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PRODUCTIVITY OF CLUSTERBEAN AS INFLUENCED BY FERTILIZER MANAGEMENT IN RAINFED ALFISOLS

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ABSTRACT

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of Scarce Rainfall Zone under rainfed conditions for three years during kharif, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuramu, Andhra Pradesh. Pooled analysis of data revealed that number of pods per plant, seed yield, gross returns, net returns and B:C ratio was not significantly influenced by different fertilizer management practices. However, the highest mean number of pods per plant was resulted with application of 20 kg K ha^{-1}, seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}. Higher gross returns were realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, highest net returns obtained with 20 kg N ha^{-1} and highest benefit cost ratio was realized with 20 kg N ha^{-1}. Application of 20 kg N ha^{-1} can be recommended to Scarce Rainfall Zone of Andhra Pradesh of for maximization of profits in clusterbean crop.

KEYWORDS: Clusterbean, fertilizer management, rainfed alfisols

INTRODUCTION

Clusterbean, popularly known as guar is a *kharif* legume crop, very drought tolerant, sun-loving but susceptible to frost and requires only 300-400 mm annual rainfall. Recently it has been classified under arid legume group and is grown for vegetable, green fodder, green manure and for grain. The crop survives best even under conditions moderate salinity and alkalinity. Clusterbean tolerates high temperatures and dry conditions and is adapted to arid and semi-arid climates (Undersander *et al*., 1991). It is a principal source of galactomannan (28-33% guar gum) and has numerous food and industrial uses *viz.,* textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc. India is leading producer of cluterbean in the world contributing to around 75–82 per cent of the total production. The consumption pattern of its seed is largely influenced by the demands from the petroleum industries in USA and oil fields in the Middle East. The trend of consumption has also increased in rest of the world that has led to its introduction in many countries. India is a leading exporter of guar gum with 80 per cent of world production, followed by Pakistan. Rajasthan is the largest clusterbean producing states in the world as it dominates the Indian production scenario contributing to 70 per cent of the total production in India followed by Haryana (12%) and Gujarat (11%). Clusterbean basically grown under arid rainfed conditions and there was huge year to year huge yield fluctuations due to erratic rainfall (Pathak *et al*., 2009; Singh *et al*., 2003 and 2005).

Clusterbean responds well to phosphorus rather than nitrogen. As N fixing legume usually require more P than N because P plays a very vital role in the nodule development and their activity (Serraj *et al*., 2004). In recent years, the continuous application of only N and P led to the deficiency of micronutrients in arid soils. Deficiency of micro nutrients has more detrimental effects on metabolic pathways, enzyme activities, performance of crops and uptake of macronutrients. Zinc application significantly increased the nitrogen activity, carbohydrate and protein content in clusterbean (Nandwal *et al*., 1990). Potassium also plays a critical role under moisture stress conditions through its influence on maintenance of turgor potential photosynthesis, translocation of photosynthates, starch synthesis and activation of number of enzymes. Vyas *et al*. (2001) observed increase in seed yield of arid legumes with increasing K levels even under low levels of soil moisture availability. The soil organic matter turnover and fertilizer use efficiency is very low due to moisture scarcity (Garg and Uday Burman, 2011).

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After seeing great revenues with the crop during previous years by Rajasthan farmers, farmers in Ananthapuram, Guntur, Kurnool, Karimnagar, Nellore, Prakasam and Ranga Reddy districts of undivided Andhra Pradesh have also started the cultivation of clusterbean for seed in more than 1000 ha (NRAA, 2014). Ananthapuram is the second most drought - affected district of India. It receives around 500 mm rainfall annually. The agriculture is predominantly dependent on rainfall which is very erratic and uncertain. Being located in the Scarce Rainfall Zone of Andhra Pradesh does not get the full benefit of either the south west or north east monsoon. Rainfed agriculture in Anantapuram district is greatly influenced by water shortage caused by low, highly variable and erratic rainfall. As the information on fertilizer management in cluterbean is meagre for Scarce Rainfall Zone of Andhra Pradesh the present study was initiated.

