Impact of Land Configuration, Life Saving Irrigation and Intercropping on Yield and Economics of Major Rainfed Crops in Southern Telangana Zone of Andhra Pradesh, India

A. Krishna[1] and A. V. Ramanjaneyulu[2]

[1]Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Palem, Mahabubnagar dist., Andhra Pradesh (509 215), India

[2]Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Palem, Mahabubnagar dist., Andhra Pradesh (509 215), India

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Correspondence to

E-mail: avr_agron@rediffmail.com

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Abstract

Three separate field experiments were conducted during *kharif* 2008-09 and 2009-10 at Regional Agricultural Research Station (ANGRAU), Palem to study the impact of land configuration, life saving irrigation and intercropping on yield and economics of major rainfed crops (castor and redgram) of Southern Telangana Zone of Andhra Pradesh. Results of pooled analysis of individual experiment revealed that life saving irrigation @ 20 mm with harvested water (from farm pond) through sprinkler method of irrigation was found to have enhanced the castor and redgram seed yield by 21.9 and 28.1%, respectively over purely rainfed crop. It also resulted in additional net returns of ₹ 4118 ha^{-1} and ₹ 12722 ha^{-1} in castor and redgram, respectively. Adoption of ridge and furrow method (1058 kg ha^{-1}) of land configuration resulted in 6.54% and 12.3% higher castor bean yield over dead furrow (993 kg ha^{-1}) and flat bed method (942 kg ha^{-1}), respectively. While, it was 6.84 and 18.2 in case of redgram. Ridge and furrow was at par with dead furrow but significantly superior to flat bed with respect to seed yield of castor. On the other hand, ridge furrow was significantly superior to dead furrow and flat bed in case of redgram. Castor + redgram (1:1) intercropping system (1417 kg ha^{-1}) being at par with sole redgram (1382 kg ha^{-1}) recorded significantly higher castor seed equivalent yield and also higher RNR index (1.67). But, sole redgram gave higher net returns (₹ 19026 ha^{-1}) and was closely followed by castor + redgram (1:1) intercropping system (₹ 18117 ha^{-1}).

1. Introduction

Nearly 70% of world's poor live in rural areas and are at the mercy of rainfall supported production systems for their income. India ranks first among the rainfed agricultural countries of the world both in terms of area (86 M ha) and value of produce. Rainfed areas in India are highly diverse, ranging from resource rich areas with good agricultural potential to resource-constrained areas with much more restricted potential. Some resource rich areas normally under temperate climate are highly productive and already have experienced widespread adoption of modern technology. On the other hand, traditional farming systems in drier and less favourable areas is more of a subsistence driven rather than a market or growth oriented activity.

At present, irrigated Agriculture in India contributes to the tune of 60% of food security while rainfed agriculture accounts for rest of the 40%. On one hand, water shortage for irrigated Agriculture is becoming acute due to rapidly growing domestic and industrial demand for water in many developing countries especially India. On the other hand, ever burgeoning population is causing lot of concern, putting greater pressure on food security. In the light of these problems, and to meet the increasing demand for food, fodder and fibre, there is an imminent need to improve the resource use efficiency of rainfed agriculture.

Southern Telangana Zone of Andhra Pradesh comprising of Mahabubnagar, Nalgonda and Ranga Reddy mostly depend on rain god for successful harvest. This zone has 60% red chalka soils (alfisols) which are characterized by shallow depth, low water holding capacity, poor infiltration rate, low N and medium to high phosphorus and potash. The productivity of

crops in these areas is very low (around 0.5 t ha^{-1}) and limited by low and variable rainfall and nutrient poor soils. The rainy season in this region starts in June and ends by September thereby limiting the crop growth period to four months. Annual precipitation varies from 600 to 800 mm with frequent dry spells causing yield losses and, at times, crop failures (Ramana et al., 2005).

Redgram and castor are the major crops among pulses and oilseeds, respectively grown widely in the zone. These two are long duration and wide spaced crops with drought resistance. However, under severe moisture stress conditions, yields get reduced. Prolonged/mid season drought during July to August is very common. These dry spells may range from a few days to two weeks or even more. Prolonged break often results in partial or complete failure of crops. Further, by the time castor and redgram reach pod/ capsule development (October to November), monsoon recedes and terminal stress occurs which will reduce the yields. Besides, the duration of the varieties for these two major crops is longer, because of which the effect of stress is more pronounced.

