Plant Archives Vol. 26, Supplement 1, 2026 pp. 522-527 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.070

EFFECT OF MICRONUTRIENT ON GROWTH AND YIELD OF SORGHUM (SORGHUM BICOLOR)-FENUGREEK (*TRIGONELLA FOENUMGRACEUM*) CROPPING SEQUENCE

S.J. Vaghela[1]*, R.A. Gami[2], K.G. Kugashiya[3] and J.N. Chaudhary[4]

[1]Scientist (Agronomy) Centre for Millets Research, Sardarkrushinagar Dantiwada Agricultural University, Deesa-385 535, Gujarat, India.

[2]Scientist (Genetics and Plant Breeding), Centre for Millets Research, Sardarkrushinagar Dantiwada Agricultural University, Deesa-385 535, Gujarat, India

[3]Scientist (Genetics and Plant Breeding), Information Technology, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar -385 506, Gujarat, India

[4]Department of Biochemistry, College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Tharad-385 565, Gujarat, India

*Corresponding author Email: sjagron@sdau.edu.in

(Date of Receiving : 06-09-2025; Date of Acceptance : 04-11-2025)

ABSTRACT

Sorghum (*Sorghum bicolor*) is among the top ten crops that feed the world (Goldschein 2011). 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. To evaluate this a field experiment on sorghum was conducted during *kharif* season in 2021, 2022 and 2023 while fenugreek was sown during *rabi* 2021-22, 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 replications 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.

Results showed that significantly higher plant height and grain yield of sorghum was recorded 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 all the treatments except treatments T_7, T_3 and T_2. Initial plant population, number of leaves per plant, leaf length, leaf width, leaf stem ratio and plant population at harvest, seed index and dry fodder yield of were found non-significant in sorghum. A thorough analysis of data of fenugreek showed that higher plant height, number of branches per plant, pod length and number of seeds per pod was recorded under treatment T_6. Number of pods per plant, seed index and stover yield of fenugreek was not significantly influenced by different treatments. Significantly highest fenugreek grain yield (1045 kg/ha) and sorghum equivalent yield (4902 kg/ha), net return (128262 (Rs./ha) and benefit cost ratio (2.00) were recorded under treatment T_6.

Sorghum under rain-fed environment of North Gujarat with following *kharif* sorghum-*rabi* fenugreek cropping sequence was 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, net profit and benefit cost ratio.
Keywords **:** Micronutrient, cropping sequence, Sorghum equivalent yield, yield attributes, net return.

Introduction

Sorghum is the most important cereal crop in world after wheat *(Triticum aestivum)*, rice (*Oryza sativa*), maize (*Zea mays)* and barley *(Hordeum vulgare* L*).* 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^{-1}. 25 % dose of N and full doses of P were applied basally 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^{-1}.

Sorghum (*Sorghum bicolor*) is among the top ten crops that feed the world (Goldschein 2011). 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. 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). The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has been working for a decade on sorghum bio-fortification for enhancing grain Fe and Zn concentration.

Some farmers do not apply any micronutrient 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 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 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)) T_7 [RDF + Soil application multi micronutrient Grade V (20 kg/ha)]. In which 25 % N and 100 %

P2O5 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 (1985) [12]. The yield of fenugreek is converted into sorghum equivalent yield.

Results and Discussion

Pooled results of three seasons

Significantly higher plant height (237.78 cm) (Table 1) was recorded under treatment T_2 and which remain statistically at par with the treatments T_6 and T_5. Days to 50 % flowering (Table 1) was recorded significantly lowest under treatment T_3. Initial plant population (Table 1), number of leaves per plant, leaf length, leaf width (Table 2), leaf stem ratio and plant population at harvest (Table 3), seed index and dry fodder yield (Table 3) were found non-significant. Grain yield (Table 4) 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, T_3 and T_2. 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).

