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Growth, Yield and Quality of Cluster Bean Varieties as Influenced by Organic Production System

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ABSTRACT

Background: Indiscriminate use of chemical fertilizers causes harmful impact on soil, environment and human being, hence demand of organic food products has shot up recently. Organic cultivation aims to optimization of crop productivity rather than its maximization through restoration and back up of ecological processes and functions of whole ecosystem. Limited varieties are available on long term performance of pulse crop varieties under organic farming system so far. Therefore, this experiment was conducted to investigate the growth and yield performance of cluster bean varieties under organic production system.

Methods: In this field-laboratory investigation during 2016-2020, eight varieties of cluster bean were studied under organic production system. Experiment was laid out in randomized block design with three replications. The recommended quantity of nutrients for cluster bean is 15:40:00 kg NPK ha^{-1} and manures were applied on nitrogen equivalent basis through organic sources. The observations on growth and yield parameters of cluster bean were recorded at the time of harvesting. Soil and plant samples were collected at time of harvesting and analyzed for available nutrients in soil and nutrient content in seed samples.

Result: Our investigation exhibited significant improvements in plant growth parameters, yield and yield attributes. The maximum plant height at harvest (123.53 cm), number of primary branches per plant (9.46), number of pods per plant (66.08), number of seeds per pod (8.66) with highest seed yield (1490.42 kg ha^{-1}) were exhibited by variety RGC-1038 followed by RGC-1055 (1365.11 kg ha^{-1}). Significant improvement in yield and yield attributes on the pooled basis were recorded in variety RGC-1038 followed by RGC-1055 and lowest seed yield (761.14 kg ha^{-1}) was found in the variety RGC-986. RGC-1038 variety recorded highest plant nutrient status as compared to other varieties. The maximum net returns (Rs.48403/-) and B:C ratio (3.09) were recorded with the variety RGC-1038. Among eight varieties of cluster bean RGC-1038 and RGC-1055 found promising for organic farming in terms of growth, seed yield, quality and net return aspects.

Key words: B:C ratio, Cluster bean, Growth, Net returns, Organic system, Varieties, Yield, Yield attribute.

INTRODUCTION

Cluster bean is known as Guar in Hindi. Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] belongs to family Leguminosae and is one of the most important cash crop grown primarily for its tender green pods and gum extraction in Arid and Semi-arid region of our country. Guar has been cultivating in India and Pakistan since ages as fodder crop, to enrich soil fertility and grains as pulse. The plant is highly drought resistant, being able to utilize efficiently all ground water. It grows therefore easily in semi arid regions where less hardy crops perish. In India it is being cultivated in area of 4255 lakh ha, with production 2415 lakh ton during 2015-16 (Meena *et al*., 2016). Among the different states of India it is mainly grown in Rajasthan, Haryana, Gujarat, Punjab and Uttar Pradesh. Rajasthan stands first with respect to area and production, occupying an area of 28.41 lakh ha and production of 12.85 lakh ton with productivity of 452 kg ha^{-1} during 2019-20 (Anonymous, 2019-20). The consumption outline of guar seeds is highly influenced by the demands from the petroleum industry. India accounts for 90 per cent of the world's guar produce, of which 72 per cent comes from Rajasthan. About 90 per cent of guar gum processed in India is exported in other countries *i.e*. USA, Germany, Russia, China and Norway. The country has exported 234,871.31 MT of guar gum to the world for the worth of Rs. 1949.07 Crores/ 262.99 USD Millions during the year 2020-21 (APEDA-2020-21). Guar has many functions for human and animal nutrition, but the gelling agents in its seeds (guar gum) are the most important use (Mudgil *et al.,* 2011). Demand is increasing due to the use of guar gum in hydraulic fracturing (oil shale gas). Guar gum is frequently used as food additive in many processed food (Li *et al.,* 2019). Guar gum supplements on serum lipid values, weigh management, post prandial glulose level, gastrointestinal health, immunity and guar gum as drug carrier (Lal *et al.,* 2021). Guar gum has a number of uses in food likewise

