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YIELD, QUALITY, NUTRIENT UPTAKE, SOIL FERTILITY AND WEED DRY WEIGHT AS INFLUENCED BY CASTOR (*RICINUS COMMUNIS* L.) INTERCROPPED WITH MUNGBEAN (*VIGNA RADIATA* L.) UNDER DIFFERENT ROW RATIOS AND SPACING DURING *RABI* SEASON

A. K. KUMAWAT, R. B. ARDESNA, DINESH KUMAR AND M. CHOUHAN
Department of Agronomy,
N.M. College of Agriculture, Navsari Agricultural University, Navsari - 396 450, INDIA
e-mail: ak47.agro@gmail.com

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***Corresponding author**

ABSTRACT
Experiment was conducted during *rabi* season of 2012-13 to study the response of castor (*Ricinus communis* L.) and mungbean (*Vigna radiata* L.) intercropping under different row spacing. The highest castor yield (2072 kg/ha) was found with sole castor (150 cm x 60 cm) while significantly higher stalk yield of castor (3545 kg/ha) was found with castor (120 cm x 60 cm) + mungbean (1:2). The highest oil content (45.26%) and oil yield (934 kg/ha) of castor was recorded with treatment T_3- sole castor (180 cm x 60 cm), whereas highest seed yield (1023 kg/ha), stover yield (2614 kg/ha) and protein content (23.15%) of mungbean were recorded with T_4- sole mungbean (40 cm x 10 cm). Whereas, higher available N and P_2O_5 in soil after harvest were observed with sole mungbean (40 cm x 10 cm). However significantly higher N uptake (56.43 kg/ha), P uptake (11.42 kg/ha) and K uptake (52.03 kg/ha) was observed with treatments T_2- sole castor (150 cm x 60 cm). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly lowest weed dry weight (2.90 g/m^2) but did not differ significantly with treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2). Hence, intercropping of castor with mungbean in 1:2 ratio is recommended.

INTRODUCTION

Castor (*Ricinus communis* L.) is the most primitive non-edible oilseed crop, belongs to family *Euphorbiaceae*. This is one of the most suitable oil seed crop which can be used to fulfill the ever increasing demand of industrial oil. The castor oil is different from other vegetable oils in the sense that it does not freeze upto -18ºC temperature. It is, therefore, considered to be the best lubricating agent particularly for both high speed engines and aeroplanes. Castor oil is also used in the manufacture of dyes, detergents, plaster of paris, soaps, costumes, polishes, greases, rubber, wetting agents, etc. It is also used as bactericides and fungicides. The demand of castor oil both, inside and outside the country has grown with the advancement of industrialization all over the world. Castor cake provides excellent organic manure with 4.5 per cent N, 2.6 per cent phosphorus and 1.0 per cent potash, 22.37 per cent protein and 45-46 per cent carbohydrates. On an average (last 3 years), India has nearly 1.02 million ha under castor cultivation with a total production of 1.57 million tonnes and productivity of 1560 kg/ha (Anon., 2012).

Green gram or mungbean (*Vigna radiata* L.), a protein rich (25%) staple food, is one of the most important pulse crops in India cultivated since ancient times. It is particularly rich in Leucine, Phenylalanine, Lysine, Valine, Isoleucine, etc. In addition to being an important source of human food and animal feed, mungbean also plays an important role in sustaining soil fertility by improving soil physical properties and fixing atmospheric nitrogen.

Intercropping has been recognized as a potentially beneficial system of crop production which can provide sustained yield advantages compared to sole cropping. To take the advantages of different rooting depths, duration, nutrient and water requirement of the crops and better utilization of all the resources, the concept of intercropping has been introduced in primitive agriculture. In the present situation, increasing agricultural production through extensive agriculture has limited scope due to limited availability of cultivable area. An area of 143.8 million ha out of 329 million of geographical area is at present under cultivation and further expansion of cultivable area is extremely difficult.

Under these circumstances, to meet the requirement of food grains for ever increasing population, the only option open is through time and space utilization in agriculture (Sankaran and Rangaswamy, 1990). Intercropping has been recognized as a potentially beneficial system of crop production and evidences indicate that intercropping can provide substantial yield advantage compared with pure cropping (Willey, 1979). Intercropping plays an important role in the food-production system of developing countries where small farms and labourintensive operation predominant, greater yield stability over different seasons and increasing yield or monetary returns and improved yields for subsequent crops are common advantages of intercropping. Recent evidence suggests that there are substantial advantages of legumes intercropping, which are achieved not by means of costly inputs but by the simple expedient of growing crops together in an appropriate geometry (Khan and Khaliq, 2004). Though intercropping of castor (*Ricinus communis* L.) and Mungbean [*Vigna radiata* (L.)] are the most dominant *rabi* season intercropping system of castor growing regions of India viz., Gujarat (Patel *et al.*, 2009). Therefore, the present study was undertaken to find out the effect of intercropping treatments with different row ratios on growth and yield efficiency of castor and mungbean.

