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Quality and economics of cowpea as influenced by genotypes, phosphorus levels and liquid based PSB

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Abstract
A field experiment was conducted to evaluate the quality and economics of cowpea genotypes to phosphorus levels and liquid based PSB during *kharif* 2019 under rainfed condition at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. Among the genotypes, the genotype DC-15 recorded significantly higher seed protein content, protein yield and B:C ratio (23.84%, 292.50 kg ha^{-1} and 2.11, respectively) over other genotypes. Whereas, the application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher seed protein content, protein yield and B:C ratio (23.81%, 320.54 kg ha^{-1} and 2.27, respectively) over other phosphorus levels. Among the interactions, DC-15 with the application of 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher seed protein content (25.10%) over the control and other treatments. The percent increase in seed protein was 17.95% over the control. Further, the genotype DC-15 with the application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher protein yield and B:C ratio (351.22 kg ha^{-1} and 2.47) over the control and other treatments.

Keywords: Cowpea genotypes, phosphorus levels, liquid based PSB, seed yield

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is protein rich food and the plant itself can be dried, stored until needed as fodder for livestock. As a nitrogen-fixing legume, cowpea improves soil fertility, and consequently helps to increase the yields of cereal crops when grown in rotation. Therefore, it is considered as a most versatile crop as it feeds people, their livestock and the next crop.

According to recent estimates, malnutrition contributes to more than one-third of all child deaths worldwide and nearly 54 per cent of deaths in developing countries (Bain *et al.*, 2013) [1]. This can be mainly a result of the consumption of high cereal-based meal, which is bulky, high energy and less nutritious. (Okoth *et al.*, 2017) [10]. Legumes along with cereals can be considered as main plant sources of energy and good quality proteins. Thus, cowpea has been promoted as a high-quality protein constituent of the daily diet among economically depressed communities in developing countries, with the aim of reducing the high prevalence of protein and energy malnutrition. (Santos and Boiteux, 2013) [15].

Cowpea is having approximately two- to four-fold greater total protein content than cereal and tuber crops. An average cowpea grain contains 23-32% protein, 50-60% carbohydrate and about 1% fat in dry basis (Jose *et al.*, 2014) [6]. Moreover, compared to cereal grains, cowpea protein is a rich source of the amino acid lysine and is used as a natural complimentary food with cereals. It is considered as an incredible source of many other health-promoting components, such as soluble and insoluble dietary fibre, phenolic compounds, minerals, and many other functional compounds, including B group vitamins (Liyanage *et al.*, 2014) [8]. Thus, cowpea contributes greatly toward improving the quality of human health by offering a number of health benefits. Next to nitrogen, phosphorus is regarded as the pioneer plant nutrient, since it enhances impact on plant growth and biological yield through energy storage and transfer in necessary metabolic processes. Phosphorus addition increased the efficiency of plants to photosynthesis, enhances the activity of rhizobia and increases the number of branches and pods per plant, consequently greater yield of pea, fababean (Lal *et al.* 2016) [7]. Because, a major portion of phosphorus in the form of soluble inorganic phosphate gets

rapidly immobilized and thereby, it is unavailable, when applied as chemical fertilizers. Hence, there is a necessity to minimize phosphorus loss from the soil for better crop production through either carrier or liquid based formulations.
Liquid biofertilizer formulation is the most promising technology and it encourages early root development, rapid cell development, produce organic acids like malic, succinic, fumaric, citric, tartaric and alpha keto glutaric acid which increases phosphorus uptake, availability of other micro nutrients (Mn, Mg, Fe, Mo, B, Zn and Cu) and the ratio of grain to straw as well as total yield.
Genotypes play a significant part in crop production and the probable yield of a genotype is determined by its genetic potential and environment. Genotypic differences by which they exhibit differential ability to grow at low or high phosphorus conditions and different forms of PSB may help in increasing fertilizer use efficiency. Therefore, this study is intended to govern the response of cowpea genotypes to differential P and PSB applications.