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acts as an appetizer, cooling agent, digestive aid, laxative, and is useful in dyspepsia and anorexia Anti-ulcer, anti-secretory, cytoprotective, hypoglycaemic, hypolipidemic and anti-hyperglycaemic effects (Mukhtar *et al.,* 2006). Abundant use of chemical fertilizers in agriculture has resulted in poor soil fertility and health of consumers. The nitrogenous fertilizers and pesticide residues have created water pollution leading to carcinogenic effect on human body and caused damage to the important organs. Application of chemical fertilizers leads to the loss of soil fertility due to imbalanced use of fertilizers which have adversely affected agricultural productivity and caused soil degradation (Wani and Lee, 1992). In this perspective, there is need to investigate suitable method of composting for agricultural solid waste management for agricultural use. Composting and vermin-composting are the recycling technologies which improve the quality of products (Jayasankar, 1994; Selvi, 1996). Addition of organic material to the soil such as FYM, vermin-compost, caster cakes *etc*. help in maintaining the soil fertility and productivity. These increases soil microbiological activities, plays key role in transformation recycling and availability of nutrients to the crop (Manivannan *et al.,* 2009). These also improve the physical properties like soil structure, porosity; reduce compaction and crusting, increases water holding capacity of soil. The availability of major and micronutrients from native source also increases with incorporation of organic matter which might be due to release of organic acid (Stevensons, 1982).

Moreover, soil organic matter in a particular soil is greatly influenced by vegetation, climate change, soil reaction and biological conditions (Meena and Sharma, 2016). Microbes are able to grow under harsh conditions and give some important understandings regarding their ability to increase under the ecological limitations of the environment (Shah *et al*., 2018). The different cultivars of cluster bean may respond differentially to organic production system under different agro-climatic situations. Therefore, an experiment was planned to examine performance of eight cultivars of cluster bean for yield and yield attributes under the organic production system in semi arid areas of Rajasthan (India).

MATERIALS AND METHODS

The experiment was carried out at ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer (Rajasthan) for 05 consecutive years during 2016 to 2020 to identify suitable cluster bean varieties under organic management system. Eight varieties (RGC-936, RGC-1001, RGC-1003, RGC-1038, RGC-986, RGC-1055, RGC-1066 and RGC-12-1) of cluster bean were tested under organic production management system. Soil of experimental site is sandy loam in nature and the experimental block was maintained as per the organic production requirements from 2011. Soil fertility status of experimental site is having organic carbon (0.26%), available nitrogen (130.4 kg ha^{-1}), available phosphorus (12.06 kg ha^{-1}) and available potassium (359.07 kg NPK ha^{-1}). The recommended dose of nutrients for cluster bean is 15:40:00 kg ha^{-1} and manures were applied on nitrogen equivalent basis through organic sources (50% by FYM, 25% by vermicompost and 25% by caster cake). Nitrogen content of farm yard, vermicompost and castor cake is 0.5 per cent, 1.0 per cent and 4.0 per cent, respectively. Experiment was laid out in randomized block design with three replications with plot size of 20 m^2. Seeds were sown during first week of July by maintaining spacing of 30 cm × 10 cm. with seed rate of 25 kg ha^{-1} after treating seeds with *Trichoderma virdae* at rate of 10 g kg^{-1}. Irrigation and intercultural operations carried out as per uniform standard practices. The observations on growth and yield parameters of cluster bean were recorded at the time of harvesting on 10 plants selected randomly. Soil and plant samples were collected at time of harvesting and analyzed for available nutrients in soil and nutrient content in seed samples. Data obtained were subjected to statistical analysis for F test as suggested by (Panse and Sukhatme, 1985).

