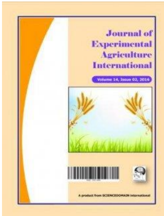

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Yield, Quality and Soil Fertility as Influenced by *Rabi* Castor (*Ricinus communis* L.) Based Intercropping System

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Authors' contributions

This work was carried out in collaboration between all authors. Author BKY designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Author GNP managed the analyses of the study. Author SKC managed the literature searches. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

An experiment was conducted at C. P. College of Agriculture, Sardarkrushinagar on loamy sand soil using a randomised block design with three replications during 2013-14. Results revealed that sole castor, castor + lucerne and castor + fenugreek (1:2) found equally effective with respect to seed yield of castor. Among the intercrops *viz*-., lucerne, chicory, fenugreek and carrot, the maximum green forage yield of lucerne/chicory, seed yield of fenugreek and root yield of carrot were obtained when they were sown as sole crop. A similar trend was also observed in stalk / dry fodder/straw / green fodder yield of castor and intercrops. *Rabi* castor intercropped with lucerne, carrot, fenugreek and chicory at 1:2 row ratio produced significantly higher castor equivalent yield, 3297, 3057, 2731 and 3237 kg ha^{-1} respectively over sole castor and other intercrops as sole. While intercropping of castor + fenugreek and castor + lucerne at 1:2 row ratio recorded significantly higher LER (Land equivalent ratio) value than sole crops and other intercropping systems. Oil content in castor/crude

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protein and crude fibre content in lucerne and chicory/total soluble salts in carrot were found higher in their sole crop treatments as compared to intercrop. Oil yield was found significantly higher in sole castor than other treatments. Nutrient status of soil *viz.*,% organic carbon, available N, P, K and S after harvest of crops did not differ significantly due to different treatments.

Keywords: Castor; castor equivalent yield; intercropping; LER; row ratio and sole crop.

1. INTRODUCTION

Castor (*Ricinus communis* L.) is a non-edible oilseed having high industrial importance due to the presence of unique fatty acid and ricinoleic acid. Castor is extensively cultivated in India, China, Brazil, Ethiopia, Thailand *etc.*,- In India total acreage, production and productivity of castor crop during 2011-12 were 11.20 lakh hectares, 15.80 lakh tonnes and 1240 kg ha^{-1}, respectively [1]. The contribution of India in the world castor acreage and production are 56 and 84 per cent, respectively. Area, production and productivity of castor in Gujarat were 4.22 lakh ha, 8.33 lakh tonnes and 1972 kg ha^{-1}, respectively [1].

It is the major non-edible oil seed crop of India, which contributes 3-4 per cent to the total oilseeds production of the country. A significant future of mixed/intercropping is that it is biologically more dynamic than a pure crop and is, therefore, less likely to succumb to vagaries of weather, for example, reduction in yield of one compound may be compensated by the other component. Thus, a mixer is intrinsically more secure and dependable in providing some more returns than sole cropping. Intercropping is growing subsidiary crops between two rows of widely spaced main crops. The main objective of intercropping is to utilize the space left between two rows of main crop and natural resources as well as to produce more grain per unit area by better use of resources. This practice lead to some benefits like yield advantages as compared to sole cropping, greater stability of yield over different seasons, insurance against aberrant weather conditions, build-up or maintenance of soil fertility, the economy of land, production of higher yield and higher economic returns per unit area in a given season.

The main principle involved in selecting intercrops is that they should not be competitive with the main crop for soil moisture, nutrients and solar radiation. Considerable work has been done in selecting suitable crops like lucerne, chicory, fenugreek and carrot which were found suitable for intercropping in fennel but there is no any information available for taking these crops as intercrops in *rabi* castor. Shortages of fodder and vegetables in the country have focused the attention on including vegetables and fodder crops in intercropping systems which have the capacity to get more return per unit area as well as to improve the physical, biological and chemical properties of soil. As the wide space is available between two paired rows in which profitable short duration crop can be grown during early growth stages of the crop as *rabi* intercrop which gives an additional income also.

2. MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of the year 2013 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District Banaskantha (North Gujarat). The field experiment was laid out in a Randomized Block Design with three replications. An experiment consists of nine treatments including sole crops and intercropping systems in additive series *viz.,* T_1: Castor sole, T_2: Lucerne sole, T_3: Chicory sole, T_4: Fenugreek sole, T_5: Carrot sole, T_6: Castor + Lucerne (1:2), T_7: Castor + Chicory (1:2), T_8: Castor + Fenugreek (1:2), and T_9: Castor + Carrot (1:2) were allotted to each plot by random method. The soil of experimental plot was loamy sand in texture, the initial soil status of organic carbon (018%), available N (148 kg ha^{-1}) is low, available P_2O_5 (47 kg ha^{-1}), available K_2O (284 kg ha^{-1}) is medium and available sulphur (9.56 ppm ha^{-1}). The organic carbon (%), available N (kg ha^{-1}), available P_2O_5 (kg ha^{-1}), available K_2O (kg ha^{-1}) and available sulphur (ppm) were estimated by Walkley and Black's rapid titration method [2], Alkaline permanganate method [2], Olsen's method [3], Flame photometer method [2] and extraction with I % NaCl [4], respectively.