Materials and Methods

The experiment was conducted in plot no. 148 of 'F' block during *kharif* 2019 under AICRP, MULLARP at MARS, Dharwad which is situated at 15°26' N latitude and 75°01' E longitude at an altitude of 678 m above mean sea level, comes under Northern Transition Zone (Zone 8) of Karnataka which lies between the Western Hilly Zone (Zone 9) and Northern Dry Zone (Zone 3).
The experiment was laid out in in two factorial RBD with single control design with twelve treatment combinations and replicated thrice. The first factor consists of three genotypes (DC-15, GC-3 and KBC-9) and second factor consists of four phosphorus levels (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) along with liquid based PSB @ 4ml kg^{-1} seeds and control (DCS-47-1+ RDF (25:50:25) N: P_2O_5: K_2O kg ha^{-1} + carrier based PSB @ 500g ha^{-1}). The texture of the experimental soil was clay loam having pH of 7.85 and electrical conductivity of 0.32 dSm^{-1}. The soil was low in available nitrogen (232.5 kg ha^{-1}), medium in available phosphorus (22.6 kg ha^{-1}) and high in available potassium (381.9 kg ha^{-1}) respectively.
The seeds were treated with *Rhizobium* @ 200 g ha^{-1} (carrier based) and liquid PSB @ 4ml kg^{-1} seed. In control, seeds were treated with carrier based PSB @ 500 g ha^{-1} and *Rhizobium* @ 200 g ha^{-1}. The spacing adopted was 45 cm × 10 cm. Nitrogen was applied through urea @ 25 kg ha^{-1} along with potassium as Murate of Potash (MOP) @ 25 kg ha^{-1} uniformly to all the treatments. Phosphorus was applied through Single Super Phosphate (SSP) @ (0, 25, 50, 75 kg ha^{-1}) as per the treatment requirements at the time of sowing.

Quality analysis

Nitrogen content was determined by Micro Kjeldahl method and expressed in per cent. (Jackson, 1973) [5]. Further, seed protein content (%) in grain was calculated by multiplying the nitrogen content with a factor 6.25. Protein yield was calculated by using the following formula.

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Seed protein content (\%)} \times \text{total seed yield (kg ha}^{-1}\text{)}}{100}$$

Economic analysis

Cost of cultivation: The price in rupees of the inputs that was prevailing at the time of their use was considered for working out the cost of cultivation per hectare treatment wise.
Gross returns: Gross returns per hectare was derived by taking into consideration the price of the product that was prevailing in market after harvest.
Net returns: The net returns per hectare was derived treatment wise by subtracting the total cost of cultivation from gross returns and expressed in rupees per hectare.
Benefit-cost ratio was calculated by using formula.

$$\text{B:C} = \frac{\text{Gross returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

The data recorded from the experiment was analyzed statistically following the procedure described by Gomez and Gomez (1984) [4]. The level of significance used in 'F' test was P=0.05 and critical difference values were calculated where the 'F' test was found significant.

Results and Discussion

Quality parameters

Quality parameters were differed significantly between the genotypes**.** The genotype DC-15 recorded significantly higher seed protein content and protein yield (23.84*%* and 292.50 kg ha^{-1}, respectively) over other genotypes. Further, lower seed protein content and protein yield (21.19*%* and 214.31 kg ha^{-1}, respectively) was recorded by the genotype GC-3 (Table 1 and Fig. 1). This might be due to the reason that the seed protein content is a genetic character which is genetically controlled. These results are in conformity with findings of Madhu (2013) [9] in mungbean and Prabhamani (2014) [12].
The protein content (%) and yield (kg ha^{-1}) was significantly affected by increasing levels of phosphorus. The application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher seed protein content and protein yield (23.81% and 320.54 kg ha^{-1}, respectively) over other phosphorus levels. However, lower seed protein content and protein yield (21.60*%* and 197.30 kg ha^{-1}, respectively) was recorded with the application of 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds (Table 1 and Fig. 1). The percent increase in protein content was 10.23% over the application of 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds. Better nitrogen fixation favoured by phosphorus in the presence of *Rhizobium* and PSB might have improved protein content of seeds. Such significant increase in protein content and yield with increasing doses of phosphorus were reported by Pandey *et al.* (2016) [11] in lentil and Singh *et al.* (2018) [16] in green gram.
Among the interactions, the genotype DC-15 with the application of 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher seed protein content (25.10%) over the control and other treatments. The percent increase in seed protein was 17.95% over the control. Whereas, the genotype DC-15 with the application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher protein yield (351.22 kg ha^{-1}) over the control and other treatments**.** It was on par with the genotype KBC-9 applied with 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds (350.25 kg ha^{-1}) This might be due to *Rhizobium* and liquid based PSB inoculation which helped the plants in fixing more atmospheric nitrogen effectively owing to effective root nodulation, which ultimately increased nitrogen availability and thereby protein synthesis over carrier based PSB due to its efficiency in shelf life and cell count. Nitrogen being main constituent of protein, it is involved in the synthesis of amino acids and there by increased protein content. These results are in line with Pandey *et al.* (2016) [11] in lentil and Choudhary *et al.* (2010) [2] in green gram.