Benefit cost ratio

Benefit cost ratio for each treatment was calculated to certain economic feasibility of the treatment using the following formula:

$$\text{B:C ratio} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

Harvest index

The harvest index was obtained by dividing the economic yield by total biological yield and expressed as percentage (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

RESULTS AND DISCUSSION

Growth attributes

Based on the analysis of data, significant variation was recorded among cluster bean varieties for the observed parameters under organic production system. The results revealed that the (Table 1) variety RGC-1038 showed significant influence on plant height at harvest (123.53 cm) followed by RGC-1066 and RGC-1055 and lowest plant height (111.54 cm) was recorded in the variety RGC-1001 among the tested varieties. The highest number of primary branches (9.46 plant^{-1}) were recorded in RGC-1038 followed by RGC-1055 (7.98 plant^{-1}) might be owing to fulfilment of nutrient requirement of the varieties at initial growth period leads to improved branching. Organic manures and bio-fertilizers influence the soil nutrient availability through better microbial activity and by releasing the nutrients from the soil, which helps in ample absorption and utilization of nutrients by the plants (Kaur, 2016). Vermicompost produced with earthworm digested organic waste are rich in NPK, micronutrients, beneficial soil microbes- nitrogen fixing and

phosphate solubilising bacteria and actinomycets. They are proving as excellent growth promoter and protector. Vermicompost also has a positive effect on vegetative growth, stimulating shoot and root development (Gopinathan and Prakash, 2015). The increase in growth parameters might be due to sufficient nutrients supply to plant continuously for various metabolic processes. Balanced and regular supply of nutrients increased the uptake of nutrients also which had possibly contributed to more vegetative growth as well as number of branches. Application of organic manures along with bio-inoculants increased germination and growth of roots and shoots. It might be probably due to their genetic characters of varieties and this variety was suited for better environmental condition. The similar results were also reported by Kumar *et al*. (2004); Gomaa and Mohamed (2007); Pawan *et al*. (2016) in cluster bean, Satish *et al*. (2017) in French bean and Sanjeev and Vishwas (2018) in cow pea.

Yield and yield attributes and Harvest index

Yield attributes like pods plant^{-1}, seeds pod^{-1}, seed yield plot^{-1} and seed yield ha^{-1} were recorded maximum with RGC-1038 followed by RGC-1055 in comparison to other varieties (Table 1). The increase in number of pods plant^{-1}, seeds pod^{-1} with the variety RGC-1038 may be attributed to higher seed yield as compared to other varieties. Moreover, the pods plant^{-1}, seeds pod^{-1} showed positive and significant correlation with seed yield. Superior yield attributing characters in variety RGC-1038 over other varieties was also recorded. Highest harvest index was also recorded with cultivar RGC-1038 followed by RGC-1066 which was *at par* with that of RGC-12-1, RGC-1055 and RGC-936 (Table 2). The differential behaviour among the cultivars could be explained solely by the variation in their genetic makeup and their counterproductive action under different climatic conditions. Good growth of the plant due to adequate supply of photosynthates for development of sink (Chavan *et al.,* 2015). Similar results were also reported by Garg *et al.* (2003), Kumar *et al*. (2004), Parihar *et al.* (2005) Gomaa and Mohamed (2007), Pawan *et al*. (2016) in cluster bean and Satish *et al*. (2017) in french bean.

Qualitative characters

The significant difference recorded in seed quality parameters such as nitrogen and protein percentage of all tested varieties under organic management system (Table 2).

Table 1: Performance of cluster bean varieties under organic management practices on growth and yield attributing characters and seed yield (Pooled of 2016 to 2020).

