Indian Journal of Agricultural Sciences **83** (11): 1194–8, November 2013/Article

Effect of nutrient management practices on the productivity, economics and soil fertility of castor (*Ricinus communis*) - sorghum (*Sorghum bicolor*) cropping system in rainfed Alfisols

P RAMESH[1], C V RAGHAVAIAH[2], I Y L N MURTHY[3] AND CH V HARIPRIYA[4]

Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Andhra Pradesh 500 030

Received: 1 October 2011; Revised accepted: 1 May 2013

ABSTRACT

A field experiment was conducted for 6 years during 2005-10 to study the effect of nutrient management practices on the productivity, economics and soil fertility of castor (*Ricinus communis* L.) - sorghum (*Sorghum bicolor* (L.) Moench.) cropping system in rainfed Alfisols of southern Telangana region of Andhra Pradesh. Application of recommended dose of NPK for castor (60-40-30 kg/ha) recorded higher seed yield (1 614 kg/ha) which was comparable with NPK + 5 tonnes FYM/ha (1 589 kg/ha) and 75 % NPK + 25 % N through FYM (1 512 kg/ha). Whereas for sorghum, recommended NPK (60-30-30 kg/ha) + 5 tonnes FYM/ha recorded higher sorghum seed yield (3 147 kg/ha) which was comparable with the treatment, recommended dose of NPK (2 718 kg/ha) and 75% NPK + 25% N through FYM (2 696 kg/ha). Imbalanced application of N alone or NP or 50 % NPK and control plots recorded significantly the lowest seed yields of both crops. Response to zinc application was observed only in third crop cycle of sorghum. The system productivity in terms of castor equivalent yield (CEY) was the highest in NPK + 5 tonnes FYM/ha treatment (2 847 kg/ha) which was 84.3 % higher than the control (1 544 kg/ha). This treatment recorded the maximum gross returns (₹. 71 175 /ha), net returns (₹. 45 025 /ha) and benefit cost ratio (2.72). At the end of 3 cropping cycles (6 years), the treatment receiving NPK + 5 tonnes FYM/ha significantly improved the soil available N, P, K, organic carbon and micro nutrient (Fe, Mn and Zn) status compared to control or imbalanced fertilizer treatments.

Key words: Alfisols, Castor - sorghum cropping system, Economics, Productivity, Rainfed, Soil fertility

Castor (*Ricinus communis* L.) - sorghum (*Sorghum bicolor* (L.) Moench.) is the most important cropping system widely practiced on Alfisols under rainfed conditions of southern Telangana region of Andhra Pradesh. They constitute the drought tolerant traditional crops that can come up well under limited soil moisture, as these areas are frequently prone to drought at one or other stage of crop growth. Castor is grown during *kharif* on an area of 2.5 lakh hectares by the resource-poor farmers with an average productivity of 500 kg/ha (Damodaram and Hegde 2010). Castor is traditionally rotated with sorghum on annual basis during rainy season as double cropping is not possible due to inadequate rainfall (<750 mm) and its erratic distribution. By and large, soil moisture and nutrients are the limiting factors for crop production under rainfed conditions in drylands. Continuous use of imbalanced and inadequate dose of fertilizers can have adverse effect on crop productivity and soil health on long-term basis (Dwivedi and Dwivedi 2007). Application of organic manures in conjunction with recommended fertilizers can have beneficial effect on crop productivity through reducing soil bulk density, enhancement in water holding capacity besides supplying macro and micronutrients (Panwar *et al*. 2010). Hence, the present investigation was carried out to study the long-term effect of individual nutrients and their combinations with and without FYM on castor-sorghum productivity, economics and soil macro and micro-nutrient status.

