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EFFECT OF NUTRIENT APPLIED ON YIELD, CONTENT AND UPTAKE OF MICRO NUTRIENT ON SORGHUM-FENUGREEK CROPPING SEQUENCE

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SUMMARY

A field experiment on sorghum was conducted during *kharif* season of 2021, 2022 and 2023 and fenugreek during *rabi* season of 2021-22, 2022-23 and 2023-24 to study the effect of nutrient on yield of sorghum-fenugreek cropping sequence at Centre for Millets Research, Sardarkrushinagar Dantiwada Agricultural University, Deesa. The experiment was carried out in randomized block design with four replications comprising seven treatments. Sorghum under rain-fed environment of North Gujarat with following *kharif* sorghum-*rabi* fenugreek cropping sequence was applied 60 kg N/ha and 40 kg P_2O_5/ha to sorghum and 20 N/ha and 40 kg P_2O_5/ha to fenugreek crop along with 1% solution of multi-micronutrient grade IV (Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5%, B-0.5%) to both the crops at 30, 45 and 60 DAS for getting higher sorghum equivalent yield and net profit. Results showed that significantly higher organic carbon (0.30 %) was recorded under treatment RDF (60 + 40 kg NP/ha). DTPA extractable Fe (3.03 ppm) and DTPA extractable Zn of soil (1.62 ppm) was observed under treatment RDF + Soil application of micronutrient as per STV while DTPA extractable Mn and DTPA extractable Cu of soil was not significantly influenced by different treatments. Fe, Mn and Zn content and uptake by fenugreek crop was not significantly influenced by different treatments. Fe, Mn, Zn and Cu uptake by plants was recorded higher under treatment RDF + Foliar spray of 1 % multi micronutrient Grade I at 30, 45 and 60 DAS). Fe, Mn and Zn content and uptake in grain was recorded significantly higher under treatment T_7 while Cu content in grain was significantly higher under treatment RDF + Foliar spray of 1 % multi micronutrient Grade IV at 30, 45 and 60 DAS while Cu uptake by grain was not significantly influenced by different treatments but highest under treatment RDF + Soil application multi micronutrient Grade V (20 kg/ha).

Key words: Micronutrient, cropping sequence, DTPA extractable, content and uptake

Sorghum has multiple uses as grain, fodder and bio energy crop. Sorghum is also known as Jowar, Indian millet or Great millet. Sorghum plants can grow under low water conditions and high temperature (Laidlaw *et al.*, 2009). Millions of peoples living in Africa and Asia depend on sorghum, as it is a staple food. In addition to this, fodder and stover are fed to millions of animals providing milk and meat for human being. Sorghum ranks third in the major food grain crops of our country. It is also eaten as parched and popped grain to some extent. Grain is also fed to cattle, poultry and swine.

Globally, sorghum is cultivated on 42.1 million hectares, producing 61.6 million tons with a productivity of 14.6 q/ha (2023-24). In India, sorghum is grown on 4.78 million hectares with a production of 4.32 million tons and an average productivity of 9.05 q/ha (2023-24). It is primarily cultivated in Maharashtra, Karnataka, Telangana, and Andhra Pradesh, which together contribute more than 80% of the total production. In Gujarat, sorghum is cultivated on an area of 1.62 lakh hectares, with a production of 1.87 lakh tons and an average productivity of 11.53 q/ha (2023-24). Major sorghum-growing districts include Banaskantha, Sabarkantha, Rajkot, Jamnagar and Kachchh, where it plays a vital role in supporting the livestock sector.

Recommended dose of sorghum is 60:40:0 kg N: P_2O_5:K_2O/ha in which 25% dose of N and full doses of P were applied as basal during final land preparation and the remaining dose of nitrogen was applied at 20, 40 and 60 days after sowing. Growth attributes of dual sorghum like plant height and stem diameter at harvest were recorded. Grain and dry fodder yields of sorghum were recorded from net plot and then expressed in tons/ha.

It is one of the cheapest sources of energy and micronutrients; and a vast majority of population in Africa and central India depend on sorghum for their dietary energy and micronutrient requirement (Parthasarathy Rao *et al.*). 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). Bio-fortification, where possible, is the most cost effective and sustainable solution for tackling micronutrient deficiencies as intake of micronutrients is on a continuing basis with no additional cost to the consumer in developing countries of arid-tropical and subtropical regions. Bio-fortification of sorghum by increasing mineral micronutrients [especially iron (Fe) and zinc (Zn)] in grain is of wide spread interest (Pfeiffer and Mc Clafferty 2007, Zhao 2008, Ashok Kumar *et al.* 2009).