MATERIALS AND METHODS

The experiment was carried out at Pulses and Castor Research Station (South Gujarat Heavy Rainfall Zone, AES-III), Navsari Agricultural University, Navsari during rabi season of 2012-13. The soil of the experimental field is classified under the order Inceptisols comprising member of fine Montmorillonitic, isohyperthemic, family of verticustrochrepts and soil series Jalalpur by the soil survey officer, Navsari, Department of Agriculture, Gujarat state (Desai and Patel, 1970) having moderate drainage capacity and good water holding capacity. The soil of experimental field was low in organic carbon (0.45%), low in available N (234.52 kg/ha), medium in available phosphorus (31.80 kg/ha) and high in available potassium (374 kg/ha). The soil was slightly alkaline in reaction with a pH of 7.8 and EC of 0.36 dS/m.

The experiment was laid out in randomized block design (RBD) with 8 treatments allocation in each replication and was replicated thrice. The experimental treatments comprise T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3). The crops were sown on 27Oct. 2012 using 'GCH-7' castor and 'CO-4'mungbean. The recommended fertilizer does of 120:25:00 kg N:P:K ha^{-1} for castor and 20:40:00 kg N:P:K ha^{-1} for mungbean was applied through urea and SSP. In intercropping combinations seed rate and fertilizers were adjusted according to the number of row arrangement. The other agronomic practices were followed as per recommendation.

The seed yield of castor and mungbean was recorded in kilogram per net plot and converted into kilogram per hectare. Oil content of castor seeds was determined by using Nuclear Magnetic Resonance (NMR) instrument as per the method suggested by Tiwari *et al.* (1974). Oil yield in kg per hectare was calculated by using the following formula.

$$\text{Oil yield (kg/ha)} \quad \frac{\text{Oil content of the seed (\%)} \quad \text{Seed yield (kg/ha)}}{100}$$

The protein content in mungbean seeds was determined by multiplying nitrogen percentage with factor 6.25 (Bhuiya and Chowdhary, 1974). Protein yield (kg/ha) was calculated by using following formula:

$$\text{Protein yield (kg/ha)} \quad \frac{\text{Protein content (\%) in seed} \quad \text{Seed yield (kg/ha)}}{100}$$

Soil samples (0-30 cm depth) were taken from four spots in each net plot and composited samples were prepared plot-wise. These samples were dried, grinded and then sieved through 2 mm size sieve for determination of available N, P_2O_5 and K_2O by the following standard methods prescribed in Table 1.

The weed samples were collected at harvest of mungbean from one meter square area. These samples were sun dried and finally dried in the electrical oven at 65° C for 24 hours. The dry weight of weeds was recorded with laboratory balance when samples attained a constant weight as g per square meter.The data were analyzed as per standard statistical procedure (RBD) suggested by Gomez and Gomez (1984). As the data on weed population and dry weight of weed showed much variation, they were subjected to square root transformation ($\sqrt{X+1}$) and then statistically analyzed by the standard method as described by Steel and Torrie (1960).

RESULTS AND DISCUSSION

The different intercropping system had significant influenced the yields and quality of castor and mungbean (Table 1). The highest yield of castor (2072 kg/ha) was recorded with the treatment T_2- sole castor (150 cm x 60 cm) but found non-significant with rest of the treatments. Treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2) recorded significantly highest stalk yield of castor but remained statistically at par with treatment T_1- sole castor (120 cm x 60 cm). The highest oil content (45.26%) and oil yield (934 kg/ha) of castor was recorded with treatment T_3- sole castor (180 cm x 60 cm).Significantly higher seed yield and stover yield as well as protein content and protein yield of mungbean were recorded with treatment T_4- sole mungbean (40 cm x 10 cm). However, with respect to protein content in mungbean seeds treatment T_4- sole mungbean (40 cm x 10 cm) did not differ significantly with treatments T_6- castor (150 cm x 60 cm) + mungbean (1:2) and T_7- castor (180 cm x 60 cm) + mungbean (1:2).The increase in yield of castor per plant might be due to wider spacing had better nutrition to individual plant which enhanced crop growth and development with more food storage which increased translocation of stored food for sink development. The yield attributes and mungbean yield on unit area basis were reduced when it was grown as intercrop in association with castor. This may probably due to mungbean and castor when grown together, they compete for common environmental resources and thus growth is reduced

Table 1: Methods of estimation of available N, P_2O_5 and K_2O from soil

Particular	Method of analysis
Available Nitrogen (kg/ha)	Alkaline $KMnO_4$ method (Subbaiah and Asija,1956)
Available P_2O_5 (kg/ha)	Olsen's method (Olsen *et al.*, 1954)
Available K_2O (kg/ha)	Flame photometric method (Jackson, 1973)

Table 2: Effect of different intercropping systems on yield and quality of castor and mungbean

Treatment	Castor				Mungbean			
	Castor yield (kg/ha)	Stalk yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	Protein content (%)	Protein yield (kg/ha)
T_1	2033	3350	44.90	911	-	-	-	-
T_2	2072	2975	45.16	931	-	-	-	-
T_3	2054	2648	45.26	934	-	-	-	-
T_4	-	-	-	-	1023	2614	23.15	236.66
T_5	1931	3547	43.85	847	211	539	21.46	45.31
T_6	1867	3017	44.13	824	250	639	22.52	56.29
T_7	1841	2762	44.32	815	222	747	22.73	50.49
T_8	1797	2696	44.04	791	259	789	21.84	56.78
S. Em. ±	128	157	1.04	56	30.00	64.00	0.31	6.58
C.D. (p=0.05)	NS	484	NS	NS	97.85	209.30	1.02	21.47

T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3).