Economics

From the present investigation, the genotype DC-15 recorded significantly higher gross returns, net returns and B: C ratio (Rs. 65516, 34506 ha^{-1} and 2.11, respectively) than the genotype GC-3 (Rs. 53898, 22888 ha^{-1} and 1.74, respectively) due to higher seed yield (Table 2 and Fig. 2) It was on par with the genotype KBC-9 (Rs. 63225, 32215 ha^{-1} and 2.04, respectively). This might be attributed to the differences in genotypes with respect to seed yield. These results are in similar line with Prabhamani (2014) [12] and Pradeepa (2014) [13]. Results revealed that among the phosphorus levels, the application of 75 kg P_2O_5 ha^{-1}+ liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher gross returns, net returns and B: C ratio (Rs. 71185, 39800 ha^{-1} and 2.27, respectively) over other phosphorus levels (Table 2 and Fig. 2) This might be due to higher seed yield. Such significant increase in gross returns, net returns and B: C ratio with increasing levels of phosphorus were reported by Rani *et al.* (2016) [14] in mungbean and Singh *et al.* (2018) [16] in greengram. Among the interactions between the genotypes and phosphorus levels, the genotype DC-15 with the application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds recorded significantly higher gross returns, net returns and B: C ratio (Rs. 77590, 46205 ha^{-1} and 2.47, respectively) over the control and other treatments. It was on par with the genotype KBC-9 with the application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds (Rs. 74279, 42894 ha^{-1} and 2.37, respectively). This might be due to efficient utilisation of resources and higher yield. Results are in conformity with Sodge *et al.* (2016) [17] and Singh *et al.* (2018) [16] in greengram. Further, liquid based formulation of PSB recorded significantly higher net returns over carrier based PSB formulation. This might be due to efficient nutrient uptake and improved yield which resulted in higher net returns. These results are in similar line with Dorle *et al.* (2015) [3].

Table 1: Protein content (%) and Protein yield (kg ha^{-1}) of cowpea as influenced by genotypes, phosphorus levels and liquid based PSB

Protein content (%)						**Protein yield (kg ha^{-1})**					
	P_1	**P_2**	**P_3**	**P_4**	**Mean**	**G × P**	**P_1**	**P_2**	**P_3**	**P_4**	**Mean**
G_1	22.21	24.07	25.10	23.98	23.84	G_1	207.94	290.65	331.01	351.22	295.20
G_2	21.83	19.75	20.78	22.41	21.19	G_2	195.06	192.83	209.21	260.14	214.31
G_3	20.77	23.07	23.79	25.04	23.17	G_3	188.89	262.42	309.85	350.25	277.86
MEAN	21.60	22.30	23.23	23.81		MEAN	197.30	248.64	283.36	320.54	
Control	21.28					Control	261.57				
	G	P	G × P	Control Vs Others			G	P	G × P	Control Vs Others	
S.Em±	0.15	0.17	0.30	0.22		S.Em±	4.78	5.52	9.56	7.04	
CD (5%)	0.44	0.50	0.87	0.64		CD (5%)	14.0	16.1	27.9	NS	

Factor 1: Genotypes (G)
G_1: DC-15
G_2: GC-3
G_3: KBC-9

Factor 2: Phosphorus levels (P)
P_1: 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_2: 25 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_3: 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_4: 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds

Control: DCS-47-1+ RDF (25:50:25 N: P_2O_5: K_2O kg ha^{-1}) + with carrier based PSB @ 500 g ha^{-1}

