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EFFECT OF ORGANIC AND INORGANIC SOURCE OF NUTRIENTS ON GROWTH AND YIELD OF FODDER SORGHUM VARIETIES

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SUMMARY

A field experiment was carried out during *kharif* -2023 at Research Farm, Department of Soil Sciences, CCS HAU, Hisar (India) to assess the effect of organic and inorganic source of nutrients on growth parameters and fodder yield of sorghum. The experiment was laid out in split plot design with three sorghum varieties (CSV 53F, HJ 541 and Duggi) in main plot and nutrient management treatments (T_1: Control, T_2: 100% RDF, T_3: 125% RDN + 100% RDP+ 100% RDK, T_4: FYM @ 15 t/ha, T_5: Vermicompost @ 5 t/ha, T_6: 100% RDF + FYM @ 15 t/ha and T_7: 100% RDF + Vermicompost @ 5 t/ha) in sub plot. For forage sorghum, the recommended dose of NPK was 75 kg N + 30 kg P_2O_5 + 30 kg K_2O per hectare. Among varieties, at flag leaf, boot and 50 percent flowering stage, maximum plant height and LAI were recorded in CSV 53F which was at par with HJ 541. The GFY of CSV 53F was 2.2 and 32.9 per cent higher over HJ 541 and Duggi (local cultivar). Among different nutrient management treatments, maximum plant height, number of leaves per plant, LAI and dry matter accumulation/ plant were recorded with the application of 100% RDF + Vermicompost @ 5 t/ha (T_7) which was at par with (100% RDF) T_2, (125% RDN + 100% RDP + 100% RDK) T_3 and (100% RDF + FYM @ 15 t/ha) T_6 at flag leaf, boot and 50% flowering stage. The performance of these growth parameters was also reflected in the fodder yield (green and dry) of the single-cut forage sorghum varieties.

Key word: Sorghum, organic nutrient, fertilizers, fodder yield, leaf to stem ratio and plant height

Sorghum [(*Sorghum bicolor* L.) Moench] is the most widely grown as forage crop of India (2.6 m ha) (Prabhakar Babu, 2018). With climate resilience, sorghum and pearl millet are seen as alternative to maize in rainfed areas (Bhattarai *et al*., 2019). In a country like India that is home to 536 million livestock (Anonymous, 2020) facing a green and dry fodder shortage of 11.23 and 23.40 %, respectively (Roy *et al*., 2019). Under such scenario, a drought-tolerant crop like sorghum contribute very significantly towards the fodder security of the country. Summer season may be tapped for cultivation of fodder sorghum as it is a drought-tolerant crop and could provide fodder during the months of acute fodder shortage (Anil *et al*., 2023). Absence of improved genotype, weed control, plant protection, and fertilizer resulted in 39, 33, 31, and 30 per cent losses, respectively, in the productivity of fodder sorghum as compared to full package of practices (Satpal *et al*., 2021). High nutrient removal by fodder crops calls for adequate supply both through native soil fertility and fertilizer and manure application (Satpal *et al*., 2025). Conventionally, inorganic fertilizers are used to boost sorghum productivity. While the continuous and excessive use of chemical fertilizers has led to soil degradation, reduced nutrient use efficiency and also decline the yield. Conversely, organic nutrient sources *viz*. farmyard manure and compost, improve the soil quality and sustainability but not meet the immediate nutrient requirements of the crop. That's why integrated nutrient management, combining both organic and inorganic nutrient sources, has emerged as a promising approach to optimize the fodder yield while maintaining soil quality. For ensuring high productivity of fodder sorghum, appropriate nutrient management is required and it is further required to maintain soil health. Using both the sources of nutrients *i.e*. organic and inorganic sources, INM is most appropriate way to maintain the sustainability of soil health under sorghum based cropping systems (Raj *et al*., 2024). Keeping the above facts in view, present study has been planned to study the effect of organic and inorganic source of nutrients on growth parameters and fodder yield of sorghum varieties.

