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Effect of different liquid biofertilizers and varying fertility levels on dry matter accumulation of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub

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Abstract
A field experiment was conducted at research farm, RARI, Durgapura during two consecutive *kharif* seasons 2018 and 2019 to study the Effect of different liquid biofertilizers and varying fertility levels on growth, yield and quality of cluster bean [*Cyamopsis tetragonoloba (L.) Tau*b]. The experiment consists of twenty four treatment combinations consisting of three fertility levels (100% RDF, 75% RDF and 50% RDF) and eight liquid biofertilizers combination (control, Rhizobium, PSB, KMB, SSB, Rhizobium+PSB, Rhizobium+ PSB+ KMB and Rhizobium+ PSB+ KMB+ SSB), thereby making twenty four treatment combinations were replicated three times in randomized block design. Result showed that application of 100% NPKS proved significantly superior over 75% RDF and 50% RDF with respect to all quality parameters (gum content and protein content). Significantly higher gum content and protein content in seed were obtained in the combination of 100% NPKS with application of Rhizobium + PSB + KMB+SSB.

Keywords: Biofertilizers, maize, nitrogen, phosphorus, potassium

Introduction
Cluster bean [*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, cluster bean 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 seeds. It is also cultivated for hay, silage and green manure (Grestaa *et al*. 2013) [2].

Raw mature clusterbean seeds contain 23% protein. 1.7% fat, 6% carbohydrate and traces of vitamins and minerals. Besides, guar pods are very good source of vitamin A, calcium, iron, phosphorus and ascorbic acid (Vijaylaxmi and Singh, 2011). It contains many important nutrients, phytochemicals such as saponin and flavonoids. It is well-known traditional plant used in folklore medicine.

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) [3].

A crop nutrient management plan is a tool that can increase the efficiency of all the nutrient. For example, (1) Nitrogen promotes the vegetative growth and increase protein content in the crop. (2) 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 seed formation when applied to legumes. It also improves the crop quality and resistance to disease. (3) Potassium also plays a major role in the transport of water and nutrients for whole of the plant in the xylem. (4) 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 helps in the maintenance or adjustment of plant nutrient supply to an optimum level for sustaining desired crop productivity and soil fertility (Anonymous, 2018) [1].

Material and Methods

The experiment was conducted on 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 experiment and a representative composite sample was prepared by mixing all these samples together. Dry matter accumulation was recorded at 30, 60 DAS and at harvest. For this, plants from one metre row length were uprooted randomly from sample rows of each plot. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70 °C till constant weight. The weight was recorded and expressed as average dry matter per metre row length.

Crop growth rate (CGR)

The CGR of a plant for a time 't' is defined as the increase in dry weight of plant material from a unit area per unit of time. It was calculated with following formula (Radford, 1967) from periodic dry matter recorded at different stages.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ (g/meter row length/day)}$$

Where

W_1 =Total dry weight of plant at time t_1

W_2 = Total dry weight of plant at time t_2

t_1 =Time at first observation

t_2 =Time at second observation

Net assimilation rate (NAR)

It is an increase in plant material per unit leaf area per unit time. The NAR is calculated by the following formula (Radford, 1967)

$$LAI = \frac{(W_2 - W_1)(\log L_2 - \log L_1)}{(t_2 - t_1)(L_2 - L_1)} \text{ (g/m}^2 \text{ leaf area/day)}$$

Effect of Fertility levels on dry matter accumulation

A perusal of data indicated that dry matter accumulation (g m^{-2}) increased significantly upto application of 100% RDF at all the growth stages during both years as well as in pooled data and represented an increase of 36.3 and 12.81 per cent at 30 DAS, 35.7 and 9.81 per cent at 60 DAS and 37.9 and 10.94 per cent at harvest over 50% RDF and 75% RDF on pooled basis.

Effect of Liquid biofertilizers on dry matter accumulation

A perusal of data revealed that various liquid biofertilizers had significant influence on the dry matter accumulation at all the stages during both the years and in pooled anlaysis. The pooled mean at 30, 60 DAS and at harvest indicated that *Rhizobium* + PSB + KMB + SSB accumulated significantly higher dry matter over all other liquid biofertilizer treatments which was at par with *Rhizobium* + PSB and *Rhizobium* + PSB + KMB. The increase in dry matter accumulation on pooled basis due to application of *Rhizobium* + PSB + KMB + SSB was 24.63, 10.35, 10.84, 14.75 and 17.88 per cent at 30 DAS, 24.99, 10.28, 12.03, 13.65 and 17.71 per cent at 60 DAS and 25.00, 9.10, 11.10, 13.88 and 17.19 per cent at harvest stage over control, *Rhizobium*, PSB, KMB and SSB, respectively.

