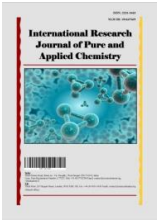

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Validation of Target Yield based Fertilizer Prescription for *Rabi* Castor in Alfisol

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Authors' contributions

This work was carried out in collaboration among all authors. Author KR conducted the experiment and analysed soil and plant samples in the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AM and TS executed the experimental work. Authors PSB and PD provided technical guidance for the study. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted from 2015-16 to 2017-18 on a Typic Rhodustalfs (Alfisol) soils of Telangana at Regional Agricultural Research Station, Palem, Nagarkurnool, Southern Telangana Zone, India to validate targeted yield based fertilizer prescription equations which developed for hybrid castor by adopting eight treatments viz., Blanket recommendation (100% RDF:80:40:30 kg N, P2O5 and K2O ha^{-1}), Blanket+5 t ha^{-1} of vermin-compost (VC), STCR-Target yield with NPK alone at 25q ha^{-1}, STCR-Target yield with IPNS at 25q ha^{-1}, STCR-Target yield with NPK alone at 30q ha^{-1}, STCR-Target yield with IPNS at 30q ha^{-1}, Farmer's practice (40:20:0kg N, P2O5 and K2O

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ha^{-1}) and Absolute control (without inorganic and organic fertilizers). The findings of these test verification trials clearly revealed that the percent achievement of the aimed yield target was within + 10 percent variation confirming the validity of the equations. Using STCR-NPK@25 and 30q ha^{-1} recorded significantly higher seed (20.74 and 22.30q ha^{-1}) and stalk (24.63 and 26.36q ha^{-1}) yield over blanket recommendation (19.40 and 23.13 q ha^{-1}), while STCR-IPNS at 25 and 30 q ha^{-1}recorde relatively higher seed (20.98 and 22.69q ha^{-1}) and stalk (25.88 and 27.13q ha^{-1}) yield over STCR-NPK alone treatments. The magnitude of built-up was higher with STCR-IPNS treatments as compared to STCR-NPK alone, blanket recommendations, farmer's practice and absolute control.

Keywords: Fertilizer; Rabi castor; yield; NPK.

1. INTRODUCTION

Castor (*Ricinus communis* L.) is one of the oilseed crops, plays an important role in country's vegetable oil economy. Being oil containing crop, it is getting attention for production of biodiesel to minimize the consumption of fossil fuel, Nahar [1]. Besides this, due to the uniform ricinoleic acid content, it utilized in traditional medicines, paints, and cosmetics and many industrial purposes, Cheema et al. [2]. The crop is growing under marginal lands of the country, which leaves the crop thirsty and hungry and results in low yield. However, castor is a long duration, widely spaced crop with a comparatively thin plant population as compared to other oilseed crops, provides ample scope for nutrient management practices to enhance growth and yield. The world production of castor seed hovers around at an average of 12.5 lakh tons with an oil fabrication of 5.5 lakh tons. India accounts for nearly 60% of world's castor area and 65% of world castor production and ranks first in both area and production in the world, followed by China and Brazil. Presently in India, castor is cultivated in an area of about 1150 thousand hectares with a total production of 1169 thousand metric tonnes and productivity of 1417 metric tonnes/hectare; Gujarat, Andhra Pradesh, Telangana and Rajasthan contribute 96% of the total castor seed production in India. Gujarat accounts for 63% of India's castor seed production followed by Andhra Pradesh, Telangana and Rajasthan. In both southern states, crop is cultivated in an area of about 230 thousand hectares with a total production of 156 thousand metric tonnes and productivity of 677 metric tonnes/hectare, SEA [3]. It is mainly grown in Mahabubnagar, Nalgonda and Rangareddy districts of Telangana under rainfed conditions, IIOR, 2019 [4].

