Effect of different liquid biofertilizers and varying fertility levels on available N, P_2O_5, K_2O and S content after harvesting in soil

The experiment was conducted on farm of Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur (Raj.) to study the effect of different liquid biofertilizers and fertility levels on growth, yield and quality of cluster bean *(cymopsis tetragonoloba)*. The test crops were raised on field during july to november *kharif*-2018 and 2019. The experiment was laid out in factorial randomized block design (FRBD). The treatment details of experiment comprised with two factors (1) eight treatment of liquid biofertilizer : control-no biofertilizers (L_0), *Rhizobium* (L_1), PSB-phosphorus solubilizing bacteria (L_2), KMB-potassium solubilizing bacteria (L_3), SSB-sulphur solubilizing bacteria (L_4) , *Rhizobium* + PSB (L_5), *Rhizobium* + PSB+ KMB (L_6) and *Rhizobium* + PSB+ KMB + SSB (L_7) and (2) three treatment of fertility levels: 100 % recommended dose of fertilizers (F_1),75% RDF (F_2) and 50 % RDF (F_3) and total number of treatment were 24. The highest nutrient status observed in 100 % RDF (F1) with *Rhizobium* + PSB+ KMB + SSB (L_7).

Key words: biofertilizers, cluster bean, fertility levels

Introduction

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] or *Guar* is a drought tolerant legume of family Fabaceae (Leguminaseae). It is an important cash crop, grown in semi-arid and arid regions of Rajasthan, Haryana and Gujarat during rainy (*Kharif*) season. In Rajasthan, clusterbean is mainly grown in Bikaner, Nagaur, Jalore, Sikar, Jaisalmer, Jaipur, Jhunjhunu and Alwar districts. It is grown for different purposes since ancient time *viz.,* vegetables, green fodder, green manure and for production of grains. It is also cultivated for hay, silage and green manure (Grestaa *et. al.* 2013).

In sandy soils of semi-arid regions, drought stress and lack of nutrients (mainly nitrogen and phosphorus) are considered as the main production constraints. Therefore, guar is expected to fit very well in this region as an important drought tolerant cash crop and soil-building crop, with respect to available nitrogen through nitrogen fixation, to maintain soil fertility and sustainable productivity (Mohamed, 2011).

A crop nutrient management plan is a tool that can increase the efficiency of all the nutrient. Nitrogen promotes the vegetative growth and increase protein content in the crop. Phosphorus enhances the activity of rhizobia, increase the formation of root nodules, stimulates early root development, helps in fixing more atmospheric nitrogen and aids in grain formation when applied to legumes. It also improves the crop quality and resistance to disease. Potassium also plays a major role in the transport of water and nutrients for whole of the plant in the xylem. In general, sulphur is required for the synthesis of vitamins and promotes nodulation in legumes. Sulphur is known to play an inevitable and imperative role in sulphur containing amino acids i.e. cysteine, cystine and methionine, vitamin and protein synthesis. The need of nitrogen, phosphorus, potassium and sulphur are determined by the crop. Biofertilizers help in the maintenance or adjustment of plant nutrient supply to an optimum level for sustaining desired crop productivity and soil fertility (Anonymous, 2018).

Biofertilizers are the products containing one or more species of microorganisms which have the capacity to mobilize nutritionally important elements from non- usable to usable form through biological processes such as nitrogen fixation, phosphate solubilization, excretion of plant growth promoting substances or cellulose and lignin biodegradation in soil, compost and other environments. They are totally harmless, pollution free and low-cost renewable agricultural inputs. They play a significant role in improving nutrient availability in plants. They are recognised as a components of integrated plant nutrient supply system (Anonymous, 2020).

Liquid biofertilizers are liquid formulations have the dormant form of desirable micro-organisms and their nutrients together with the substances that encourage formation of resting spores or cysts for longer shelf life and tolerance to unfovourable conditions. The dormant form of reaching the soil, germinate to create the fresh batch of active cells. These cells developed and multiply by utilizing the carbon source in the soil or from root exudates. The merits of liquid biofertilizers over conventional carrier based biofertilizers are: longer shelf life (12- 24 months), high temperature tolerance, nil contamination chances, no loss of properties due to storage at high temperature up to 45° C, higher populations can be maintained more than 109 cells and stored up to 12 to 24 months, easy to handle by the farmers, higher export potential and dosages are ten times less than carrier-based inoculants and quality control protocols are quick and very easy. A lot of work done on carrier-based biofertilizers in the context of organic food production. In view of the advantages of liquid biofertilizers over carrier based formulations, research has now been started on the production and testing of liquid biofertilizers. Consequently, liquid biofertilizers are specifically formulated solution that contains beneficial micro-organism which improves nutrient uptake by converting it in soluble form, increase soil fertility, produces plant growth promoting substances and plant hormones thereby reduces chemical fertilizer usage up to 20-30% (Manohar, 2017)