Varieties	Plant height (cm)	No. of primary branches plant^{-1}	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed yield (kg plot^{-1})	Seed yield (kg ha^{-1})
RGC-936	113.86	6.17	47.22	8.17	2.35	1172.44
RGC-1001	111.54	6.37	45.12	8.01	2.44	1221.56
RGC-1003	112.47	6.11	48.36	8.12	2.51	1255.14
RGC-1038	123.53	9.46	66.08	8.66	2.98	1490.42
RGC-986	135.60	5.34	36.16	7.93	1.52	761.14
RGC-1055	118.97	7.98	62.54	8.60	2.73	1365.11
RGC-1066	120.12	6.48	44.34	8.31	2.41	1202.72
RGC-12-1	119.43	5.96	48.29	8.11	2.41	1206.69
SEm±	0.58	0.58	0.58	0.24	0.16	77.86
CD (P≤0.05)	2.22	2.57	1.73	0.40	0.35	173.79
Y×T	2.15	2.15	2.15	NS	0.58	290.18

Table 2: Performance of cluster bean varieties under organic management practices on quality and quality attributing characters (Pooled of 2016 to 2020).

Varieties	Biomass yield (kg ha^{-1})	Harvest index	Nitrogen (%)	Protein (%)
RGC-936	3704.69	24.15	4.75	29.67
RGC-1001	4061.99	23.23	4.53	28.30
RGC-1003	4094.23	23.50	4.73	29.55
RGC-1038	4495.70	25.44	4.80	30.01
RGC-986	3630.76	17.35	4.66	29.10
RGC-1055	4275.41	24.70	4.81	30.06
RGC-1066	3526.99	25.39	4.65	29.05
RGC-12-1	3618.66	25.05	4.70	29.37
SEm±	191.76	0.58	0.58	0.58
CD (P≤0.05)	465.16	1.71	0.93	0.93
Y×T	714.65	2.15	2.15	2.15

The maximum nitrogen and protein percentage was found in variety RGC-1055 (4.81% and 30.06%) followed by RGC-1038 (4.80% and 30.01%) at par with RGC-936, RGC-1003 and RGC-12-1 and minimum was found in variety RGC-1001 (4.53% and 28.3%). It is prominent that RGC-1038 and RGC-1055 are the one of the top performing varieties of cluster bean in organic farming practices. Higher nutrient content in plant tissue favours the higher growth and yield characters. The higher nutrient accumulation at initial growth stages of crop with recommended nutrients is due to availability of nutrient along with faster dry matter accumulation. These results are in close conformity with Henri *et al.* (2008), Uma and Malathi (2009), Razvi *et al.* (2011) in common bean, Dhakal *et al*. (2016) and Wankhade *et al*. (2016) in cluster bean.

Effect of different varieties of cluster bean on soil properties

The soil organic carbon (SOC) and availability of major plant nutrients like available N, P and K in soil after completion of 05 years from all the plots were measured and presented (Table 3). The highest available N in soil was recorded in variety RGC-1003 and 1066 (168.93 kg ha^{-1}) followed by RGC-1038 (167.67 kg ha^{-1}) and the lowest in RGC-12-1 (154.29 kg ha^{-1}). Likewise highest available phosphors was recorded in the variety RGC-1038 (26.16 kg ha^{-1}) and the lowest in RGC-12-1 (23.29 kg ha^{-1}). However decrease in potash (K_2O) content was recorded over the period and maximum was recorded in RGC-986 (348.92 kg ha^{-1}) and the lowest in RGC-1066 (330.90 kg ha^{-1}). Monocropping without addition of fertilizers and organic manures resulted in reduced availability of K compared with the initial values.

This is most likely due to crop removal not being replaced by the addition of fertilizer K resulting in the reduction in soil extractable K and the mining of less available K pools or reserves (Sathish *et al*., 2016; Srinivasarao *et al*., 2007). The organic carbon status in soil was significantly improved over the period (from initial to final status) however; different varieties of cluster bean were not significantly performed under organic production system. Legumes are soil-amendment crops with strong benefits on soil health and need to be an essential element of the farming systems (Dhakal *et al.,* 2016). Legumes have positive effects on soil processes such as benefiting agro ecosystems, agricultural productivity, soil conservation, soil biology, SOC and N stocks, soil chemical and bodily properties, BNF, nitrous oxide (N_2O) emission and nitrate (NO_3) leaching by means of lowering the need for chemical fertilizers. Above all, legumes are now utilized as soil nourishment agents. However, these benefits on soil health need to be quantified, and their mechanisms understood. Thus, incorporating legumes as a section of cropping systems is pertinent to higher soil fitness and productivity (Hauggaard-Nielsen *et al.* 2007). Legume-based rotation induces modifications in the pH of the rhizosphere sector of soil. Root exudation of legumes and change or release of organic acids on the epidermal cell of root surfaces can

Table 3: Soil fertility status influenced by different varieties of cluster bean (initial and after 05 years).