MATERIALS AND METHODS

The field experiment was carried out at Research Farm, Department of Soil Science, CCS

Haryana Agricultural University, Hisar during *kharif* season (rainy season) of 2023. The experiment study site was located at 29° 16′ N latitude and 75° 7′E longitude with an elevation of 215.2 m above mean sea level in the south-western part of Haryana and the north-western part of India. The climatic conditions of Hisar are semi-arid with hot summer, dry desiccating winds and severe cold winter. The mean annual temperature of this region is 24.8° C, with extremely hot summers with maximum temperature reaching 47° C whereas, winters are markedly cold with minimum temperature going down to 1° C. The mean annual precipitation of Hisar is 443 mm. Weekly weather parameters *i.e.* temperature (°C), relative humidity (%) and rainfall (mm) during the crop duration are given Fig. 1. The soil texture of experiment site was sandy loam. The site pH (1:2), EC (dS/m), SOC (%), available N, P and K (kg/ha) was 8.3, 0.36, 0.52, 117, 15 and 328, respectively. The experiment was sown in split-plot design with two factors where factor A (main plot) includes three different varieties *viz.* CSV 53F, HJ 541 and Duggi and factor B (sub plot) includes seven different source of nutrients viz. T_1- Control, T_2- 100% RDF (75 kg N + 30 kg P_2O_5 + 30 kg K_2O per ha), T_3- 125% RDN + 100% RDP+ 100% RDK, T_4- FYM @ 15 t/ha, T_5- Vermicompost @ 5 t/ha, T_6- 100% RDF + FYM @ 15 t/ha and T_7 - 100% RDF + Vermicompost @ 5 t/ha. Sowing of the trial was done manually with a row spacing of 25 cm on July 24, 2023. All other standard agronomic practices were followed uniformly in all the treatments as per the package of practices for *kharif* crops of CCS Haryana Agricultural University, Hisar, India (Anonymous, 2023). The data was analysed using OPSTAT software available at CCS Haryana Agricultural University website (Sheoran *et al.*, 1998). The results are presented at five per cent level of significance (p=0.05) for making comparison between treatments.

RESULTS AND DISCUSSION

Varieties

Data presented in Table 1 reveal that the plant population at 20 days after sowing and at the harvest *i.e.* 50 percent flowering stage. There was no significant variation in number of plants per meter row length. As the fodder sorghum matured, there was a progressive increase in plant height which is depicted in Table 1. However, the most rapid growth was observed during the panicle initiation stage and the flag leaf stage, compared to the boot stage and the 50 percent flowering stage (harvest stage) in terms of plant height. At panicle initiation stage, the plant height was found to be non-significant. At flag leaf, boot and 50 percent flowering stage, the maximum plant height was recorded in CSV 53F (164.3, 259.0 and 262.4

TABLE 1

Effect of varieties and nutrient management treatments on plant population and plant height of fodder sorghum at four different stages

Treatments	Plant population (per m row length)		Plant height (cm)			
	20 DAS	At harvest (50% flowering stage)	Panicle initiation stage	Flag leaf stage	Boot stage	50% flowering stage
Factor A: Varieties (Main plot)						
V_1: CSV 53F	14.7	16.0	95.6	164.3	259.0	262.4
V_2: HJ 541	14.5	16.0	95.9	162.8	255.8	260.9
V_3: Duggi	14.0	16.2	93.6	130.2	177.3	191.3
SE(m)±	0.2	0.2	0.6	1.0	1.4	1.4
C.D. at 5%	NS	NS	NS	4.0	5.8	5.8
Factor B: Source of nutrients (Sub plot)						
T_1: Control	14.0	15.8	91.2	131.6	177.2	184.1
T_2: 100% RDF	14.1	15.8	95.2	159.0	237.6	246.1
T_3: 125% RDN + 100% RDP + 100% RDK	14.9	16.2	96.1	160.5	239.0	252.1
T_4: FYM @ 15 t/ha	14.0	15.9	92.5	142.0	230.3	232.3
T_5: Vermicompost @ 5 t/ha	14.1	16.7	93.3	143.6	234.3	235.4
T_6: 100% RDF + FYM @ 15 t/ha	14.9	16.0	98.4	163.4	244.4	256.7
T_7: 100% RDF + Vermicompost @ 5 t/ha	14.9	16.0	98.7	166.8	252.1	259.9
SE(m)±	0.3	0.6	2.0	3.1	5.6	5.5
C.D. at 5%	NS	NS	NS	9.1	16.2	15.8

cm, respectively) which was at par with HJ 541 (162.8, 255.8 and 260.9 cm, respectively) and the minimum plant height was recorded in Duggi.

