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Effect of super early genotypes under graded levels of nutrients on yield attributes, yield and economics of redgram

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Abstract
India is the leading producer of pulses in the world. In spite of being a leading producer, India is still importing pulses to meet consumer demand, due to low productivity of pulses due to various reasons. Hence, there is a need to improve the productivity of pulses. A field experiment was conducted in Split-Plot design during *kharif*, 2021-22 to know the effect of super early varieties of redgram under graded levels of nutrients on growth, yield and economics. The present study revealed that among the five super early varieties of redgram tested, ICPL 11301 performed better than other varieties in terms of yield and economic returns indicating its suitability for cultivation in the rainfed *alfisols* of Southern Agro-climatic Zone of Andhra Pradesh. Application of 125 % RDF (25 kg N, 62.5 kg P_2O_5 and 50 kg K_2O ha^{-1}) obtained higher seed yield and monetary returns in redgram beyond which the response is marginal and uneconomical. A super early variety of redgram, ICPL 11301 with the application of 125 % RDF (25 kg N, 62.5 kg P_2O_5 and 50 kg K_2O ha^{-1}) was considered as the best agronomic intervention for enhanced productivity and higher monetary returns.

Keywords: Redgram, super early varieties, graded level of nutrients, growth, yield, economics

Introduction
In modern agriculture, pulses and cereals play a significant role in food and nutritional security. Pulses are next to cereals in importance to human nutrition and occupy a unique position in the Indian diet. Pulses are also called as "*poor man's meat*" due to their rich source of protein, iron, iodine, vitamins and essential amino acids (Samantaray *et al*., 2020) [12].
Legumes play a major role in conserving natural resources by forming an excellent soil cover, and adds huge amount of organic matter through their profuse root system, leaf fall, and biomass, thereby improving the soil's physical conditions (Kumar *et al*., 2020) [5]. The steady increase in the Indian population together with the stagnant production of pulses over the past four decades resulted in decreased availability of pulses which in turn led to imbalanced nutrition in humankind.
Considering the present-day shortage of high-protein food and to provide nutritional security among people, diversification of crops with legumes is the best option. Among pulses, redgram [*Cajanus cajan* (L.) Millsp] is rated high because of its proven role in soil rejuvenation and sustainability of cropping systems. Redgram is one of the principal grain legume crops cultivated in India, which accounts for 90 % of global production confined within the country. In India, redgram is cultivated in an area of 47.24 lakh hectares with a production of 43.16 lakh tonnes with a productivity of 914 kg ha^{-1}. Whereas, in Andhra Pradesh, redgram is grown under rainfed conditions to an extent of 2.31 lakh hectares, with an annual production of 8.38 lakh tonnes and productivity of 363 kg ha^{-1} during 2020-21 (*www.indiastat.com*).
Redgram is traditionally grown as an annual pulse crop in Asia, Africa, the Caribbean islands and Latin America. It is a good source of protein (20-22 %), vitamins (thiamine, riboflavin, niacin and choline) and minerals such as iron, iodine, calcium, phosphorus, sulphur and potassium. In addition to its primary use as a dhal, its immature green seeds and pods are consumed as vegetables (Yadav *et al*., 2021) [20]. The dried stalks of the redgram are used as fuelwood. Apart from this, redgram enriches the soil through symbiotic nitrogen fixation, releases phosphorus bound in the soil, recycles the soil nutrients and adds sufficient organic matter and other nutrients through the leaf litter. It has wider adaptability to drought due to its

deep taproot system and tap the nutrients and moisture from the deeper subsoils.