Table 1: Effect of different liquid biofertilizers and varying fertility levels on dry matter at different stages of cluster bean

Treatments	Dry matter accumulation (g/m²)								
	30 DAS			60 DAS			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
Fertility levels									
100% RDF	26.04	26.26	26.15	77.17	80.11	78.64	91.88	94.06	92.97
75% RDF	23.12	23.23	23.18	70.23	72.93	71.58	81.99	85.61	83.80
50% RDF	19.07	19.32	19.19	57.32	58.61	57.96	66.99	67.89	67.44
SEm ±	0.35	0.38	0.26	1.24	1.33	0.91	1.39	1.54	1.04
CD (P = 0.05)	1.00	1.08	0.72	3.54	3.78	2.55	3.96	4.38	2.91
Liquid biofertilizers									
Control	20.05	20.15	20.10	59.89	61.59	60.74	69.99	72.00	71.00
Rhizobium	22.30	23.10	22.70	68.18	69.50	68.84	80.40	82.30	81.35
PSB	22.98	22.22	22.60	66.66	68.88	67.77	78.88	80.88	79.88
KMB	21.70	21.96	21.83	65.80	67.80	66.80	76.60	79.25	77.93
SSB	21.50	21.00	21.25	62.00	67.00	64.50	75.05	76.40	75.73
Rhizobium + PSB	23.97	24.90	24.44	74.00	76.09	75.05	86.91	89.55	88.23
Rhizobium + PSB+ KMB	24.50	25.00	24.75	74.55	76.55	75.55	87.00	89.77	88.39
Rhizobium + PSB+ KMB + SSB	24.95	25.15	25.05	74.86	76.98	75.92	87.48	90.01	88.75
SEm ±	0.57	0.62	0.42	2.03	2.17	1.48	2.27	2.51	1.69
CD (P = 0.05)	1.63	1.76	1.18	5.78	6.17	4.17	6.46	7.16	4.76
CV (%)	7.53	8.10	7.82	8.92	9.21	9.07	8.48	9.14	8.82

Discussion

the results revealed that application of varying fertility treatments had remarkable effect on all the dry matter accumulation at 30, 60 DAS and at harvest with the corresponding increase in fertility levels in both the years as well as in pooled. This increase was, by and large, statistically significant due to 100% RDF (20 kg N + 40 kg P_2O_5 + 20 kg k_2O + 20 kg S/ha) over 50% RDF (10 kg N + 20 kg P_2O_5 + 10 kg k_2O + 10 kg S/ha) and 75% RDF (15 kg N + 30 kg P_2O_5 + 15 kg k_2O + 15 kg S/ha). The significant increase in dry

matter accumulation might be due to increase in amount of growth substances and phytohormones with increased availability of nitrogen (Singh and Kumar. 2016) [5]. Perhaps the increase in growth promoting substances with higher amount of nitrogen brought about increase in the dry matter and biomass production. As nitrogen is one of the major and essential plant nutrients required for growth and development, the increased availability of nitrogen might have increased cell number and cell elongation resulting in better growth in terms of plant height and dry matter accumulation. Nitrogen hastens the rate of photosynthesis by increasing the supply of carbohydrates to the plant. Hence, dry matter accumulation increased. Increased availability of phosphorus owing to its application in soluble form to the soil which was otherwise low to medium in its P content might have led to significant improvement in the concentration and uptake of this nutrient which in turn helped in early root development and ramification, thereby leading to better growth in terms of dry matter accumulation.

Conclusion

On the basis of two-year experimentation, it may be concluded that fertility level of 100% RDF recorded highest dry matter accumulation which was closely followed by 75% RDF. Application of Rhizobium + PSB + KMB+SSB was found most suitable liquid biofertilizers combination. Therefore, the combination of 75% RDF (N:P:K:S-15:30:15:15) along with Rhizobium + PSB + KMB+SSB is recommended for higher cluster bean crop dry matter production in semi arid eastern plain zone (IIIa) of Rajasthan.

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