The data on leaf area index (LAI) and the number of leaves per plant is depicted in the Table 2 which reveal that the maximum leaf area index (LAI) measured at panicle initiation, flag leaf, boot and 50 percent flowering stage was found in CSV 53F (0.93, 2.91, 5.77 and 6.99, respectively) which was at par with HJ 541 (0.91, 2.86, 5.62 and 6.87, respectively) and the minimum leaf area index (LAI) was recorded in Duggi. Additionally, the maximum number of leaves per plant at panicle initiation, flag leaf, boot and 50 percent flowering stage was observed in HJ 541(6.72, 8.33, 11.71 and 13.86, respectively) which was at par with CSV 53F (6.55, 8.27, 11.62 and 13.74, respectively) and the minimum number of leaves per plant was recorded in Duggi. The data pertaining to dry matter accumulation is presented in Table 3 which increased progressively as the fodder sorghum matured. Still, the most rapid increase was observed at the panicle initiation stage and flag leaf stage compared to the boot stage and 50 percent flowering stage, *i.e.*, the harvest stage. At panicle initiation stage, the dry matter accumulation was found to be non-significant. At flag leaf, boot and 50 percent flowering stage, the maximum dry matter accumulation was also recorded in CSV 53F (74.60, 112.69 and 121.38 g/plant, respectively) which was at par with HJ 541. Data presented in Table 3 reveal

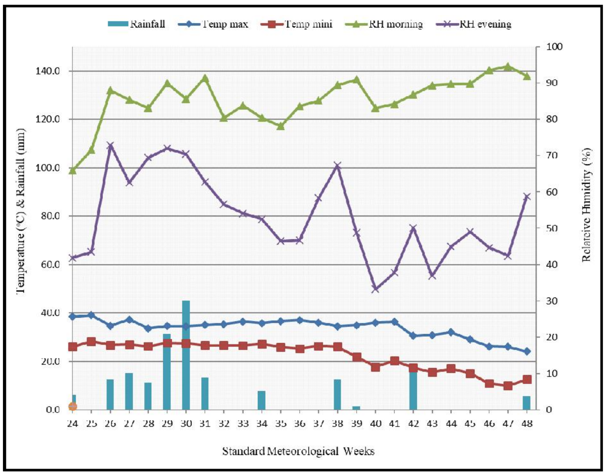

Fig. 1. Mean weekly meteorological data during *Kharif* season (2023).

that leaf to stem ratio (L:S) was found to be non-significant while the maximum stem girth was recorded in Duggi (a local cultivar). Furthermore, CSV 53F was found to be significantly lower in stem girth. By virtue of genetic trait, Duggi exhibited shorter height and more stem girth than that of other varieties which was not a desirable character for fodder sorghum.

The fodder yield data depicted in Fig. 2(a) reveals that the maximum green and dry fodder yield (42.70 and 11.41 t/ha, respectively) were recorded in CSV 53F which were at par with HJ 541 (41.76 and 11.16 t/ha, respectively). Furthermore, Duggi (local cultivar) was found to be significantly low in fodder

TABLE 2

Effect of varieties and nutrient management treatments on number of leaves per plant and LAI of fodder sorghum at four different stages

