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Short communication

Performance of sorghum under integrated nutrients management

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Sorghum (*Sorghum bicolor* L. Moench) cultivation is declining, with acreage shifting to more profitable crops. The global area under sorghum cultivation is 41.97 Mha, with annual production of 65.2 Mt. Globally, India ranks third in sorghum area (4.82 Mha) and seventh in production 4.4 MT with a productivity of 989 kg ha^{-1} (Anonymous, 2021). The performance of the monsoon influences the annual variation in sorghum and millet output, which is largely unirrigated. Sorghum is known to have adopted to marginal soils with poor nutrient supply and is resilient to abiotic stresses like heat and drought allowing it to thrive even in adverse and marginal conditions. However, the area under *kharif* sorghum cultivation is decreasing rapidly due to various reasons. This decline in yields has been attributed to the reduction in soil fertility and droughts as a result of climate change (Nyamangara *et al*.2014). Of late, *rabi* sorghum has also been successfully introduced in the rice fallow of coastal Andhra Pradesh (Patil *et al*. 2012). The organic fertilizer primarily enhances soil organic matter, improves soil structure, while the inorganic fertilizer supply nutrients that are easily available Godara *et al.* (2012). The efficiency of fertiliser use is increased by using biofertilizers and along with application of FYM in combination with chemical fertilisers, which boosts crop productivity. Therefore, integrated use of inorganic and bio-fertilizers could play an instrumental role in enhancing wheat productivity Gupta et al. (2020). By applying manures and bio-fertilizers consortia in a sensible manner, the yield and nutrient uptake of sorghum in rice fallows may be improved. In light of this, the current study was conducted to evaluate the effects of inorganic fertilisers and the bio fertilizer consortia on the productivity and uptake of nutrients in sorghum.

The field experiment was conducted at Agricultural College Farm, Bapatla, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India during *rabi* (December–April), 2018–19. The study site located in coastal region of Krishna Agro-climatic Zone of Andhra Pradesh situated at 15º54' N latitude and 80º25' E longitude with an altitude of 5.49 m above the mean sea level (MSL) and about 8 km away from the Bay of Bengal. Weekly mean maximum temperatures ranged from 25.6 to 34.7°C with an average of 31.6°C. The weekly mean minimum temperatures ranged from 14.2 to 25°C with an average of 19.7°C. The weekly mean relative humidity was 70.3 percent on average, ranging from 40.6 to 77.9 percent. During the crop growth season, 54 mm of rain fell overall. The experimental soil was near neutral with a pH of 6.94, low in organic carbon (0.4%) and available N (224 kg ha^{-1}), medium in available P (38 kg P_2O_5 ha^{-1}) and high in K (482 kg K_2O ha^{-1}). The trial comprised of seven treatments viz.,T_1: Control, T_2: 100% Recommended dose of fertilizers, T_3: 50% RDF + Biofertilizer consortium, T_4:75% RDF + Biofertilizer consortium, T_5:100% RDF + Biofertilizer consortium, T_6: 125% RDF+Biofertilizer consortium, T_7: Biofertilizer consortium only (RDF = 100, 60, 40 NPK only) (Biofertilizer Consortium = *Azospirillum*, Phosphate Solubilizing Bacteria (PSB) and Potassium releasing bacteria (KRB) in liquid form) was conducted in a randomized block design (RBD) and each replicated thrice. Sorghum cultivar, high yielding hybrid (CSH-16) in the requisite number of plots were manually sown with a seed rate of 12 kg ha^{-1} and a 45 cm×15 cm spacing. Nitrogen (100 kg ha^{-1}) was administered twice in equal portions, half at 30 DAS and the other half at 30 days after the first application, in the form of urea (46% N). Paraquat @ 2.5 ml L^{-1} was used to avoid rice ratooning. The data on ancillary traits were recorded on five tagged plants in the net plot area. The length of ear heads was measured from base to tip of the ear head and filled grain number $earhead^{-1}$ for tagged 5 plants and the mean value was computed, the weight of 1000 grains (g) was recorded from the grain samples drawn randomly from the net plot produce of

each treatment. Grain yield was worked out as the sun-dried ears from net plot and expressed in kg ha^{-1}. The plant samples collected at 30, 60 and 90 DAS were washed with dilute HCl and then with distilled water. The samples were shade dried initially and then oven dried at 60°C±2°C temperature till a constant dry weight was obtained and powdered in willey mill.

The economics of different treatments were calculated by considering the input costs and output prices prevailing at the time of the harvest. The cost of cultivation (COC), gross returns (GRs), net returns (NRs) and returns ₹$^{-1}$Investment were computed by the formulas furnished below.