The decision on fertilizer use requires knowledge of the expected crop yield response to the nutrient application, which is function of crop nutrient needs, supply of nutrients from indigenous sources, and the short and long-term fate of the applied fertilizer nutrients, Dobermann et al. [5]. Based on this concept, Truog [6] illustrated the possibility of "Prescription method" of fertilizer use for obtaining high yields using empirical values of nutrient availability from soil and fertilizer. However, Ramamoorthy et al. [7] established the theoretical basis and field experimental proof and validation for the fact that Liebig‟s Law of minimum of plant nutrition in long back, Liebig [8] to operate equally well for N, P and K for high yielding varieties. The specific yield equation based on soil health besides ensuring sustainable crop production, also steers the farmers towards the economic use of costly fertilizer inputs depending on their financial status, Bera et al. [9]. A linear response of seed yield (1620 kg ha^{-1}) and higher gross return (Rs. 54320 ha^{-1}), net return (Rs. 35135 ha^{-1}) and B:C ratio (2.6) was observed due to application of 40 kg P_2O_5 ha^{-1}+seed treatment of PSB 20g kg^{-1} compared to biophos (30gm/50gm of seeds) alone, and similar results were observed at farmers fields of Gudihalli village in Chitradurga District for validation of technology, Kumar et al. [10]. With this background, a study was intended to find the relationship between nutrients supplied by the soil and added by organic and inorganic sources and to validate fertilizer prescription equations developed for the desired yield target of hybrid castor on Alfisol at Southern Telangana Zone, India.

2. METHODOLOGY

Validation experiments were conducted for three years during *rabi* 2015-16 to 2017-18 to validate the fertilizer prescription equations developed for hybrid castor at Regional Agricultural Research Station (RARS), Palem, Southern Telangana Zone, India on soil series of typic rhodustalfs (Alfisol). The soil of experimental site was sandy clay loam in texture, slightly alkaline (pH 7.21) in reaction, non-saline (0.12 dS m^{-1}), low in organic

carbon (0.41%), available N (144.83 kg ha^{-1}), medium in available P_2O_5 (41.38 kg ha^{-1}) and medium in available K_2O (286.04 kg ha^{-1}) and fertilizer prescription equations developed for hybrid castor is furnished below:

Where, FN, FP_2O_5 and FK_2O are fertilizers N, P_2O_5 and K_2O in kg ha^{-1}; T is the yield target in q ha^{-1}; SN, SP and SK are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1} and VCN, VCP and VCK are the quantities of N, P and K in kg ha^{-1} supplied through Vermi Compost (VC). The pH of the soil was estimated in 1:2 ratio of soils and water suspension by using digital pH meter and electrical conductivity was estimated with the same soil water supernatant solution of 1:2 using an electrical conductivity meter, Jackson, [11]. Organic carbon was determined by the modified Walkley–Black [12] wet digestion method. Available (mineralizable) N was estimated with alkaline 0.32% $KMnO_4$ in the Kelplus distillation unit as per Subbaiah and Asija [13]. Available P was extracted with 0.5 M $NaHCO_3$ (pH 8.5) and estimated spectro-photometrically by following procedure given by Olsen et al. [14]. Available K was extracted with neutral 1N NH_4OAC and estimated by flame emission spectroscopy, Muhr et al. [15]. The hybrid castor variety PCH-111 was used as a test crop and treatments were laid in randomized complete block design with three replications. The treatments were imposed as follows: T_1–Blanket recommendation (100% RDF-80:40:30 kg N, P_2O_5 and K_2O ha^{-1}), T_2–Blanket+5 ton ha^{-1} of VC, T_3–STCR-Target yield with NPK alone at 5q ha^{-1}, T_4–STCR-Target yield with IPNS at 25q ha^{-1}, T_5–STCR-Target yield with NPK alone at 30q ha^{-1}, T_6–STCR-Target yield with IPNS at 30 q ha^{-1}, T_7–Farmer's practice (40:20:0kg N, P_2O_5 and K_2O ha^{-1}) and T_8–Absolute control (without inorganic and organic fertilizers). According to the treatment schedule, entire dose of phosphorus and potassium (40 and 30 kg ha^{-1}) were applied in the form of single super phosphate (SSP) and muriate of potash (MOP) as basal. Nitrogen was applied in the form of urea in 3 equal splits (1/3rd basal, 1/3rd at first inflorescence stage and 1/3rd at second inflorescence stage). The data obtained from various parameters were analyzed in Randomized complete Block Design (RCDB) statistical procedure, Panse and Sukhatme [16]. The appropriate standard error of mean (S.E.m±) and the critical difference (C.D.) was calculated at 5% level of probability and benefit-cost ratio (B:C ratio) was worked out based on the standard procedure, Gittinger [17].

