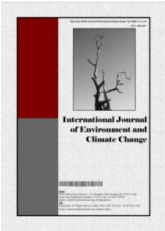

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Evaluation and Identification of *Rabi* Castor Based Profitable Cropping Systems on Alfisols in Southern Telangana

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Authors' contributions

The research work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The experiment was aimed at identifying the *rabi* castor based profitable cropping systems for Alfisols of Southern Telangana Zone.
Study design: Split plot design with three replications
Place and duration of study: Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India during *rabi* season of 2010-11 and 2011-12.
Methodology: The experiment was laid out in a split plot design with five preceding crops (mung bean, fodder jowar, corn, pearlmillet and sesame) in main plots and four nitrogen levels of rabi castor in sub plots (0, 40, 80 and 120 kg N ha^{-1}). The growth parameters, yield attributes, seed yield, water use efficiency and economics were studied.
Results: The results showed that among different proceeding crops evaluated that significantly higher castor seed yield and castor equivalent yield were obtained when rabi castor was preceded

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by corn (1973 and 2931 and kg ha^{-1}) and mung bean (1868 and 2696 kg ha^{-1}) as compared to that of sesame (1672 and 2207 kg ha^{-1}), pearl millet (1823 and 2199 kg ha^{-1}) and fodder jowar (1783 and 2154 kg ha^{-1}). However, higher total system gross returns (Rs. 1,04,118 ha-1) and net returns (Rs. 52,462 ha^{-1}) were accrued when rabi castor was grown after corn only, but, a higher B:C ratio was realized due to mung bean as a preceding crop (2.12). Though castor during rabi season responded similarly to 80 and 120 kg N ha^{-1} in terms of castor seed yield (2275 and 2381 kg ha^{-1}) and castor equivalent yield (2887 and 3013 kg ha^{-1}), application of 120 kg N ha-1to castor resulted in accruing of higher system net returns (Rs. 60,638 ha^{-1}) and B:C ratio (2.27). However, the results of interaction further showed that rabi castor preceded by mung bean with the application of 80 kg N ha^{-1} was found profitable (Rs. 75,573 ha^{-1}). It was closely followed by corn-castor system (Rs. 73,289 ha^{-1}).

Keywords: Economics; equivalent yield; nitrogen levels; preceding crops; rabi castor.

1. INTRODUCTION

Castor (*Ricinus communis*) is an important industrial and non-edible oilseed crop grown across wide ranging agro-climatic regions of the world. India is the global leader with maximum area (69.4%), production (85.8%) and productivity (1751 kg ha^{-1}) [1]. It's oil contains a hydroxy fatty acid known as ricinoleicacid to the tune of 85-90%, hence, is considered as a versatile industrial raw material [2]. Castor is predominantly grown on light textured Alfisols under rainfed conditions during *kharif* season in South India in general and Southern Telangana Zone (STZ) in particular. It's cultivation is threatened by mid or terminal season drought due to partial or complete failure of monsoon and also *Botryotina gray* rot (BGR) due to incessant rainfall coupled with high humidity of >85-90% resulting in low productivity of 500 to 600 kg ha^{-1} [3,4]. Further, exponential horizontal expansion under Bt cotton and corn during *kharif* season in STZ has replaced the castor at a faster pace. However, castor being a commercial crop having immense export potential, is earning more than Rs. 4000 crores of foreign exchange in India. Hence, there is an imminent need to enhance castor area and productivity by growing it in *rabi* season during which *BGR* and moisture stress are altogether can be avoided. *Rabi* casor was proved to have given higher economic returns besides minimal risk of weed, pest and disease menace. It has to be sown on 1st October for achieving higher seed yield, profits and water use efficiency [5]. Though several crops such as cereals, millets, legumes and horticultural crops can be rotated with castor, it is essential to evaluate and suggest short duration and economically superior crop(s) during *kharif* season to facilitate sowing of *rabi* castor at optimum time and also for sustaining the productivity of the system. Hence, a field study was executed to evaluate and identify *rabi* castor based profitable cropping systems in rain starved Southern Telangana Zone.

