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Performance of alternate crops to rice under Nagarjuna Sagar project right canal area in Palnadu region of Andhra Pradesh

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Abstract
The experiment entitled "Evaluation of performance of alternate crops to rice under NSP right canal area" was conducted at Agricultural Research Station, Jangamaheswarapuram during *kharif* season, 2018-19, 2019-20 & 2020-21 with an objective of finding the profitable alternate crop to Rice under non releasing of water from NSP right canal area. During *kharif*, 2018-19, among the nine alternate crops tested, the castor (84.55 q ha^{-1}) performed better followed by foxtail millet (66.38 q ha^{-1}) as per crop equivalent yields. During *kharif*, 2019-20, Castor recorded highest crop equivalent yields (65.29 q ha^{-1}) followed by Groundnut (37.42 q ha^{-1}). During *Kharif*, 2020-21, Groundnut crop (70.48 q ha^{-1}) registered highest values of crop equivalent yields followed by Castor (55.36 q ha^{-1}) crop. Among millet crops growing of foxtail millet resulted in higher values of crop equivalent yield followed by proso millet and finger millet.

Keywords: NSP (Nagarjuna Sagar project), REY (Rice equivalent yield), BC ratio, right canal area, *kharif* season

Introduction
In India, agriculture is mainly dependent on the performance of southwest monsoon (the variability in the amount and distribution, probability of occurrence and onset of effective monsoon). Characterization of onset of effective monsoon (OEM) and prediction of rainfall at different probability levels were of paramount importance in rainfed agriculture for determining sowing time and cropping systems, especially for upland rice ecosystem because slight delay in sowing of direct seeded upland crops may lead to drastic reduction of yield (Panigrahi and Panda, 2002) [7]. Out of 42.3 million ha of total rice area in India, upland rice occupies 6.1 million ha of which 4.3 million ha are located in eastern India with very low (<1 t/ha) and unstable productivity (Aggarwal *et al.*, 2008) [1].

In spite of getting low and unstable yield in upland rice ecosystem due to erratic southwest monsoon, moisture stress during crop growth period, light textured soils with low water retention and fertility status, existence of biological constraints like weeds (*Cyperus rotundus*, *Echinochloa colona*), diseases (blast, brown spot) and pests (gundhi bag, termite, worms), farmers of this region grow rice on such land due to lack of knowledge of alternate sustainable cropping systems. Under this situation crop diversification and rice substitution with low water requiring rainfed crops like maize (*Zea mays* L.), blackgram (*Phaseolus mungo* L.), greengram (*Vigna Aureous* L.), cowpea (*Vigna unguiculata* (L.) walp), groundnut (*Arachis hypogea* L.), pigeonpea (*Cajanas cajan* L.) etc. (through sole or intercropping) may be best option to the hands of farmers for mitigating drought and increased productivity of upland rice ecosystem with assured and early return (Kar and Verma, 2002) [5]. Rice crop is grown during *kharif* & *Rabi* season in palnadu region by using Nagarjuna Sagar Project right canal water as a major source of irrigation. Nursery sowings of Rice will be done during second fortnight of July and transplanting will be done from second fortnight of August onwards under NSP right canal if irrigation water releases for cultivation during normal years. Sometimes the nursery sowing and transplanting will be further delayed by one more month if release of irrigation water delayed i.e. upto second fortnight of September and it will be considered as late *Kharif*. The amount of irrigation water & time of release of irrigation water from canal is uncertain which is completely depends on rainfall received upstream Almatti reservoir in Karnataka and Srisailam reservoir in Andhra Pradesh. Due to scanty rainfall upstream NSP (El-Nino) (Sulochan Gadgil & Franchis, 2016) [9] in the years 2015, 2016 & 2017, irrigation water is not

released for Rice cultivation which necessitates farmers to go for alternate crops to Rice. In this context, finding alternate profitable crops to Rice under rainfed situation is became an area of concern under NSP` Right canal area. Hence, the experiment "Evaluation of Performance of Alternate crops to Rice under Nagarjuna Sagar Project Right canal area in Palnadu Region" was conducted at Agricultural Research Station, Jangamaheswarapuram, Gurazala, Guntur district of Andhra Pradesh during *kharif* season, 2018-19, 2019-20 & 2020-21.

Materials & Methods

The experiment was laid down in Randomized Block Design (RBD) with three replications. Nine crops namely T_1: Sorghum, T_2: Pearl millet, T_3: Foxtail millet, T_4: Finger millet, T_5: Proso millet, T_6: Cowpea, T_7: Groundnut, T_8: Castor and T_9: Sesamum was selected as treatments. The experiment was conducted during 2018-19, 2019-20 & 2020-21 in the month of August. The package of practices followed in experiment is as follows.