MATERIAL AND METHODS

A field experiment was conducted to study fertilizer management in clusterbean in alfisols of scarce rainfall zone of Andhra Pradesh under rainfed conditions for three years during *kharif*, 2013-14, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuram, Andhra Pradesh. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.34%) and low in available nitrogen (138 kg ha^{-1}), medium in available phosphorous (28 kg ha^{-1}) and potassium (215 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. The treatments consisted of eleven treatments viz., T_1: Control (No N, P and K), T_2: 20 kg N ha^{-1}, T_3: 20 kg P ha^{-1}, T_4: 20 kg K ha^{-1}, T_5: 20 kg N + 20 kg P ha^{-1}, T_6: 20 kg P + 20 kg K ha^{-1}, T_7: 20 kg N + 20 kg K ha^{-1}, T_8: 20 kg N + 20 kg P ha^{-1}+ 20 kg K ha^{-1}, T_9: T8 + 25 kg Zn SO_4 ha^{-1}, T_{10}: T8 + 3 kg Bo ha^{-1}, T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. The individual plots were laid out according to the layout plan. Healthy seeds of clusterbean (var. RGC 1025) with good germination percent (95%) was used for sowing purpose As per the treatments, N, P_2O_5 and K_2O was applied at the time of sowing through urea, single super phosphate and muriate of potash respectively. All other cultural practices were kept normal and uniform for all treatments. At harvest, five plants were randomly selected from each treatment for recording growth parameters such as plant height, number of pods per plant, number of seeds per pod and test weight. The grain and haulm yield from the net plot (5 m x 5 m) of each treatment was recorded and expressed in kg ha^{-1}. Labour wages and cost of inputs were worked out to compute the cost of cultivation. Gross returns were calculated based on the prices in the local market prices for clusterbean and net returns were worked out by subtracting the total cost of cultivation from gross returns.

RESULTS AND DISCUSSION

Rainfall and crop performance

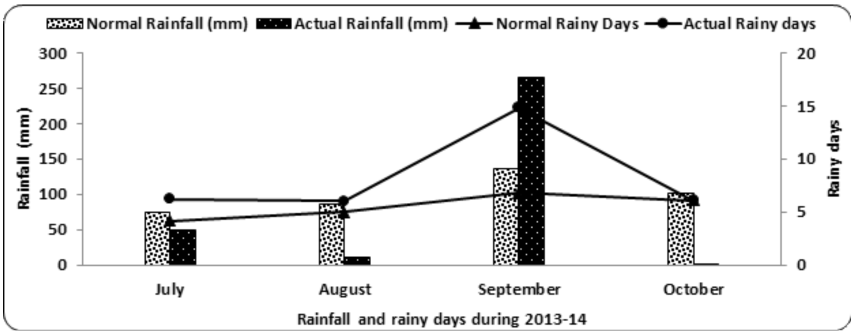
In 2013-14, annual rainfall received (431.8 mm) in 23 rainy days was 75.7 per cent of normal annual rainfall (570 mm). During 2013-14, crop was sown on 12-7-2013 and harvested on 4.10.2013 with crop duration of 85 days. During the crop period 328.4 mm rainfall was received in 11 rainy days (Table 1). In 2014-15, annual rainfall 375.2 mm received in 26 rainy days it was 65.8 per cent of normal annual rainfall (570 mm). During 2014-15, crop was sown on 16-7-2014 and harvested on 10-10-2014 with 86 days crop duration. During this period 160.6 mm rainfall was received in 10 rainy days. In 2015-16, annual rainfall 641 mm received in 44 rainy days it was 108 per cent of normal annual rainfall (590.6 mm). During 2015-16, crop was sown on 19-6-2015 and harvested on 11-9-2015 with a crop duration of 84 days. During this period 212.6 mm rainfall was received in 14 rainy days. The average seed yield during 2015 was higher by 40 per cent and 25 per cent compared to 2013 and 2014 respectively and was attributed to optimum soil moisture resulted through sufficient rainfall received in 14 rainy days during different phenophases especially during pod initiation to pod development and pod development to maturity whereas in 2013, 267.1 mm rainfall received in 8 rainy days during pod development to maturity resulted in excess moisture in soil profile which hindered pod development resulting in less test weight and seed yield. Higher seed yield during 2015 compared to 2013 and 2014 was also attributed to fairly higher test weight.