2. MATERIALS AND METHODS

2.1 Characterization of Experimental Site

A research trial was conducted during *rabi* 2010-11 and 2011-12 at the Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University, Palem, Telangana state, India. The study site was located at 16^{0}35' N latitude and 78^{0}1' E longitude and an altitude of 642 above mean sea level (MSL) in Southern Telangana Zone (STZ). The experimental soil was near neutral with a pH of 6.6, low in organic carbon (0.32%) and available N (227 kg ha^{-1}), high in available P (75.7 kg P_2O_5 ha^{-1}) and K (420.3 kg K_2O ha^{-1}) as per the procedures suggested by [6-9].

2.2 Treatments, Agronomic Management and Statistical Design

The experiment was laid out in a split plot design (SPD) with five preceding crops (mung bean, fodder jowar, corn, pearl millet and sesame) in main plots and four nitrogen levels in sub plots (0, 40, 80 and 120 kg N ha^{-1}) in sub plots and replicated thrice (Fig. 1). The five preceding crops were sown on 28-06-2010 and 28-06-2011 on the receipt of soil profile soaking monsoon rains under rainfed conditions during *kharif* season, while *rabi* castor was sown on 05-10-2010 and 14-10-2011 under irrigated conditions as an irrigated dry (ID) crop, with recommended package of practicesas furnished below in Table 1.

A gross plot size of 5.4mx6.0m and a net plot size of 3.6 mx4.8m were maintained. Five healthy plants with uniform growth were tagged from the net plot of each treatment to record the ancillary characters. Seed yield was recorded from the net plot, after harvesting and threshing of respective crops. While, in case of *rabi* castor, picking was done from three different order spikes during February and March months and the spikes were subjected to threshing. Seed from three pickings was gathered to have final seed yield. The water use efficiency (WUE: kg ha^{-1} mm^{-1}) was computed by dividing the castor equivalent yield with amount of water used by summing up the water applied for *rabi* castor and effective rainfall received during entire duration of respective cropping systems. The gross returns were calculated by multiplying the respective crop yield with market price and the net returns by deducting the cost of cultivation from gross returns. Further, the benefit:cost (B:C) was computed by dividing the gross returns with cost of cultivation.

The ancillary data was analysed using split plot design (SPD) with the help of OPSTAT software. The significance among the various treatments was determined using the f-test and the least significant differences (p=0.05) [10] to draw valid conclusions.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

A perusal of pooled data presented in Table 2 indicated that the growth parameters like plant height, no. of branchesand nodes plant^{-1} of *rabi* castor were not significantly influenced by either various preceding crops or graded level of nitrogen.

3.2 Growth and Yield Attributes

The preceding crops failed to exert any significant influence on total and effective no. of spikes of *rabi* castor. Further, the castor produced significantly longer spikes when preceded by pearl millet as compared to other crops. Further, all the yield attributes like total and effective spike length, the total and effective no. of spikes plant^{-1} improved with graded levels of N and reached highest at 120 kg N ha^{-1}. However, it was at par with 80 kg N ha^{-1} for effective spike length and effective no.of spikes plant^{-1} (Table 2).

3.3 Yield

Rabi castor seed yield was not significantly influenced by preceding crops. It might be due to non-significant difference for most of the growth and yield attributes except spike length. However, greater improvement in castor seed yield was witnessed due to nitrogen levels. The pooled data of two years in Table 3 indicated that significantly higher castor seed yield was obtained with the application of nitrogen at 120 kg N ha^{-1} (2381 kg ha^{-1}) over lower nitrogen levels (40 kg and 0), but, it was statistically at par with 80 kg N ha^{-1} (2275 kg ha^{-1}). The per cent yield improvement was 124.8% and 50.8% due to 120 kg N ha^{-1} over 40 kg N ha^{-1} and no N application, respectively. The probable reasons for such a positive response to 120 kg N ha^{-1} was the availability of nitrogen in synchrony with the crop which has resulted in better vegetative growth, root development, efficient photosynthesis,significantly longer and more no. of spikes resulting in greater seed yield of castor. The response of castor to higher levels of nitrogen supply was reported by several wrokers [11,12,13].