Fenugreek is generally cultivated as leafy vegetable, condiment and medicinal purpose. Almost all plant parts including leaf, tender stem and seeds are commonly used for consumption by the people in their daily diet. It has a high medicinal value as it prevents constipation, removes indigestion, stimulates spleen and liver and is appetizing and diuretic (Kumar *et al.*, 1997). Fenugreek roots are act as supply of nitrogen for plant as a result enriches the soil. India is among one of the largest producer and exporter of this spices throughout the world. The mineral nutrition elements plays essential roles such as constituent of cell structures and cell metabolites, in cell osmotic relations and turgor related processes, energy transfer reactions, enzyme catalyzed reactions and plant reproduction. Micronutrients like zinc, iron, boron, manganese, copper, molybdenum etc. leads to significant changes in growth parameters like plant height, number of pods, root nodulation and other changes like higher seed yield, seed germination, increase in phosphorus uptake etc. For acquiring the higher yield potential, supplementation of micronutrients are extremely essential.

Some farmers do not apply any micronutrient containing fertilizer leading to deficiency of nutrients in soil and further resulted in lower yield with low nutritional quality of grain and fodder. Hence, the present experiment had planned to study response of micro nutrient application to *kharif* sorghum-*rabi* fenugreek to enrich the grain and fodder with micronutrient.

Economics like cost of cultivation and net return were worked out by using prevailing market prices of inputs during the period of investigation. Net return was estimated by subtracting total cost of cultivation from gross return. Benefit-cost ratio (BCR) was worked out by using the formula.

MATERIALS AND METHODS

A field experiment on sorghum was conducted during *kharif* season in 2021, 2022 and 2023 and fenugreek during *rabi 20*21-22, 2022-23 and 2023-24 to study the effect of micronutrient on yield of sorghum-fenugreek cropping sequence at Centre for Millets Research, Sardarkrushinagar Dantiwada Agricultural University, Deesa. The experiment was carried out in randomized block design with four replication comprising seven treatments *viz*., T_1 [RDF (60 + 40 kg NP/ha)], T_2 (RDF + Soil application of micronutrient as per STV), T_3 (RDF + Foliar spray of 1 % multi micronutrient Grade I at 30, 45 and 60 DAS),T_4 (RDF + Foliar spray of 1 % multi micronutrient Grade II at 30, 45 and 60 DAS), T_5 (RDF + Foliar spray of 1 % multi micronutrient Grade III at 30, 45 and 60 DAS), T_6 (RDF + Foliar spray of 1 % multi micronutrient Grade IV at 30, 45 and 60 DAS) and T_7 [RDF + Soil application multi micronutrient Grade V (20 kg/ha)]. In which 25 % N and 100 % P_2O_5 applied as basal and 75 % N applied in three equal splits each at 20, 40 and 60 DAS in sorghum while in fenugreek 50 % N and 100 % P_2O_5 applied as basal and 50 % N apply in at 30 DAS. Sorghum variety Gujarat Jowar 43 and fenugreek variety GM 2 was taken for experiment. The RDF of sorghum was 60-40 NP kg/ha and fenugreek 20-40 NP kg/ha. The total rainfall received was 708.00 mm during 2021, 1125.0 during 2022 and 629.5 mm during 2023, with 29, 43 and 21 rainy days respectively. The average monthly air temperature and relative humidity were almost similar during all the years.

Sorghum was sown in the second week of August, the third week of July and first week of July during *Kharif* 2021, *Kharif* 2022 and *Kharif* 2023, respectively and harvested last week of November, first week of November and second week of November during *Kharif* 2021, *Kharif* 2022 and *Kharif* 2023, respectively. Fenugreek was sown in the last week of November, the third week of November and last week of November during *rabi* 2021, *rabi* 2022 and *rabi* 2023, respectively and harvested first week of March for all the years. The number of irrigations applied in the *kharif* sorghum was 4, 3 and 4 during *Kharif* 2021, *Kharif* 2022 and *Kharif* 2023 and *rabi* fenugreek was 7, 6 and 6 during *rabi* 2021, *rabi* 2022 and *rabi* 2023, respectively. Economic crops were taking into account the prevailing minimum support price (MSP)/market prices of the crops. The statistical analysis of data of various characters was done using analysis of variance techniques as suggested by Panse and Sukhatme (1967). The yield of fenugreek is converted into sorghum equivalent yield. DTPA extractable micronutrient in soil and content and uptake by crop was analyzed after completion of sequence.