MATERIALS AND METHODS

A fixed plot field experiment was conducted during 2005-10 at Narkhoda research farm of the Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh on alfisols under rainfed conditions. The eco-region is characterized as semi-arid tropical (SAT) climate and the soil has been classified as red sandy loam with pH 6.3, EC 0.35 dS/m, low

[1]Principal Scientist (e mail: pramesh.icar@gmail.com), National Academy of Agricultural Research Management, Rajendranagar, Hyderabad 500 030; [2] Former Principal Scientist (raghavaiah_c@yahoo.com); [3]Principal Scientist (e mail: murthyiyln @dor-icar.org.in); [4]Technical Officer (T6)

in organic carbon (0.29%) and available nitrogen (160 kg/ha), medium in available phosphorous (23.6 kg/ha) and potassium (262 kg/ha) at the initiation of the experiment. Castor variety 48-1 was sown during the first week of July 2005, 2007 and 2009 and harvested during January 2006, 2008 and 2010. Sorghum hybrid CSH14 was sown during the first week of July 2006, 2008 and 2010 and harvested during October of the same year. Thus for every 2 years, one crop cycle is completed.

The treatments comprised: T1-recommended N alone (60 kg N/ha for castor and 60 kg N/ha for sorghum), T2-recommended dose of NP (60 kg N + 40 kg P_20_5/ha for castor and 60 kg N + 30 kg P_20_5/ha for sorghum), T3–100% recommended dose of NPK (60 kg N + 40 kg P_2O_5 + 30 kg K_2O/ha for castor and 60 kg N + 30 kg P_2O_5 + 30 kg K_2O/ha for sorghum), T4 – 50% recommended dose of NPK (30 kg N, 20 kg P_2O_5 + 15 kg K_2O/ha for castor and 30 kg N + 15 kg P_2O_5 + 15 kg K_2O/ha for sorghum), T5 – 75% NPK + 25% N through FYM (45 kg N + 30 kg P_2O_5 + 22.5 kg K_2O/ha + 3 tonnes/ha FYM for castor and 45 kg N + 22.5 kg P_2O_5 + 22.5 kg K_2O/ha + 3 tonnes/ha FYM for sorghum). T6 - 100% recommended dose of NPK, P through single super phosphate, T7 - 100% recommended dose of NPK to both the crops + 10 kg Zn/ha for sorghum, T8 – 100% recommended dose of NPK + 5 tonnes/ha FYM to both the crops and T9 – no fertilizer control. These nine treatments were replicated thrice in randomized block design at a permanent site. The dosage of farmyard manure according to different treatments was applied 2-3 weeks before sowing of the respective crops. In all the treatments, diammonium phosphate (DAP) was used as a source of N and P except in treatments T1 and T6. Half the dose of nitrogen and full dose of phosphorus and potash as per treatments was applied as basal dose at the time of sowing. The remaining nitrogen was top dressed in 2 splits ¼ at 30 days and ¼ at 60 days after seeding in both the crops. Zinc oxide as per treatment was applied to sorghum crop to supply zinc. Sorghum crop was sown at 45 cm × 10 cm spacing, while castor was sown at 90 cm × 60 cm spacing. The net plot size was 7.2 m × 4.8 m. The total rainfall received during the crop season (June- October) was 838, 567, 542, 877, 638 and 975 mm in 2005, 2006, 2007, 2008, 2009 and 2010, respectively. Comparison among different treatments was made by converting yield of 2 crops into castor equivalent yield on prevailing market price basis. The equivalent yield was calculated as under.

$$\text{Castor equivalent yield (kg/ha)} = \text{Yield of sorghum (kg/ha)} \times \frac{\text{Price of sorghum (₹/kg)}}{\text{Price of castor (₹/kg)}}$$

At the end of the cropping cycle, the soil samples (0-15 cm) were collected and analyzed for N, P, K, organic carbon and micronutrients (S, Cu, Fe, Mn and Zn) by adopting standard analytical methods (Singh *et al*. 2005). Statistical analysis of the data was carried out using standard analysis of variance.

RESULTS AND DISCUSSION

The amount of rainfall received during the crop season (June-October) ranged from 542 mm in 2007 to 975 mm in 2010 as against 20 years average of 550 mm. In rainfed areas, it is not the total rainfall but the distribution of rainfall is the most important criteria for successful crop production. Eventhough, the total rainfall in 2010 is the highest (975 mm), the productivity of sorghum crop is low due to flash rains received in September (422 mm), causing waterlogging and poor grain filling.

