

Yield, quality and soil fertility as influenced by *rabi* castor (*Ricinus communis* L.) based intercropping system

Abstract

An experiment comprising nine treatments of sole crops and intercropping systems viz., Castor sole, Lucerne sole, Chicory sole, Fenugreek sole, Carrot sole, Castor + Lucerne (1:2), Castor + Chicory (1:2), Castor + Fenugreek (1:2), and Castor + Carrot (1:2) was conducted in a randomized block design with three replications. Sole castor, castor + lucerne and castor + fenugreek (1:2) found equally effective with respect to ~~seed yield of castor~~. These treatments were found significantly superior than rest of the treatments. With regards to 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. Similar trend was also observed in stalk / dry fodder / straw / green fodder yield of castor and intercrops. Oil content in castor / crude protein and crude fiber content in lucerne and chicory / total soluble salts in carrot were found higher in their sole crop treatments as compared to when they were grown as intercrop. Oil yield was found significantly higher in sole castor than other treatments but it was statistically at par with castor + Lucerne and castor + fenugreek at 1:2 ratio. 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.

Key words: Castor, intercropping, row ratio and sole crop

INTRODUCTION

Castor (*Ricinus communis* L.) is a non-edible oilseed having high industrial importance due to 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, respectively (SEA., 2013). The contribution of India in the world castor acreage and production are 56 and 84 per respectively. Area, production and productivity of

32 castor in Gujarat were 4.22 lakh ha, 8.33 lakh ~~tones~~ and 1972 kg/ha, respectively (SEA,
33 ~~Annual report 2012-2013~~).

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

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

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58 MATERIALS AND METHODS

59 A field experiment was conducted during *rabi* season of the year 2013 at Agronomy
60 Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada
61 Agricultural University, Sardarkrushinagar, District Banaskantha (North Gujarat). The field
62 experiment was laid out in a Randomized Block Design with four replications. An

63 experiment consists of nine treatments including sole crops and intercropping systems viz., T₁
 64 : Castor sole, T₂ : Lucerne sole, T₃ : Chicory sole, T₄ : Fenugreek sole, T₅ : Carrot sole, T₆ :
 65 Castor + Lucerne (1:2), T₇ : Castor + Chicory (1:2), T₈ : Castor + Fenugreek (1:2), and T₉ :
 66 Castor + Carrot (1:2) were allotted to each plot by random method. The soil of experimental
 67 plot was loamy sand in texture, low in organic carbon and available nitrogen, medium in
 68 available phosphorus and potassium. Organic carbon (%), available N (kg ha⁻¹), available
 69 P₂O₅ (kg ha⁻¹), available K₂O (kg ha⁻¹) and available sulphur (ppm ha⁻¹) were estimated by
 70 Walkley and Black's rapid titration method (Jackson, 1973), Alkaline permanganate method
 71 (Jackson, 1973), Olsen's method (Jackson, 1954), Flame photometer method (Jackson, 1973)
 72 and Extraction with 1 % NaCl (William and Steinbergs, 1959), respectively.

73 Among the intercrops, legumes and fodder crops were chosen because of being
 74 widely used in common diet of livestock. Lucerne and Chicory are the most important green
 75 forage crops by virtue of their excellent forage quality, flavor, taste and softness. Fenugreek
 76 and carrot are also eaten as raw vegetable and seed production. Full dose of P₂O₅ and half
 77 dose of N were applied as basal at the time of sowing of rabi castor and remaining half dose
 78 of N was applied in two equal splits at 40 and 70 days after sowing. In lucerne and fenugreek,
 79 full dose of N and P₂O₅ was applied as basal. While in carrot and chicory full dose of P₂O₅
 80 and half dose of N was applied as basal at the time of sowing and remaining half dose of
 81 nitrogen was applied in two equal split at 35 and 60 days after sowing. The castor, lucerne
 82 and chicory were given 10 irrigations each of 50 mm depth whereas five irrigations were
 83 applied to carrot and fenugreek crops. Two common light irrigations viz. first irrigation at the
 84 time of castor sowing and second irrigation at intercrop sowing were given to each crop for
 85 good germination and establishment of seedling. The recommended dose of fertilizer of rabi
 86 castor: 80-25-00, lucerne: 20-40-00, chicory: 150-30-00, fenugreek: 20-40-00 and carrot: 80-
 87 60-00 NPK kg/ha.

88 Random seed samples were drawn from the produce of each net plot to estimate the
 89 oil content of castor seed. The oil content in castor seed samples was determined by IBM
 90 DC/20 series, NMR (Nuclear Magnetic Resonance) analyzer. Oil yield (kg ha⁻¹) was worked
 91 out by using following formula

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil (\%)} \times \text{seed yield (kg ha}^{-1}\text{)}}{100}$$

92 The crude protein content and crude fiber content were measured with the help of
 93 INSTALAB 600 NIR product analyzer and it was expressed as percentage on dry weight
 94 basis (Nortvedt *et al.*, 1998).