3. RESULTS AND DISCUSSION

3.1 Seed and Stalk Yield (q ha^{-1}) of Castor

The seed and stalk yield of castor influenced by different treatments during three *rabi* seasons (2015-16 to 2017-18) presented in Table 2. It is clear that the seed yield of castor varied from year to year and ranged from 6.71 to 18.11, 8.01 to 23.04, 8.83 to 26.91q ha^{-1} and stalk yield varied from 8.53 to 23.71, 12.64 to 25.85 and 13.07 to 31.82q ha^{-1} for different treatments evaluated during 2015-16, 2016-17 and 2017-18 respectively. Pooled STCR-IPNS@30q ha^{-1} significantly increased the seed and stalk yield (22.69 and 27.13q ha^{-1}) as compared to blanket recommendation (100% RDF as 80:40:30 kg N, P_2O_5 and K_2O ha^{-1}), blanket recommendation along with vermicompost@5 t ha^{-1} and farmer's practice (40:20:0 kg N, P_2O_5 and K_2O ha^{-1}), which were recorded as 19.40, 20.16 & 16.61 and 23.13, 23.74 & 19.55q ha^{-1} respectively (Table 2). Among the treatments, STCR-IPNS@30q ha^{-1} recorded numerically higher seed and stalk yield (22.69 and 27.13 q ha^{-1}) over STCR-NPK@30q ha^{-1}, STCR- IPNS@25q ha^{-1} and STCR-NPK alone@25q ha^{-1} as 22.30, 20.98 & 20.74 and 26.46, 25.88 & 24.63q ha^{-1} sequentially. These results elucidated the beneficial effect of STCR-IPNS treatments on the seed and stalk yield of castor which might be due to meeting the immediate nutrient requirement of the crop through inorganic fertilizers in the early growth stages and continuous supply of nutrients throughout the crop growth period by the organic sources and these findings were supported by Padmavathi et al. [18] and Singh et al. [19].

3.2 Total NPK Uptake by Castor Crop

The total NPK uptake (kg ha^{-1}) of castor crop presented in Fig. 1, which experiment conducted continuously from 2015-16, 2016-17 and 2017-18. The total NPK uptake varied from 9.9 to 34.7, 6.7 to 16.9 & 8.12 to 31.01 kg ha^{-1} in 2015-16; 13.2 to 40.1, 7.4 to 19.6 & 11.35 to 38.31 kg ha^{-1} in 2016-17 and 18.3 to 48.8, 10.2 to 21.9 & 16.39 to 46.37 kg ha^{-1} in 2017-18. Due to the poor monsoons and prolonged dry spells, the total uptake was slightly low in the order of 2015-16<2016-17<2017-18. Among the treatments, STCR-IPNS@30q ha^{-1} registered numerically higher values of total NPK uptake as 34.7, 16.9 & 31.01 kg ha^{-1} in 2015-16; 40.1, 19.6 & 38.31 kg ha^{-1} in 2016-17 and 48.8, 21.9 & 46.37 kg ha^{-1} in 2017-18 over blanket recommendation with vermi compost@5 t ha^{-1} (23.6, 12.7 & 21.22 kg

ha^{-1} in 2015-16, 29.1, 14.8 & 27.30 in kg ha^{-1} in 2016-17 and 30.6, 15.3 & 28.41 kg ha^{-1} in 2017-18), STCR-IPNS@25q ha^{-1} (32.8, 15.6 & 29.16 kg ha^{-1} in 2015-16; 35.3, 17.1 & 33.48 kg ha^{-1} in 2016-17 and 39.9, 19.7 & 38.33 kg ha^{-1} in 2017-18) and farmer practice (16.6, 9.0 & 13.11 kg ha^{-1} in 2015-16; 21.5, 8.2 & 19.68 kg ha^{-1} in 2016-17 and 24.0, 13.2 & 22.87 in 2017-18). Significant differences in total uptake of N, P and K can be attributed to the fact that the application of soil test based fertilizers made castor plant demand to grow more profusely and produce more yield by harmonizing nutrients among themselves and with the soil available nutrients and these results corroborate the findings of Gudadhe et al. [20] and Sharma et al. [21].

