommended nutrient + 5 tonnes per hectare poultry manure similar findings in mungbean were also observed by Mathur *et al*. (2007) due in application of 10+20 and 20+40 kg N + P2O5 ha^{-1}. The maximum plant height was also recorded by Chaudhary (2010) and Peter and satish (2015) [12] with the application biofertilizer. Naveen and Mavada (2012) [10] observed greater plant height with the application of nutrient sources with biofertilizers. Singh (2014), Tyagi *et al*. (2014) [16], Zaman (2010) [19] and Ismael *et al*. (2015) [4] also recorded similar findings.

Table 1: Effect of nutrient sources and biofertilizers on growth parameters and yield of mungbean

Treatment	Plant height (cm)			Trifoliate leaves plant $^{-1}$		Number of branches plant^{-1}		Leaf area (cm^2 plant^{-1})		Dry matter (g plant^{-1})		Root length (g plant^{-1})				Effective nodules plant^{-1}	Root dry weight	Seed yield (t ha^{-1})
	50 DAS	75 DAS	At harvest	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	50 DAS	75 DAS	
Sources of nutrients																		
Control	14.52	27.92	39.52	4.7	17.0	1.85	4.38	241.9	2048.3	3.19	24.95	8.8	19.9	3.3	4.8	0.28	1.61	0.97
RDF 1.0	18.08	38.12	46.89	8.5	23.9	3.02	5.78	711.1	2803.5	4.34	36.74	14.1	23.8	6.5	11.1	0.28	2.28	1.79
FYM 1.0	17.36	37.59	45.56	8.9	22.5	2.92	5.86	682.2	2564.8	4.03	31.83	13.4	22.0	5.9	10.6	0.28	1.81	1.61
RDF 0.5 + FYM 0.5	18.6	38.33	48.06	9.5	26.5	2.84	6.01	770.1	3030.3	4.52	36.88	13.8	22.8	7.7	11.0	0.25	1.96	2.04
SEm±	0.49	1.11	0.8	0.6	1.7	0.28	0.18	65.5	101.7	0.46	2.16	0.5	0.4	0.4	0.9	0.02	0.16	0.06
CD (P=0.05)	1.73	3.91	2.82	2.2	6.0	N/A	0.63	231.1	358.7	NS	7.61	1.7	1.6	1.3	3.2	0.07	0.54	0.22
Biofertilizer																		
Rhi	17.23	37.03	45.30	8.5	22.9	2.68	5.53	680.5	2674.3	3.95	32.21	13.4	22.4	7.2	13.7	0.27	1.96	1.67

Rhi + PSB+ VAM	18.12	39.15	46.3	8.8	24.8	3.33	6.00	743.2	2933.3	5.12	37.16	14.4	24.2	8.0	12.9	0.28	2.29	1.84
PSB+VAM	17.28	36.61	44.2	7.9	22.0	2.59	5.56	613.3	2602.6	4.33	33.67	12.0	21.9	6.6	9.1	0.29	1.88	1.63
No BF	15.9	29.16	44.1	6.4	20.2	2.02	4.93	368.3	2236.8	2.68	27.36	10.2	20.0	1.6	1.8	0.24	1.53	1.27
SEm ±	0.16	0.98	0.3	0.2	0.7	0.13	0.23	27.9	52.1	0.26	1.28	0.5	0.5	0.4	1.0	0.03	0.19	0.03
CD (P=0.05)	0.48	2.87	1.1	0.5	1.9	0.38	0.68	82.0	152.9	0.75	3.76	1.4	1.4	1.1	2.9	0.08	0.54	0.09

Table 2: Interaction effect of nutrient sources and biofertilizers on growth parameters and yield of mungbean

Treatment		Plant height cm	Trifoliate leaves plant	Leaf area (cm^2 $plant^{-1}$)	Dry matter g $plant^{-1}$	Root length (cm)	Seed yield ($t\ ha^{-1}$)
		At harvest	50 DAS	50 DAS	At harvest	50 DAS	
Main plot	Sub plot						
Control	Rhi	39.4	5.1	269.1	39.4	8.83	0.97
	Rhi+PSB+VAM	41.2	4.7	252.53	41.2	9.00	1.03
	PSB+VAM	39.3	4.7	256.16	39.3	9.73	1.00
	No BF	38.1	4.3	189.83	38.1	7.77	0.87
RDF 1.0	Rhi	48.1	9.3	833.7	48.1	15.40	1.97
	Rhi+PSB+VAM	47.8	10.0	911.03	47.8	16.83	2.17
	PSB+VAM	47.5	8.0	700.77	47.5	14.53	1.76
	No BF	44.2	6.6	398.7	44.2	9.50	1.37
FYM 1.0	Rhi	45.1	8.9	709.43	45.1	14.07	1.57
	Rhi+PSB+VAM	47	9.7	836.73	47	15.33	1.77
	PSB+VAM	43.6	9.2	740.37	43.6	14.33	1.63
	No BF	46.6	7.8	442.16	46.6	9.73	1.47
RDF0.5 + FYM0.5	Rhi	48.7	10.8	909.56	48.7	15.40	2.23
	Rhi+PSB+VAM	49.4	10.8	972.5	49.4	16.60	2.23
	PSB+VAM	46.6	9.7	755.7	46.6	9.50	2.13
	No BF	47.6	6.8	442.47	47.6	13.77	1.37
SEm± for comparing biofertilizers at same level of nutrient		1.6	1.2	131.01	1.6	0.9	0.12
SEm± for comparing nutrients at same level Biofertilizer		1	0.7	81.41	1	0.9	0.08
CD (P=0.05) for comparing biofertilizers at same level of nutrient		2.6	3.3	185.3	2.6	2.9	0.22
CD (P=0.05) for comparing nutrients at same level Biofertilizer		3.4	2.4	270.2	3.4	2.9	0.27