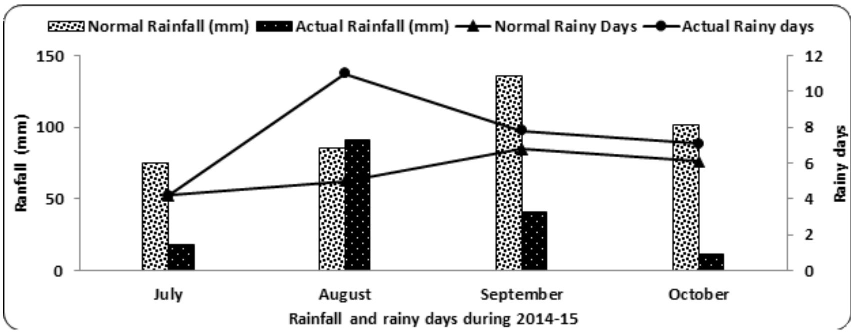
Growth

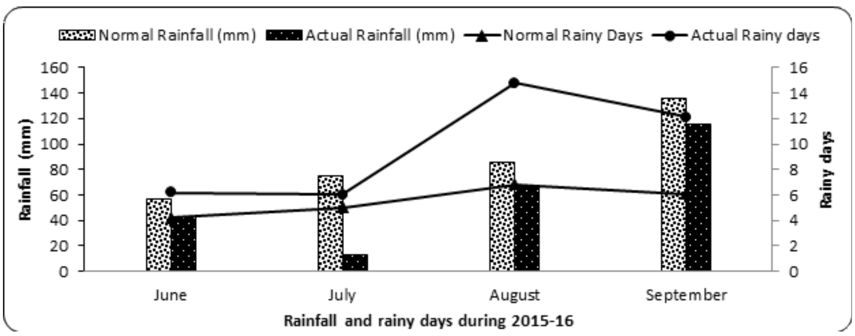
The data pertaining to plant height and yield attributes of clusterbean as influenced by fertilizer management practices was presented in Table 2. Plant height of clusterbean measured at harvest was not significantly influenced by different fertilizer management practices during three years of study. However, tallest plants were

Table 1. Rainfall and rainy days during crop growth period

Parameter	2013-14	2014-15	2015-16
Date of sowing	12-07-2013	16-07-2014	19-06-2015
Date of harvesting	04-10-2013	10-10-2014	11-09-2015
Crop duration (days)	85	86	84
Normal annual rainfall (mm)	573	570	591
Actual annual rainfall (mm)	431.8	375.2	641
Rainfall during crop period (mm)	328.4	160.6	212.6
Number of rainy days during the year	23	26	44
Number of rainy days during crop period	11	10	14







noticed with control, application of 20 kg N ha^{-1} and 20 kg K ha^{-1} in 2013, 2014 and 2015 respectively. The trend was not similar during three years of experimentation. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on plant height of clusterbean. However, the highest mean plant height was observed with application of 20 kg K ha^{-1}. These results are in agreement with Ayub *et al.* (2012) who reported that application of P alone could not produced significantly higher plant height over control treatment.

Yield attributes

Different fertilizer management practices had no significant influence on number of pods per plant in 2013 and 2015 where as in 2014 significant variation was noticed (Table 2). The highest number of pods per plant was obtained with control, 20 kg K ha^{-1} in 2013 and 2015 respectively. Whereas in 2014 highest number of pods per plant was noticed with 20 kg P ha^{-1} which was significantly comparable with other treatments and superior to control, 20 kg N + 20 kg K ha^{-1}, 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1} and 20 kg N + 20 kg P + 20 kg K + 25 kg Zn So_4+ 3 kg Bo ha^{-1} treatments. Pooled analysis of data revealed that number of pods per plant was not significantly influenced by different fertilizer management practices. However, the highest mean number of pods per plant was resulted with application of 20 kg K ha^{-1}.

