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RESEARCH NOTE

Effect of fortification of organics with iron and zinc on growth, yield and economics of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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A field experiment was conducted during *rabi* 2016 under rainfed condition on clay loam soil at All India Coordinated Sorghum Improvement Project, Main Agricultural Research Station, Dharwad (Karnataka) to study the effect of fortification of organics with iron and zinc in rabi sorghum under rainfed condition. The experiment was laid out in randomized complete block design with three replications and eleven treatments. Results of the study revealed that soil application of RDF + Enriched FYM 1 (*i.e.* 50 kg FYM ha ^{1} + 3.75 kg $ZnSO_4$ ha ^{1} $FeSO_4$ ha ^{1}) recorded significantly higher grain yield (4287 kg ha^{-1}), fodder yield (7.51 t ha^{-1}), gross returns (₹ 211924 ha ^{1}), net returns (85702 ha ^{1}) and BC ratio (3.50) over control, recommended dose of fertilizer and recommended package of practices. The growth and yield parameters *viz.*, leaf area (48.08 dm^2 plant^{-1}), grain weight (62.33 g plant^{-1}) and test weight (37.77 g) were significantly higher with same treatment.

Keywords: Fortification, Iron, Organics

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the world's most important nutritional cereal crop and also the major staple food and fodder crop for millions of people in semi-arid tropics. The area under *kharif* sorghum is less compared to *rabi* sorghum. *Rabi* sorghum is the major dry land crop currently grown over an area of 3.89 million hectares with a production of 3.14 million tones and productivity of 808 kg ha^{-1} (Anon., 2014). Insufficient micronutrient availability in soils not only causes low crop productivity but also poor nutritional quality of the crops and consequently contributes to malnutrition in the human population (Kumssa *et al.,* 2015). The micronutrient enrichment of staple food crops in general and rabi sorghum in particular has been considered as a sustainable strategy for immediate solution to tackle the problems of micronutrient deficiencies in human beings. Fortification is a potential cost-effective and sustainable agronomic way to enrich the micronutrient content in food grains and fodder. It is an upcoming strategy for dealing the deficiencies of micronutrients in the developing world. Post-rainy (*rabi*) sorghum that are predominantly grown for food and fodder has lower zinc and iron content than that of rainy season sorghum (Kumar *et al.,* 2013). Usually the farmers do not apply recommended dose of fertilizer including micronutrients to *rabi* sorghum. Some farmers do not apply any fertilizer leading to deficiency of nutrients in soil and further resulted in lower yield with low quality of grain and fodder. Hence, there is need to enrich the grain and fodder with micronutrients (iron and zinc). Since the information on fortification of organics with iron and zinc in *rabi* sorghum is quite meager, the present experiment was planned to study the effect of fortification of organics with iron and zinc in *rabi* sorghum.

The field experiment was conducted during *rabi* 2016 under rainfed condition at All India Coordinated Sorghum Improvement Project, Main Agricultural Research Station, Dharwad (Karnataka) which is situated at 15^{0}29' N latitude, 74^{0}59' E longitude at an altitude of 689 m above mean sea level and it comes under Northern transition zone (Zone-8) of Karnataka. The soil was clay loam, medium in organic carbon (0.59 %), low in available nitrogen (245 kg ha^{-1}), medium in available phosphorous (22.64 kg ha^{-1}), high in available potassium (357.36 kg ha^{-1}), medium in available sulphur (19.80 kg ha^{-1}), deficient in iron (4.24 mg kg^{-1}) and zinc (0.54 mg kg^{-1}) and calcareous in nature (8.05% free $CaCO_3$ content) with pH 7.45. The experiment was laid out in Randomized complete block design with three replications. There were eleven treatment combinations consisted of control, recommended dose of fertilizer (RDF), recommended package of practices (RPP), four levels of enriched FYM and four levels of enriched vermicompost. FYM and vermicompost @ 50 kg ha ^{1} each were mixed with different quantities of $ZnSO_4$ as per the treatments (3.75, 7.5, 11.25 and 15 kg ha ^{1}). Little quantity of water was added to the mixture at field capacity and the mixture was kept in polythene bags under anaerobic condition for 15 days for incubation. The moisture content in the mixture was checked weekly twice. Similar method was followed for $FeSO_4$. Sorghum variety SPV-2217 was sown at 45 × 15 cm spacing using a seed rate of 7.5 kg ha ^{1}. Nitrogen and phosphorus were applied at the rate of 50:25 kg per hectare in the form of urea and diammonium phosphate respectively were mixed with Enriched FYM or vermicompost as per the treatments at the time of sowing. The other recommended pacakage of practices were followed to raise the crop. A rainfall of 41.6 mm was received on 29th September and sowing was done. The total rainfall received during cropping period was 124.0 mm which was distributed in 9 rainy days. The crop was sown on 29/09/2016 and harvested on 10/02/2016. The data collected on different parameters were subjected to statistical analysis as described by Panse and Sukhatme (1967) for better interpretation of results.