Varieties	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			Organic carbon (%)		
	Initial (2016)	After *Rabi* crop harvest (2020)	Change (%)	Initial (2016)	After *Rabi* crop harvest (2020)	Change (%)	Initial (2016)	After *Rabi* crop harvest (2020)	Change (%)	Initial (2016)	After *Rabi* crop harvest (2020)	Change (%)
RGC-936	130.46	154.71	24.25	12.06	23.42	11.36	359.07	339.42	-19.65	0.26	0.34	0.08
RGC-1001	130.46	165.16	34.70	12.06	25.53	13.47	359.07	345.82	-13.25	0.26	0.33	0.07
RGC-1003	130.46	168.93	38.47	12.06	25.59	13.53	359.07	344.38	-14.69	0.26	0.32	0.06
RGC-1038	130.46	167.67	37.21	12.06	26.16	14.10	359.07	346.69	-12.38	0.26	0.34	0.08
RGC-986	130.46	165.58	35.12	12.06	24.96	12.90	359.07	348.92	-10.15	0.26	0.32	0.06
RGC-1055	130.46	156.80	26.34	12.06	23.99	11.93	359.07	335.70	-23.37	0.26	0.34	0.08
RGC-1066	130.46	168.93	38.47	12.06	24.99	12.93	359.07	330.90	-28.17	0.26	0.33	0.07
RGC-12-1	130.46	154.29	23.83	12.06	23.29	11.23	359.07	341.50	-17.57	0.26	0.32	0.06
CD (P≤0.05)	NS	8.12	2.26	NS	1.85	1.12	NS	11.57	2.12	NS	NS	0.051

Table 4: Economics of cluster bean varieties grown under organic production system (Pooled of 2016 to 2020).

Varieties	Cost of cultivation/ha	Gross return/ha	Net return/ha	B:C ratio
RGC-936	23165	56256	33091	2.43
RGC-1001	23165	58637	35472	2.53
RGC-1003	23165	60240	37075	2.60
RGC-1038	23165	71568	48403	3.09
RGC-986	23165	36528	13363	1.58
RGC-1055	23165	65520	42355	2.83
RGC-1066	23165	57744	34579	2.49
RGC-12-1	23165	57936	34771	2.50

also enhance P availability (Varma *et al.,* 2017); Lal, (2015).

Economic analysis

The net return and B:C ratio were higher in variety RGC 1038 over other varieties (Table 4). Similarly, the significant higher net returns were recorded on pooled basis Rs. 48403/- with B:C ratio (3.09) in RGC-1038 followed by RGC-1055 Rs. 42355/- with B:C ratio (2.83) which was significantly superior to rest of the varieties.

CONCLUSION

Based on the findings it could be concluded that among the cluster bean varieties tested, RGC-1038 and RGC-1055 found promising in term of growth, yield and yield attributes, quality and net return under organic production system. Selection of proper and responsive variety in any crop under organic production system plays a vital role. RGC-1038 and RGC-1055 are most suitable varieties under organic management system as these are responded to high yield level and produced more biomass which could be further recycled to produce compost. Application of 50 per cent FYM, 25 per cent vermin-compost and 25 per cent castor cake on nitrogen equivalent basis along with *Trichoderma virdae* and Phosphorus solubilising bacteria (PSB) as seed treatment is suffice the demand of cluster bean varieties for achieving quality seed yield.

Conflict of interest

All authors declared that there is no conflict of interest.

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