Number of seeds per pod did not varied significantly due to adopted fertilizer management practices during all the three years of investigation. However, the highest number of seeds per pod was recorded with 20 kg N ha^{-1}, 20 kg N + 20 kg P ha^{-1} and 20 kg N + 20 kg P ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was similar only during second and third year of study. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on number of seeds per pod. However, the highest number of seeds per pod was noticed with 20 kg N + 20 kg P ha^{-1}. These results are contradictory with the findings by Burman *et al.* (2007) who reported that application of nitrogen (20 kg ha^{-1}) in association with P (20 kg ha^{-1}) significantly enhanced yield attributes of clusterbean under rainfed condition of Jodhpur in a two years study. Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P ha^{-1} increased yield attributes of clusterbean under rainfed conditions.

During the three years of study, there was no significant difference in test weight of clusterbean due to different fertilizer management practices. However, the highest test weight was attained with 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4 ha^{-1}, 20 kg N + 20 kg K ha^{-1}, 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was not similar during three years of study. Pooled analysis of data also indicated that fertilizer management practices had no significant influence on test weight. However, the highest test weight was obtained with 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4 ha^{-1} .

Seed and haulm yield

Data pertaining to seed yield, haulm yield and economics of clusterbean as influenced by fertilizer management practices is presented in Table 3. Seed yield of clusterbean was not significantly differed due to different fertilizer management practices during all three years of experimentation. However, the highest seed yield was recorded with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. The trend was not similar during three years of study. Pooled analysis also indicated that mean seed yield was not influenced significantly due to different fertilizer management practices. However, the maximum mean seed yield was registered with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1} followed by 20 kg N ha^{-1} treatment. Raj Singh and Khan (2002) found that application of 20 kg N and 40 kg P ha^{-1} increased seed yield of clusterbean under rainfed conditions. Burman *et al.* (2007) found that application of nitrogen (20 kg ha^{-1}) in association with P (20 kg ha^{-1}) significantly enhanced the seed yield of clusterbean under rainfed conditions of Jodhpur in a two years study. The contradictory results might have been due to differences in fertility status of soil. Under moisture stress conditions the plant response to applied fertilizers is frequently reduced (Bradford and Hsiao, 1992). It is agreed that plant response to applied nutrients by rainfed crops is not assured and sometimes may not be profitable unless proper soil moisture is available. However, the degree of yield response varied with rainfall pattern, intensity of drought, native soil fertility and crop species. Application of P was observed to enhance drought tolerance under different intensities of water stress in clusterbean genotypes (Burman *et al.*, 2009). Efficient translocation of accumulated assimilates to the reproductive parts under comfortable nitrogen nutrition might be responsible for

Table 2. Plant height and yield attributes of clusterbean as influenced by fertilizer management practices in rainfed alfisols