Significantly higher castor equivalent yield (CEY) was obtained when *rabi* castor was preceded by corn (2931 kg ha^{-1}) and mung bean (2696 kg ha^{-1}) as compared to that of sesame (2207 kg ha^{-1}), pearlmillet (2199 kg ha^{-1}) and fodder jowar (2154 kg ha^{-1}). Similarly, castor responded upto 80 and 120 kg N ha^{-1} in terms of CEY (2887 and 3013 kg ha^{-1}). This was in tune with the findings of [12,13,14]. The per cent improvement in CEY was 82.4 and 37.1% due to 120 kg N ha^{-1} over 40 kg N ha^{-1} and control, respectively.

3.4 Water Use Efficiency

Significantly higher water use efficiency (WUE) was obtained when *rabi* castor was preceded by mung bean (2.66) and corn (2.65)which was due to significantly higher CEY as compared to that of pearl millet (2.17), fodder jowar and sesame (2.13). It means that mung bean-castor and corn-castor are water use efficient cropping systems on Alfisols. Among nitrogen levels, application of 120 kg N ha^{-1} resulted in significantly higher water use efficiency (2.91) over lower nitrogen levels (40 and 0), but, statistically at par with that of 80 kg N ha^{-1} (2.78) (Table 3).

3.5 Economic Analysis

Higher total system gross returns and net returns were realized when castor was preceded by corn (Rs. 1,04,118 and 52,462 ha^{-1}). It was closely followed by mung bean (Rs. 98,209 and 52,053 ha^{-1}) as compared to that of sesame (Rs. 83,711 and 37,555 ha^{-1}), pearl millet (Rs. 78,986 and 33,330 ha^{-1}) and fodder jowar (Rs. 77,171 and 32,265 ha^{-1}). However, higher benefit:cost ratio was obtained from castor preceded by mung bean (2.12) and corn (2.01) (Table 3). It can be attributed to higher seed yield and CEY with mung bean/corn-castor systems than other. Further, higher total system gross and net returns and benefit:cost ratio (Rs. 1,08,513, 60,638 ha^{-1}and 2.27) were accrued with the supply of 120 kg N ha^{-1} to *rabi* castor. It was closely followed by 80 kg N ha^{-1}. (Rs. 1,04,987, 57,600 ha^{-1} and 2.21). It was mainly due to higher castor seed yield and CEY at 120 and 80 kg N ha^{-1}.

3.6 Interaction

Interaction between preceding crops and N applied to *rabi* castor revealed that castor responded significantly upto 80 kg N ha^{-1} only when preceded by corn and mung bean, but, upto 120 kg N ha^{-1} when preceded by sesame, fodder jowar and pearl millet, in respect of castor seed yield and CEY (Table 4 and 5). The same trend was observed with regard to WUE (Table 6), total system gross returns (Table 7), total system net returns (Table 8) and B:C ratio (Table 9). Similar observations were made earlier by few researchers [13,14,15]. The beneficial effect of legumes in a system has been thoroughly demonstrated in this field investigation. Further, the synergistic effect of legumes towards the improvement of yield can linked to the symbiotic fixation of atmospheric nitrogen which improved the nutrition of the plant [16]. Furthermore, it has been shown that legumes plays a positive role in the solubilization of phosphorus (P) and improves productivity.