Treatments	Number of leaves per plant				Leaf area index			
	Panicle initiation stage	Flag leaf stage	Boot stage	50% flowering stage	Panicle initiation stage	Flag leaf stage	Boot Stage	50% flowering stage
Factor A: Variety (Main plot)								
V_1: CSV 53F	6.55	8.27	11.62	13.74	0.93	2.91	5.77	6.99
V_2: HJ 541	6.72	8.33	11.71	13.86	0.91	2.86	5.62	6.87
V_3: Duggi	5.95	7.55	10.59	11.76	0.76	2.74	5.43	6.09
SE(m)±	0.04	0.06	0.08	0.10	0.01	0.03	0.06	0.04
C.D. at 5%	0.17	0.26	0.32	0.39	0.02	0.11	0.23	0.15
Factor B: Source of nutrients (Sub plot)								
T_1: Control	4.27	4.83	7.96	8.90	0.78	2.70	5.47	6.24
T_2: 100% RDF	6.68	8.54	11.75	13.79	0.87	2.82	5.61	6.63
T_3: 125% RDN + 100% RDP + 100% RDK	6.75	8.68	11.88	13.94	0.88	2.88	5.63	6.75
T_4: FYM @ 15 t/ha	6.57	8.28	11.46	13.34	0.85	2.74	5.51	6.53
T_5: Vermicompost @ 5 t/ha	6.61	8.35	11.54	13.40	0.86	2.78	5.54	6.55
T_6: 100% RDF + FYM @ 15 t/ha	6.95	8.80	12.24	14.20	0.90	2.95	5.73	6.91
T_7: 100% RDF + Vermicompost @ 5 t/ha	7.01	8.86	12.30	14.26	0.92	2.98	5.75	6.93
SE(m)±	0.12	0.17	0.23	0.28	0.02	0.06	0.07	0.12
C.D. at 5%	0.36	0.49	0.67	0.80	0.05	0.18	0.20	0.35

yield. The differences observed among sorghum cultivars could be attributed to variations in their genetic makeup (Hanuman *et al.*, 2008). The distinct behaviour of these genotypes of fodder sorghum may also be explained entirely by differences in their genetic composition (Meena *et al.*, 2012). The results were in conformity with the findings of Satpal *et al.* (2020). The GFY of CSV 53F was 2.2 and 32.9 per cent higher over HJ 541 and Duggi (local cultivar). Satpal *et al.* (2021) also reported that improved genotype could contribute up to 39% in fresh fodder yield of forage sorghum cultivation while compared with full package of practices.

Source of nutrients

Data presented in Table 1 reveal that the plant population at 20 days after sowing (DAS) and at harvest was not affected significantly by different nutrient management treatments. However, a slight reduction in plant population was observed from 20 DAS to the harvest stage due to mortality of some plants. The data on plant height which was not affected significantly at panicle initiation stage. However, at flag leaf, boot and 50% flowering stage it was influenced by nutrient management treatments. The maximum plant height was recorded in T_7 (166.8, 252.1 and 259.9 cm, respectively) which was at par with T_2, T_3 and T_6. At 50% flowering stage, the minimum plant height was observed in the control (184.1 cm) which was 33.6, 36.9, 39.4 and 41.2 percent lower than the highest value observed with the application of T_2, T_3, T_6 and T_7. Data presented in Table 2 reveal that maximum leaf area index (LAI) at panicle initiation, flag leaf, boot and 50 percent flowering stage was recorded in T_7 (0.92, 2.98, 5.75 and 6.93, respectively) which was at par with T_6, T_3 and T_2 followed by T_5 and T_4 and minimum was recorded in T_1. Furthermore, the maximum number of leaves per plant at panicle initiation, flag leaf, boot and 50 percent flowering stage was recorded in T_7 (7.01, 8.86, 12.30 and 14.26, respectively) which were at par with T_2, T_3 and T_6. Dry matter accumulation on per plant basis was not affected significantly at panicle initiation stage; however, at flag leaf, boot and 50 percent flowering stage, maximum dry matter accumulation was recorded in T_7 (74.31, 108.52 and 122.78 g plant^{-1}, respectively) which was at par with T_2, T_3 and T_6 (Table 3). The improved agronomic growth parameters could be attributed due to enhanced photosynthetic activity sustained by the continuous nutrient supply provided through the combined use of organic and