Table 3: Effect of different intercropping systems on Nutrient status of soil after harvest and nutrient uptake by castor and mungbean

Treatment	Nutrient Status of soil after Harvest			Nutrient uptake by Castor			Dry weight
	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	N uptake (Kg /ha)	P uptake (Kg /ha)	K uptake (Kg /ha)	of weeds (g/m^2) at harvest
T_1	237.90	29.90	401.30	55.93	11.42	45.65	3.54(11.61)
T_2	249.97	34.00	403.83	56.43	11.28	43.74	3.75(13.08)
T_3	260.73	40.50	405.33	55.02	10.55	41.51	4.07(15.59)
T_4	265.50	42.40	406.60	-	-	-	2.90(7.39)
T_5	246.53	34.63	401.87	53.10	10.77	52.03	3.18(9.18)
T_6	256.83	37.90	404.30	51.66	9.99	46.05	3.33(10.06)
T_7	265.00	39.43	406.07	49.15	9.10	41.15	3.68(12.53)
T_8	270.23	40.50	408.70	49.42	9.05	40.16	3.38(10.42)
S. Em. ±	6.32	1.19	9.94	1.68	0.33	2.08	0.12
C.D. (p=0.05)	19.16	3.62	NS	5.17	1.03	6.41	0.35

*Data in parenthesis indicate actual value and those outside are transformed values; T_1- sole castor (120 cm x 60 cm), T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_4- sole mungbean (40 cm x 10 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2), T_6- castor (150 cm x 60 cm) + mungbean (1:2), T_7- castor (180 cm x 60 cm) + mungbean(1:2) and T_8- castor (180 cm x 60 cm) + mungbean (1:3).

reflecting in yield reduction. The results are in conformity with those of reported by Manukonda and Shaik, (2007); Rani, (2008); Sardana *et al*. (2008); Patel *et al.* (2009) and Ghilotia *et al*. (2015).

Different intercropping systems also influenced nutrient status of soil, nutrient uptake by castor and dry weight of weeds (Table 3). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly higher available N (265.50 kg/ha) and P_2O_5 (42.40 kg/ha) in soil after the harvesting of crop but, in case of available N treatment T_4 did not differ significantly with all the left over treatments except treatment T_1- sole castor (120 cm x 60 cm, while in case of available P_2O_5 treatment T_4- sole mungbean (40 cm x 10 cm) found statistically at par with treatment T_3- sole castor (180 cm x 60 cm) only. Treatment T_8- castor (180 cm x 60 cm) + mungbean (1:3) recorded highest available K_2O (408.70 kg/ha) in soil after harvest and originate statistically non-significant.Improvement in N status could be attributed to nitrogen fixation ability of the legume crops while improved P_2O_5 might be ascribed to the development of P_2O_5 solubilizing organisms in root zone of legume. Similar results were also observed by Bishnoi and Singh (1986) in Pigeonpea.

Significantly higher N uptake (56.43 kg/ha) by castor crop was recorded with treatment T_2- sole castor (150 cm x 60 cm) and found at par with treatments T_1- sole castor (120 cm x 60 cm), T_3- sole castor (180 cm x 60 cm), T_5- castor (120 cm x 60 cm) + mungbean (1:2) and T6. Significantly higher P uptake (11.42 kg/ha) by castor crop was observed in treatment T_1- sole castor (120 cm x 60 cm,) but did not differ with treatments T_2- sole castor (150 cm x 60 cm), T_3- sole castor (180 cm x 60 cm) and T_5- castor (120 cm x 60 cm) + mungbean (1:2). Treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2) recorded significantly higher K uptake (52.03 kg/ha) and remained statistically at par with treatment T_1- sole castor (120 cm x 60 cm) and T_5- castor (120 cm x 60 cm) + mungbean (1:2). Treatment T_4- sole mungbean (40 cm x 10 cm) recorded significantly lowest weed dry weight (2.90 g/m2) although it remained at par with treatment T_5- castor (120 cm x 60 cm) + mungbean (1:2). This might be due to mungbean is a smoother crop which grow fast in the initial stage and utilize more resources viz., light, water, space and nutrient and finely reduce the weed population and dry weight of weeds.The results corroborate with the findings of Prasad and Verma (1986), Singh and Singh (1988) Gupta and Rathore (1993), Patel *et al*. (2009) and Singh (2009).

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