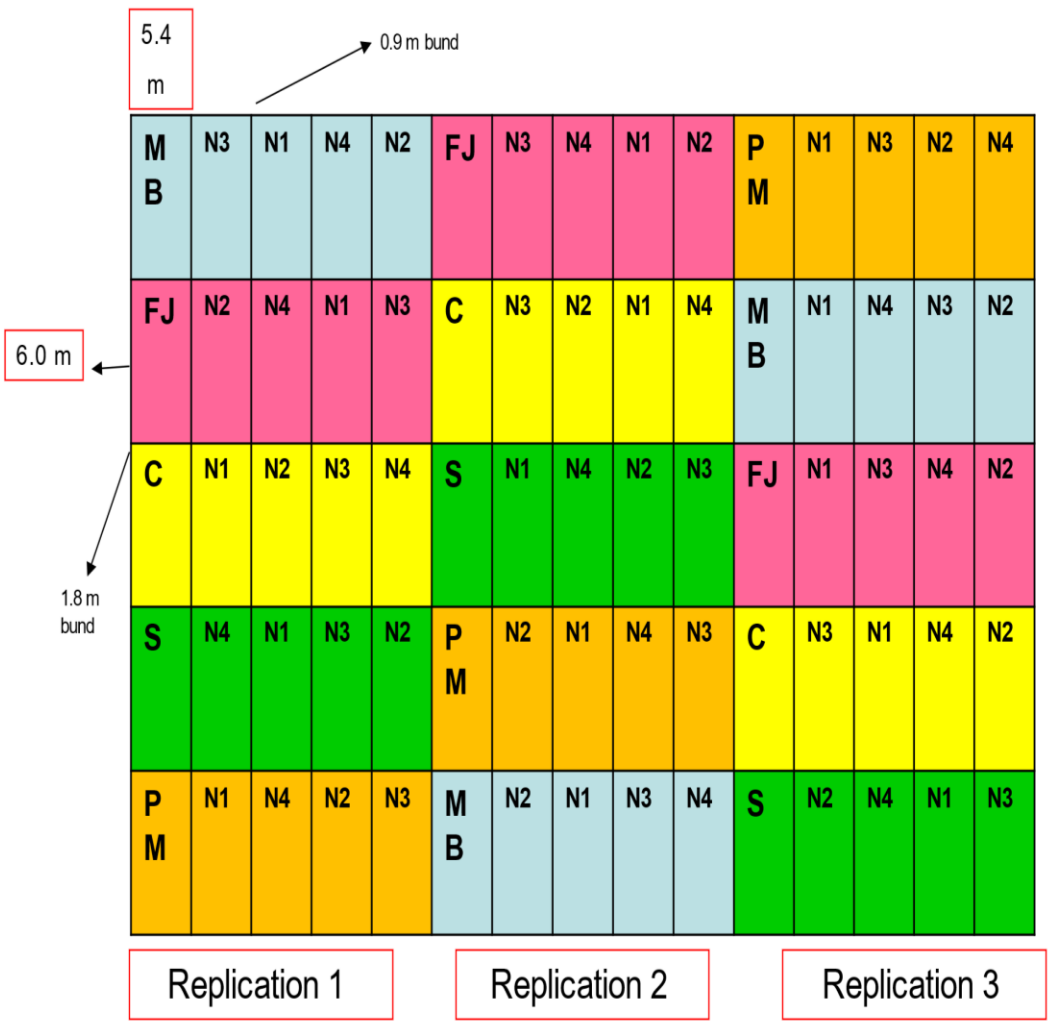

Fig. 1. Lay out the experimental field

Table 1. Package of practices followed for different crops in the experiment

S.No.	Name of the crop	Variety	Duration (days)	Spacing (cmxcm)	Seed rate (kg ha^{-1})	Seed treatment (g or ml kg^{-1})	Fertilizer schedule (kg N, P_2O_5, K_2O ha^{-1})*	Weed control	Plant protection	Harvesting dates
Kharif										
1	Mung bean (MB)	MGG- 295	80	30x10	20.0	Imidachlopri d (5)	20-50-0	Pre-em. application of Pendimethalin (5 ml lit^{-1}) followed by two hand weedings	Acephate (1.5 g lit^{-1})	17-09-2010 and 18-09-2011
2	Fodder Jowar (FJ)	CSV 21F	60	45x15		Thiram (3)	60-30-20	Pre-em. application of Atrazine (5 g lit^{-1}) followed by two hand weedings	-	01-09-2010 and 31-08-2011
3	Corn (C)	DHM-117	95	60x20	20.0	Carbendazim (3)	180-60-60	Pre-em. application of Atrazine (5 g lit^{-1}) followed by two hand weedings	Leaf blight (Dithane Z-78 @ 2.5 g lit^{-1})	30-09-2010 and 02-10-2011
5	Pearl millet (PM)	PHB-3	80	45x15	5.0	Thiram (3)	60-30-20	Pre-em. application of Atrazine (3 g lit^{-1}) followed by two hand weedings	-	17-09-2010 and 15-09-2011
5	Sesame (S)	YLM-17	80	45x10	6.75	Imidachloprid (2)	40-20-20	Pre-em. application of Pendimethalin (3 ml lit^{-1}) followed by two hand weedings	Phyllody (Dimethoate @ 2 ml lit^{-1})	17-09-2010 and 15-09-2011
Rabi										
1	Castor	PCH-111	150	90x60	5.0	Carbendazim (3)	N as per treatment** 40-30 kg P_2O_5, K_2O ha^{-1}	Pre-em. Application of Pendimethalin (5 ml lit^{-1}) followed by two times intercultivations and two intra row hand weedings	Leaf hopper (Acephate 1.5 g lit^{-1}; Dimethoate 2.0 ml lit^{-1}) Semilooper and Spodoptera (Novoluron 2.0 ml lit^{-1})	February and March 2011 and 2012