The variation in growth, yield and economics of *rabi* sorghum was significant due to different treatments (Table 1). Application of RDF + Enriched FYM 4 and RDF + Enriched vermicompost 4 recorded on par plant height of 196.2 cm and 192.0 cm respectively and were significantly higher over rest of the treatments. The leaf area at harvest was significantly higher with the soil application of RDF + Enriched FYM 1 (48.08 dm^2 plant^{-1}) as compared to control, recommended dose of fertilizer and recommended package of practice. The higher

Table 1. Growth, yield and economics of *rabi* sorghum as influenced by fortification of organics with iron and zinc

Treatments	Plant height (cm)	Leaf area (dm^2 $plant^{-1}$)	Grain weight (g $plant^{-1}$)	Test weight (g)	Grain yield (kg ha^{-1})	Fodder yield (t ha^{-1})	Harvest index (%)	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
T_1 - Control (No nutrients)	176.3	38.92	38.67	32.24	3029	4.48	40.43	83340	54042	2.84
T_2 - Recommended dose of fertilizer (RDF)	183.9	41.31	47.56	34.28	3742	6.41	36.87	104786	73004	3.30
T_3 - Recommended package of practice (RPP)	185.8	43.69	52.56	34.52	3809	6.77	36.07	106784	71952	3.07
T_4 - RDF + Enriched FYM 1	189.0	48.08	62.33	37.77	4287	7.51	36.37	119942	85702	3.50
T_5 - RDF + Enriched FYM 2	186.6	46.39	58.56	36.20	4080	7.34	35.76	114477	79870	3.31
T_6 - RDF + Enriched FYM 3	187.9	44.16	54.64	35.37	3945	6.98	36.15	110482	75507	3.16
T_7 - RDF + Enriched FYM 4	196.2	44.36	55.56	35.30	3950	6.81	36.75	110277	74935	3.12
T_8 - RDF + Enriched vermicompost 1	186.2	47.00	59.67	37.40	4092	7.11	36.53	114387	80007	3.33
T_9 - RDF + Enriched vermicompost 2	189.4	44.11	54.89	35.44	3963	6.88	36.62	110771	76024	3.19
T_{10} - RDF + Enriched vermicompost 3	186.7	45.25	56.33	36.03	4054	7.09	36.36	113403	78288	3.23
T_{11} - RDF + Enriched vermicompost 4	192.0	44.67	56.56	36.13	4039	7.17	36.02	113165	77683	3.19
S.Em. ±	1.6	1.69	3.36	0.72	120.50	0.29	1.24	3066	3066	0.09
C.D. (P=0.05)	4.8	4.98	9.90	2.11	355.47	0.84	NS	9044	9044	0.26