Fungi, bacteria and cyanobacteria are the main source of bioferlizers. Fungi are non-green microorganisms; aside from making phosphorus available in the soil for plant uptake, they help to aggregate the soil structure. Cyanobacteria are symbiotically associated with Azolla and also known as blue-green algae. Species of blue green algae are Nostoc and Anabaena. Examples of fungal biofertilizers are Mycorrhiza, Fusarium species and Penicillum species. Examples of bacterial biofertilizers are Azotobacter, Azospirillum, Clostridium, Rhizobium, *etc*. A combination of biological and chemical sources of nitrogen are cheaper and impressive way of increasing production under limited resources (Ansari *et. al*. 2015).

Biofertlizers are applied as grain treatment or applied in the soil. Biofertilizers in lquid formulaton are easy to handle and applied @3-5 ml/kg grain just before sowing. Soil applied biofertiizers are mixed in compost or farm yard manure and kept it for over night and then incorporated in soil just before sowing. Now a days in addition to N, P and K fixing biofertilizer, liquid bifertilizers for sulphur, zinc and manganese are also available. These liquid biofertilizers are easy to handle and cost effective (Kumar *et. al.* 2017).

MATERIALS AND METHODS

The experiment was conducted at farm of Rajasthan Agricultural Research Institute (RARI), Durgapura, Jaipur (Raj.). The test crops were raised on field during *kharif*-2018 and *kharif*-2019 respectively. Geographically this place is situated at 75º47 East longitudes, at 26º51 North latitude and at altitude of 390 m above mean sea level in Jaipur district of Rajasthan. According to NARP, this region falls under Agro-climatic zone IIIa (Semi-arid eastern plain zone) of Rajasthan.

Soil samples were taken randomly from 15 cm depth from different spot of experimental field just before the layout of the experiment and a representative composite sample was prepared by mixing all these samples together .The composite soil sample was analysed for various physical and chemical constituents. The results of the mechanical, chemical and physical properties of the soil along with the methods used for determination are presented.

Table 1 Physico-chemical properties of experimental field

	Properties	Values		Methods of analysis and references
		2018	2019	
A.	**Mechanical analysis**			
(i)	Coarse sand (%)	20.3	19.9	International pipette method (Piper, 1950)
(ii)	Fine Sand (%)	59.4	59.6	-do-
(iii)	Silt (%)	11.4	11.6	-do-
(iv)	Clay (%)	8.9	8.9	-do-
(v)	Textural class	Loamy sand	Loamy sand	USDA Triangle (Soil survey Staff, 1975)
B.	**Physical analysis**			
(i)	Bulk density (Mg/m^3)	1.52	1.50	Core sampler method (Chopra and Kanwar, 1976)
(ii)	Particle density(Mg/m^3)	2.65	2.58	-do-

(iii)	Field capacity (%)	12.50	12.35	Pressure membrane apparatus (Richards, 1954)
(iv)	Permanent wilting point (%)	2.64	2.73	-do-
(v)	Porosity (%)	39.2	40.0	Method No. 40, USDA Hand Book No. 60 (Richards, 1954)
C.	**Chemical analysis**			
(i)	Organic carbon (%)	0.18	0.21	Rapid titration method (Walkley and Black's, 1947)
(ii)	Available N (kg/ha)	141.09	144.22	Alkaline permanganate method (Subbiah and Asija, 1956)
(iii)	Available P_2O_5 (kg/ha)	50.01	54.09	Olsen's method (Olsen *et al.,* 1954)
(iv)	Available K_2O (kg/ha)	127.88	130.84	Flame photometer method (Metson, 1956)
(v)	Available S (kg/ha)	20.88	22.09	Terbimetric method (Chesnin and Yien,1950)

The climate of this place is semi-arid characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5 $^{\circ}$C) and winter (4°C). The average rainfall of this region is between 500-700 mm per annum which is mostly received during July to September. The sporadic showers in winters are also common.