*Legend *Source: N: urea (46% N); P_2O_5: Single super phosphate (SSP: 16% P_2O_5); K_2O: Muriate of potash (MOP: 60% K_2O),*
Corn: Nitrogen in three equal split doses at basal, knee high stage and flowering; entire phosphorus as basal, potash in equal splits with half as basal and half at flowering
Pearl millet: Nitrogen in two equal splits with half as basal and half at 30 DAS, entire phosphorusand potash as basal.
Sesame: Nitrogen in two equal splits with half as basal and half at 30 DAS, entire phosphorus and potash as basal.
Fodder jowar: Nitrogen in two equal splits with half as basal and half at 30-35 DAS, entire phosphorus and potash as basal.
Mung bean: Entire nitrogen and phosphorus basal.
***N dose was applied as per the treatment for rabi castor, with 50%N as basal and remaining 50%N in three equal split doses at 30, 60 and 90 DAS, entire phosphorus and potash as basal*

Table 2. Effect of N levels on growth and yield attributes of *rabi* castor grown after different *kharif* preceding crops (Pooled data of 2010-11 and 2011-12)

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of nodes plant^{-1}	Total spike length (cm)	Eff. spike length (cm)	No. of spikes plant^{-1}	No. of effective spikes plant^{-1}
Preceding crops							
Mung bean	63.4	3.22	12.8	46.8	44.6	7.63	6.94
Fodder Jowar	62.5	3.22	11.8	44.2	42.6	7.32	6.69
Corn	63.1	3.12	12.0	47.5	45.4	7.31	6.68
Pearl millet	65.5	3.18	12.5	56.7	53.8	8.65	7.73
Sesame	63.3	3.07	13.2	47.2	45.0	6.94	6.04
SEm±	3.1	0.28	0.4	1.7	1.76	0.56	0.53
CD (0.05)	NS	NS	NS	5.5	5.74	NS	NS
N levels (kg ha^{-1})							
0	59.4	2.95	12.9	41.7	39.9	5.94	5.46
40	64.6	3.19	12.7	47.9	45.5	7.37	6.61
80	64.5	3.19	12.2	51.8	49.7	7.97	7.27
120	65.7	3.32	12.0	52.4	50.0	8.99	7.92
SEm±	2.1	0.18	0.3	1.2	1.12	0.32	0.24
CD (0.05)	NS	NS	NS	3.4	3.22	0.93	0.70

Table 3. Effect of N levels on the productivity, WUE and economics of *rabi* castor grown after different *kharif* preceding crops (Pooled data of 2010-11 and 2011-12)

Treatments	Castor seed yield (kg ha^{-1})	Castor seed equivalent yield (kg ha^{-1})	Water used (mm)	WUE (kg ha^{-1} mm^{-1})	Castor gross returns (Rs ha^{-1})	Preceding crop gross returns (Rs ha^{-1})	Total system gross returns (Rs ha^{-1})	Total system net returns (Rs ha^{-1})	B:C ratio
Preceding crops									
Mung bean	1868	2696	1013.9	2.66	68770	29440	98209	52053	2.12
Fodder Jowar	1783	2154	1013.9	2.13	65366	11804	77171	32265	1.71
Corn	1973	2931	1116.3	2.65	70963	33155	104118	52462	2.01
Pearl millet	1823	2199	1013.9	2.17	65607	13379	78986	33330	1.72
Sesame	1672	2207	1034.7	2.13	64391	19321	83711	37555	1.81
SEm±	78	86		0.08	2007	786	2073	2073	0.04
CD (0.05)	NS	281		0.26	NS	2568	6752	6752	0.14
N levels (kg ha^{-1})									
0	1059	1652	1038.5	1.59	39909	20633	60541	15291	1.34
40	1578	2197	1038.5	2.12	58233	21483	79716	32591	1.69
80	2275	2887	1038.5	2.78	83334	21652	104987	57612	2.21
120	2381	3013	1038.5	2.91	86602	21911	108513	60638	2.27
SEm±	56	50		0.05	1005	540	1132	1132	0.02
CD (0.05)	161	146		0.14	2904	NS	3269	3269	0.07