Castor seed yield

In the first year of study (2005), the treatment receiving recommended NPK (60-40-30 kg/ha) recorded significantly the highest castor seed yield (1 997 kg/ha) compared to the treatment receiving N alone (1 559 kg/ha) or NP (1 638 kg/ha) but was on par with the treatment receiving NPK + 5 tonnes FYM/ha (1 792 kg/ha) or 75% NPK + 25% N through FYM (1 815 kg/ha). Similar yield trend was also observed in 2007. However in the third crop cycle (2009), highest castor seed yield was obtained in NPK + 5 tonnes FYM/ha (1 427 kg/ha) which was on par with the treatment receiving NPK (1 198 kg/ha). On an average, application of recommended dose of NPK resulted in similar castor seed yield (1 614 kg/ha) to that of NPK + 5 tonnes FYM/ha (1 589 kg/ha) or 75% NPK + 25% N through FYM (1 512 kg/ha). Applying phosphorus through single super phosphate (SSP) was not found beneficial compared to diammonium phosphate (DAP) in all the three years of study (Table 1).

Sorghum seed yield

Application of NPK + 5 tonnes FYM/ha recorded the highest sorghum seed yield, both in 2006 (3 125 kg/ha) and 2008 (4 012 kg/ha) which were on par with the yields obtained in NPK alone (2 979 kg/ha in 2006 and 3691 kg/ha in 2008). However in the third year (2010), NPK + 5 tonnes FYM/ha recorded significantly the highest seed yield (2 305 kg/ha) compared to NPK alone (1 486 kg/ha). Similarly the response of zinc (10 kg/ha) was not observed in the first two years but in the third year (2010), it recorded higher seed yield (1 721 kg/ha) compared to the treatment receiving NPK alone (1 486 kg/ha). On an average, application of NPK + 5 tonnes FYM/ha recorded 15.7% increases in sorghum seed yield (3 147 kg/ha) compared to NPK alone (2 718 kg/ha). Application of 75% NPK + 25% N through FYM recorded seed yield (2 696 kg/ha) comparable to 100% recommended NPK (2 718 kg/ha).

Higher yield in both castor and sorghum with high fertilizer input was due to readily available plant nutrients leading to greater photosynthetic activity in comparison with low doses of fertilizers. The complementary effect of FYM @ 5 tonnes/ha on grain yield of sorghum was found more than that observed on castor bean yield, signifying the differential response of crops to fertilizer/crop nutrition.

Similar findings have been reported by Narayan *et al.* (2009). The positive effect of P was more pronounced than K in sorghum; while in castor besides N, the influence of P and K was more positive in producing yield (Table 1). In both the crops, 25% of N could be substituted by application of farmyard manure as it gave similar yields. Application of FYM facilitates N availability during entire crop growth phases due to slow mineralization of organic N from farmyard manure in castor-sorghum sequence. Enhancement of castor yield due to adoption of integrated nutrient management (INM) practices was also reported by Singh *et al.* (2006), Reddy *et al*. (2006) and Patel *et al.* (2007).

Castor equivalent yield

To compare the cropping system productivity, the yield of sorghum grain was converted into castor equivalent yield considering the market value of both the crops in the system. It was observed that application of recommended dose of NPK + 5 tonnes FYM/ha gave substantially higher castor equivalent yield (2 847 kg/ha) which was 84. 3% higher than that of the control (1 544 kg/ha). Application of recommended dose of NPK recorded similar castor equivalent yield (2 701 kg/ha) to that of 75% NPK + 25% N through FYM (2 590 kg/ha). Imbalanced application of N alone (2 164 kg/ha) or NP (2 381 kg/ha) and inadequate dose of fertilizers (50% NPK) recorded the lowest castor equivalent yield (1 960 kg/ha) compared to the balanced NPK application (Table 2).