Table 1: Seed rate, Spacing, Fertilizer dose applied for different crops during crop growth

S. No	Crop	Seed rate (kg ha^{-1})	Spacing (cm)	Fertilizer dose (N,P,K) (Kg ha^{-1})
1.	Sorghum	8	45x15	Basal-40-60-40 Top – 40 N (30DAS)
2.	Pearl millet	4	45 x 15	Basal-40-40-30 Top – 40 N (30DAS)
3.	Foxtail millet	5	25 x 10	Basal- 20-30-0 Top- 20 N (30DAS)
4.	Finger millet	5	22.5 x 10	Basal-30-40-30 Top – 30 N (35 DAS)
5.	Proso millet	8	30 x 10	Basal – 20-20-20
6.	Cowpea	40	30 x 10	Basal – 20-40-0 Top- 20-25 (at 25 DAS)
7.	Groundnut	150 (kernels)	30 x 10	20-40-50
8.	Castor	2	90 x 90	Basal – 12-16-12 Top- 6 (60-65 DAS) 6 kg (90-95 DAS)
9.	Sesamum	6	30 x 10	Basal – 16-8-8 Top- 16 (30 DAS)

The Experiment was conducted on black soil with a P^H 7.78, EC 2.17 ds m^{-1} and organic matter content 0.54, Available Nitrogen (308 kg ha^{-1}), Available Phosphorus (28 kg ha^{-1}) and Available Potassium (402 kg ha^{-1}). The rainfall particulars during the period under study were obtained from the meteorological observatory at Agricultural Research Station, Jangamaheswarapuram. During 2018-19, a total rainfall of 550.7 mm was received in 20 rainy days as against the decennial average of 501.8 mm received in 23.4 rainy days for the corresponding period. During 2019-20, a total rainfall of 516.8 mm was received in 31 rainy days as against the decennial average of 502.6 mm received in 24.5 rainy days for the corresponding period. During 2020-21, a total rainfall of 522.6 mm of rainfall was received in 26 rainy days as against the decennial average of 539.6 mm received in 25.9 rainy days for the corresponding period.

The yield obtained from different crops was converted into Rice Equivalent Yield (REY) by using the formula given by Ahlawat and Sharma (1993) [2]. B:C ratio and Net returns (Rs. ha^{-1}) was also calculated by using the formula given below.

$$\text{Rice equivalent yield} = \frac{\text{yield of each crop (kg/ha) X Economic value of respective crop (Rs/kg)}}{\text{Economic value of Rice (Rs/kg)}}$$

$$\text{Benfit cost ratio} = \frac{\text{Gross returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Net returns (Rs. ha^{-1}) = Gross returns (Rs. ha^{-1}) - Cost of cultivation (Rs. ha^{-1})

The data recorded on various parameters of crop during the course of investigation was statistically analyzed following the analysis of variance for randomized block design as suggested by Panse and Sukhatme (1985) [8]. Statistical significance was tested with 'F' test at 5 per cent level of probability and compared the treatmental means with critical difference.

Results & Discussion

Crop equivalent yields (q ha^{-1})

During *kharif*, 2018-19, Among the nine alternate crops tested, the castor (84.55 q ha^{-1}) performed better followed by foxtail millet (66.38 q ha^{-1}) as per crop equivalent yields. The highest crop equivalent yield was recorded with castor which is due to rainfall received during January month (38.6 mm of rainfall in 03 rainy days) facilitated tertiary spike development and prolonged crop duration upto 178 days. The third highest crop equivalent yield was recorded with Groundnut (47.79 q ha^{-1}). Similar results were obtained by Koutroubas *et al.* (2000) [6] as the sufficient soil moisture found to increase the length of plant life cycle and a number of secondary spikes and flowering in tertiary spikes.

During *kharif*, 2019-20, Castor (65.29 q ha^{-1}) performed better crop equivalent yields and then followed by Groundnut (37.42 q ha^{-1}). Sesamum has occupied third place by recording crop equivalent yield of 24.18 q ha^{-1}. The seed yield and crop equivalent yields of all minor millets were reduced drastically in 2019-20 (Proso millet, Finger millet& Foxtail millet) due to rainfall coincidence with the grain filling, physiological maturity and harvesting stage of the crop during October (160 mm of rainfall in 10 rainy days) when compared to 2018-19.

During *Kharif*, 2020-21, Groundnut crop (70.48 q ha^{-1}) registered highest values of crop equivalent yields followed by Castor (55.36 q ha^{-1}) crop. The reasons behind the highest yields in Groundnut are receipt of rainfall at Groundnut pegging stage. Similar results were obtained by Vorasoot *et al.* (2003) [10], El Boraei *et al.* (2009) [4] and Arash Khonok *et al.* (2015) [3] as water available in the root zone during pegging stage will be helpful in getting of Ca ions for proper filling of pods in Groundnut. The Castor crop gave higher values of yield because of rainfall at no. of spikes plant^{-1}, Flowering & capsule development were good and the results are in conformity with the results obtained by Koutroubas *et al.* (2000) [6]. The Sesamum crop recorded lower yields compared to previous years due to shattering losses caused by rainfall during the October month (38.8 mm of rainfall in 2 rainy days).