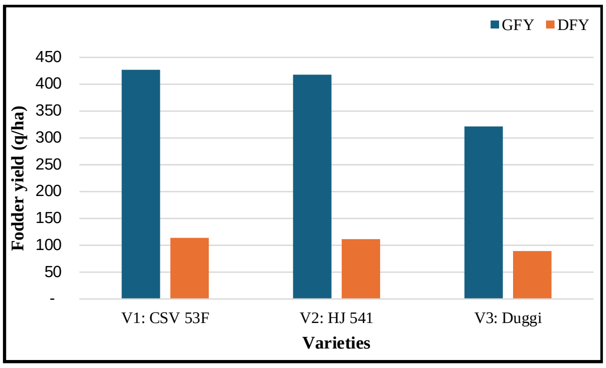

Fig. 2(a). Fodder yield of sorghum.

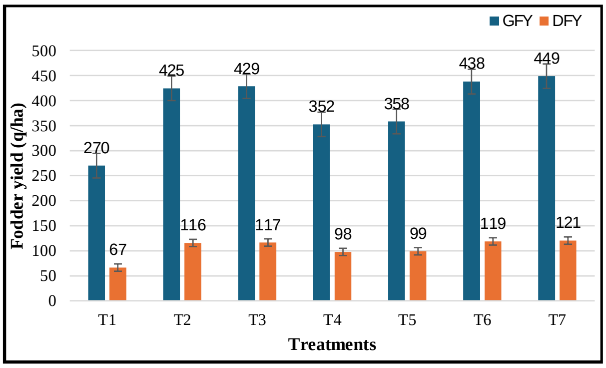

Fig. 2(b). Fodder yield of sorghum.

inorganic nutrient sources. In contrast, the sole application of inorganic nutrients led to rapid nutrient availability, which also boosted photosynthetic activity. The production of dry matter rely on photosynthesis, which was influenced by the size and efficiency of the assimilating area. These findings align with those of Biswas *et al.* (2019), who reported significantly improved growth attributes when 25% of nitrogen was substituted with FYM or vermicompost, compared to the sole application of nitrogen from inorganic sources. The results were consistent with the findings of Hugar *et al.* (2010) and Kaur and Satpal (2019).

The data on the L:S and stem girth at 50 percent flowering stage is depicted in the Table 3 which reveals that the maximum stem girth was recorded with the application T_4 which was at par with T_5. In contrast, followed by the inorganic source of nutrients then integrated application of organic and inorganic sources of nutrients *i.e.* T_6 and T_7. The lowest stem girth was recorded in the control. The increase in stem girth could be attributed to a steady nutrient supply provided by organic nutrient treatments. This improvement was likely due to higher nutrient availability in treatments utilizing inorganic sources and integrated nutrient management. These findings align with those of Biswas *et al.* (2019) and Kaur and Satpal (2019). However, the maximum fresh and dry leaf stem ratios were recorded with the application of T_7 which was found at par with treatments T_2, T_3 and T_6. The minimum fresh and dry leaf stem ratios were recorded in the T_1. This could be attributed to a consistent nutrient supply through integrated nutrient treatments, which enhanced all growth parameters, including the crop leaf stem ratio. The increase in the leaf-stem ratio was likely due to the greater nutrient availability in treatments where 100% of the recommended nitrogen dose was provided through inorganic sources. These findings align with the results reported by Kaur and Satpal (2019).

