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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE AND ECONOMICS OF SORGHUM AND SOIL FERTILITY

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ABSTRACT

A field experiment was conducted at Deesa (Gujarat) to study the effect of integrated nutrient management on yield, nutrient uptake and economics of sorghum and soil fertility during summer seasion of 2012. The experiment was carried out in a randomized block design with eleven treatments and three replications. The results indicated that the green foliage and dry matter yields of sorghum increased by 32.0 and 32.6 % with RDF + 10t FYM + 4 kg Zn ha^{-1} over RDF alone. The maximum value of protein content (9.60%) was recorded with the 10t FYM + RDF + 4kg Zn ha^{-1} and proved superior to rest of the treatments. HCN content in sorghum plants at 20 and 40 days after sowing decreased with all the treatments over RDF. The minimum and maximum values of HCN content were recorded under RDF + 10t FYM + 4 kg Zn ha^{-1} and RDF, respectively. The uptake values of N, P, K, Fe and Zn in sorghum plant were maximum under the treatment of RDF + 4kg Zn ha^{-1} along with 10t FYM ha^{-1}. The lowest values of nutrients uptake by sorghum plants were recorded in RDF alone. Maximum net profit (` 30125 ha$^{-1}$ and B:C ratio (3.1) were recorded with conjoint use of 100% NPK + 10t FYM + 4kg Zn ha$^{-1}$: which was ` 9368 ha^{-1}higher than 100% NPK alone. The combind application of 100% NPK + 10t FYM + 4 kg Zn ha^{-1} gave significantly higher values of available N (207.3 kg ha^{-1}) available P (30.8 kg ha^{-1}), K (505 kg ha^{-1}) and zinc (0.90 mg kg^{-1}) in post harvest soil. Available Fe and Zn content were found to be higher in the treatment combination of 100% NPK + 10t FYM + 20 kg Fe ha^{-1} and 100% NPK + 10t FYM + 4kg Zn ha^{-1}, respectively. The miniimum amounts of available nutrients were recorded under 100% NPK alone treatment.

***Key words*: *Sorghum,* FYM, fertilizer, yield, quality, nutrient uptake**

INTRODUCTION

Sorghum [*Sorghum bicolor* L. Munch] is the king of millets and third important crop in the country after rice and wheat. Sorghum is not only staple food but it is also required to fulfill fodder requirement in order to make animal husbandry sector more viable. There is a great need to maintain regular well balanced supply of more nutritious feed and fodder in the state. It is an important food, feed, fodder and ration for human, cattle and poultry. Its grains have about 10-12 % protein, 3% fat and 70 % carbohydrate. In India, the area under sorghum is approximately 11.13 million hectares with an annual production of about 11.62 million tonnes and an average productivity of 1040 kg ha^{-1}. The balanced fertilization has shown positive effects on various aspects of growth, development and biological yield of the crop in comparison to nutrient use in single or in combination. The fertilization includes combined use of all essential plant nutrients in optimum quantities, proportion and their application at appropriate time through suitable source and methods under specific cropping system and agro climatic zones. Micronutrients are important for maintaining soil health and also for increasing productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth and development of plants. Increased removal of micronutrients as a consequence of adoption of HYVs and intensive cropping together with shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained. The role of zinc and iron in crop nutrition is well recognized as these are used for bio-synthesis of plant auxins, nitrogen metabolism, oxidation-reduction reactions, which are considered to be necessary for plant growth and development, chlorophyll formation, photosynthesis, important enzyme system and

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respiration in plants. Results of multi-location investigation have revealed significant increases in grain and fodder yield of sorghum due to zinc and iron fertilization (Dakshinamurthy and Rao 2008 Verma *et al.,* 2005, Singh *et al.,* 2016). In view of the above mentioned facts, present investigation was undertaken to achieve attainable yield of sorghum crop through integrated nutrient management.