Traditional long-duration varieties of redgram take a longer time to mature and avoid the opportunity of raising the other crop in the succeeding season. Indeed, there is an enormous yield gap in redgram between what is achievable and its genetic potential due to its photo and thermosensitivity, nonsynchronous maturity, biotic and abiotic stress. The majority of redgram cultivars in worldwide belong to long (>180 days) and medium (160-180 days) maturity groups. A small portion of redgram varieties belong to the early (120-140 days) maturity group. These long and medium duration varieties have longer vegetative growth phase of 120-160 days, which is mainly attributed to its slow initial growth (Srivastava *et al*., 2012) [15], that leads to poor productivity and less efficient in utilization of land and other growth resources.

Under a changing climate scenario, super early genotypes of redgram help in achieving a higher harvest index. With the introduction of super early redgram varieties maturing within 90-100 days opens the possibility to explore redgram cultivation during the off-season and non-traditional niches, aiming for an increase in national production pool of pulses. Super early varieties also demonstrated photo insensitivity, maturity synchrony, hardiness and adaptability to multiple cropping systems (Saxena *et al*., 2019) [13]. There is a need to evaluate super early varieties of redgram to fit in different cropping system and to enhance the productivity.

The low yield of redgram is not only due to its cultivation on marginal and sub marginal lands, but also due to poor crop management. Among the various reasons for low productivity in redgram, the role of balanced nutrient supply in pulses to be of paramount importance. Imbalanced nutrient use, especially of major nutrients, has created concern in India as it may affect overall pulse productivity (Umesh *et al*., 2013) [16].

The response of redgram to applied phosphorus and potassium was higher than nitrogen. Phosphorous is an important mineral element for redgram as it helps in root development, participates in synthesis of phosphates and phosphoproteins, helps in better nodulation and efficient functioning of bacterium in nodules for fixation of atmospheric nitrogen to be utilized by the plant during seed development stage. Potassium also plays a crucial role in redgram by enhancing the production of starch and sugars that benefit the symbiotic bacteria. It is the most effective cation for the activation of several enzymes and helps the plant to adapt to terminal moisture stress at reproductive stage. Hence, there is a need for judicious management of plant nutrients through application of different nutrients to increase the productivity and profitability of redgram cultivation.

Materials and Methods

The experiment entitled "Performance of super early varieties of redgram [*Cajanus cajan* (L.) Millsp.] under graded levels of nutrients" during *kharif*, 2021-22 in field No. 45 of wetland farm, S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University which is geographically situated at 13.5° N latitude and 79.5° E longitude and at an altitude of 182.9 m above mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The soil of the experimental site was sandy loam in texture, neutral in soil reaction, low in organic carbon (0.42 %), available nitrogen (194 kg ha^{-1}) and available potassium (141 kg ha^{-1}) and medium in available phosphorus (45 kg ha^{-1}). The present experiment was laid out in a split-plot design and replicated thrice. The treatments include five varieties *viz.*, ICPL 11301 (V_1), ICPL 20325 (V_2), ICPL 20338 (V_3), ICPL 11255 (V_4) and ICPL 88039 (V_5) as main plots and three nutrient levels *viz.*, 100 % RDF (N_1), 125 % RDF (N_2) and 150 % RDF (N_3) as sub plots. Healthy and well matured seeds were used for sowing @ 12 kg ha^{-1}. The seeds were dibbled @ 2 to 3 $hill^{-1}$ with a spacing of 45 cm x 15 cm. Fertilizer doses were applied as per the treatments *i.e*., N_1 : 100 % RDF (20 kg N, 50 kg P_2O_5, and 40 kg K_2O ha^{-1}), N_2 : 125 % RDF (25 kg N, 62.5 kg P_2O_5 and 50 kg K_2O ha^{-1}) and N_3 : 150 % RDF (30 kg N, 75 kg P_2O_5, 60 kg K_2O ha^{-1}) as basal through urea, single super phosphate and muriate of potash, respectively to the respective plots as per the treatments. All other recommended management practices were followed to raise the crop. The data recorded on various parameters of yield attributes and yield during the course of the investigation were statistically analyzed by following the analysis of variance procedure suggested by Panse and Sukhatme (1985) [7].

