INTERNATIONAL RESEARCH JOURNAL OF HUMANITIES AND INTERDISCIPLINARY STUDIES
(Peer-reviewed, Refereed, Indexed & Open Access Journal)
DOI : 03.2021-11278686 ISSN : 2582-8568 IMPACT FACTOR : 5.71 (SJIF 2021)

Impact of graded levels of fertility and biofertilizers on yield attributes and yields of mungbean [*Vigna radiata* (L.) Wilczek]

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DOI No. 03.2021-11278686 **DOI Link ::** https://doi-ds.org/doilink/06.2021-45656839/IRJHIS2106036

Abstract:
Mungbean is an important dietary protein source among the pulses. It is an extraordinary source of vitamin C and antioxidants when used in sprouted form. But this crop is generally grown on marginally fertile lands which results in low productivity, poor quality and less remuneration. Therefore, the present study was intended to find out the ways and means to solve the nutrient management issues with an integrated approach to improve the yield, quality and net returns of mungbean crop. The field experiment was conducted on clay loam soil taking four levels of fertility [75% Recommended Dose of Fertilizers (RDF), 75% RDF+ Vermicompost (VC) @ 2 t ha^{-1}, 100% RDF and 100% RDF+VC @ 2 t ha^{-1}) and four levels of biofertiliizers (control, Rhizobium, Phosphate Solubilizing Bacteria (PSB) and Rhizobium + PSB). These treatments were evaluated in factorial randomized block design with three replications taking mungbean as test crop. The application of fertility level significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, seed and haulm yield and net returns up to 75% RDF+VC @ 2 t ha^{-1}. Seed inoculation with Rhizobium + PSB significantly increased the dry matter accumulation, number of pods per plant, number of seeds per pod, seed yield and net returns. The interactive effect of fertility levels and biofertilizers significantly influenced the seed and haulm yield and net returns and maximum reported with the application of 100% RDF+VC @ 2 t ha^{-1} and Rhizobium + PSB combination, which was at par with75% RDF+VC @ 2 t ha^{-1} and Rhizobium + PSB combination.
Keywords: *Mungbean, yield, quality, net returns, graded levels of fertility, Vermicompost, Rhizobium, PSB.*

INTRODUCTION:

Mungbean [*Vigna radiata* (L.) Wilczek] commonly known as greengram, is one of the important *kharif* pulse crop. It ranks third after chickpea and pigeonpea among the pulses grown in India. It is quite versatile crop grown for seeds, green manure and forage; as mixed or sole crop either on residual moisture of the previous crop or as a catch crop to make use of the land left fallow between two main season crops. It makes a good manure if incorporated into soil. Further, it enriches the soil by atmospheric nitrogen fixation through root nodules. The crop gives heavy vegetative growth and covers the ground so well that it checks the soil erosion in problem areas and can later be ploughed down for green manure. It has massive assurance as a substitute pulse crop in dry land farming. This crop is of great importance because of availability of short duration (65-70 days), high yielding and quick growing varieties.

In India, mungbean is grown on 40.57 lakh hectare area with a production of 20.09 lakh tons and average productivity of 471.93 kg ha^{-1}. The major mungbean growing States of the country are Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Odisha. Rajasthan ranks first in both area (17.21 lakh ha; 40.43%) and production (7.47 tons; 37.18%) in India with an average productivity of 434.05 kg ha^{-1} (GOI, 2018).

Mungbean is cultivated in arid and semi-arid districts of Rajasthan namely Sikar, Jhunjhunu, Nagpur, Jaipur, Ajmer, Pali, Churu, Bhilwara, Rajsamand, Udaipur, Jodhpur *etc.* Although mungbean is a legume and capable of fixing atmospheric nitrogen, still it responds to small quantity of nitrogenous fertilizers applied as starter dose. In terms of significance, phosphorus is most indispensable mineral nutrient for pulse crops as it helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation. Phosphorus is an essential constituent of nucleic acids such as ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), adenosine diphosphate (ADP) and adenosine triphosphate (ATP), nucleoproteins, amino acids, proteins, phosphatides, phytin, several co-enzymes *viz.* thiamine, pyrophosphate and pyrodoxyl phosphate.

Biofertilizers, a component of integrated nutrient management are considered to be cost effective, eco-friendly and renewable source of non-bulky, plant nutrient supplementing component in sustainable agriculture. Their role assumes a special significance in present context of very high costs of chemical fertilizers.