Economic returns

Recommended dose of NPK + 5 tonnes FYM/ha recorded the maximum gross returns (₹ 71 175 /ha), net returns (₹ 45 025 /ha) and benefit cost ratio (2.72) even though, the cost of cultivation was the highest (₹ 26 150 /ha) among the treatments (Table 2). Application of recommended dose of

Table 1 Effect of nutrient management practices on seed yield of castor and sorghum

Treatment		Castor seed yield (kg/ha)				Sorghum seed yield (kg/ha)			
Castor	Sorghum	2005	2007	2009	Mean	2006	2008	2010	Mean
N (60 kg/ha)	N (60 kg/ha)	1 559	1 362	1 026	1 315	1 734	2 862	1 770	2 122
NP (60-40 kg/ha)	NP (60-30 kg/ha)	1 638	1 385	1 116	1 379	2 493	3 469	1 557	2 506
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)	1 997	1 648	1 198	1 614	2 979	3 691	1 486	2 718
50 % NPK (30-20-15kg/ha)	50 % NPK (30-15-15 kg/ha)	1 748	1 291	763	1 267	1 127	3 230	846	1 734
75 % NPK + 25 % N (FYM)	75 % NPK + 25 % N (FYM)	1 815	1 515	1 207	1 512	2 978	3 276	1 836	2 696
NPK (P through SSP)	NPK (P through SSP)	1 769	1 477	1 177	1 474	2 660	3 263	1 392	2 438
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)+10 kg Zn/ha	1 717	1 379	1 058	1 384	2 784	3 536	1 721	2 680
NPK + 5 t FYM/ha	NPK + 5 t FYM/ha	1 792	1 549	1 427	1 589	3 125	4 012	2 305	3 147
No fertilizer (control)	No fertilizer (control)	1 364	1 059	607	1 010	1 841	1 846	315	1 334
SEm ±		82.8	89.1	87.3	77.1	307	365	211	187
CD (P= 0.05)		248	267	261	232	920	1 096	633	561

Table 2 Effect of nutrient management practices on total system productivity (castor-sorghum cropping system) expressed in terms of castor equivalent yield and economic returns (mean of 3 cropping cycles)

Treatment		Castor equivalent yield (kg/ha)	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Castor	Sorghum					
N (60 kg/ha)	N (60 kg/ha)	2 164 (40.1)*	54 100	22 860	31 240	2.36
NP (60-40 kg/ha)	NP (60-30 kg/ha)	2 381 (54.2)	59 525	24 200	35 325	2.45
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)	2 701 (74.9)	67 525	24 900	42 625	2.71
50 % NPK (30-20-15 kg/ha)	50 % NPK (30-15-15 kg/ha)	1 960 (26.9)	49 000	22 650	26 350	2.16
75 % NPK + 25 % N (FYM)	75 % NPK + 25 % N (FYM)	2 590 (67.7)	64 750	24 525	40 225	2.64
NPK (P through SSP)	NPK (P through SSP)	2 449 (58.6)	61 225	25 400	35 825	2.41
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)+10 kgZn/ha	2 456 (59.0)	61400	25 900	35 500	2.37
NPK + 5 t FYM/ha	NPK + 5 t FYM/ha	2 847 (84.3)	71 175	26 150	45 025	2.72
No fertilizer (control)	No fertilizer (control)	1 544	38 600	20 400	18 200	1.89

* Percent increase in yield over the control

Market price of sorghum seed: ₹ 10 /kg, castor bean: ₹ 25 /kg

Input price (₹/kg) of urea, DAP, SSP, MOP, FYM and Zn are 5.6, 12, 4.4, 6, 0.25 and 100, respectively.

NPK recorded ₹ 67 525 /ha of gross returns, ₹ 42 625 /ha of net returns with a benefit cost ratio of 2.71. This was closely followed by the treatment, 75% NPK + 25% N through FYM. There was a great reduction in economic returns when imbalanced fertilizers were applied to the castor-sorghum cropping system indicating the importance of the balanced and integrated plant nutrition.