Results and Discussion

Yield Attributes

The yield attributing characters of redgram were differed significantly due to varieties and nutrient levels, whereas, the interaction effect failed to exert any significant influence (Table 1).

The redgram variety ICPL 11301 (V_1) recorded higher yield attributes *viz.*, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod length and test weight which was statistically at par with that of ICPL 20325 (V_2). Whereas, hundred seed weight was significantly higher with ICPL 11301 (V_1) among the varieties tested. The lowest values of these yield attributes were recorded with ICPL 11255 (V_4), which was however comparable with ICPL 20338 (V_3). This might be due to a better balance was maintained between vegetative and reproductive phase and synchronized flowering in redgram altered the source-sink relationship due to rapid translocation of nutrients from leaves to the developing pods which increased the number of pods $plant^{-1}$. These findings are in accordance with the findings reported by Vales *et al*. (2012) [17], Deepika (2020) [1] and Shruthi (2020).

With regards to nutrient doses tried, the highest nutrient dose, 150 % RDF (N_3) resulted in higher number of pods $plant^{-1}$, number of seeds pod^{-1}, pod length and hundred seed weight, which was on par with 125 % RDF (N_2). Significantly lower yield attributing characters were observed with 100 % RDF (N_1). Higher yield attributing characters with highest nutrient level may be due to adequate and continuous supply of nutrients which had positive influence on total number of pods $plant^{-1}$. Similar results stating that total number of pods $plant^{-1}$ increased with increase in nutrient levels were also reported earlier by Jamprangi *et al*. (2014) [4], Divyavani *et al*. (2020) [3] and Preetham *et al*. (2020) [10].

Table 1: Yield attributing characters of redgram as influenced by varieties and nutrient levels

Treatments	Number of seeds pod^{-1}	Number of pods plant^{-1}	Pod length (cm)	Hundred seed weight (g)
Varieties (V)				
V1 - ICPL 11301	3.7	45.4	5.8	9.42
V2 - ICPL 20325	3.6	45.1	5.6	8.89
V3 - ICPL 20338	2.8	31.3	4.4	7.70
V4 - ICPL 11255	2.7	29.4	4.2	7.44
V5 - ICPL 88039	3.2	40.3	5.0	8.30
SEm±	0.08	1.25	0.15	0.170
CD (P=0.05)	0.3	3.8	0.5	0.52
Nutrient levels (N)				
N1 - 100 % RDF	2.8	31.9	4.7	7.95
N2 - 125 % RDF	3.5	40.7	5.0	8.43
N3 - 150 % RDF	3.6	42.3	5.2	8.68
SEm±	0.07	1.02	0.06	0.143
CD (P=0.05)	0.2	3.0	0.2	0.43
Varieties (V) × Nutrient levels (N)				
N at V				
SEm±	0.14	1.99	0.26	0.236
CD (P=0.05)	NS	NS	NS	NS
V at N				
SEm±	0.16	2.19	0.21	0.263
CD (P=0.05)	NS	NS	NS	NS

Seed Yield

The seed yield of redgram was significantly influenced by the varieties and nutrient levels tried, while the interaction effect was not statistically traceable (Table 2).

Higher seed yield was registered with the variety ICPL 11301 (V_1) which was distinctly superior to rest of the varieties tried. The next best varieties were ICPL 20325 (V_2) and ICPL 88039 (V_5) with significant disparity between them. The lowest seed yield was noticed with the variety ICPL 11255 (V_4). Application of 150 % RDF (N_3) resulted in a higher seed yield followed by 125 % RDF (N_2) with no significant difference between them, while the lowest seed yield was observed with 100 % RDF (N_1). Differences in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink. The superiority of ICPL 11301 (V_1) in the number of pods plant^{-1}, number of seeds pod^{-1} and hundred seed weight had a positive effect on the seed yield of redgram. Similar results of higher seed yield with different genotypes were reported by Srivastava *et al.* (2012) [15], Vales *et al.* (2012) [17] and Ranjani *et al.* (2018) [11].