COC (₹ha^{-1}) =input cost +labour cost
GRs (₹ha^{-1}) =seed yield ×market price
NRs (₹ha^{-1}) =GRs ha^{-1}– COC ha^{-1}
Returns Investment^{-1} (₹) =INR/ COC

Table 1: Effect of integrated nutrients management on yield attributes and yield of sorghum under rice fallow

Treatments	Earhead length (cm)	Test weight (g 1000 grains^{-1})	Filled grains ear head^{-1}	Protein content (%)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	27.3^{c}	24.6^{a}	1032^{c}	6.5^{d}	2880^{c}	5529^{c}
T_2	32.1^{ab}	25.6^{a}	1198^{abc}	8.5^{ab}	3854^{ab}	7129^{ab}
T_3	29.5^{abc}	25.2^{a}	1149^{bc}	7.3^{cd}	3184^{c}	6049^{bc}
T^4	31.4^{abc}	25.3^{a}	1197^{abc}	7.9^{bc}	3460^{bc}	6505^{abc}
T_5	32.5^{ab}	25.8^{a}	1283^{ab}	8.7^{ab}	3918^{ab}	7209^{ab}
T_6	33.2^{a}	26.3^{a}	1359^{a}	9.1^{a}	4135^{a}	7524^{a}
T_7	28.8^{bc}	24.9^{a}	1050^{c}	7.2^{cd}	3016^{c}	5706^{c}
S.Em ±	1.22	1.2	49.6	0.34	198.4	419.3
LSD (*p*=0.05)	3.8	NS	152.8	1.04	612	1292.1

Statistical analysis for the data recorded was done by following the analysis of variance technique for randomized block design with factorial concept as suggested by Gomez and Gomez (1984). Statistical significance was tested by applying F-test at 0.05 level of probability and critical differences were calculated for those parameters which turned to the significant (*p*=0.05) in order to compare the effects of different treatment. Yield of sorghum was highest when the crop received recommended dose of fertilizer (RDF) along with biofertilizer consortium and resulted in significantly higher grain yield (4135 kg ha^{-1}) and stover yield (7524 kg ha^{-1}), were recorded in T_6 treatment and remained on par with T_5 and T_2 treatments (Table 1). The yield attributes were greatly enhanced by the use of increased levels of inorganic fertilizers up to 125% RDF and biofertilizers consortium (T_6) treatment. With the application of T_6 treatment improved ear head length (33.2 cm), filled grains ear head^{-1} (1359) as compared to control treatment. Different dose of fertilizers did not bring out any significant change in 1000 seed weight (Table 1).

Table 2: Effect of integrated nutrients management on economics of sorghum

Treatment	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Returns per rupee
T_1	20750	49005	28256	1.56
T_2	24994	64912	37918	1.86
T_3	23372	52667	27296	1.53
T^4	24433	57059	30626	1.63
T_5	25494	65637	38143	1.85
T_6	26555	71710	43154	1.88
T_7	21250	51829	30579	1.63
S.Em ±	1473	3842	1975	0.1
LSD (*p*=0.05)	4538	11838	6085	0.4

The T_6 treatment significantly increased grain (30.3%) and stover (26.5%) yields compared to control. Similar results were also reported by Kaufman *et al.* (2013). Increased N, P and K uptake as well as increased panicle number and test weight may also contribute to higher grain and stover yields at higher recommended dose of fertilizers (Uchino *et al.,* 2013, Sami *et al.,* 2014). Further, this could be ascribed to its positive influence on both vegetative and reproductive phases of the crop which lead to increase in stover yield. Increased

photosynthetic rate might have also resulted in higher accumulation of drymatter and ultimately enhanced stover yield (Reddy *et al.,* 2021). Improvement in various yield attributing characters and yield due to N and P fertilization is in close conformity with the findings of Singh and Sumeriya, (2012).

The gross returns (₹71710 ha^{-1}), net returns (₹43154 ha^{-1}) as well as and returns $₹^{-1}$ invested (1.88) were also highest with125% RDF combined with biofertilizer consortium (T_6) treatment (Table 2) due to higher grain and stover yields.

However, the latter T_5 treatment gave on par net returns (₹38143 ha^{-1}) and 1.85 returns $₹^{-1}$ invested. The treatment effect on the grain and stover production are the primary cause of this trend in economic returns. The results confirm the findings of Jat et al. (2013) and Mishra et al. (2009). The present study revealed that integrated application of 125% RDF + biofertilizers consortium resulted in significantly higher nutrient content and uptake in grain and straw and remained at par with treatment of 100% RDF + biofertilizer consortium in almost all parameters.

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