Soil fertility status

At the end of 3 cropping cycles (6 years), recommended dose of NPK + 5 tonnes FYM/ha recorded significantly higher soil available nitrogen (194 kg N/ha), phosphorus (36.6 kg P/ha) and potassium (342 kg K/ha) compared to the control (136 kg N, 18.2 kg P and 238 kg K /ha). This treatment leaves a net positive balance of 34 kg N, 13 kg P and 80 kg K compared to 19 kg N, 7.8 kg P and 32 kg K in recommended NPK applied plot at the end of the cropping cycle. In the plot where manures were not applied (control), the soil fertility declined by 24 kg N, 5.4 kg P and 24 kg K after 6 years (Table 3). This clearly showed the importance of balanced and integrated use of fertilizers and manures for sustaining soil fertility and crop productivity on a long term basis.

Application of recommended dose of NPK + 5 tonnes FYM/ha resulted significantly the highest soil organic carbon (0.37%) compared to either control (0.25%), N alone (0.28%) or NP application (0.31%). Application of balanced fertilizers with or without FYM improved the soil organic carbon compared to the control (Table 4). In general, there is a decline in the micronutrient status of the soil (Cu, Fe, Mn

Table 3 Effect of nutrient management practices on soil available N, P and K status at the end of 3 cropping cycles in 2010

Treatment		Nitrogen (kg/ha)	Change over the initial (+/–)	Phos-phorus (kg/ha)	Change over the initial (+/–)	Potassium (kg/ha)	Change over the initial (+/–)
Castor	Sorghum						
N (60 kg/ha)	N (60 kg/ha)	171	+11	19.5	–4.1	244	–18
NP (60-40 kg/ha)	NP (60-30 kg/ha)	174	+14	27.1	+3.5	252	–10
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)	179	+19	31.4	+7.8	294	+32
50 % NPK (30-20-15 kg/ha)	50 % NPK (30-15-15 kg/ha)	170	+10	28.2	+4.6	272	+10
75 % NPK + 25 % N (FYM)	75 % NPK + 25 % N (FYM)	180	+20	34.3	+10.7	306	+44
NPK (P through SSP)	NPK (P through SSP)	172	+12	30.4	+6.8	282	+20
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha) +10 kg Zn/ha	178	+18	32.5	+8.9	280	+18
NPK + 5 t FYM/ha	NPK + 5 t FYM/ha	194	+34	36.6	+13.0	342	+80
No fertilizer (control)	No fertilizer (control)	136	–24	18.2	–5.4	238	–24
SEm ±		4.7		2.1		8.4	
CD (P= 0.05)		14.1		6.3		25.1	
Initial soil nutrient status in 2005		160		23.6		262	

Table 4 Effect of nutrient management practices on soil organic carbon and micronutrient status at the end of 3 cropping cycles in 2010

Treatment		Soil organic carbon (%)	Soil micronutrient status (mg/kg)				
Castor	Sorghum		S	Cu	Fe	Mn	Zn
N (60 kg/ha)	N (60 kg/ha)	0.28	33.9	0.61	6.9	9.5	0.44
NP (60-40 kg/ha)	NP (60-30 kg/ha)	0.31	36.3	0.64	7.4	8.9	0.40
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha)	0.35	37.0	0.78	8.5	8.1	0.37
50 % NPK (30-20-15 kg/ha)	50 % NPK (30-15-15 kg/ha)	0.34	34.4	0.75	7.5	7.5	0.40
75 % NPK + 25 % N (FYM)	75 % NPK + 25 % N (FYM)	0.35	43.0	0.86	9.8	12.7	0.72
NPK (P through SSP)	NPK (P through SSP)	0.34	45.1	0.58	8.0	8.1	0.47
NPK (60-40-30 kg/ha)	NPK (60-30-30 kg/ha) +10 kg Zn/ha	0.35	36.9	0.57	8.1	10.2	0.86
NPK + 5 t FYM/ha	NPK + 5 t FYM/ha	0.37	42.7	0.94	11.1	15.6	0.73
No fertilizer (control)	No fertilizer (control)	0.25	27.0	0.51	6.5	7.4	0.37
SEm ±		0.02	2.7	0.04	0.4	0.5	0.04
CD (P= 0.05)		0.05	NS	NS	1.3	1.6	0.12
Initial soil nutrient status in 2005		0.29	22.4	2.0	8.4	9.6	0.60