Among the intercrops, legumes and fodder crops were chosen because of being widely used in common diet of livestock. Lucerne and chicory are the most important green forage crops by virtue of their excellent forage quality, flavour, taste and softness. Fenugreek and carrot are also eaten as a raw vegetable and seed production. A full dose of P_2O_5 and half dose of N were applied as basal at the time of sowing of *rabi* castor and remaining half dose of N was applied in two equal splits at 40 and 70 days after sowing. In lucerne and fenugreek full dose of N and P_2O_5 was applied as basal. While in carrot and chicory, a full dose of P_2O_5 and half dose of N were applied as basal at the time of sowing and remaining half dose of nitrogen was applied in two equal split at 35 and 60 days after sowing. The castor, lucerne and chicory were given 10 irrigations each of 50 mm depth whereas five irrigations were applied to carrot and fenugreek crops. Two common light irrigations *viz*., first irrigation at the time of castor sowing and second irrigation at intercrop sowing were given to each crop for good germination and establishment of the seedling. The recommended dose of fertilizer of *rabi* castor: 80-25-0, lucerne: 20-40-0, chicory: 150-30-0, fenugreek: 20-40-0 and carrot: 80-60-0 N- P_2O_5-K_2O kg ha^{-l}.

Random seed samples were drawn from the produce of each net plot to estimate the oil content of castor seed. The oil content in castor seed samples was determined by IBM DC/20 series, NMR (Nuclear Magnetic Resonance) analyzer. Oil yield (kg ha^{-l}) was worked out by using the following formula

$$\text{Oil yield (kg ha}^{-l}) = \frac{\text{Oil (\%)} \times \text{seed yield (kg ha}^{-l})}{100}$$

The crude protein content and crude fibre content were measured with the help of INSTALAB 600 NIR product analyzer and it was expressed as a percentage on a dry weight basis [5].

3. RESULTS AND DISCUSSION

Castor equivalent yield (Table 1) was significantly higher with intercropping of castor with lucerne at 1:2 rows ratio than rest of the treatments but it remained at par with castor + carrot and castor + chicory in 1:2 row ratio, because of additional advantage of intercrop yields and higher yield of castor with intercrops recorded with component crops in these treatments. Additionally, efficient utilization of natural recourses by component crops having a different rooting pattern, canopy depth and nutrient requirement in the intercropping system resulted in the highest castor equivalent yield. These findings are in conformity with those reported by Porwal et al. [6] and Patel et al. [7]. Land equivalent ratio (LER) indicated that 38-60 per cent higher yield advantage was found in castor with carrot, chicory, lucerne and fenugreek at 1:2 row ratio over their sole crops (Table 1). Castor + fenugreek, castor + lucerne, and castor + chicory were equally effective and found significantly superior over rest of the intercrops and their respective sole crop system. The higher yield of castor and land utilization in the intercropping system recorded higher LER as compared to sole crop. This was due to the extra yield obtained from intercrops and makes the combination of higher advantageous over sole crops due to development of the better complementary relationship. These results corroborate with the finding of Chandra and Sujatha [8] and Basith and Mohammad [9].

Seed and stalk yields (kg ha^{-l}) were recorded higher by sole castor than rest of the intercropping treatments, which could be attributed to no competition offered by intercrops in sole cropping system. Among the intercropping treatments, castor + lucerne (1:2) and castor + fenugreek (1:2) were found equally efficient to castor sole as lucerne and fenugreek crops have ability to fix atmospheric N and supply it to the associated castor crop and suppressed the weeds and higher sunshine availability to castor. Lower seed and stalk yields were noticed under castor intercropping with carrot and chicory at 1:2 row ratios (Table 1). This might be due to higher competition offered by intercrops for natural resources like space, plant nutrients, moisture and incoming solar radiation. The findings are in agreement with the results reported by Dhimmer [10] and Singh [11].

Green forage and dry fodder yields of lucerne and chicory, seed and straw yield of fenugreek and root and green forage yields of carrot were reduced in intercropping systems as compared to their respective sole cropping (Table 1). Such variation could be ascribed due to competition for natural resources like soil moisture, plant nutrients, space and sunlight which are responsible for less photosynthesis rate resulted in the lower accumulation of photosynthates in seed and dry matter per plant when grown as intercrop in comparison to sole crop. These findings are in close vicinity with the results of Srilatha et al. [12].