The highest stalk yield was obtained with the variety ICPL 88039 (V_5), while the lowest stalk yield was produced with ICPL 11255 (V_4) among the varieties tested. The nutrient dose of 150 % RDF (N_3) resulted in higher stalk yield compared to the lowest nutrient dose of 100 % RDF (N_1).

Table 2: Seed and stalk yield of redgram as influenced by varieties and nutrient levels

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Varieties (V)		
V1 - ICPL 11301	1279	1721
V2 - ICPL 20325	1176	1575
V3 - ICPL 20338	974	1428
V4 - ICPL 11255	971	1423
V5 - ICPL 88039	1075	1870
SEm±	30.1	41.1
CD (P=0.05)	91	126
Nutrient levels (N)		
N1 - 100 % RDF	1007	1474
N2 - 125 % RDF	1118	1636
N3 - 150 % RDF	1160	1699
SEm±	20.3	29.5
CD (P=0.05)	60	89
Varieties (V) × Nutrient levels (N)		
N at V		
SEm±	47.7	65.8
CD (P=0.05)	NS	NS
V at N		
SEm±	46.2	66.5
CD (P=0.05)	NS	NS

Economics of Redgram

Gross returns, net returns and benefit-cost ratio of redgram crop were altered to a significant extent by different varieties and nutrient levels. The interaction effect between varieties and nutrient levels was found to be non-significant (Table. 3). The highest gross and net returns and benefit-cost ratio were realized with the variety ICPL 11301 (V_1), followed by ICPL 20325 (V_2) and ICPL 88039 (V_5), while they were found to be the lowest with ICPL 11255 (V_4). This might be owing to better nutrient use efficiency resulting in increased seed and stalk yields. Present investigation confirms the results reported by Umesh *et al*. (2013) [16] and Singh *et al.* (2016) [14]. Application of 150 % RDF (N_3) resulted in higher values of gross, net returns and benefit cost ratio which were on par with 125 % RDF (N_2) and both of these nutrient levels were significantly superior to 100 % RDF (N_1). This could be due to the manifestation of higher seed and stalk yields fetching of higher net returns at increased levels of nutrients. Similar findings have also been reported by Nagamani (2015) [6] and Ware *et al*. (2018) [18].

Table 3: Gross and net returns and benefit-cost ratio of redgram cultivation as influenced by varieties and nutrient levels

Treatments	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit-cost ratio
Varieties (V)			
V1 - ICPL 11301	52007	29113	2.27
V2 - ICPL 20325	47831	24937	2.08
V3 - ICPL 20338	39692	16686	1.73
V4 - ICPL 11255	39578	16673	1.71
V5 - ICPL 88039	43948	21054	1.91
SEm±	1103	918	0.048
CD (P=0.05)	3656	3042	0.16
Nutrient levels (N)			
N1 - 100 % RDF	41038	18416	1.81
N2 - 125 % RDF	45522	22628	1.98
N3 - 150 % RDF	47274	24034	2.03
SEm±	808	627	0.037
CD (P=0.05)	2423	1874	0.11
Varieties (V) × Nutrient levels (N)			
N at V			
SEm±	1912	1590	0.083
CD (P=0.05)	NS	NS	NS
V at N			
SEm±	1853	1473	0.082
CD (P=0.05)	NS	NS	NS

Conclusion

The application of nutrient doses on different super early varieities significantly influenced on yield attributes, yield and economics of redgram. it could be inferred that cultivation of the super early redgram variety ICPL 11301 with the application of 125 % RDF (25 kg N, 62.5 kg P_2O_5 and 50 kg K_2O ha^{-1}) is promising in realizing higher seed yield and monetary returns on sandy loam soils of Southern Agro-climatic Zone of Andhra Pradesh.

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