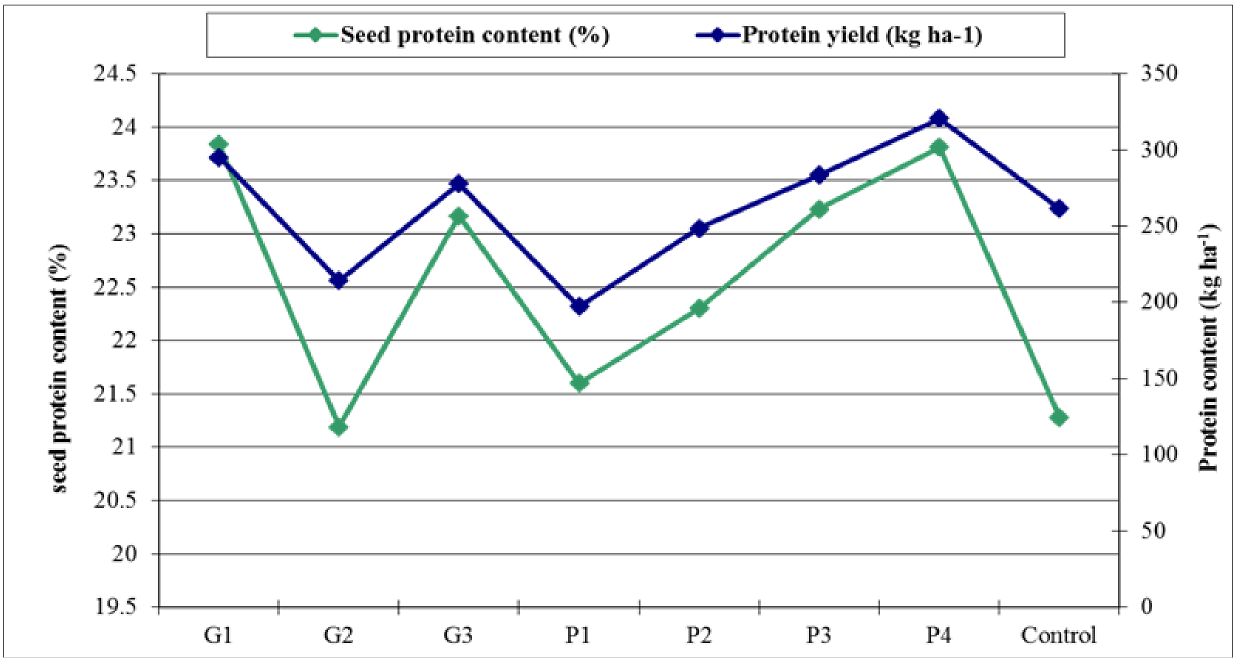
Table 2: Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}) and B:C ratio of cowpea as influenced by genotypes, phosphorus levels and liquid based PSB

Gross returns (Rs. ha^{-1})						**Net returns (Rs. ha^{-1})**					**B: C ratio**				
	P_1	P_2	P_3	P_4	MEAN	P_1	P_2	P_3	P_4	MEAN	P_1	P_2	P_3	P_4	MEAN
G_1	50230	64245	69999	77590	65516	19595	33360	38864	46205	34506	1.64	2.08	2.25	2.47	2.11
G_2	47934	52156	53817	61685	53898	17299	21271	22682	30300	22888	1.56	1.69	1.73	1.97	1.74
G_3	48827	60710	69082	74279	63225	18192	29825	37947	42894	32215	1.59	1.97	2.22	2.37	2.04
MEAN	48997	59037	64299	71185		18362	28152	33164	39800		1.60	1.91	2.07	2.27	
Control	65651					34626					2.12				
	G	P	G × P	Control Vs Others		G	P	G × P	Control Vs Others		G	P	G × P	Control Vs Others	
S.Em±	1014	1171	2028	1493		1014	1171	2028	1493		0.03	0.04	0.07	0.05	
CD (5%)	2960	3418	5919	4357		2960	3418	5919	4357		0.10	0.11	0.19	0.14	