leaf area in the treatment can be related to the fact that when iron and zinc enriched organics were applied to the soil, the photosynthetic and metabolic rates were increased in plant along with increase in cell division and cell elongation (Hossain *et al.,* 2011). Soil application of RDF + Enriched FYM 1 produced significantly higher grain weight per plant (62.33 g $plant^{-1}$) as compared to control (38.67 g $plant^{-1}$), recommended dose of fertilizer (47.56 g $plant^{-1}$) and recommended package of practice (52.56 g $plant^{-1}$) and the increase in grain weight per plant was to the tune of 38.0, 23.7 and 15.7 per cent over control, recommended dose of fertilizer and recommended package of practice respectively. Test weight is one of the most important yield parameter which is directly related to the grain yield. Significantly higher test weight was recorded with RDF + Enriched FYM 1 (37.77 g) compared to control (32.24 g), recommended dose of fertilizer (34.28 g) and recommended package of practice (34.52 g). The increase in the yield attributes could be due to continuous supply of organically chelated iron and zinc to the crop. Iron and zinc are part of the photosynthesis, assimilation and translocation of photosynthates from source (leaves) to sink (ear). Nalina (2013) observed the higher test weight (35.83 g) and grain weight (21.57 g $plant^{-1}$) in *rabi* sorghum with foliar application of $ZnSO_4$(0.5%) over RDF alone.

Application of RDF + Enriched FYM 1 recorded significantly higher grain yield (4287 kg ha^{-1}) over control (3029 kg ha^{-1}), recommended dose of fertilizer (3742 kg ha^{-1}) and recommended package of practice (3809 kg ha^{-1}) and the yield increase was to an extent of 29.3, 12.7 and 11.1 per cent over control, recommended dose of fertilizer and recommended package of practice respectively. The increase in grain yield of *rabi* sorghum was due to increased grain weight (62.33 g $plant^{-1}$) and test weight (37.77 g) compared to control, recommended dose of fertilizer and recommended package of practice. Similarly, fodder yield was also significantly higher in the same treatment (7.51 t ha^{-1}) as compared to control (4.48 t ha^{-1}), recommended dose of fertilizer (6.41 t ha^{-1}) and recommended package of practice (6.77 t ha^{-1}) and there was an yield increase to the extent of 40.3, 14.6 and 9.9 per cent over control, recommended dose of fertilizer and recommended package of practice respectively. Harvest index was not differed significantly due to different treatments. Similar observations were recorded by Absul *et al.* (2016) who reported the higher grain yield (20.58 q ha^{-1}) and fodder yield (28.69 q ha^{-1}) in *kharif* sorghum with soil application of RDF+ 15 kg $ZnSO_4$ ha^{-1}+ FeSO4 ha^{-1} over other treatments. Increase in yield was due to improved availability of iron and zinc which could be attributed to the formation of stable organometalic complexes with organic matter, especially during the enrichment process to last for a longer time and release the nutrients slowly in the soil system in such a way that the nutrients are protected from fixation and made available to the plant root system throughout the crop growth (Meena *et al.*, 2006). The soil application of RDF + Enriched FYM 1 realized significantly higher gross returns (₹ 1,19,942 ha^{-1}), net returns (₹ 85,702 ha^{-1}) and BC ratio (3.50) as compared to other treatments which was mainly due to higher grain and fodder yield compared to others. Significantly, the lower gross returns (₹ 85,702 ha^{-1}), net returns (₹ 83,340 ha^{-1}) and BC ratio (2.84) were obtained in control compared to other treatments which was due to lower grain and fodder yield of *rabi* sorghum. Patel *et al.*(2016) in sorghum reported that soil application of 7.5 kg ha^{-1} $ZnSO_4$ +three foliar sprays of $ZnSO_4$ (0.5) realized the higher net returns (₹ 31,753 ha^{-1}) and BC ratio (4.86) compared to other treatments.

Based on the results, it was concluded that soil application of RDF with Enriched FYM 1 i.e., 50 kg FYM ha^1 + 3.75 kg $ZnSO_4$ ha^1 + 50 kg FYM ha^1 + 3.75 kg $FeSO_4$ ha^1 to *rabi* sorghum found optimum for getting higher grain yield, fodder yield and also higher net returns compared to recommended package of practice of FYM @ 3 t ha^1+50:25 kg N and P_2O_5 ha^1+$ZnSO_4$@ 15 kg ha^1.

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