Table 1. Yield and quality of castor and inter crops as influence by different treatments

Treatments	Castor equivalent yield (kg ha^{-1})	Land equivalent ratio (LER)	Seed yield/ green forage yield/ root yield (kg ha^{-1})	Stalk yield/ dry or green fodder yield / straw yield (kg ha^{-1})	Oil content (%) in castor seed	Oil yield (kg ha^{-1})	Crude protein content/ total soluble salts (%) in carrot root	Crude fibre content (%)
Castor sole	2315	1.00	2315	2616	48.70	1127	-	-
Lucerne sole	1803	1.00	19800	3400	-	-	18.65	20.6
Chicory sole	1763	1.00	30300	5419	-	-	20.41	10.7
Fenugreek sole	823	1.00	816	1353	-	-	-	-
Carrot sole	2284	1.00	16518	18704	-	-	12.60	2.35
Castor + Lucerne (1:2)	3297	1.54	2267 (10900)	2539 (1879)	48.14	1091	18.13	20.4
Castor + Chicory (1:2)	3057	1.46	1974 (18280)	2171 (3140)	47.85	945	20.22	10.5
Castor + Fenugreek (1:2)	2731	1.60	2154 (534)	2391 (958)	48.05	1035	-	-
Castor + Carrot (1:2)	3237	1.38	1761 (9783)	1919 (15163)	47.32	833	12.25	2.20
S.Em.±	110	0.06	-	-	1.55	52	-	-
C.D. (0.05)	321	0.17	-	-	NS	158	-	-

**Data presented in parenthesis indicates intercrops values*

Table 2. Effect of different treatments on residual soil fertility after harvest of the crops

Treatments	Nutrient status in soil after harvest				
	Organic carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potash (kg ha^{-1})	Available sulphur (ppm)
Castor sole	0.19	141.45	45.68	280.64	10.23
Lucerne sole	0.21	158.45	51.26	286.42	10.09
Chicory sole	0.20	151.60	48.50	279.68	9.94
Fenugreek sole	0.20	155.26	49.71	282.34	10.57
Carrot sole	0.19	142.30	46.35	280.12	9.85
Castor+ Lucerne (1:2)	0.23	152.56	48.62	286.40	9.88
Castor+ Chicory (1:2)	0.22	151.85	46.21	284.20	10.13
Castor+ Fenugreek (1:2)	0.21	148.62	46.89	283.61	9.95
Castor+ Carrot (1:2)	0.20	142.17	44.15	276.56	9.82
S.Em.±	0.008	4.13	1.60	7.57	0.35
C.D. (0.05)	NS	NS	NS	NS	NS
Initial soil nutrient status	0.17	143.50	47.50	282.00	9.23

The sole crop and intercropping systems exerted their non-significant effect on the oil content of castor (Table 1), but marginally higher oil content was recorded with castor grown as a sole crop as compared to different intercropping systems. The decrease in oil content of castor grown in the intercropping system might be due to sharing of natural resources like space, plant nutrient, moisture and incoming solar radiation. Similar findings were recorded by Singh [11] and Singh et al. [13].

Lower values of crude protein content in lucerne and chicory and total soluble salts in carrot were recorded when they were grown as intercrop with castor at 1:2 row ratio (Table 1). Moreover, the higher crude fibre content of sole crops (lucerne and chicory) was ascribed as compared to their respective intercropping systems *i.e.* lucerne, chicory and carrot (Table 1). This might be due to higher competition offered by intra row spacing for natural resources like space, plant nutrients, moisture and incoming solar radiation.

The sole crop and intercropping systems did not exert their significant effect on soil available organic carbon, nitrogen, phosphorus, potassium and sulphur after harvest of the crops (Table 2). However, a slight improvement in organic carbon of soil was found in castor + lucerne intercropping (1:2 row ratio) at the end of cropping as compared to initial nutrients status of the soil. This might be due to the nitrogen fixing behaviour of lucerne (leguminous crop). Similar results for intercropping systems in mustard + lucerne were also reported by Patel et al. [14] and Singh et al. [13] in sandy loam soils of north Gujarat. Available N, P and K content increased in the soil after harvest of crops might be due to the complementary effect of lucerne and fenugreek throughout the crop growth period. These results are in conformity with findings of Patel et al. and Singh et al. However, growing of castor as a sole crop as well as castor + carrot as intercropping reduced the nutrient status of available N, P_2O_5 and K over the initial fertility status of the soil.

4. CONCLUSION

On the basis of one year study, it can be concluded that the highest seed yield (2315 kg ha^{-1}) and stalk yield (2616 kg ha^{-1}) of castor was recorded when it was grown as sole crops as compared to intercrops. Castor seed equivalent yield (CEY) (3297 kg ha^{-1}) was significantly higher when it was intercropped with lucerne than rest of the treatments. Oil content of castor seed did not show a significant difference due to the different sole and intercropping treatments. Oil yield of castor seed was significantly higher when it was grown as the sole and significantly at par when it intercropped with lucerne and fenugreek than rest of the treatments and castor grown in intercropped did not effect on nutrient status in the soil after harvest of the crop on loamy sand soil of North Gujarat Agro-climatic condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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