In the semi-arid areas which are characterized by low and variable rainfall, promising technologies for improving soil and moisture conservation are urgently needed (Chiroma et al., 2008) as they help to post pone or relieve the stress. The information on the impact of easily adoptable methods like land configuration, life saving supplemental irrigation and intercropping are available in many crops across the country but meager in case of castor and redgram. Hence this study was conducted with easy to adopt soil moisture conservations practices to support the crops so as to enhance the yield and income of rainfed farmers.

2. Materials and methods

Field experiments were carried out during *kharif*, 2008-09 and 2009-10 in the experimental farm of Regional Agricultural Research Station, Palem to study the effect of soil and moisture conservation techniques on yield and economics of major rainfed crops of Southern Telangana Zone of Andhra Pradesh. The experimental site was sandy loam in texture with low N (210 kg N ha^{-1}), medium phosphorus (30.0 kg P_2O_5 ha^{-1}) and high potash (400 kg K_2O ha^{-1}). First two experiments were conducted separately on unreplicated large plots (each treatment: 36 x 12 m^2) with different sets of treatments as detailed below. While the third experiment was conducted with six treatments and three replications in a randomized block design with each treatment measuring 10.8 × 3.6 m^2 plot size.

I. Irrigation:

a. Life saving irrigation with farm pond water (through Sprinkler) b). Rainfed

II. Land configuration:

a. Ridge and furrow at 45 DAS b. Dead furrow at 45 DAS (3.6 m interval) c. Flat bed

III. Intercropping:

a. Sole castor b. Sole redgram c. Sole groundnut d. Castor + Groundnut (1:4) e. Redgram + Groundnut (1:5) f. Castor + Redgram (1:1)

In the first two experiments, five random samples each measuring 7.2 x 3.6 m^2 were taken while harvesting and recording the yield. The data of first two experiments (separately) were subjected to t-test and that of third experiment to three times replicated randomized block design (RBD), respectively as per the procedure given by Gomez and Gomez (1984) in order to compare the treatments and draw valid conclusions. All the agronomic and need based plant protection measures were followed to keep crops free from pest and diseases. Benefit:cost (b:c) ratio was calculated by dividing the net returns with cost of cultivation. Relative net returns index was calculated by using the following formula

$$\text{RNR index} = \frac{(YbPb)+(YiPi)\pm(Dbi)}{(PbYbb)}$$ (Jain and Rao, 1980)

Table 1: Details of different crops, varieties, date of sowing, spacing, fertilizer levels and date of harvest of the experiments

S. No.	Crop	Variety	Date of sowing		Spacing (cm^2)	Nutrients applied	Date of harvest	
			2008-09	2009-10			2008-09	2009-10
1	Castor	Haritha (drought and wilt resistant)	31-7-08	15-07-09	90 x 60	60-40-30 kg N, P_2O_5, K_2O ha^{-1}	30-11-08 24-12-08 20-01-09	18-11-09 16-12-09 08-01-10
2	Redgram	PRG-158 (drought and wilt resistant)	31-7-08	15-07-09	90 x 20	20-50-30 kg N, P_2O_5, K_2O ha^{-1}	10-01-09	04-01-10
3	Groundnut	TMV-2 (drought resistant)	31-7-08	15-07-09	30 x 10	20-50-30 kg N, P_2O_5, K_2O ha^{-1}	30-11-08	17-10-09

Where Yb: Yield of base crop Yi: Yield of intercrop
Pb: Price of base crop Pi: Price of intercrop
Ybb: Yield of sole crop Dbi: Differential cost of cultivation of intercropping in comparision with sole crop

During 2008-09, 547.1 mm rainfall was received during crop growth period against the normal rainfall of 649.1 mm leaving a deficit rainfall of 15.71%, while, during 2009-10, 707.4 mm rainfall was received making it 8.98% excess rainfall. Though amount of rainfall received during 2009-10 was more than that of 2008-09, more than 50% of the rainfall was received with in a week i.e., during last week of September to first week of October, 2009 (Figure 1) making it distributed unequally during crop growth period.