and Zn) when chemical fertilizers alone were applied over 6 years. Integrated use of NPK + 5 tonnes FYM/ha or 75% NPK + 25% N through FYM treatment recorded higher content of micronutrients especially Fe, Mn and Zn. Higher content of sulphur was observed in FYM applied treatments (42.7 – 43.0 mg/kg) and in single super phosphate (SSP) applied plot (45.1 mg/kg) even though, they did not differ from the control (27.0 mg/kg). Among the micronutrients, zinc assumes a prominent role, as it reaches very near to the critical level (0.37 – 0.40 mg/kg) after 6 years. In these soil types, a critical level of 0.375 mg/kg zinc was already reported by Murthy *et al*. (2009). This may be the reason why sorghum responded to zinc application only in the third cropping cycle (Table 1). The soil available zinc content was improved (0.86 mg/kg) due to zinc application compared to the other treatments. Increased soil fertility and micronutrient availability due to application of organic amendments was also reported by Panwar *et al.* (2010) and Ramesh *et al.* (2010).

From the study, it can be concluded that the conjunctive use of recommended dose of NPK fertilizers along with 5 tonnes FYM/ha to castor-sorghum cropping system results in not only higher productivity and economic returns but also sustain the long-term soil fertility in terms of soil organic carbon, macro and micro nutrient status.

REFERENCES

Damodaram T and Hegde D M. 2010. *Oilseeds Situation in India: A Statistical Compendium.* Directorate of Oilseeds Research, Rajendranagar, Hyderabad, p 434.

Dwivedi B S and Dwivedi V. 2007. Monitoring soil health for higher productivity. *Indian Journal of Fertilizers* **3** (1):11-23.

Murthy I Y L N, Padmavathi P and Padmaiah M. 2009. Critical level of DTPA-zinc for castor (*Ricinus communis* L.) in Alfisols. *Agropedology* **19** (2): 139–42.

Narayan S, Mavarkar T K, Prabhakara S and Sridhara S. 2009. Performance of castor (*Ricinus communis* L.) genotypes at different integrated nutrient management practices under irrigated conditions. *Journal of Oilseeds Research* **26**(1):41–3.

Panwar N R, Ramesh P, Singh A B and Ramana S. 2010. Influence of organic, chemical and integrated management practices on soil organic carbon and soil nutrient status under semi-arid tropical conditions in central India. *Communications in Soil Science and Plant Analysis* **41**:1 073–83.

Patel K S, Patel B A, Patel M K, Patel G N and Pathak H C. 2007. Integrated nutrient management for castor-sorghum (fodder) cropping system. *Journal of Oilseeds Research* **24**(1):124–7.

Ramesh P, Panwar N R and Singh A B. 2010. Crop productivity, soil fertility and economics of soybean, chickpea and blond psyllium under organic nutrient management practices. *Indian Journal of Agricultural Sciences* **80** (11): 965–9.

Reddy P K A, Sambasiva Reddy A and Padmavathi P. 2006. Effect of irrigation and integrated nutrient management on seed and oil yield of *rabi* castor, *Ricinus communis* L. *Journal of Oilseeds Research* **23**(2):239–41.

Singh D, Chhonkar P K and Dwivedi B S. 2005. *Manual on Soil, Plant and Water Analysis*, Westville Publishing House, New Delhi, p 200.

Singh I, Rathore M S, Chandan M S and Rao D S. 2006. Nutrient management in irrigated castor, (*Ricinus communis* L.) through integrated approach in Rajasthan. *Journal of Oilseeds Research* **23**(2):346–7.