RESULTS AND DISCUSSION

Pooled results of three years

Grain yield of sorghum (Table 1) was significantly higher under treatment T_6 (RDF + foliar spray of 1% multi micronutrient (Grade-IV) at 30, 45 and 60 DAS) and remain statistically at par with treatments T_7 [RDF + Soil application multi micronutrient Grade V (20 kg/ha)], T_3 (RDF + Foliar spray of 1 % multi micronutrient Grade I at 30, 45 and 60 DAS) and T_2 (RDF + Soil application of micronutrient as per STV) Similar results were also reported by Malek *et. al.* (2018) in chickpea. Supplementation of multi micronutrients through foliar along with soil application is essential for better crop growth and yield. Similarly, the beneficial effect of combined soil and foliar application of multi micronutrients mixture on growth and yield have been reported on sorghum (Choudhary *et al.*, 2015). Significantly highest fenugreek grain yield (1045 kg/ha) and sorghum equivalent yield (4902 kg/ha) were recorded higher under treatment T_6 (RDF + Foliar spray of 1 % multi micronutrient Grade IV at 30, 45 and 60 DAS). The increase in grain yield may be due to indeterminate growth pattern, higher rate of CO_2 fixation and RuBP carboxylase activity during crop growth. Similar results were also reported by Arjunan and Srinivasan (1989) in groundnut and Malek *et. al.* (2018) in chickpea.

TABLE 1
Yield of sorghum and fenugreek as influenced by different treatments

Treatment	Sorghum		Fenugreek grain yield (kg/ha)	Sorghum equivalent yield (kg/ha)
	Grain yield (kg/ha)	Dry fodder yield (kg/ha)		
T_1	1950	12017	734.00	3541
T_2	2400	13378	779.25	4088
T_3	2485	12981	847.59	4322
T_4	2252	12546	802.03	3990
T_5	2354	12523	783.04	4051
T_6	2637	14449	1045.24	4902
T_7	2502	13274	821.76	4283
S. Em. ±	85	716	53.48	162
CD at 5%	240	NS	164.81	458

Results showed that significantly higher organic carbon (0.30 %) was recorded under treatment RDF (60 + 40 kg NP/ha). DTPA extractable Fe (3.03 ppm) and DTPA extractable Zn of soil (1.62 ppm) was observed under treatment RDF + Soil application of micronutrient as per STV while DTPA extractable Mn and DTPA extractable Cu of soil was not significantly influenced by different treatments. Fe, Mn and Zn content and uptake by fenugreek crop was not significantly influenced by different treatments. Fe, Mn, Zn and Cu uptake by plants was recorded higher under treatment RDF + Foliar spray of 1 % multi micronutrient Grade I at 30, 45 and 60 DAS). Fe, Mn and Zn content and uptake in grain was recorded significantly higher under treatment T_7 [RDF + Soil application multi micronutrient Grade V (20 kg/ha)],

TABLE 2
Organic carbon, DTPA extractable Fe, Mn, Zn and Cu as influenced by different treatments

Treatment	Organic carbon (%)	DTPA extractable Fe of soil (ppm)	DTPA extractable Mn of soil (ppm)	DTPA extractable Zn of soil (ppm)	DTPA extractable Cu of soil (ppm)
T_1	0.30	2.87	10.12	1.01	0.37
T_2	0.29	3.03	10.56	1.62	0.39
T_3	0.27	2.36	9.55	0.75	0.38
T_4	0.28	2.49	10.51	0.91	0.38
T_5	0.28	2.94	11.13	0.72	0.38
T_6	0.29	2.22	9.97	1.14	0.39
T_7	0.29	2.48	10.90	1.59	0.38
S. Em. ±	0.005	0.17	0.48	0.08	0.007
CD at 5%	0.01	0.50	NS	0.24	NS

TABLE 3

Fe, Mn. Zn and Cu content in plant as influenced by different treatments

Treatment	Fe content in plant (ppm)	Mn content in plant (ppm)	Zn content in plant (ppm)	Cu content in plant (ppm)
T_1	100.15	17.52	22.73	5.46
T_2	103.38	19.03	25.43	6.26
T_3	102.24	19.37	26.24	6.05
T_4	107.68	19.00	21.65	5.87
T_5	102.29	18.71	21.07	6.63
T_6	101.95	19.33	24.37	6.07
T_7	107.86	18.41	23.99	4.52
S. Em±	8.94	1.06	1.75	0.64
CD at 5%	NS	NS	NS	NS