Table 4. Effect of interaction between preceding crops and N levels on castor seed yield (kg ha^{-1})

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	1277	1443	2473	2278	**1868**
Fodder Jowar	983	1687	2103	2357	**1783**
Corn	993	1863	2557	2477	**1973**
Pearl millet	1007	1747	2140	2397	**1823**
Sesame	1033	1150	2103	2400	**1672**
Average	**1059**	**1578**	**2275**	**2381**	
		SEm±	CD (0.05)		
N at same level of preceding crops		156	376		
Preceding crops at same level of N		133	401		

Table 5. Effect of interaction between preceding crops and N levels on castor equivalent yield (kg ha^{-1})

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	2017	2220	3345	3200	**2696**
Fodder Jowar	1360	2097	2450	2710	**2154**
Corn	1980	2833	3507	3403	**2931**
Pearl millet	1403	2133	2470	2790	**2199**
Sesame	1500	1703	2660	2963	**2207**
Average	**1652**	**2197**	**2887**	**3013**	
		SEm±	CD (0.05)		
N at same level of preceding crops		172	344		
Preceding crops at same level of N		131	397		

Table 6. Effect of interaction between preceding crops and N levels on system WUE (kg ha^{-1}mm^{-1})

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	1.99	2.19	3.30	3.16	**2.66**
Fodder Jowar	1.34	2.07	2.42	2.67	**2.13**
Corn	1.80	2.56	3.17	3.09	**2.65**
Pearl millet	1.38	2.10	2.44	2.76	**2.17**
Sesame	1.45	1.65	2.57	2.86	**2.13**
Average	**1.59**	**2.12**	**2.78**	**2.91**	
		SEm±	CD (0.05)		
N at same level of preceding crops		0.16	0.33		
Preceding crops at same level of N		0.12	0.37		

Table 7. Effect of interaction between preceding crops and N levels on total system gross returns (Rs ha^{-1})

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	73696	81111	122198	11532	**98209**
Fodder Jowar	49168	75396	88147	95972	**77171**
Corn	70419	102140	125414	118498	**104118**
Pearl millet	52147	79678	86620	97500	**78986**
Sesame	57276	60254	102554	114761	**83711**
Average	**60541**	**79716**	**104987**	**108513**	
		SEm±	CD (0.05)		
N at same level of preceding crops		4146	7750		
Preceding crops at same level of N		3016	9239		

Market price: Castor: Rs. 38.00 kg^{-1} seed; Mung bean: Rs. 34.00 kg^{-1} seed; Fodder jowar: Rs. 2.00 kg^{-1} green fodder; Corn: Rs. 9.25 kg^{-1} seed; Pearl millet: Rs. 10.50 kg^{-1} seed; Sesame: 55.00 kg^{-1} seed

Table 8. Effect of interaction between preceding crops and N levels on total system net returns (Rs ha^{-1})

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	29196	34736	75573	68707	**52053**
Fodder Jowar	5918	30271	42772	50097	**32265**
Corn	20419	50265	73289	65873	**52462**
Pearl millet	8147	33803	40495	50875	**33330**
Sesame	12776	13879	55929	67636	**37555**
Average	**15291**	**32591**	**57612**	**60638**	
		SEm±	CD (0.05)		
N at same level of preceding crops		4146	7750		
Preceding crops at same level of N		3016	9239		

Table 9. Effect of interaction between preceding crops and N levels on B:C ratio of the system