3. Results and Discussion

3.1. Life saving irrigation

Agarwal (2000), Sharma et al., (2005) and Wani et al., (2003) opined that water harvesting has become the backbone in furthering the watershed programs in rainfed areas in most states of India and the available runoff can be harvested for it's utilization to provide supplemental irrigation to the standing *kharif* rainfed crops to offset mid-season dry spells/terminal drought (flowering- grain filling stage).

A perusal of data presented in Table 2 revealed that irrigation @ 20 mm with harvested water of farm pond through sprinkler method at capsule formation stage (75 DAS: 15-10-08) and flowering to capsule formation stage (62 DAS: 17-09-09) resulted in enhancing castor bean yield by 25.6% during

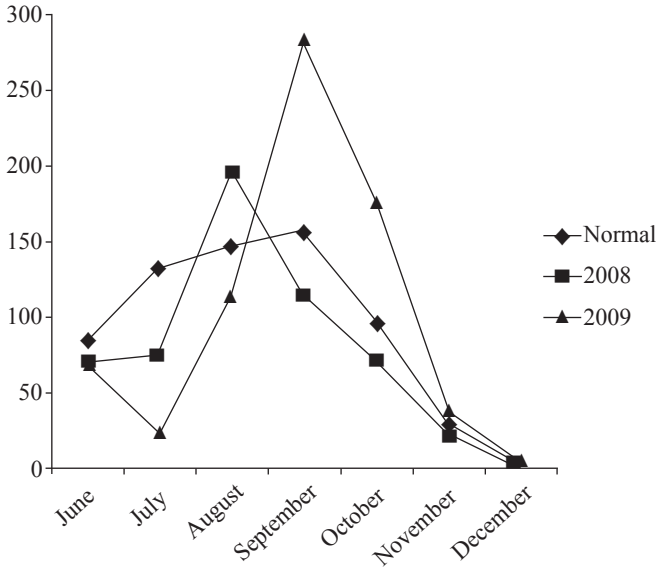

Figure 1: Monthly rainfall for the crop period recorded during 2008-09 and 2009-10 at RARS, Palem

Table 2: Yield and economics of castor and redgram as influenced by life saving irrigation (Kharif 2008-09 and 2009-10)

Treatment	Seed yield (kg ha^{-1})	% increase over rain-fed	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio	Seed yield (kg ha^{-1})	% increase over rain-fed	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio	Seed yield (kg ha^{-1})	% increase over rain-fed	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
	2008-09						2009-10						Pooled					
	Castor						Castor						Castor					
Life saving irrigation	1191	25.6	29783	18750	11033	0.6	843	16.0	25284	21250	4034	0.2	1017	21.9	27533	20000	7533	0.4
Rainfed	941	-	23515	18000	5515	0.3	727	-	21814	20500	1314	0.1	834	-	22665	19250	3415	0.2
T-test CD	85.4						NS						94.3					
	Redgram						Redgram						Redgram					
Life saving irrigation	1452	18.9	50812	18250	32562	1.8	1511	38.4	67995	19250	48745	2.5	1481	28.1	59404	18750	40654	2.2
Rainfed	1221	-	42720	17500	25220	1.4	1092	-	49145	18500	30645	1.7	1156	-	45932	18000	27932	1.6
T-test CD	79.4						93.6						59.4					

Market price of Castor seed: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10) Redgram seed: ₹ 35 kg^{-1} (2008-09) and ₹ 45 kg^{-1} (2009-10), Groundnut pods: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10)

2008-09 (1191 kg ha^{-1}) and 16.0% during 2009-10 (843 kg ha^{-1}) over the crop grown rainfed conditions (941 and 727 kg ha^{-1}). Thus, an average of 21.9% more castor bean yield was obtained with additional net returns of ₹ 4118 ha^{-1} due to life saving irrigation over control (834 kg ha^{-1}, ₹ 3415 ha^{-1}). During 2009-10, life saving irrigation and rainfed treatments were found to be at par in respect of castor seed yield mainly because of heavy rainfall during last week of September (211.2 mm in three rainy days) and first week of October 2009 (165.4 mm in three rainy days). It means during *kharif* 2009, though the amount of rainfall is more than that *kharif* 2008 but 50% of total rainfall was received with in one week time making it distributed unequally during crop growth period.