3.3 Post-Harvest Soil Fertility Status

The pooled post-harvest soil fertility status with respect to $KMnO_4$-N, Olsen-P and NH_4OAc-K furnished in Table 3 and indicated build-up & maintenance of soil fertility due to soil test based fertilizer recommendation under IPNS. A perusal data on soil pH, EC and organic carbon status indicated a non-significant influence among treatments at the study area. The significantly superior pooled post-harvest soil fertility status was registered in STCR-IPNS@30 q ha^{-1} (181.9, 61.3 and 396.03 kg ha^{-1} of available N, P_2O_5& K_2O respectively) over blanket recommendation along with vermi compost@100%RDF:80:40:30 kg N, P_2O_5 and K_2O ha^{-1}+VC@5 t ha^{-1} (164.06, 49.18 & 368.33kg ha^{-1} of available N, P_2O_5 & K_2O respectively) and at par with STCR-NPK@30 q ha^{-1}, STCR-IPNS@25 q ha^{-1}and STCR-NPK@25 q ha^{-1}(177.58, 59.70 & 387.18; 174.55, 59.13 & 381.26 and 171.47, 53.59 & 377.61 kg ha^{-1} of available N, P_2O_5 & K_2O respectively), whereas lowest fertility status was observed in farmer's practice and control treatment (126.76, 35.88 & 334.26 and 114.28, 28.10 & 317.29 kg ha^{-1} of available N, P_2O_5 & K_2O respectively). Despite higher removal of nutrients, the fertility status was maintained in STCR-IPNS as compared to STCR-NPK alone and this could be due to the prevention of losses of nutrients under IPNS, even after meeting the crop needs. Similar trend of the result was also observed by Kirankumar et al. [22] for Bt-cotton, Coumaravel and Santhi [23] for maize and Santhi et al. [24] for beetroot in Alfisol.

Table 1. Fertilizer prescription equations developed for hybrid castor is furnished

Hybrid Castor	Hybrid castor yield Target at 25 and 30 q ha^{-1} with chemical fertilizers	Hybrid castor yield Target at 25 and 30 q ha^{-1}with Integrated Plant Nutrition System
FN	15.54 T – 2.30 SN	15.54 T – 2.30 SN – 2.04 VC N
FP_2O_5	4.72 T – 6.44 SP	4.72 T – 6.44 SP – 0.60 VC P
FK_2O	4.75 T – 0.44 SK	4.75 T – 0.44 SK – 0.45 VC K

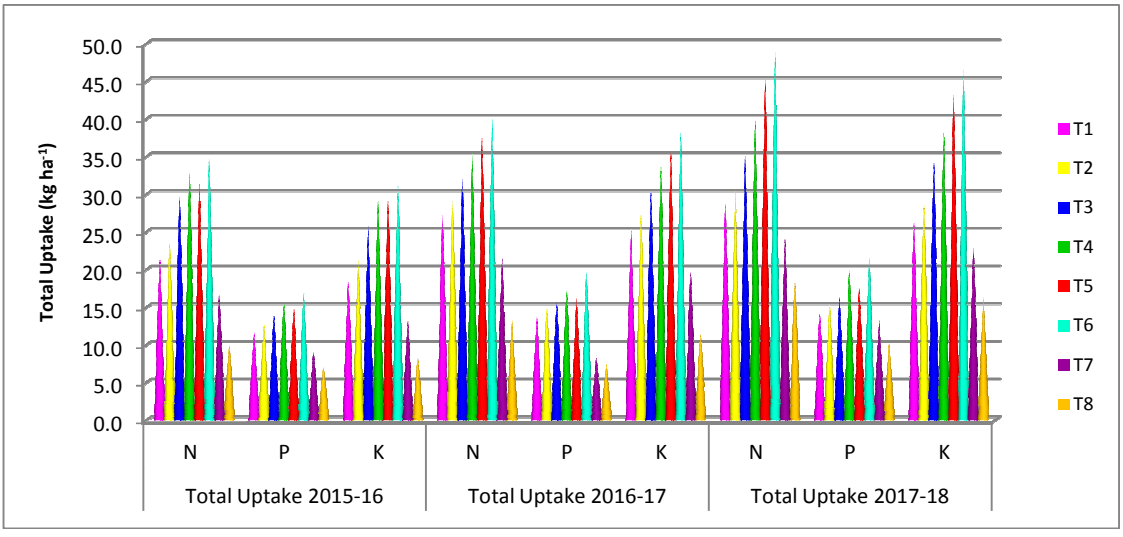

Fig. 1. Effect of STCR-models on total nutrient uptake (kg ha^{-1}) of castor

Table 2. Influence of targeted yield approach on seed and stalk yield (q ha^{-1}) of Castor