Treatments	Control	40 kg N ha^{-1}	80 kg N ha^{-1}	120 kg N ha^{-1}	Average
Mung bean	1.66	1.75	2.62	2.46	**2.12**
Fodder Jowar	1.14	1.67	1.94	2.09	**1.71**
Corn	1.41	1.97	2.41	2.25	**2.01**
Pearl millet	1.19	1.74	1.88	2.09	**1.81**
Sesame	1.29	1.30	2.20	2.43	
Average	**1.34**	**1.69**	**2.21**	**2.27**	
		SEm±	CD (0.05)		
N at same level of preceding crops		0.09	0.16		
Preceding crops at same level of N		0.06	0.19		

4. CONCLUSION

Growing *rabi* castor with mung bean or corn as preceding crop and fertilized with 80 kg N ha^{-1} can be recommended on light textured Alfsiols of Southern Telangana for realizing significantly higher system productivity and economic benefits besides water use efficiency. Further, castor grown after fodder jowar, sesame and pearlmillet demanded higher N with less economic returns, hence, can't be advocated.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. Food and Agriculture Organisation of the United Nations. Rome, Italy; 2019.
2. Gudadhe JD, Thanki RM, Pankhaniya RB, Ardeshna VG. Response of *Rabi* hybrid castor to rate and source of nitrogen with and without biofertiliser. Indian Journal of Fertilizers. 2017;13 (7):42-46.
3. Ramanjaneyulu AV, Dharma Reddy K, Vishnuvardhan Reddy A, Nagesh Kuma MV, KhayumAhammed S, Gouri Shankar V, Neelima, TL. Upscaling and outsclaing of *rabi* castor in Andhra Pradesh-opportunities and limitations. International Journal of Bio-resource and Stress Management. 2014;5(1):138-142.
4. Madhu M, Venkataramana M. Performance *rabi* castor (*Ricinus communis* L.) under zero-tilled condition after different preceding crops. Journal of Oilseeds Research. 2017a;34(2):89-92.
5. Ramanjaneyulu AV, Vishnuvardhan Reddy A, Madhavi A. The impact of sowing date and irrigation regime on castor (*Ricinus communis* L.) seed yield, oil quality characteristics and fatty acid composition during post rainy season in South India. Industrial Crops and Products. 2013;44:25-31.
6. Jackson ML. Soil chemical analysis (2nd Ed.). Prentice Hall of India, New Delhi. 1973;498.
7. Walkley A, Black IA. An examination of the Degtareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37:29-38.
8. Olsen SR, Cole CW, Watanabe RS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium carbonate. US Department of Agriculture, 1954;2:939.
9. Subbaiah BV, Asija GL. A rapid procedure for estimation of available nitrogen in soils. Current Science. 1956;65(7):477-480.
10. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR Publication. New Delhi. 1985;296.
11. Patel RM, Patel MM, Patel, GN. Effect of spacing and nitrogen levels on rabi castor, Ricinus communis grown under different cropping sequences in north Gujarat agro-climatic condition. Journal of Oilseeds Research. 2009;26(2):123-125.
12. Shinde RS, Kalegore NK, Gagare Yogini, M. Effect of plant spacing and fertilizer levels on yield and yield attributes of castor (*Ricinus communis* L.). International Journal Current Microbiological Applied Sciences. 2018;6:1738-1743.
13. Bhargavi B, Sree Rekha M, Prasad PVN, Jayalaitha K. Growth and yield of castor hybrids at varying nitrogen levels in Andhra Pradesh, India. International Journal Current Microbiological Applied Sciences. 2018;7(8):3178-3183.
14. Madhu M, Venkata Ramana M, Sidevi S. Economics of zero-till *rabi* castor (*Ricinus communis* L.) under the influence of different preceding crops. Indian Journal of Dry land Agriculture & Development. 2017b;32(2):13-17.
15. Patel KS, Patel GN, Patel MK, Pathak, HC, Patel JK. Nitrogen requirement of *rabi* castor, *Ricinus communis* L. under different crop sequences. Journal of Oilseeds Research. 2005;22 (1):209-210.

16. Odhiambo GD, Ariga ES. Effect of intercropping corn and beans on Striga incidence and grain yield, Seventh Eastern and Southern Africa Regional Corn Conference. 2001;183-186.

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