Treatments	Plant height (cm)				Number of pods per plant				Number of seeds per pod				Test weight (g)			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
T_1: Control (No N, P and K)	40.3	36.7	23.5	33.5	33.6	11.7	15.4	20.2	6.6	6.0	6.3	6.3	28.4	35.0	32.6	32.0
T_2: 20 kg N ha^{-1}	37.7	42.3	23.4	34.5	26.6	16.6	14.1	19.1	6.7	6.1	6.4	6.4	30.3	33.3	34.4	32.7
T_3: 20 kg P ha^{-1}	36.5	41.3	25.4	34.4	23.9	22.0	19.5	21.8	6.5	6.3	6.4	6.4	29.7	35.1	32.9	32.6
T_4: 20 kg K ha^{-1}	36.8	40.4	30.3	35.8	27.8	19.5	21.9	23.1	6.5	6.3	6.3	6.4	29.8	34.9	37.2	34.0
T_5: 20 kg N + 20 kg P ha^{-1}	33.1	42.0	28.3	34.5	28.0	18.8	19.7	22.2	6.6	6.5	7.6	6.9	29.9	34.5	33.1	32.5
T_6: 20 kg P + 20 kg K ha^{-1}	38.7	35.0	28.2	33.9	28.1	20.3	15.7	21.4	6.3	6.1	6.6	6.3	30.7	33.5	35.3	33.2
T_7: 20 kg N + 20 kg K ha^{-1}	33.9	36.6	25.3	31.9	27.7	13.9	18.3	20.0	6.4	6.2	7.0	6.5	30.6	37.0	31.5	33.1
T_8: 20 kg N + 20 kg P ha^{-1} + 20 kg K ha^{-1}	38.3	37.1	26.7	34.0	28.5	20.1	18.4	22.4	6.7	6.2	6.6	6.5	30.0	34.0	32.1	32.0
T_9: T8 + 25 kg Zn SO_4 ha^{-1}	36.7	40.7	27.0	34.8	21.7	20.3	19.1	20.4	6.2	6.1	7.0	6.5	35.4	34.2	32.8	34.1
T_{10}: T8 + 3 kg Bo ha^{-1}	39.0	37.6	27.2	34.6	26.1	14.3	20.5	20.3	6.5	6.2	6.0	6.3	29.7	34.4	36.7	33.6
T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}	35.4	39.2	27.0	33.9	32.4	14.2	17.3	21.3	6.5	6.1	6.9	6.5	29.6	34.3	37.0	33.6
S.Em ±	1.78	3.01	2.32	1.45	2.59	2.14	2.35	2.01	0.16	0.27	0.34	0.16	1.38	0.94	2.27	1.07
CD at 5%	NS	NS	NS	NS	NS	6.35	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Yield and economics of clusterbean as influenced by fertilizer management practices in rainfed alfisols

Treatments	Seed yield (kg ha^{-1})				Haulm yield (kg ha^{-1})				Gross Returns (₹ ha^{-1})				Net Returns (₹ ha^{-1})				B : C ratio			
	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
T_1: Control (No N, P and K)	591	665	643	633	1726	761	1459	1315	20694	21960	19279	20644	11394	12660	9979	11344	1.23	1.36	1.07	1.22
T_2: 20 kg N ha^{-1}	668	709	689	689	2002	954	1709	1555	23368	23412	20674	22484	13809	13853	11115	12926	1.44	1.45	1.16	1.35
T_3: 20 kg P ha^{-1}	459	733	718	637	1723	1089	1451	1421	16048	24191	21552	20597	5773	13916	11277	10322	0.56	1.35	1.10	1.00
T_4: 20 kg K ha^{-1}	664	599	755	673	1664	790	1667	1374	23245	19761	22650	21885	13374	9889	12779	12014	1.35	1.00	1.29	1.22
T_5: 20 kg N + 20 kg P ha^{-1}	556	513	779	616	1592	811	1648	1350	19455	16919	23363	19912	8921	6385	12830	9379	0.85	0.61	1.22	0.89
T_6: 20 kg P + 20 kg K ha^{-1}	505	659	753	639	1441	1009	1286	1245	17660	21747	22579	20662	6813	10900	11733	9816	0.63	1.00	1.08	0.90
T_7: 20 kg N + 20 kg K ha^{-1}	501	598	908	669	1424	1118	1708	1417	17518	19745	27240	21501	7388	9616	17110	11371	0.73	0.95	1.69	1.12
T_8: 20 kg N + 20 kg P ha^{-1} + 20 kg K ha^{-1}	533	520	891	648	1514	717	1415	1215	18642	17163	26719	20841	7537	6059	15614	9737	0.68	0.55	1.41	0.88
T_9: T8 + 25 kg Zn SO_4 ha^{-1}	466	639	856	654	1378	1089	1510	1326	16315	21074	25676	21022	3760	8520	13121	8467	0.30	0.68	1.05	0.67
T_{10}: T8 + 3 kg Bo ha^{-1}	674	612	854	713	1827	929	1406	1387	23577	20211	25629	23139	11722	8357	13774	11284	0.99	0.70	1.16	0.95
T_{11}: T8 + 25 kg Zn SO_4 ha^{-1} + 3 kg Bo ha^{-1}	524	600	751	625	1551	855	1710	1372	18352	19799	22520	20224	5347	6794	9516	7219	0.41	0.52	0.73	0.56
S.Em ±	64.2	73.4	85.8	51.4	183	123	198	95	2248	2421	2574	1667	2248	2421	2574	1667	0.19	0.22	0.24	0.16
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.59	0.64	NS	NS