A thorough analysis of data presented in table 4 indicated that higher plant height of fenugreek (58.43 cm) was recorded under treatment T_6 and found significantly at par with T_2, T_3 and T_7. Significantly highest number of branches was recorded under treatment T_6 (6.63) and remain statistically at par with treatment T_7. Number of pods per plant was not significantly influenced by different treatments. Pod length (8.16 cm) and number of seeds per pod (12.05) (Table 5) recorded significantly highest under treatment T_6. Seed index and stover yield (Table 6) of fenugreek was not significantly influenced by different treatments. Significantly highest fenugreek grain yield (1045 kg/ha) and sorghum equivalent yield (4902 kg/ha) were recorded under treatment T_6. The increase 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.

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 in North Gujarat agro-climatic zone-IV following *kharif* sorghum-*rabi* 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.

Table 1: Growth attributes of dual sorghum as influenced by different treatments

Treatment	Initial plant population (Net plot)	Plant height at harvest (cm)	Days to 50 % flowering	No. of leaves per plant
T_1	238.41	219.64	68.33	10.12
T_2	239..08	237.78	67.94	10.40
T_3	237.83	225.64	67.92	12.12
T_4	237.92	223.63	68.19	10.47
T_5	238.00	228.37	69.89	11.02
T_6	238.92	235.17	68.67	11.00
T_7	238.67	223.71	68.83	10.82
S. Em. ±	0.74	4.08	0.31	0.382
CD at 5%	NS	11.55	0.88	NS
C.V. %	3.02	6.35	1.62	6.71
Y × T	**NS**	**NS**	**NS**	**1.03**

Table 2: Growth attributes of dual sorghum as influenced by different treatments

Treatment	Leaf length (cm)	Leaf width (cm)	Leaf stem ratio	Plant population (Net plot) (at harvest)
T_1	73.01	7.30	0.12	237.25
T_2	75.95	7.45	0.14	237.08
T_3	75.32	7.52	0.15	236.92
T_4	75.91	7.55	0.14	236.92
T_5	74.42	7.38	0.14	236.83
T_6	75.53	7.80	0.15	237.58
T_7	72.11	7.60	0.15	237.50
S. Em. ±	1.35	0.16	0.03	1.82
CD at 5%	NS	NS	NS	NS
C.V. %	6.47	6.89	13.0	2.95
Y × T	**NS**	**NS**	**0.03**	**NS**

Table 3: Seed index and yield of sorghum as influenced by different treatments

Treatment	Seed index (g)	Grain yield (kg/ha)	Dry fodder yield (kg/ha)
T_1	2.82	1950	12017
T_2	2.90	2400	13378
T_3	2.92	2485	12981
T_4	2.83	2252	12546
T_5	2.83	2354	12523
T_6	2.90	2637	14449
T_7	2.82	2502	13274
S. Em. ±	0.04	85	716
CD at 5%	NS	240	NS
C.V. %	4.78	11.96	20.24
Y × T	**NS**	**NS**	**NS**

Table 4: Growth attributes of fenugreek as influenced by different treatments

Treatment	Initial plant population (Net plot)	Plant height at harvest (cm)	No. of branches per plant	No. of pods per plant
T_1	506.25	53.63	5.50	20.65
T_2	504.42	56.33	5.62	20.77
T_3	505.25	56.32	5.27	22.52
T_4	502.33	51.00	5.75	22.12
T_5	504.58	51.03	5.42	22.00
T_6	509.83	58.43	6.63	24.17
T_7	506.75	55.34	6.10	21.07
S. Em. ±	4.67	1.21	0.18	1.04
CD at 5%	NS	3.43	0.55	NS
C.V. %	3.50	7.69	7.08	8.60
Y × T	**NS**	**NS**	**0.58**	**2.67**

Table 5: Growth attributes of fenugreek as influenced by different treatments

Treatment	Pod length (cm)	No of seeds per pod	Plant population at harvest (Net plot)
T_1	7.47	10.28	491.08
T_2	7.58	10.97	490.42
T_3	7.36	10.88	490.75
T_4	7.61	10.13	487.50
T_5	7.49	10.10	492.75
T_6	8.16	12.05	493.83
T_7	7.60	10.50	495.67
S. Em. ±	0.15	0.29	3.86
CD at 5%	0.43	0.83	NS
C.V. %	6.98	9.81	2.97
Y × T	**NS**	**NS**	**NS**