Factor 1: Genotypes (G)
G_1: DC-15
G_2: GC-3
G_3: KBC-9

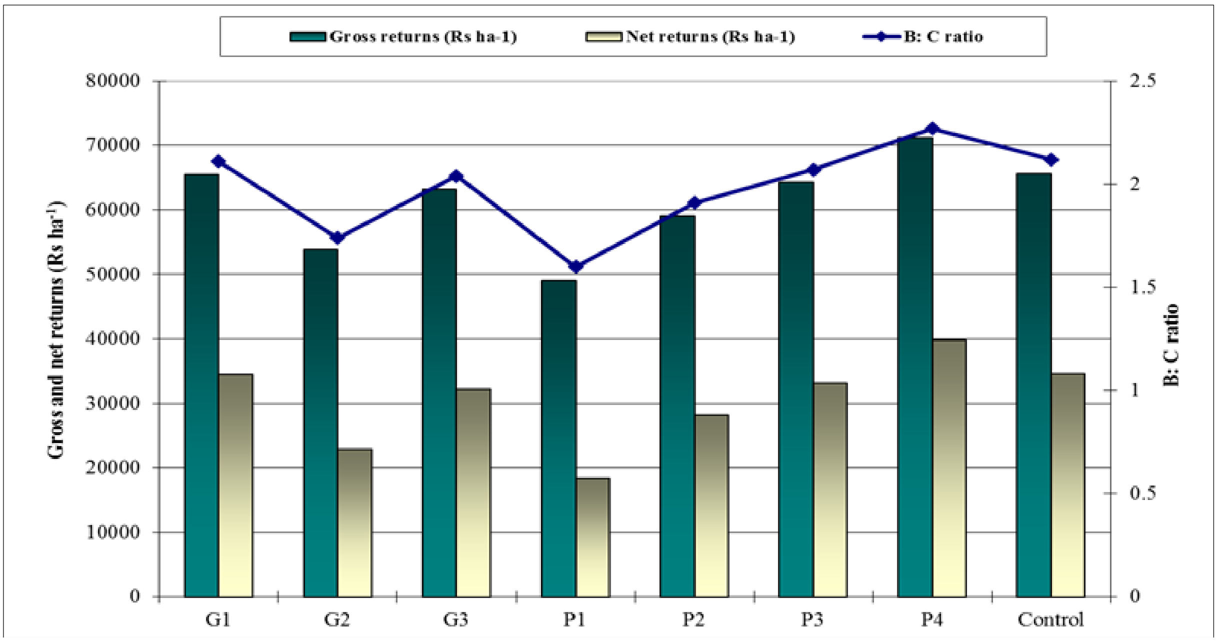
Factor 2: Phosphorus levels (P)
P_1: 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_2: 25 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_3: 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
P_4: 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds

Control: DCS-47-1+ RDF (25:50:25 N: P_2O_5: K_2O kg ha^{-1}) + with carrier based PSB @ 500 g ha^{-1}



Legend
Genotypes (G): G_1: DC-15, G_2: GC-3, G_3: KBC-9
Phosphorus levels (P): P_1: 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_2: 25 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_3: 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_4: 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
Control: DCS-47-1+ RDF (25:50:25 N: P_2O_5: K_2O kg ha^{-1}) + with carrier based PSB @ 500 g ha^{-1}

Fig 1: Seed protein content (%) and protein yield (kg ha^{-1}) as influenced by cowpea genotypes, phosphorus levels and liquid based PSB



Legend
Genotypes (G): G_1: DC-15, G_2: GC-3, G_3: KBC-9
Phosphorus levels (P): P_1: 0 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_2: 25 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_3: 50 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds, P_4: 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds
Control: DCS-47-1+ RDF (25:50:25 N: P_2O_5: K_2O kg ha^{-1}) + with carrier based PSB @ 500 g ha^{-1}

Fig 2: Gross and net returns (Rs ha^{-1}) as influenced by cowpea genotypes, phosphorus levels and liquid based PSB

Conclusion

The application of 75 kg P_2O_5 ha^{-1} + liquid PSB @ 4ml kg^{-1} seeds to the genotype DC-15 is optimum to get better quality parameters and high net returns in Northern Transitional Zone (Zone-8) of Karnataka.

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