Trifoliate Leaves: Number of trifoliate leaves of mungbean significantly affected by nutrient sources and biofertilizers at 50, 75 DAS and at harvest stages (Table 1 & 2). The interaction effect of nutrient sources and biofertilizers were also found significant (Table 1 & 2). Significantly higher trifoliate leaves were recorded from RDF0.5 + FYM 5 t ha^{-1} followed by RDF and FYM @ 10 t ha^{-1} over control at 50 and 75 DAS. Maximum number of trifoliate leaves were recorded from *Rhizobium*+ PSB+VAM followed by PSB+VAM and *Rhizobium* over control at all stages. Largest number of leaves, leaf area and petiole length was recorded due to application of poultry manure with biofertilizer by Zaman (2010) [19], 200% NPK with seed inoculation by Ismael *et al.* (2015) [4] organic manure 10 t ha^{-1} + 50% recommended dose of NPK fertilizer + biofertilizer by Jawhara *et al.* (2016) [6], and application of 100% RDF + vermicompost @ 1.0 t ha^{-1} + *Rhizobium* by Tyagi *et al.* (2014) [16].

Number of branches: Number branch of mungbean significantly affected by nutrient sources and biofertilizers at all growth stages except it was non-significant at 50 DAS due to nutrient sources. The interaction effect of nutrient sources and biofertilizer were found non-significant for number of branches at all stages. Among different nutrient sources relatively higher branches (3.02) were recorded from RDF followed by FYM 10 t ha^{-1} and RDF0.5 + FYM 5 t ha^{-1} at 25 DAS. Significantly higher number of branches were recorded from RDF0.5 + FYM 5 t ha^{-1} followed by FYM @ 10 t ha^{-1} and RDF over control at 75 DAS stage. No significant difference was found between remaining treatments over control at 75 DAS stage. Among different biofertilizers significantly maximum branches were recorded from *Rhizobium*+PSB+VAM followed by *Rhizobium* and PSB+VAM over no BF at 50 DAS. At 75 DAS stage number of branches from *Rhizobium*+PSB+VAM was significantly higher over all other treatments and PSB+VAM at par with *Rhizobium* gave significantly higher number of branches than no BF (Table 1 & 2). Zaman (2010) [19], Ibrahim *et al.* (2015) [3], (Jawhara and Owied, 2016) [6], opined that the use of organic manure and inorganic fertilizers individually or in integration significantly influenced number of branches per plant.

Leaf area: Leaf area of mungbean significantly affected by nutrient sources and biofertilizers at all the stages of growth (Table 1 & 2). The interaction effect of nutrient sources and biofertilizers were also found significant for leaf area at 50 DAS stage only. Among different nutrient sources significantly higher leaf area was recorded from FYM 10 t ha^{-1} followed by RDF0.5+FYM 5 t ha^{-1} over control and RDF was found at par with control at 25 DAS. However, significantly higher leaf area was recorded from RDF0.5+FYM 5 t ha^{-1} over control at 50 DAS and over control and FYM 10 t ha^{-1} at 75 DAS stage. Among different biofertilizers significantly higher leaf area was recorded from *Rhizobium*+PSB+VAM followed by *Rhizobium* and PSB+VAM over control at all stages. No significant difference was found between *Rhizobium* and PSB+VAM and *Rhizobium*+ PSB+VAM at 25 DAS. However, at 50 and 75 DAS highest leaf area were recorded from *Rhizobium*+PSB+VAM, which was at par with *Rhizobium* and significantly superior over PSB+VAM and control. At 50 DAS, the highest leaf area was found due to interaction effect of Rhi+PSB+VAM in combination with RDF0.5+ FYM 5 t ha^{-1}, which was significantly higher over no inoculation and

PSB+VAM and at par with *Rhizobium* at the same level of source of nutrients.