Use of biofertilizers can have a greater importance in increasing fertilizer use efficiency. Indian soils are of low to medium status for available nitrogen and available phosphorus. The seed of pulses is inoculated with *Rhizobium* with an objective of increasing their number in the rhizosphere, so that there is substantial increase in the microbiologically fixed nitrogen for the plant growth. The alliance of *Rhizobium* and pulse crops enables in enhancing fertility of soil and is a worth effective approach of nitrogen fertilization in legumes.

Most of the soils of Rajasthan are low in available phosphorus and organic matter. Seeds of pulses when inoculated with phosphate solubilizing bacteria they secret acidic substances and solubilize the unavailable soil phosphorus. The inoculation with phosphate solubilizing bacteria may increase yield of crops by 10-30 per cent (Tilak and Annapurna, 1993). Therefore, there may be a substantial saving of applied nitrogen and phosphorus when seeds are inoculated with *Rhizobium* and phosphate solubilizing bacteria inoculants.

Vermicompost is ecofriendly, cost effective and an effective way to recycle agricultural and kitchen waste. Vermicompost is a recent innovation in composting technology. Among the organic manures, vermicompost is found significantly superior over other manures (Chandra *et al*. 2012). It is a mixture of earthworm's castings, organic material, humus and other organisms. Agricultural residues, animal wastes, dairy and poultry wastes, food industry wastes, biogas sludge can all be recycled to give vermicompost. In recent years, use of vermicompost has been advocated in integrated nutrient management system in field crops (Shroff and Devathali, 1992). In Rajasthan, large quantities of crop residues are left after the harvest of wheat, sorghum, maize, cotton *etc.* where vermicomposting may be efficiently used. Looking towards the above facts, an experiment was undertaken to study the impact of graded levels of fertility and biofertilizers on yield attributes and yield of mungbean.

MATERIALS AND METHODS:

A field experiment was conducted at Agronomy Farm in Field No. D-5, Rajasthan College of Agriculture, Udaipur, (Rajasthan) which is situated at Southern part of Rajasthan at an altitude of 582.17 metre above mean sea level and at 24º35′ N latitude and 73º42′ E longitude to study the impact of graded levels of fertility and biofertilizers on yield attribute and yield of mungbean. The experiment was conducted during *kharif,* 2014 on clay loam soil. The experiment was laid out according to factorial randomized block design with three replications. The experiment comprised with four fertility levels (75% RDF, 75% RDF+VC @ 2 t ha^{-1}, 100% RDF and 100% RDF+VC @ 2 t ha^{-1}) and four biofertiliizers levels (control, *Rhizobium*, PSB and *Rhizobium* + PSB) which were applied to the mungbean var. SML-668. The RDF (recommended dose of fertilizers) was 20 kg N and 40 kg P_2O_5 per hectare. The soil of the experimental site was clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and DTPA extractable micronutrients sufficiently above the critical limits. The nutrients were applied through urea and DAP as basal dose and whole amount of vermicompost as per treatment was broadcasted uniformly at the time of sowing and incorporated in the soil.The required seeds were treated with Bavistin @ 2 g/kg of seed to control seed borne diseases. Later on seeds were inoculated with *Rhizobium* and PSB culture or both as per treatments, using standard method and dried in shade.

The dry matter accumulation at 45 days after sowing whereas number of pods per plant, number of seeds per pod, seed and haulm yield recorded at harvest of the crop. The economics of treatments is the most important consideration making any recommendation to the farmers for its wide adoption. For calculation of economics, the average treatment yield along with prevailing market rates for inputs and outputs were used. Hence, to evaluate the effectiveness and profitability of the treatments comprehensive economics including net returns and B/C ratio was calculated so that most effective and remunerative treatment could be recommended (Aswal and Yadav, 2007).

In order to test the significance of variation in experimental data obtained for various treatment effects, the data were statistically analyzed as described by Fisher (1950). The critical differences were calculated to assess the significance of treatment mean wherever the 'F' test was found significant at 5 per cent level of probability.

RESULTS AND DISCUSSION:

Effect of graded levels of fertility:

Application of graded levels of fertility significantly enhanced the growth, yield attributes and protein content of green gram. The maximum dry matter accumulation at 45 days after sowing, number of pods/plant, number of seeds/pod and protein content in seeds were found under application of 100%RDF+VC @ 2t ha^{-1} which was at par with the 75% RDF+VC @ 2 t ha^{-1}. (Table 1). The similar trend was also observed for the seed yield, haulm yield, biological yield, net returns and B/C ratio (Table 2). The increase in test weight was found non-significant with the application of different fertility levels. The efficiency of inorganic fertilizer is much pronounced when it is combined with organic manures (vermicompost). The increased vegetative growth and the balanced C:N ratio might have increased the synthesis of carbohydrates, which ultimately promoted yield (Meena *et al.* 2020). As a result, almost all growth and yield attributes of crop resulted into significant improvement due to vermicompost and fertilizer in combination. The significant improvement in seed yield under the influence of combined application of fertilizer and vermicompost was largely a function of improved growth and the consequent increase in different yield attributes as mentioned above. The higher yield of mungbean might be due to enhanced vegetative growth in terms of dry matter and number of branches per plant provided more sites for the translocation of photosynthates and ultimately resulted in increased number of yield attributes. Vermicompost advanced the biophysical properties of soil which include delivery of almost all of the essential plant nutrients for boom and improvement of plant, for that reason balanced nutrients beneath beneficial surroundings might have helped in production of new tissues and improvement of new shoots. The beneficial effect of organic manures on yield attributes was probably due to enhanced supply of macro and micronutrients during entire growing season (Yadav *et al.* 2005). Vermicompost also functions as energy source for soil microflora, which bring about transformation of nutrients, held in the soil or applied by the fertilizers, in a form that may without problems be utilized by growing plants which can be beneficial for root development and crop yield. The release of organic acids during the process of decomposition also solublizes native P leading to increased P availability. The inherent P content of organic materials also enriches with P and through mineralization mode, P becomes available for crop growth (Pattanayak *et al.*, 2009). Similar results due to application of fertilizers and organic manures were also reported by Mathur *et al*. (2007), More *et al.* (2008) and Choudhary and Yadav (2011), Mehta *et al*. (2012), Das *et al*. (2013), Gajera *et al.* (2014), Meena *et al.*(2014) and Jaga and Sharma (2015).

Effect of biofertilizers:

Further, the data presented in Table 1 revealed that the seed treatment with either *Rhizobium* or PSB or both *Rhizobium* + PSB significantly improved the growth, yield attributes and quality of mungbean over control (No seed treatment). The maximum dry matter accumulation at 45 days after sowing, pods per plant, seeds per pod and protein content of seeds were found under seed treatment with both *Rhizobium* + PSB. Similarly, the seed yield, haulm yield, biological yield, net returns and B/C ratio also found maximum under seed treatment with both *Rhizobium* + PSB (Table 2). This is probably because of the fact that *Rhizobium* inoculation enhanced the root nodulation through better root improvement and more nutrient availability, resulting in vigorous plant development and dry matter accumulation which led to better flowering, fruiting and pod formation and in the long run there was beneficial effect on seed yield of mungbean. The results of this investigation are in close conformity with the findings of Mian *et al.* (2005), Balachandran *et al*. (2005), Bakthavathsalam and Deivanayaki (2007), Mehta *et al*. (2012) and Nyoki and Ndakidemi (2014).

In the present study, since the available P was medium, PSB might have helped in reducing P fixation by its effect and also solubilized the unavailable native phosphorus by phosphate solubilizing microorganisms through production of organic acids like glutamic, succinic, lactic, oxalic, malic, fumaric, tartaric, ketobutyric, propionic and formic acids. Some of these acids (hydroxy acids) may form chelates with cations such as Ca^{++} and Fe^{++}, resulting in effective solublization of phosphorus. In addition to phospohate solubilization, these microbes can mineralize organic phosphorus into a soluble form. These reactions take place in the rhizosphere and the microorganisms render more phosphorus into soil solution than is required for their own growth and metabolism, the surplus is thus available for plant to absorb. Such improvement under increased availability of P might have promoted metabolic processes in plants resulting in greater meristematic activities and apical growth, thereby improving effect leading to more uptake of nutrient and reflected in better growth and yield attributes viz., dry matter accumulation, pods per plant and seeds per pod. The increase in seed, haulm and biological yields was due to the cumulative effect of increased growth and yield attributes. The observed additive influence of *Rhizobium* + PSB is attributable to mutually beneficial a synergistic role played by each group of biofertilizers used. These results are supported from the findings reported by Khatkar *et al.* (2007) and Rathore *et al*. (2010). The findings of this investigation are also in line with these studies of Bansal (2009), Kumawat *et al*. (2013), Gajera *et al*. (2014), Meena *et al.* (2014), Tyagi *et al.* (2014) and Urmila *et al.* (2016).