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96 **RESULTS AND DISCUSSION**

97 **Significantly** higher seed and stalk yields (~~kg/ha~~) were recorded by sole castor than
 98 rest of the intercropping treatments, but it remained statistically at par with castor + lucerne
 99 and castor + fenugreek with row ratio of 1:2, which could be attributed to higher and
 100 optimum plant densities in sole cropping system. Among the intercropping treatments, castor
 101 + lucerne (1:2) and castor + fenugreek were found equally efficient to castor sole as lucerne
 102 and fenugreek crops have ability to fix atmospheric N and supply it to the associated castor
 103 crop and suppressed the weeds and higher sunshine availability to castor. Lower seed and
 104 stalk yields were noticed under castor intercropping with carrot and chicory at 1:2 row ratios
 105 (Table 1). This might be due to higher competition offered by intercrops for natural resources
 106 like space, plant nutrients, moisture and incoming sun radiation. The findings are in
 107 agreement with the results reported by Dhimmer (2009) and Singh (2009).

108 Green forage and dry fodder yields of lucerne and chicory, seed and straw yield of
 109 fenugreek and root and green forage yields of carrot were reduced in intercropping systems as
 110 compared to their respective sole cropping (Table 1). Such variation could be ascribed due to
 111 increase in plant densities since these were grown as intercrops with castor and higher
 112 competition for natural resources like soil moisture, plant nutrients, space and sunlight which
 113 are responsible for less photosynthesis rate resulted in lower accumulation of photosynthates
 114 in seed and dry matter per plant in comparison to sole crop. These findings are in close
 115 vicinity with the results of Srilatha *et al.*, (2002).

116 The sole crop and intercropping systems exerted their non-significant effect on oil
 117 content of castor (Table 1), but marginally higher oil content was recorded with castor grown
 118 as sole crop as compared to different intercropping systems. The decrease in oil content of
 119 castor grown in intercropping system might be due to ~~higher competition offered by~~
 120 ~~intercrops for~~ natural resources like space, plant nutrient, moisture and incoming sun
 121 radiation. Similar findings were recorded by Singh (2009) and Singh *et al.*, (2013).

122 Further, the intercropping systems could not exert their **significant effect** on crude
 123 protein content of lucerne and chicory fodder and total soluble salts in carrot. While lower
 124 values of crude protein content in lucerne and chicory and total soluble salts in carrot were
 125 recorded when they were grown as intercrop with castor at 1:2 row ratio (Table 1). Moreover,
 126 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 ~~exerted~~ did not exert their significant effect on soil available organic carbon, nitrogen, phosphorus, potassium and sulphur after harvest of the crops (Table 2). However, 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 soil. This might be due to the nitrogen fixing behavior of lucerne (leguminous crop). Similar results for intercropping systems in mustard + lucerne were also reported by Patel *et al.*; (2007) and Singh *et al.*; (2013) in sandy loam soils of north Gujarat. Further, higher available nitrogen, phosphorus and potassium were observed in lucerne grown as sole, whereas, fenugreek sole **established its superiority by recording higher** available sulphur after harvest of the crop (Table 2). Available N, P and K content increased in 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.*; (2007) and Singh *et al.*; (2013). However, growing of castor as a sole crop as well as castor + carrot as intercropping reduced the nutrient status of available N, P₂O₅ and K over the initial fertility status of the soil.

CONCLUSION

On the basis of one year study, it can be concluded that the highest seed yields (2315 kg/ha) and stalk yield (2616 kg/ha) of castor were recorded when they were grown as sole crops as compared to intercrops. Oil content of castor seed did not showed significant difference due to different sole and intercropping treatments. Oil yield (kg/ha) of castor seed was significantly higher when it was grown as 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 soil after harvest of crop on loamy sand soil of North Gujarat Agro-climatic condition.

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184 **Table 1: Yield and quality of castor and inter crops as influence by different treatments**

Treatments	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	2616	48.70	1127	-	-
Lucerne sole	19800	3400	-	-	18.65	20.6
Chicory sole	30300	5419	-	-	20.41	10.7
Fenugreek sole	816	1353	-	-	-	-
Carrot sole	16518	18704	-	-	12.60	2.35
Castor + Lucerne (1:2)	2267 (10900)	2539 (1879)	48.14	1091	18.13	20.4
Castor + Chicory (1:2)	1974 (18280)	2171 (3140)	47.85	945	20.22	10.5
Castor + Fenugreek (1:2)	2154 (534)	2391 (958)	48.05	1035	-	-
Castor + Carrot (1:2)	1761 (9783)	1919 (15163)	47.32	833	12.25	2.20
S. Em.±	-	-	1.55	51.61	-	-
C. D. (0.05)	-	-	NS	158.54	-	-

185 *Data presented in parenthesis indicates intercrops values

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191 **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

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