MATERIALS AND METHODS

A field experiment was conducted during summer season of 2012 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. It is situated at 24° 12' North latitude and 72° 12' East longitude with an elevation of 136.4 meters above the mean sea level. It represents the North Gujarat Agro-climatic zone, which falls under semi-arid region. The soil of experimental plot was loamy sand in texture, low in organic C (4.9 g kg^{-1}), available N (160 kg ha^{-1}), available Fe (4.2 mg kg^{-1}), P (26 kg ha^{-1}) and medium in Zn (0.55 mg kg^{-1}) and rich in K (420 kg ha^{-1}).The experminent consisted of eleven treatments viz., T_1 RDF (80+40+00 NPK kg ha^{-1}) ,T_2(RDF+5 t FYM ha^{-1}),T_3(RDF+10t FYM ha^{-1}),T_4(RDF + 5 t FYM +10 Kg Fe ha^{-1}), T_5 (RDF + 5 t FYM + 20 Kg Fe ha^{-1}), T_6 (RDF+ 5 t FYM + 2 Kg Zn ha^{-1}), T_7 (RDF+ 5 t FYM + 4 Kg Zn ha^{-1}), T_8 (RDF + 10t FYM + 10Kg Fe ha^{-1}), T_9 (RDF + 10t FYM + 20Kg Fe ha^{-1}), T_{10} (RDF + 10t FYM + 2Kg Zn ha^{-1}) and T_{11} (RDF + 10 t FYM+ 4 Kg Zn ha^{-1}) were tried in a randomized block design with three replications. Fertilizer application was made as per treatments. Full dose of phosphorus, K, Fe and Zn and half dose of nitrogen were applied at the time of sowing in furrow through diammonium phosphate, muriate of potash, $FeSO_4$, $ZnSO_4$ and urea as basal application. The quantity of nitrogen supplied through DAP was adjusted with urea. The remaining dose of nitrogen was top dressed at 30 DAS. Green foliage and dry matter yields were recorded at harvest. Plant samples were digested in a di-acid mixture of HNO_3 and $HClO_4$ (4:1) for all the nutrients except nitrogen. Sample digests were analysed for P, K, S, Zn and Fe using standAR procedures (Jackson, 1973). Nitrogen content in plants was determind by Kjeldahl method. Soil samples collected after harvest of the crop were analysed for available nutrients by standard methods (Jackson, 1973).

RESULTS AND DISCUSSION

Yield

Data (Table 1) indicated that the highest average yield of green foliage (146.6 q ha^{-1}) and dry matter (28.0 q ha^{-1}) were obtained with 100% NPK applied along with FYM and Zn (T_{11}) and the lowest in 100% NPK alone. Use of 100% NPK + 10t FYM ha^{-1} resulted in 7.8 % increase in green foliage and dry matter yields over 100% NPK alone, respectively. The beneficial effect of FYM on yield was also reported by Singh *et al.,* (2016). Application of 100% NPK + 10t FYM + 4 kg Zn ha^{-1} increased the green foliage and dry matter yields significantly by 32.0 and 32.6 % over 100% NPK alone. Application of 100% NPK + 10t FYM + 20 kg Fe ha^{-1} also increased the green foliage and dry matter yield by 22.4 and 24.3 % respectively over 100% NPK alone. The increase in green foliage yield was mainly due to enhanced rate of photosynthesis and cabohytrate metabolism as influenced by fertilizers, zinc and iron (Singh *et al.,* 2016). These findings indicate that integrated use of 100% NPK and FYM, and Zn or Fe proved to be better proportion over use of optimum dose indicating the benifits of integrated use of fertilizers and manures (Kushwaha *et al.,* 2014).

Quality

An appraisal of data (Table 3) revealed that the different treatments did not exhibit any significant influence on HCN content at 20 and 40 DAS. The minimum HCN content (131 mg kg^{-1} and 102.8 mg kg^{-1}) was recorded under the treatment T_{11} (RDF+ 4kg Zn + 10t FYM ha^{-1}). Application of 100% NPK (T_1) recorded the highest value of HCN content (164.5mg kg^{-1} and127.8mg kg^{-1}) at 20 and 40 DAS, respectively.Significant effect on protein content in sorghum crop was noticed with the different treatments. However, integration of Fe, Zn or FYM in combination with RDF increased the protein content. Significantly highest protein content (9.60%) was observed under T_{11} (RDF + 10 t FYM + 4 kg Zn ha^{-1}). The increase in protein content might be due to balanced use of nutrients which favoured the better root growth and Zn enhanced the cation exchange capacity of the roots which in turn enhanced the absorption of essential elements especially of N which is responsible for higher protein content. More or less similar results were also reported by Bhoya Mitesh *et al.,* (2013) and Rana *et al.,* (2013).

Table 1: Effect of various treatments on yields, quality and economics of fodder sorghum