Interactive effect of fertility levels and biofertilizers:

The interactive effect of fertility levels and seed treatment with biofertilizers on seed and haulm yield was found significant (Table 3). Maximum seed and haulm yield (1386.07 and 1850.80 kg ha^{-1}, respectively) was obtained under treatment combination F_4B_3, which was at par with the treatment combinations of F_2B_3. Minimum seed and haulm yield (814.50 and 1070.40 kg ha^{-1}) was obtained under treatment combination F_1B_0. The increase in seed and haulm yield might be due to the fact that fertility levels and biofertilizers had an additive effect and the experimental soil was medium in N and P, supplemented by fertility levels (RDF + vermicompost) and biofertilizers incorporation improved the overall physical and chemical condition of soil and increased water and nutrient retention in the root zone by reducing infiltration and percolation. Thus, improved the availability of both water and nutrients to plants for their better growth and development and ultimately increased these parameters of mungbean. These results are in the line with the findings of Sharma *et al.* (2006), Meena *et al.* (2014) and Verma *et al.* (2018).

CONCLUSION:

On the basis of results of this field experiment, it can be concluded that under agro climatic condition of zone IV-a (Sub-humid Southern Plain and Aravali Hills) of Rajasthan, application of 75% RDF+VC @ 2 t $ha^{-1}$with Rhizobium + PSB (F_2B_3), is the better option for realizing higher productivity, quality and net returns of mungbean.

ACKNOWLEDGEMENT:

The authors are grateful to Heads, Department of Soil and Water Engineering, Department of Agronomy and Department of SoilScience & Agricultural Chemistry, Maharana Pratap University of Agriculture and Technology, Udaipur - 313001 Rajasthan, India, for providing laboratory, instructional farm and instrumental facilities, respectively and thank also due to the Dean, Rajasthan College of Agriculture, Udaipur for providing necessary facilities during the course of investigation.

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Table1: Effect of fertility levels and biofertilizers on yield attributes and quality of mungbean

Treatments	Dry matter accumulation at 45 DAS	No. of pods plant^{-1}	No. of Seeds pod^{-1}	Test Weight (g)	Protein (%)
Fertility levels					
75%RDF	8.08	16.83	6.27	45.83	19.71
75% RDF+VC (2 t ha^{-1})	11.68	19.82	7.09	46.31	23.36
100%RDF	8.79	17.63	6.47	46.00	20.63
100%RDF+ VC (2 t ha^{-1})	11.83	20.09	7.11	46.35	24.08
SEm±	0.19	0.22	0.05	0.47	0.29
CD (P= 0.05)	0.55	0.62	0.15	NS	0.84
Biofertilizers					
Control	7.56	16.15	6.17	45.05	18.23
Rhizobium	10.60	19.23	6.85	46.52	22.89
PSB	10.40	18.99	6.84	46.33	22.79
Rhizobium + PSB	11.81	20.00	7.08	46.58	23.87
SEm±	0.19	0.22	0.05	0.47	0.29
CD (P= 0.05)	0.55	0.62	0.15	NS	0.84

Table 2: Effect of fertility levels and biofertilizers on yield and net returns of mungbean

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Net returns (₹ ha^{-1})	B/C Ratio
Fertility levels					
75%RDF	900.81	1111.15	2011.96	28424	1.61
75% RDF+VC (2 t ha^{-1})	1149.02	1502.95	2651.97	36661	1.76
100%RDF	992.49	1244.15	2236.64	32549	1.74
100%RDF+ VC (2 t ha^{-1})	1205.39	1546.15	2751.54	38837	1.80
SEm +	27.69	44.30	71.99	1422	0.04
CD (P= 0.05)	79.97	127.95	207.92	4108	0.12
Biofertilizers					
Control	900.05	1109.35	2009.40	25944	1.38
Rhizobium	1096.55	1400.75	2497.30	35882	1.88
PSB	1070.80	1359.55	2430.35	34543	1.81
Rhizobium + PSB	1180.30	1534.75	2715.05	40102	2.08
SEm +	27.69	44.30	71.99	1422	0.04
CD (P= 0.05)	79.97	127.95	207.92	4108	0.12

Table: 3 Interactive effect of fertility levels and biofertilizers on seed and haulm yield of mungbean

Treatments	F_1	F_2	F_3	F_4
		Seed yield		
B_0	814.50	957.21	851.67	976.82
B_1	924.25	1183.96	1028.42	1249.57
B_2	916.75	1144.46	1012.92	1209.07
B_3	947.75	1310.46	1076.92	1386.07
SEm±	55.38			
CD (P= 0.05)	159.94			
		Haulm yield		
B_0	1070.40	1117.00	1116.20	1133.80
B_1	1116.20	1585.20	1269.20	1632.40
B_2	1104.20	1522.00	1244.40	1567.60
B_3	1153.80	1787.60	1346.80	1850.80
SEm±	88.60			
CD (P= 0.05)	255.90			