the beneficial effect on elevating the stature of all the yield attributes. Similar results were also reported by Singh and Singh (1989) and Sharma and Nehara (2004). Higher guar yield with application of nitrogen, as noticed in the present investigation confirms the documented evidence of Bamboo and Rana (1995), Patel *et al*. (2005), Sharma and Nehara (2004) and Rathore *et al*. (2007). The studies of Vyas *et al*. (2001) also indicated that seed yield of arid legumes increased with increasing K levels even under low levels of soil moisture availability.

The haulm yield was not significantly varied due to various fertilizer management practices during three years of experimentation. The highest haulm yield was recorded with 20 kg N ha^{-1}, 20 kg N + 20 kg K ha^{-1}, 20 kg N ha^{-1} treatments in 2013, 2014 and 2015 respectively. Pooled analysis also indicated that there was no significant difference in mean haulm yield due to different fertilizer management practices. Highest mean haulm yield was obtained with 20 kg N ha^{-1} treatment.

Economics

Gross returns, net returns and B:C ratio for different fertilizer management practices were calculated, analyzed statistically and presented in Table 3. During three years of experimentation, gross returns were not significantly influenced by various fertilizer management practices. However, highest gross returns were realized with 20 kg N + 20 kg P + 20 kg K+ 3 kg Bo ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} treatments in 2013, 2014 and 2015 respectively. Pooled analysis revealed that gross returns were not significantly influenced by various fertilizer management practices. Net returns obtained by different fertilizer management practices were not differed significantly during three years of experimentation. However, higher net returns were obtained with 20 kg N ha^{-1}, 20 kg P ha^{-1}, 20 kg N + 20 kg K ha^{-1} during 2013, 2014 and 2015 respectively. . Pooled analysis indicated that net returns were not significantly influenced by different fertilizer management practices. Benefit cost ratio was significantly influenced by fertilizer management practices during 2013 and 2014 and significantly comparable during 2015. During year 2013 higher benefit cost ratio was registered with 20 kg N ha^{-1} treatment which was significantly on par with 20 kg K ha^{-1}, control, 20 kg N + 20 kg P + 20 kg K + 25 kg Zn SO_4+ 3 kg Bo ha^{-1}, 20 kg N + 20 kg P ha^{-1} treatments and significantly superior to other treatments. During 2014, highest benefit cost ratio was realized with 20 kg N ha^{-1} treatment which in turn was comparable with control, 20 kg P ha^{-1}, 20 kg K ha^{-1}, 20 kg P + 20 kg K ha^{-1}, 20 kg N + 20 kg K ha^{-1} and significantly superior to other treatments. During the year 2015 the benefit cost ratio was not significantly influenced by fertilizer management practices. However, the highest benefit cost ratio was obtained with 20 kg N + 20 kg K ha^{-1}. In pooled analysis also, benefit cost ratio was not significantly influenced by various fertilizer management practices. However the highest benefit cost ratio was realized with 20 kg N ha^{-1} followed by control and 20 kg K ha^{-1}.

From the results, it is concluded that application of 20 kg N ha^{-1} is recommended for Scarce Rainfall Zone of Andhra Pradesh to obtain higher net returns in clusterbean.

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