Treatments	2015-16		2016-17		2017-18		Pooled Seed Yield (kg ha^{-1})	Pooled Stalk Yield (kg ha^{-1})	Pooled B:C ratio
	Seed Yield (kg ha^{-1})	Stalk Yield	Seed Yield	Stalk Yield	Seed Yield	Stalk Yield			
T_1: Blanket recommendation (100%RDF:80:40:30 kg N, P_2O_5 and K_2O ha^{-1})	15.11	19.04	20.08	22.78	23.02	27.58	19.40	23.13	2.10
T_2: Blanket recommendation (100%RDF:80:40:30 kg N, P_2O_5 and K_2O ha^{-1}) + VC at 5 t ha^{-1}	15.94	20.13	20.73	23.06	23.81	28.03	20.16	23.74	2.01
T_3:STCR-Target yield with NPK alone at 25 q ha^{-1}	17.04	21.53	21.13	23.32	24.05	29.06	20.74	24.63	2.12
T_4:STCR-Target yield with IPNS at 25 q ha^{-1}	17.21	22.47	21.32	24.87	24.41	30.29	20.98	25.88	2.04
T_5:STCR-Target yield with NPK alone at 30 q ha^{-1}	18.06	23.09	22.72	25.11	26.13	31.17	22.30	26.46	2.15
T_6:STCR-Target yield with IPNS at 30 q ha^{-1}	18.11	23.71	23.04	25.85	26.91	31.82	22.69	27.13	2.06
T_7:Farmer's practice (40:20:0 kg N, P_2O_5 and K_2O ha^{-1})	10.01	12.73	18.04	20.61	21.78	25.31	16.61	19.55	1.94
T_8:Absolute control (without any inorganic and organic fertilizers)	6.71	8.53	8.01	12.64	8.83	13.07	7.85	11.41	0.61
S Em (±)	0.36	0.74	0.63	0.84	0.81	0.95	0.78	0.84	--
CD (P = 0.05)	1.13	2.28	1.94	2.59	2.97	2.94	2.41	2.61	--

Table 3. Influence of STCR approachon post-harvest soil fertility status of castor

Treatments	pH	EC (dS m^{-1})	O.C. (%)	N kg ha^{-1}	P_2O_5	K_2O
T_1: Blanket recommendation (100%RDF:80:40:30 kg N, P_2O_5 and K_2O ha^{-1})	7.21	0.12	0.41	159.27	45.44	357.21
T_2: Blanket recommendation (100%RDF:80:40:30 kg N, P_2O_5 and K_2O ha^{-1}) + VC at 5 t ha^{-1}	7.20	0.11	0.41	164.06	49.18	368.33
T_3:STCR-Target yield with NPK alone at 25 q ha^{-1}	7.21	0.12	0.42	171.47	53.59	377.61
T_4:STCR-Target yield with IPNS at 25 q ha^{-1}	7.19	0.11	0.41	174.55	57.13	381.26
T_5:STCR-Target yield with NPK alone at 30 q ha^{-1}	7.21	0.11	0.42	177.58	59.70	387.18
T_6:STCR-Target yield with IPNS at 30 q ha^{-1}	7.21	0.10	0.41	181.90	61.30	396.03
T_7:Farmer's practice (40:20:0 kg N, P_2O_5 and K_2O ha^{-1})	7.18	0.09	0.40	126.76	35.88	334.26
T_8:Absolute control (without any inorganic and organic fertilizers)	7.18	0.09	0.40	114.28	28.10	317.29
S Em(±)	N.S.	N.S.	N.S.	3.37	2.45	5.89
CD (P=0.05)	0.053	0.41	4.35	10.81	8.12	20.07

4. CONCLUSION

To conclude, soil test based IPNS for desired yield targets of castor was developed and validated on typic rhodustalfs of Telangana taking into account of crop nutrient requirement and contribution of N, P and K from various nutrient sources (soil, fertilizer and vermi compost). The STCR-IPNS@25q ha^{-1} was effective and economical as compared with any other treatments and this study will help to make guidelines for the amount of fertilizer used in castor cultivation at Southern Telangana Zone. The specific target yield equation based on soil health will not only ensure sustainable crop production but also steer the farmers towards economic use of costly fertilizer inputs depending on their financial status and prevailing market price of the crop under consideration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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