Like wise, in case of redgram, when life saving irrigation (20 mm) was given through sprinklers during pre-flowering stage (20-10-08 and 20-10-09), seed yield could be increased to the tune of 18.9% and 38.40% during 2008-09 (1452 kg ha^{-1}) and 2009-10 (1511 kg ha^{-1}) when compared to control (1221 and 1092 kg ha^{-1}). It also resulted in additional net returns of ₹ 12722 ha^{-1} and b:c ratio of 2.20 over rainfed crop (₹ 27932 ha^{-1}, 1.60). Unlike castor, redgram responded well to irrigation/rainfall due to better drought resistance and rejuvenating capacity. These results are in conformity with that of Sharma et al., (2005) who reported that water used in supplemental irrigation had the highest marginal productivity and increase in rainfed production above 50% was achievable and provision of critical irrigation has the potential to improve yields by 29 to 114% or 1.25 to 3.3 folds for different crops in various locations across the country. As concluded by Kanwar (1999) that research at national and international research institutes and also demonstrations in farmers' fields has conclusively shown that highest gains and acceptance was seen with in-situ/ex-situ rainwater harvesting and its subsequent utilization in the field for improving productivity of dry lands. Significant yield improvements could be made in rice, sorghum, maize, cotton, sesame, soybean and chickpea. The overall productivity in the identified rainfed districts covering an area of 27.5 M ha in the country can be enhanced to a level of 2.65 t ha^{-1} from the existing aggregated level of 1.2 t ha^{-1} (Sharma et al., 2005). Subba Reddy et al., (2006) reported 31, 42, and 49% increase in redgram seed yield when supplemental irrigation of 5 cm was given at early (vegetative), mid (flowering) and terminal (pod formation) stages in Alfisols in Hyderabad. Economic yield of dry land crops can be improved by 20-30% when farm pond water is applied either through sprinkler or drip system for one hour during dry spell or critical stages (ANGRAU 2012-13).

3.2. Land configuration methods

Efficient conservation of soil moisture is the basic prerequisite for successful production crops under dry land conditions. The results furnished in Table 3 revealed that though seed yield of castor was higher with ridge and furrow method, it was not significantly affected by land configuration methods during *kharif* 2008-09. Nearly 19.7% and 7.6% more seed yield was recorded when land was worked into ridges and furrows (980 kg ha^{-1}) as compared to dead furrow (881 kg ha^{-1}) and flat bed (819 kg ha^{-1}) during *kharif* 2009-10. Significantly higher seed yield of redgram (1279 kg ha^{-1}) was obtained when ridge and furrow were made at 45 DAS for moisture conservation than that of flat bed (1067 kg ha^{-1}), but at par with that of dead furrow made after every 4 rows at 45 DAS (1158 kg ha^{-1}) during *kharif* 2008-09. Similar trend was observed during 2009-10 also in case of redgram.

The pooled data revealed that ridge and furrow method (1058 and 1202 kg ha^{-1}) being at par with that of dead furrow (993 and 1125 kg ha^{-1}) resulted in significantly higher seed yield over flat bed method (942 and 1017 kg ha^{-1}) in case of seed yield of castor and redgram, respectively. Ridge and furrow method gave an additional net returns of ₹ 1288 and 2351 ha^{-1}, ₹ 2251 and 6317 ha^{-1} over dead furrow and flat bed methods of land configuration in castor and redgram, respectively. The results of present investigation was in conformity with the following findings reported by various workers across the country. As reported by Shivakumar et al., (2006), the grain yield of greengram was higher when sown on broad beds with furrows compared to flat bed sowing, but land configuration treatments had no impact on the productivity of wheat.