Treatments	Yield (q ha^{-1})		Protein (%)	HCN (mgkg^{-1})		Net return (`.ha^{-1})	B : C Ratio
	Green foliage	Dry matter		20 DAS	40 DAS		
T_1 - RDF(80+40 NP kgha^{-1})	110.9	28.0	8.46	164.5	127.9	20757	2.6
T_2 - RDF + 5 t FYM ha^{-1}	118.3	30.1	8.48	159.7	124.2	22560	2.7
T_3 - RDF + 10 t FYM ha^{-1}	121.4	31.2	8.50	157.9	122.8	23190	2.7
T_4 - RDF + 5 t FYM + 10 kg Fe ha^{-1}	123.6	31.7	8.58	153.7	119.6	23941	2.8
T_5 - RDF + 5 t FYM+ 20 kg Fe ha^{-1}	126.4	32.5	8.60	150.4	117.0	24751	2.8
T_6 - RDF+ 5 t FYM + 2 kg Zn ha^{-1}	127.6	32.8	8.62	149.8	116.5	24963	2.8
T_7 - RDF+ 5 t FYM + 4 kg Zn ha^{-1}	128.3	33.1	8.63	145.0	112.8	24920	2.8
T_8 - RDF + 10 t FYM + 10 kg Fe ha^{-1}	132.5	34.0	8.66	141.1	109.8	26317	2.9
T_9 - RDF + 10 t FYM + 20 kg Fe ha^{-1}	135.8	34.8	8.86	139.6	108.6	27283	3.0
T_{10} - RDF + 10 t FYM+ 2 kg Zn ha^{-1}	139.9	35.9	9.07	137.4	106.8	28353	3.0
T_{11} - RDF + 10 t FYM + 4 kg Zn ha^{-1}	146.6	37.1	9.60	131.0	102.8	30125	3.1
S.Em. ±	**2.45**	**0.65**	**0.25**	**4.12**	**2.52**	-	-
C. D. (P=0.05)	**7.31**	**1.95**	**0.75**	**12.38**	**7.56**	-	-

Economics

It is evident from Table 1 that the integration of 100% NPK + 10t FYM + 4 kg Zn ha^{-1} (T_{11}) was found to be most profitable treatment in sorghum exhibiting highest net return of ` 30125 ha$^{-1}$ and benefit: cost ratio of 3.1 followed by `27283 ha^{-1} in the treatment having 100% NPK + 10t FYM + 20 kg Fe ha^{-1}. Treatment T_{11} gave an extra net profit of ` 9368 ha$^{-1}$ over 100% NPK alone ($T_1$). This might be attributed to the higher yield of sorghum under these treatments. These findings are in accordance with the findings of Rana *et al.,* (2013) and Sharma and Singhal (2014). The lowest net return of `20757 ha^{-1} and B:C ratio (2.6) were recorded under 100% NPK alone (T_1).

Table 2: Effect of various treatments on uptake of N, P, K (kgha^{-1}), Fe and Zn uptake (gha^{-1}) by fodder sorghum

Treatments	Nitrogen	Phosphorus	Potassium	Iron	Zinc
T_1 - RDF(80+40 NP kgha^{-1})	46.2	8.7	80.7	110.9	53.0
T_2 - RDF + 5 t FYM ha^{-1}	49.4	9.3	85.6	117.6	56.2
T_3 - RDF + 10 t FYM ha^{-1}	50.7	9.6	87.9	120.6	57.6
T_4 - RDF + 5 t FYM + 10 kg Fe ha^{-1}	51.1	9.8	89.4	122.8	58.7
T_5 - RDF + 5 t FYM+ 20 kg Fe ha^{-1}	52.8	10.0	91.5	125.6	60.0
T_6 - RDF+ 5 t FYM + 2 kg Zn ha^{-1}	53.4	10.1	92.6	127.1	60.7
T_7 - RDF+ 5 t FYM + 4 kg Zn ha^{-1}	54.7	10.2	94.8	130.1	62.1
T_8 - RDF + 10 t FYM + 10 kg Fe ha^{-1}	55.5	10.7	98.3	135.0	64.5
T_9 - RDF + 10 t FYM + 20 kg Fe ha^{-1}	56.8	11.4	101.2	139.0	66.4
T_{10} - RDF + 10 t FYM+ 2 kg Zn ha^{-1}	58.4	11.5	104.5	143.5	68.6
T_{11} - RDF + 10 t FYM + 4 kg Zn ha^{-1}	61.8	11.8	110.6	153.9	72.7
S.Em. ±	**1.32**	**0.48**	**2.4**	**3.1**	**1.6**
C. D. (P=0.05)	**3.84**	**1.42**	**7.0**	**9.3**	**4.6**