Result and discussion

Fertility levels: Data (Table 4.28) indicated that 100% RDF caused positive influence on the available N, P_2O_5, K_2O and S content (kg ha^{-1}) in soil after harvesting during individual years as well as in pooled mean. In the pooled mean, the increased with 100% RDF in available N, P_2O_5, K_2O and S content was 19.05, 18.32, 33.47 and 26.53 percent and 7.65, 6.08, 7.27, 8.39 percent over 50% and 75% RDF levels, respectively. Each level being significantly higher than the preceding level.

Table 4.28 Effect of different liquid biofertilizers and varying fertility levels on available N, P_2O_5, K_2O and S content after harvesting in soil

Treatments	Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)			Available S (kg/ha)		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Fertility levels												
100% RDF	156.79	157.58	157.18	56.96	61.98	59.47	152.07	155.80	153.94	26.61	27.67	27.14
75% RDF	145.45	146.57	146.01	53.78	58.33	56.06	141.74	145.29	143.51	24.63	25.45	25.04
50% RDF	129.63	134.41	132.02	48.16	52.37	50.26	113.11	117.57	115.34	20.95	21.96	21.45
SEm ±	3.45	3.36	2.41	0.31	0.30	0.22	1.50	1.53	1.07	0.25	0.28	0.19
CD (P = 0.05)	9.83	9.57	6.77	0.88	0.86	0.61	4.27	4.36	3.01	0.71	0.79	0.53
Liquid biofertilizers												
Control	132.22	135.55	133.89	51.03	55.55	53.29	128.00	131.44	129.72	22.90	23.79	23.35
Rhizobium	153.01	154.91	153.96	52.00	56.61	54.31	130.83	134.45	132.64	23.02	24.08	23.55
PSB	134.95	137.00	135.98	53.80	58.50	56.15	129.36	133.41	131.39	23.55	24.11	23.83
KMB	133.85	136.79	135.32	51.93	56.00	53.97	141.44	145.50	143.47	23.69	24.29	23.99
SSB	132.91	136.11	134.51	51.55	55.87	53.71	128.96	132.21	130.59	25.25	26.56	25.91
Rhizobium + PSB	154.23	155.97	155.10	54.00	58.97	56.49	133.22	137.79	135.51	23.99	24.68	24.34
Rhizobium + PSB+ KMB	154.91	156.00	155.46	54.50	59.17	56.84	145.55	150.11	147.83	24.00	24.90	24.45
Rhizobium + PSB+ KMB + SSB	155.55	157.17	156.36	54.93	59.81	57.37	147.76	151.51	149.64	26.09	27.77	26.93
SEm ±	5.64	5.49	3.93	0.50	0.49	0.35	2.45	2.50	1.75	0.41	0.45	0.31
CD (P = 0.05)	16.05	15.63	11.05	1.43	1.40	0.99	6.98	7.12	4.92	1.16	1.29	0.86
CV (%)	5.75	5.27	5.51	2.85	2.56	2.70	5.42	5.38	5.40	5.09	5.45	5.28

Liquid biofertilizers: It was apparent from the data (Table 4.28) that the application of different liquid biofertilizers significantly influenced the N, P_2O_5, K_2O and S content (kg ha^{-1}) in soil after harvest of cluster bean. The highest N, K_2O, P_2O_5 and S content (kg ha^{-1}) (16.78, 7.66, 15.36 and 15.33 percent) was recorded with *Rhizobium* + PSB + KMB + SSB in the pooled mean. The maximum nitrogen content recorded with the application of Rhizobium biofertilizer in L_6, L_5 *and* L_1 which were statistically at par with L_7 and significantly higher over rest of the treatments. Significant improvement in available N and P status in soil was also reported due to Rhizobium inoculation. The treatment L_7 recorded the highest available phosphorus content by the use of phosphorus biofertilizers but it was at par with L_6, L_5 and L_2. By the use of potassium bio-fertilizer the higher available potassium content found in L_6 and L_3 which were statistically at par with L_7 and significantly superior than rest of the treatments. The L_4 was recorded the second highest available sulphur content in soil which was significantly higher than rest of the treatments.

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