Economics

During *kharif*, 2018-19, among the nine alternate crops tested, the highest gross returns was recorded with Castor crop (Rs. 1,69,117) followed by foxtail millet crop (Rs. 1,32,761), whereas, the highest values of BC ratio was recorded with

foxtail millet (3.58) followed by castor (3.43).

During *kharif*, 2019-20, the highest gross returns with Castor crop (Rs. 1,63,215) followed by Groundnut crop (Rs. 93,566). The higher values of net returns recorded with Castor crop (Rs. 1,25,000) followed by Sorghum crop (Rs. 61163) because of cost of cultivation charges is more to groundnut crop than castor crop. The highest values of highest values of BC ratio recorded with castor (3.27) crop and then followed by sorghum (2.03). The Sesamum recorded lower values of rice equivalent yields but the BC ratio is (1.10) because of cost of cultivation charges less & sale price of seed was high during the year. During *Kharif*, 2020-21, the higher values of monetary benefits were registered with Castor crop (Rs. 82,464) followed by Groundnut crop (Rs. 72,456). The highest values of BC ratio recorded with Castor (2.92) crop & Prosomillet (2.92) and then followed by Foxtail millet crop (1.55)

Table 2: Seed Yield & REY of alternate crops to Rice under NSP right canal area in Palnadu region of Andhra Pradesh

Treatments	Seed yield (kg ha^{-1})			Rice Equivalent Yield (kg ha^{-1})			Sale price (Rs. q^{-1})		
	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
T_1 : Sorghum	3644	2281	2476	3644	3650	3219	2000	4000	2600
T_2 : Pearl millet	3317	1291	2365	2819	2065	2365	1700	4000	2000
T_3 :Foxtail millet	5310	523	1333	6638	884	2817	2500	4200	4225
T_4 : Finger millet	3415	1111	1111	4269	2133	1556	2500	4790	2800
T_5 :Proso millet	3431	850	1714	5147	1611	3943	3000	4740	4600
T_6 :Cowpea	1144	784	730	2288	1882	2190	4000	6000	6000
T_7 :Groundnut	2124	1127	2349	4779	3743	7048	4500	8300	5500
T_8 :Castor	3758	1127	2460	8456	6529	5536	4500	9500	4500
T_9 :Seasamum	866	605	190	3464	2418	762	8000	10000	8000
SE(m)±	223	70	103.1	334	150.3	235.8			
C.D@5%	668	211	309.1	1001	450	706.8			
C.V (%)	13.0	8.9	10.9	13.0	9.4	12.7			

Table 3: Economics of alternate crops to Rice under NSP right canal area in Palnadu region of Andhra Pradesh

Treatments	Crop duration			Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B:C Ratio		
	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21	2018-19	2019-20	2020-21
T_1 : Sorghum	110	103	104	72875	91255	64381	42783	61163	34381	1.42	2.03	1.15
T_2 : Pearl millet	110	95	93	56388	51634	47302	26850	22096	17902	0.91	0.75	0.61
T_3 :Foxtail millet	84	80	83	132761	22089	56333	103776	3104	34271	3.58	0.16	1.55
T_4 : Finger millet	85	82	110	85375	53333	31111	54914	22872	4049	1.80	0.75	0.15
T_5 :Proso millet	85	83	78	102941	40275	78857	71187	8521	58732	2.24	0.27	2.92
T_6 :Cowpea	84	95	95	45751	47059	43810	11290	12598	8185	0.33	0.37	0.23
T_7 :Groundnut	97	94	112	95588	93566	129206	56203	54181	72456	1.43	1.38	1.28
T_8 :Castor	178	185	165	169117	163215	110714	130902	125000	82464	3.43	3.27	2.92
T_9 :Seasamum	83	80	86	69281	60458	15238	40481	31658	-11212	1.41	1.10	-0.42

Conclusions

During the investigation, it was found that, the stable values of yield & crop equivalent yields to Rice recorded with castor crop followed by groundnut crop. Among millets Foxtail millet performed well in terms of yield and rice equivalent yield. Foxtail millet crop has also recorded `highest value of BC ratio i.e 3.58. Similar trend was observed in case of Proso millet. In case of millets care should be taken that the withdrawal of southwest monsoon should not coincide with the harvesting stage. If the amount of rainfall during crop growing months is above the normal rainfall then Groundnut, Castor crops are suitable alternate crops to Rice during the period of non receipt of NSP canal water for Rice cultivation. If the amount of rainfall is more than normal rainfall the millet crops won't perform well under high moisture conditions. During present study, based on market prices growing of Sesame crop is also a suitable alternate crop to Rice.

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