Table 6 : Yield attributes of fenugreek and sorghum equivalent yield as influenced by different treatments

Treatment	Seed index (g)	Grain yield (kg/ha)	Fenugreek stover yield (kg/ha)	Sorghum equivalent yield (kg/ha)
T_1	1.26	734.00	2232.42	3541
T_2	1.28	779.25	2369.52	4088
T_3	1.31	847.59	2897.19	4322
T_4	1.22	802.03	2272.77	3990
T_5	1.32	783.04	2149.08	4051
T_6	1.26	1045.24	2758.46	4902
T_7	1.26	821.76	2339.58	4283
S. Em. ±	0.05	53.48	231.28	162
CD at 5%	NS	164.81	NS	458
C.V. %	6.52	11.33	10.75	13.96
Y × T	**0.12**	**133.39**	**370.64**	**NS**

Table 7: Economics of different treatments (Pooled)

Treatment	Sorghum equivalent yield (kg/ha)	Dry fodder yield (kg/ha)	Fenugreek stover yield (kg/ha)	Gross return (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1	3541	12017	2232	197045	114535	82510	1.72
T_2	4088	13378	2370	223396	117545	105851	1.90
T_3	4322	12981	2897	229218	128935	100283	1.78
T_4	3990	12546	2273	214341	128575	85766	1.67
T_5	4051	12523	2149	215638	128215	87423	1.68
T_6	4902	14449	2758	256477	128215	128262	2.00
T_7	4283	13274	2340	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

References

Ashok, K.A., Reddy, B.V.S., Ramaiah, B., Sanjana, R.P., Sahrawat, K.L. and Upadhyaya, H.D. (2009). Genetic variability and plant character association of grain Fe and Zn in selected core collections of sorghum germplasm and breeding lines. *J SAT Agril Res.,* **7**, 1–4.

Arjunan, N., Srinivasan, P.S. (1989). Pre-sowing seed hardening for drought tolerance in groundnut (*Arachis hypogaea* L.). *Madras Agric J*., **76**, 523-26.

Choudhary, S.K., Mathur, A.K., Purohit, H.S., Jain, H.K. (2015) Effect of micronutrients on yield attributes and yield of sorghum. *Annals Plant and Soil Res.,* **1**, 180-182.

Christopher, L.A., Krishnan, P.K., Geethalakshmi, L. (1997). Micronutrient fertilization in groundnut. *Madras Agric J*., **34**, 362-63.

Goldschein, E. (2011). The 10 most important crops in the world. Business Insider. (http://www.businessinsider. com/10-crops-that-feed-the-world-2011-9?op=1&IR=T).

Malek, M.Z., Bhadane, R.S., Patel, D.B. and Tadvi, S.N. (2018). Dry matter partitioning in black gram (*Vigna mungo* L.) influenced by micro-nutrients application. *Int J Chem Stud.,* 6: 2422-2425.

Parthasarathy Rao, P., Birthal, B.S., Reddy Belum, V.S., Rai, K.N. and Ramesh S. (2006). Diagnostics of sorghum and pearl millet grains-based nutrition in India. *Int Sorghum and Millets Newsletter,* **47**, 93–96.

Pfeiffer, W.H., McClafferty B. (2007). Harvest Plus: Breeding crops for better nutrition *Crop Sci*., **47**, S88-S105.

Zhao, Z. (2008). The Africa biofortified sorghum project Applying biotechnology to develop nutritionally improved sorghum for Africa. Pages 273–277 *in* Biotechnology and sustainable agriculture 2006 and beyond. Proceedings of the 11th IAPTC&B Congress, Aug 31–18, 2006, Beijing, China (Xu Z, Li J, Xue J and Yang W, eds.). *The Netherlands: Springer.*