The data in the Fig. 2 (b) reveal that the highest green and dry fodder yield were recorded in the in T_7 (44.87 and 12.06 t/ha, respectively) which was at par with T_2, T_3 and T_6. High yields were observed with treatments combining organic and inorganic source of nutrients, particularly vermicompost with inorganic source of nutrient, due to enhanced growth traits like plant height, leaf number, and LAI, which improved photosynthesis and nutrient uptake. Higher nutrient content in Vermicompost and their faster release contributed in yield advantage over FYM application. Nabi *et al*. (2021) found that growth parameters were highest when 100% RDF was applied. Similar results were observed with a combination of inorganic and organic treatments, such as 75% RDF along with 25% vermicompost. These treatments led to the highest leaf-to-stem ratio, as improved nutrient uptake supported normal physiological processes like photosynthesis, resulting in the highest dry matter accumulation. Chahal *et al*. (2021) concluded that applying 100% Recommended Dose of Fertilizer (RDF) from either inorganic sources or a combination of organic sources, such as FYM at 10 t ha^{-1} along with biofertilizers like *Azotobacter* and PSB, had similar effects on yield attributes and yield.

Interaction effect

The interaction effect between varieties (Factor A) and source of nutrients (Factor B) was found to be non-significant for the plant population (at 20 DAS and at harvest stage), plant height, number of leaves per plant, leaf area index, dry matter accumulation/plant (Panicle initiation, flag leaf, boot and 50% flowering stage), stem girth and L:S.

CONCLUSION

Based on results of the study, it may be concluded that among varieties, single-cut fodder sorghum variety CSV 53F perform superior in different growth parameters and fodder yield which was at par with HJ 541. The GFY of CSV 53F was 2.2 and 32.9 per cent higher over HJ 541 and Duggi (local cultivar). Among different nutrient management treatments, maximum plant height, number of leaves per plant, LAI, dry matter accumulation/plant and fodder yield were recorded with the application of 100% RDF +

TABLE 3

Effect of varieties and nutrient management treatments on dry matter accumulation of fodder sorghum at four different stages

Treatments	Dry matter accumulation (g/plant)				Stem girth (cm)	Leaf-stem ratio	
	Panicle initiation stage	Flag leaf stage	Boot stage	50% flowering stage		Fresh	Dry
Factor A: Variety (Main plot)							
V_1: CSV 53F	47.41	74.60	112.69	121.38	5.09	0.28	0.12
V_2: HJ 541	46.70	73.34	110.46	119.75	5.04	0.27	0.12
V_3: Duggi	46.37	55.76	83.20	103.81	6.25	0.26	0.11
SE(m)±	0.35	0.50	0.69	0.77	0.03	0.01	0.01
C.D. at 5%	NS	2.03	2.79	3.09	0.12	NS	NS
Factor B: Source of nutrients (Sub plot)							
T_1: Control	44.25	50.73	88.14	94.54	4.48	0.17	0.03
T_2: 100% RDF	46.78	70.78	103.45	117.78	5.59	0.29	0.13
T_3: 125% RDN + 100% RDP + 100% RDK	47.22	71.93	105.69	119.79	5.70	0.30	0.15
T_4: FYM @ 15 t/ha	45.98	66.70	100.73	114.28	5.83	0.22	0.07
T_5: Vermicompost @ 5 t/ha	46.19	68.05	101.25	115.08	5.75	0.25	0.09
T_6: 100% RDF + FYM @ 15 t/ha	48.36	72.81	107.04	120.63	5.47	0.32	0.16
T_7: 100% RDF + Vermicompost @ 5 t/ha	49.02	74.31	108.52	122.78	5.40	0.33	0.18
SE(m)±	1.07	1.57	2.27	2.42	0.1	0.02	0.02
C.D. at 5%	NS	4.51	6.53	6.97	0.28	0.05	0.05

Vermicompost @ 5 t/ha (T_7) which was at par with (100% RDF) T_2, (125% RDN + 100% RDP + 100% RDK) T_3 and (100% RDF + FYM @ 15 t/ha) T_6 at flag leaf, boot and 50% flowering stage. The results indicate that integration of inorganic and organic nutrient sources, such as vermicompost and FYM, in conjunction with the recommended fertilizer doses, presents a more sustainable and effective alternative to rely exclusively on inorganic fertilizers. The adoption of the balanced nutrient management strategy fosters sustainable agricultural practices while maintaining crop performance. Among the organic nutrient sources, vermicompost has proven to be a more effective alternative to FYM, demonstrating superior results in terms of plant growth and yield.

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