Uptake of nutrients

The uptake of N, P, K, Fe and Zn differed significantly due to different treatments (Table 2). Recommended dose of fertilizers when applied with 10t FYM ha^{-1} and supplementary nutrients viz 4 kg Zn and 20 kg Fe ha^{-1} recorded significantly higher uptake of N, P, K, Fe and Zn over the 100% NPK alone (T_1). This might be due to the favourable effects of FYM in conjunction with fertilizers on growth and yield parameters which resulted in more dry matter yield and consequently more utilization of nutrients by the crop. These findings are in close conformity with those of Singh and Singh (2004) and Kushwaha *et al.,* (2014). Integration of FYM in INM resulted in the higher uptake of N, P and K over rest of the treatments. This may probably be due to enhanced nutrient retention and reduced fixation capacity of soil. Highest uptake of Fe (153.9 g ha^{-1}) was observed with 100% NPK + 10t FYM + 4 kg Zn ha^{-1}. This might be due to increased dry matter yield of the crop. Patel *et al.,*(2008) and Yadav *et al.,* (2011) also reported similar results for iron uptake by the crop. The highest Zn uptake (72.7g ha^{-1} was recorded under the treatment of 100% NPK along with 10t FYM and 4 kg Zn ha^{-1}. This increase in Zn uptake by the crop is attributed to increased zinc content and dry matter yield due to this treatment. Similar results were reported by Jain and Dhama (2006).

Soil fertility

Addition of FYM alongwith 100% NPK and Zn or Fe improved the status of available N in post harvest soil over 100% NPK (T_1) alone which may be attributed to increased availability of N in soil due to application of inorganic fertilizers and FYM. Organic manure (10t FYM ha^{-1}) addition alongwith Zn or Fe also enhanced the available N over 100% NPK alone. The maximum and minimum values of available N content in soil were recorded under T_{11} and T_1 treatment, respectively. The results indicated the benefits accruing from integrated use of fertilizers and manures which is also evident from the yield data. These findings are in line with the findings of Yadav *et al.,* (2011). Available P content of the soil increased in all the treatments and the highest value (30.8 kg ha^{-1}) was recorded in 100% NPK + FYM + Zn (T_{11}) treatment (Table 3). This shows that the use of fertilizers alongwith FYM helps in increasing the available P content in soil (Jain and Dahama, 2006). This increase available P content due to use of fertilizers and manures may be attributed to higher availability of P in soil. Available K content in soil ranged from 417.7 kg ha^{-1} at 100% RDF to 505.0 kg ha^{-1} under 100% RDF + FYM + Zn (T_{11}). This increase in available K may be due to application of manure and fertilizers.

Table 3: Effect of various treatments on available nutrition post harvest soil

Treatments	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Fe (mg kg^{-1})	Zn (mg kg^{-1})
T_1 - RDF(80+40 NP kgha^{-1})	165.6	26.9	417.7	4.5	0.57
T_2 - RDF + 5 t FYM ha^{-1}	180.6	27.5	433.3	4.7	0.59
T_3 - RDF + 10 t FYM ha^{-1}	190.0	29.6	441.6	4.8	0.60
T_4 - RDF + 5 t FYM + 10 kg Fe ha^{-1}	194.3	28.8	457.2	4.9	0.58
T_5 - RDF + 5 t FYM+ 20 kg Fe ha^{-1}	195.2	28.2	459.7	4.9	0.57
T_6 - RDF+ 5 t FYM + 2 kg Zn ha^{-1}	195.6	27.8	467.5	4.8	0.80
T_7 - RDF+ 5 t FYM + 4 kg Zn ha^{-1}	190.9	28.6	471.6	4.9	0.85
T_8 - RDF + 10 t FYM + 10 kg Fe ha^{-1}	203.5	30.5	473.2	5.2	0.78
T_9 - RDF + 10 t FYM + 20 kg Fe ha^{-1}	203.4	30.4	476.8	5.4	0.77
T_{10} - RDF + 10 t FYM+ 2 kg Zn ha^{-1}	202.7	30.2	486.9	5.1	0.88
T_{11} - RDF + 10 t FYM + 4 kg Zn ha^{-1}	207.3	30.8	505.0	5.1	0.90
S.Em. ±	**4.48**	**0.68**	**4.16**	**0.14**	**0.03**
C. D. (P=0.05)	**13.25**	**2.06**	**12.50**	**0.43**	**0.11**

Data on available Fe content (Table 3) clearly show that available Fe content in treatment devoid of applied Fe was lower than with Fe. The reduction in soil iron as a result of cropping could possibly be due to continuous absorption of Fe by the crop from the native soil source. There was a significant build up of available Fe in post harvest soil due to different treatments and maximum value (5.4 mg kg^{-1}) was recorded under 100% NPK + 10t FYM + 20 kg Fe ha^{-1}. All the integrated combinations of nutrient exhibited higher available Fe content in soil as compared to 100% NPK alone. This is an indication of the iron supplying capacity of FYM and ferrour sulphate. Available Zn content in post harvest soil increased significantly with 100% NPK + FYM and 100% NPK + FYM + Zn (T_{11}). This increase in the farmer treatment appears to be due to mineralization of organically bound forms of Zn in the FYM and later due to zinc application. Similar results were reported by Verma *et al.,* (2005).

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