Dry matter: Higher dry matter accumulation was recorded from RDF0.5 + FYM 5t ha^{-1} followed by RDF and FYM 10 t ha^{-1} over control (Table 1 & 2). Significantly higher dry matter accumulation was recorded at 50 and 75 DAS stages from *Rhizobium*+PSB+VAM followed by PSB+VAM and *Rhizobium* over control. Highest values of dry matter accommodation was also obtained by use of organic manure 10 t ha^{-1}+50% RDF + biofertilizer (Jawhara and Owied, 2016) [6], 100% RDF + vermicompost @ 1.0 t ha^{-1} + *Rhizobium* Tyagi *et al*. (2014) [16], 30:70:00 kg NPK ha^{-1} More *et al*. (2008) [9], and use of poultry manure@ 20 tones ha^{-1} with biofertilizer (Zaman, 2010) [19].

Root parameter

Root parameters of mungbean significantly affected by nutrient sources and biofertilizers at 50 and 75 DAS stages of growth (Table 1 & 2). The interaction effect of nutrient sources and biofertilizer were also found significant for root length at 50 DAS stage. Significantly longer roots were recorded from RDF followed by RDF0.5 + FYM 5 t ha^{-1} and FYM 10 t ha^{-1} at 50 and 75 DAS stages. Among different biofertilizer significantly longer root length was recorded from *Rhizobium*+PSB+VAM followed by PSB+VAM and *Rhizobium* over control at 25, 50 DAS stages. Hamim (2016) reported that the potassium application significantly increased the root length over control at all growth stages. Maximum root length of 19.4 and 26.7 cm was recorded with application of 80 kg K_2O ha^{-1} at 60 and 90 DAS. Biofertilizer (*Azotobactor spp*) treatment showed significant increase in root length (Peter and satish 2015) [12]. Walpola and Yoon (2013) [13] found higher root length from the plants inoculated with *P. agglomerans* and *B. anthina*.

Significantly higher root dry weight was recorded from RDF followed by RDF0.5 + FYM 5 t ha^{-1} and FYM 10 t ha^{-1} over control at all stages except at 75 DAS. However, significantly higher root dry weight was recorded from *Rhizobium* +PSB+VAM followed by PSB+VAM and *Rhizobium* over control at 75 DAS stage. Walpola, and Yoon (2013) [13] observed more root dry weight from the plants inoculated with *P. agglomerans* and *B. anthina* and amended with TCP. Zaman (2010) [19] found that the poultry manure @ 20-ton ha^{-1} with biofertilizer ranked first in respect of promoting root dry weight.

Maximum total number of root nodules (7.7) were recorded from RDF0.5 + FYM 5 t ha^{-1} followed by RDF and FYM @ 10 t ha^{-1} and 75 DAS and from *Rhizobium*+PSB+VAM followed by *Rhizobium* and PSB+VAM over control at 50 DAS stage. The study of Naveen and Mavada (2012) [10] revealed that the 100% RDN through vermicompost applied with and without biofertilizers significantly increase root nodules plant^{-1} as compared to control. Kausale *et al.* (2007) [8] obtained significantly highest number of root nodules at 30, 45, 60, 90 DAS and at harvest with the application of 25 kg N ha^{-1} and 50 kg P ha^{-1}.

Yield

Seed yield tone per hectare of mungbean significantly affected by nutrient sources and biofertilizers at different treatment (Table 1 & 2). Interaction effect of the nutrient sources and biofertilizer treatments on Seed yield tone per hectare was also observed to be significant (Table 1 & 2). Zaman (2010) [19] also observed that the poultry manure induced significant effect to cause variation in seed yield and harvest index. Biological yield was maximum where poultry manure@ 10 tonne ha^{-1} was applied with biofertilizers. The enhanced seed and stover yield due to different nutrients application may be attributed to the activation of metabolic processes, where role in faster cell division and cell elongation with enhanced assimilation rates is well known. The stimulation effects nutrients sources and biofertilizers on growth and yield attributes and enhanced nitrogen activity in plant which in turn reflected positively on economic yield of the crop**.** The improved fertility status of the plots, which received RDF0.5 + FYM 5 t ha^{-1} with *Rhizobium*+ PSB+VAM might have improved the plant growth and yield attributes it gave 2.33 t ha^{-1}. The results are in close conformity with the findings of Verma *et al.* (2017) [17], Choudhary (2010) [2], Naveen and Mavada (2012) [10] and Sardar *et al.* (2007) [14].

Conclusion

Based on the above findings it can be concluded that for better growth application of 15:30:20 kg N: P: K ha^{-1} through fertilizers+ 5 t FYM ha^{-1} found best among sources of nutrients. Among biofertilizers, application of *Rhizobium* + PSB + VAM performed best with respect to growth and yield. The highest growth, and yield can be obtained with the application of 15:30:20 kg N: P: K ha^{-1}+ 5t FYM ha^{-1} along with *Rhizobium* + PSB + VAM in the Kandahar province of Afghanistan.

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