In Tamil Nadu, ridges and furrows land configuration was identified as an important agricultural practice to augment groundnut productivity besides improving microclimatic conditions as compared to flat-bed and broad-bed furrow methods (Subrahmaniyan et al., 2008). According to Selvaraj et al., (1999), tied ridges stored 14% more soil water and produced 14% and 11% more grain and straw yields of sorghum, respectively, than flat bed. However, crop yield in Tied ridges was comparable with Open ridge method in alfisols.

Compartmental bunding stored 22% more soil moisture and increased the yield of sorghum + pigeonpea intercropping than flat bed (FB) in a low rainfall year. In a high rainfall year, broad bed and furrow (BBF) produced 34% and 33% more grain yield of sorghum and pearl millet base crops, on broadbed and furrow recorded maximum babycorn, green fodder yield and nitrogen uptake. Maximum net return (₹ 45 120) was realized with broadbed and furrow method, while benefit: cost ratio was

Table 3: Yield and economics of castor and redgram as influenced by land configuration methods (Kharif 2008-09 and 2009-10)

Treatment	S Y	%I O	G T	a b	N R	B:C	S Y	%I O	G T	a b	N R	B:C	S Y	%I O	G T	a b	N R	B:C
	2008-09						2009-10						Pooled					
	Castor						Castor						Castor					
R F	1135	6.60	28380	18950	9430	0.5	980	19.7	29400	21450	7950	0.4	1058	12.3	28890	20200	8690	0.4
D F	1105	3.90	27625	18375	9250	0.5	881	7.6	26429	20875	5554	0.3	993	5.41	27027	19625	7402	0.4
F B	1064	-	26600	18000	8600	0.5	819	-	24579	20500	4079	0.2	942	-	25589	19250	6339	0.2
T	NS						88.8						69.7					
	Redgram						Redgram						Redgram					
R F	1279	19.8	44776	18450	26326	1.4	1124	16.4	50580	20450	30130	1.5	1202	18.2	47678	19450	28228	1.5
D F	1158	8.52	40533	17875	22658	1.3	1093	13.2	49172	19875	29297	1.5	1125	10.6	44852	18875	25977	1.4
F B	1067	-	37353	17500	19853	1.1	966	-	43470	19500	23970	1.2	1017	-	40411	18500	21911	1.2
T	127.4						120.0						83.5					

Market price of Castor seed: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10) Redgram seed: ₹ 35 kg^{-1} (2008-09) and ₹ 45 kg^{-1} (2009-10), Groundnut pods: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10); S Y = Seed yield (kg ha^{-1}); %I O = % increase over flat bed; G T = Gross returns (₹ ha^{-1}); a b = Cost of cultivation (₹ ha^{-1}); N R = Net returns (₹ ha^{-1}); B:C = B:C ratio; R F = Ridge and furrow; D F = Dead furrow; F B = Flat bed; T = T-test CD;

higher with paired row sowing on flatbed. Functional leaves were maximum with flatbed sowing + earthing (Panwar and Munda, 2006) in babycorn in Meghalaya. Grain yield of sorghum under open ridges (OR) and tied ridges (TR) treatments exceeded that of flat bed (FB) by 23% and 35%, respectively. The corresponding increases in water use efficiency (WUE) with these treatments, relative to FB were 23% and 33%, respectively (Chiroma et al., 2008).

Ridge and furrow method of planting was found to be more appropriate under Vertisols while in coarse textured Alfisols, flat sowing and later earthing up was better for castor and sunflower crops (Balaganvi et al., 2009).

3.3. Intercropping

Though the concept of intercropping is not new but it has relevance till date in dry land agriculture, as it acts as an insurance against crop failure besides enhancing unit^{-1} area productivity and reducing the pest load (Ramanjaneyulu and Bucha Reddy, 2001). Sole redgram was found to have significantly outyielded other treatments viz., redgram + groundnut (1:5) (1259 kg ha^{-1}), castor + groundnut (1:4) (1174 kg ha^{-1}), sole castor (953 kg ha^{-1}) and sole groundnut (847 kg ha^{-1}), however, was found to be at par with castor + redgram (1:1)(1459 kg ha^{-1}) with respect to castor seed equivalent yield during 2008-09 (Table 4). On the contrary, castor + redgram (1:1) (1375 kg ha^{-1}) recorded significantly higher castor seed equivalent yield during 2009-10.