TABLE 4

Fe, Mn, Zn and Cu uptake by plant as influenced by different treatments

Treatment	Fe uptake by plant (g/ha)	Mn uptake by plant (g/ha)	Zn uptake by plant (g/ha)	Cu uptake by plant (g/ha)
T_1	265.33	51.88	56.86	13.94
T_2	280.64	59.55	65.42	16.23
T_3	357.49	80.76	82.96	19.63
T_4	295.19	57.64	56.73	15.66
T_5	263.60	52.18	53.26	16.62
T_6	316.47	67.83	72.92	18.50
T_7	287.69	51.75	62.63	12.20
S. Em. ±	51.39	9.70	9.53	2.08
CD at 5%	NS	NS	NS	NS

while Cu content in grain was significantly higher under treatment RDF + Foliar spray of 1 % multi micronutrient Grade IV at 30, 45 and 60 DAS while Cu uptake

TABLE 5

Fe, Mn, Zn and Cu content in grain as influenced by different treatments

Treatment	Fe content in grain (ppm)	Mn content in grain (ppm)	Zn content in grain (ppm)	Cu content in grain (ppm)
T_1	70.57	12.86	25.23	6.05
T_2	81.85	13.65	30.96	7.16
T_3	73.38	13.82	28.75	7.56
T_4	61.61	13.67	27.41	6.32
T_5	70.53	14.31	26.02	7.02
T_6	76.68	15.10	31.95	9.03
T_7	84.95	15.76	33.41	7.02
S. Em. ±	4.22	0.38	1.16	0.34
CD at 5%	12.08	1.13	3.36	0.99

TABLE 6

Fe, Mn, Zn and Cu uptake by grain as influenced by different treatments

Treatment	Fe uptake by grain (g/ha)	Mn uptake by grain (g/ha)	Zn uptake by grain (g/ha)	Cu uptake by grain (g/ha)
T_1	66.14	12.05	23.65	5.70
T_2	78.49	12.99	29.40	6.76
T_3	78.68	14.95	30.92	8.10
T_4	62.45	13.87	28.08	6.41
T_5	70.17	14.29	26.08	7.05
T_6	99.04	19.39	41.18	11.63
T_7	83.92	15.34	32.78	6.93
S. Em. ±	6.73	0.81	2.20	0.96
CD at 5%	19.21	2.35	6.35	NS

by grain was not significantly influenced by different treatments but highest under treatment RDF + Soil application multi micronutrient Grade V (20 kg/ha).

TABLE 7

Economics of different treatments (Pooled)

Treatment	Sorghum equivalent yield (kg/ha)	Dry fodder yield (kg/ha)	Gross return (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1	3541	12017	197045	114535	82510	1.72
T_2	4088	13378	223396	117545	105851	1.90
T_3	4322	12981	229218	128935	100283	1.78
T_4	3990	12546	214341	128575	85766	1.67
T_5	4051	12523	215638	128215	87423	1.68
T_6	4902	14449	256477	128215	128262	2.00
T_7	4283	13274	228428	115495	112933	1.98

Selling Price :

Sorghum Grain	:	Rs. 30/kg
Sorghum dry Fodder	:	Rs. 7/kg
Fenugreek grain	:	Rs. 65/kg
Fenugreek stover	:	Rs. 3/kg

Similar results were also reported by Prasad *et al.* 2014 in cereal grains and Velu *et al.* 2014 in wheat crop and Singh and Chauhan, 2017 on sorghum.

ECONOMICS

Economics of different treatments (Table 7) showed that maximum gross (Rs. 2,56,477/ha) and net return (Rs. 1,28,262/ha) with BCR of 2.0 was obtained with treatment T_6 (RDF + Foliar spray of 1 % multi micronutrient Grade IV at 30, 45 and 60 DAS) in pooled results. However, treatment T_1 (RDF) recorded the lowest gross (Rs. 1,97,045/ha) and net returns (Rs. 82,510/ha).

CONCLUSION

From the results of present research it can be concluded that under North Gujarat agro-climatic zone-IV following sorghum-fenugreek cropping sequence are recommended to apply 60 kg N/ha and 40 kg P_2O_5/ha to sorghum and 20 N/ha and 40 kg P_2O_5/ha to fenugreek crop along with 1% solution of multi-micronutrient grade IV (Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5%, B-0.5%) at 30, 45 and 60 DAS for getting higher yield and net profit and micronutrient uptake in grain after completion of sequence.

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