Pooled data of 2008-09 and 2009-10 revealed that castor + redgram (1:1) (1417 kg ha^{-1}) being at par with sole redgram (1382 kg ha^{-1}) was found to be significantly superior to all other treatments (Table 4). Sole groundnut and castor were found to be siginificantly inferior to all other treatments under test in respect of castor seed equivalent yield. Though, higher net returns (₹ 19026 ha^{-1}) were accrued due to sole redgram, RNR index was found to be more with castor + redgram intercropping (1:1) (1.67).

Review of research on intercropping systems through out the country revealed that based on seed equivalent yield, net returns and b:c ratio, castor + pigeonpea (2:1) intercropping system was found to be better than castor + sunflower/greengram (2:2), castor + maize (2:1) and castor + pigeonpea (1:1) on red chalka soils of Southern Telangana Zone (Leela Rani, 2008) However, she added that the remunerative crop combination and row ratio may change from year to year depending on the prevailing market price. Among the intercropping systems, groundnut with pigeonpea in 5:2 ratio or with maize in 4:2 row proportion was found remunerative on rainfed alfisols of West Bengal (Dutta and Bandopadhyay, 2006).

Table 4: Yield, economics and RNR index of castor, groundnut and redgram as influenced by intercropping (*kharif* 2008-09 and 2009-10)

Treatments	BY	IY	CY	GT	AB	NR	R
			2008-09				
Sole castor	953	-	953	23833	18000	5833	1.00
Sole redgram	1128	-	1579	39472	17500	21972	1.00
Sole groundnut	847	-	847	21167	17500	3667	1.00
Castor + g'nut (1:4)	607	568	1174	29361	23500	5861	1.46
Redgram + g'nut (1:5)	463	609	1258	31439	24000	7439	0.96
Castor + redgram (1:1)	591	620	1459	36483	20000	16483	1.61
SEm±	44		52				
CD (*p*=0.05)	137		163				
			2009-10				
Sole castor	816	-	816	24467	20500	3967	1.00
Sole redgram	791	-	1186	35580	19500	16080	1.00
Sole groundnut	648	-	648	19453	18500	953	1.00
Castor + g'nut (1:4)	410	474	884	26533	24500	2033	1.25
Redgram + g'nut (1:5)	438	526	1182	35467	24500	10967	1.14
Castor + redgram (1:1)	507	579	1375	41250	21500	19750	1.73
SEm±	47		72				
CD (*p*=0.05)	149		227				
			Pooled				
Sole castor	884	-	884	24150	19250	4900	1.00
Sole redgram	959	-	1382	37526	18500	19026	1.00
Sole groundnut	748	-	748	20310	18000	2310	1.00
Castor + g'nut (1:4)	508	521	1029	27947	24000	3947	1.35
Redgram + g'nut (1:5)	451	567	1220	33453	24250	9203	1.05
Castor + redgram (1:1)	549	599	1417	38867	20750	18117	1.67
SEm±	36		42				
CD (*p*=0.05)	113		132				

Market price of Castor seed: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10) Redgram seed: ₹ 35 kg^{-1} (2008-09) and ₹ 45 kg^{-1} (2009-10), Groundnut pods: ₹ 25 kg^{-1} (2008-09) and ₹ 30 kg^{-1} (2009-10); BY = Base crop yield (kg ha^{-1}); IY = Intercrop yield (kg ha^{-1}); CY = Castor seed equivalent yield (kg ha^{-1}); GT = Gross returns (₹ ha^{-1}); AB = Cost of cultivation (₹ ha^{-1}); N R = Net returns (₹ ha^{-1}); R = RNR index

4. Conclusions

From the foregoing results and discussion, it can be concluded that a life saving irrigation to castor and redgram during critical stages, land configuration into ridge and furrow or dead furrow helped in enhancing the yield particularly in a drought year than in normal year. Intercropping of redgram + castor (1:1) or sole redgram were found to be remunerative than castor + groundnut (1:4) or redgram + groundnut (1:5), sole groundnut and sole castor.

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