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Effect of different organic nutrient sources on growth parameters and yield of fodder sorghum

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Abstract
The field experiment was conducted during kharif season of 2023 at Agronomy Farm of Department of Agronomy, CCS Haryana Agricultural University, Hisar to study the effect of organic sources of nutrients on growth parameters and yield of fodder sorghum. The experiment was laid out in randomized block design keeping eleven treatments consisting of different sources of nutrients with three replications. There was significant difference among treatments in respect of growth, green and dry fodder yield of single cut forage sorghum. The maximum plant height (275.67 cm), number of leaves (14.94), dry matter accumulation (130.71 g), leaf area index (6.79), green fodder yield (521.30 q/ha) and dry fodder yield (137.80 q/ha) were recorded with the application of inorganic fertilizers (RDF) as followed by vermicompost @ 7.5 t ha^{-1}. In summarize, application of 100% RDF was the most suitable fertilization practice to achieve maximum yield under semi-arid conditions of Haryana.

Keywords: Sorghum, single-cut, vermicompost, fodder yield, biochar

Introduction
India remains largely an agrarian economy, with around two-thirds of its population engaged in livestock and allied sectors for their livelihood. Livestock not only provides a critical income stream but also ensures livelihood security, particularly for small and marginal farmers. It contributes approximately 14% to rural household income and holds a substantial place in the rural economic framework. The total livestock population in the country is estimated at 536 m, with cattle constituting 37%, goats 21.23%, and pigs 20% (Anonymous, 2020) [1]. The livestock sector contributes 4.11% to India's overall GDP and accounts for 25.6% of the agricultural GDP. Forages play a vital role in livestock rearing, with high-quality fodder being essential to fully harness the genetic potential of improved cattle breeds. The performance of the livestock industry is heavily reliant on the availability of adequate and nutritious green fodder and concentrates to support animal maintenance, growth, and productivity. However, despite its significance, only 4.4% of the country's land area is allocated to fodder cultivation, with fodder sorghum occupying approximately 2.3 m ha. Against the estimated need of 827.19 mt of green fodder and 426.1 mt of dry fodder, the actual availability is 734.2 mt and 326.4 mt, respectively (Roy *et al*., 2019) [16]. To address this gap between demand and supply, it is essential to adopt high-yielding fodder crops and varieties, along with appropriate agronomic practices. Among various fodder crops, sorghum (*Sorghum bicolor* L.) stands out as a crucial option. It can be grown across a wide range of climatic conditions in the northern, central, and western regions of the country. Sorghum, also known as jowar or the camel crop, is a resilient member of the Gramineae family. It is well-adapted to tropical and subtropical climates due to its strong tolerance to drought and salinity (Devi *et al*., 2018) [4]. In the context of environmental conservation, soil health maintenance, and sustainable agricultural productivity, it is essential to move away from chemical fertilizers. Enhancing sorghum yield, particularly in high-yielding varieties, depends greatly on improved nutrient management strategies. As environmental challenges increasingly threaten sustainability, adopting eco-friendly farming practices becomes crucial for safeguarding the well-being of soils, ecosystems, animals, and human populations. Organic manures provide an affordable and sustainable alternative to costly synthetic fertilizers, especially for farmers in rainfed regions with limited resources.

These natural inputs supply essential nutrients and promote the activity and proliferation of beneficial soil organisms, thereby improving nutrient absorption in crops and reducing the harmful effects of chemical inputs (Singh *et al*., 2019) [20]. The use of organic manures contributes to better physical and biochemical soil properties (Panwar *et al*., 2021) [14]. This includes improved water retention, higher cation exchange capacity, increased populations of beneficial microorganisms, enhanced soil structure and aggregate stability, and reduced bulk density. (Stamatiadis *et al*., 1999) [22].

Materials and Methods

A field experiment was carried out during the kharif season of 2023 at the Agronomy Research Farm, under the Department of Agronomy at CCS Haryana Agricultural University, Hisar. The experimental site is located at 29°10' N latitude and 75°46' E longitude, with an elevation of 215.2 m above sea level, within the state of Haryana, India. Weekly meteorological data, including temperature (°C), relative humidity (%), and rainfall (mm) recorded during the season, are presented in Fig. 1. The soil at the site was characterized as low in available nitrogen (122.65 kg/ha), medium in available phosphorus (12.42 kg/ha), and high in available potassium (220.35 kg/ha), with an organic carbon content of 0.42%. The experiment was conducted in randomized block design (RBD) with 11 treatments [T_1: Control (No RDF); T_2: RDF (75:30:30) NPK kg ha^{-1}); T_3: FYM @ 5 t ha^{-1}; T_4: FYM @ 10 t ha^{-1}; T_5: FYM @ 15 t ha^{-1}; T_6: Vermicompost @ 2.5 t ha^{-1}; T_7: Vermicompost @ 5 t ha^{-1}; T_8: Vermicompost @ 7.5 t ha^{-1}; T_9: Biochar @ 2.5 t ha^{-1}; T_{10}: Biochar @ 5 t ha^{-1}; T_{11}: Biochar @ 7.5 t ha^{-1}] and each treatment was replicated thrice. Single cut variety of forage sorghum 'HJ 541' was used in the experiment. The crop was sown on 4th July, 2023, maintaining an inter-row spacing of 25 cm.

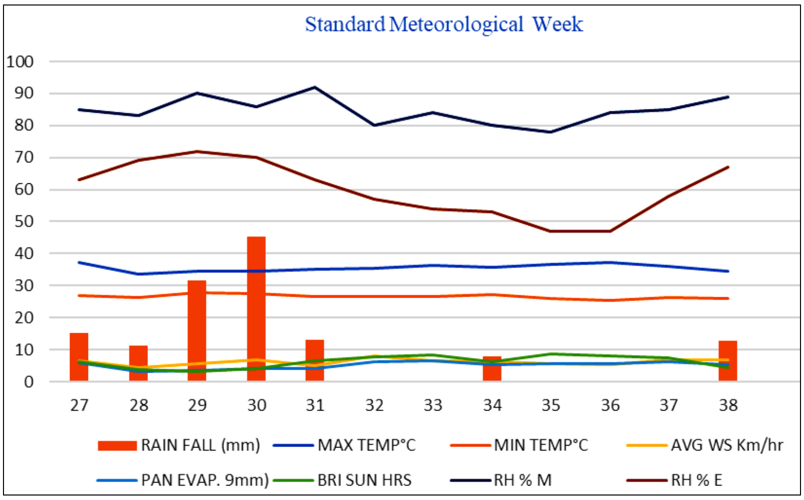

Fig 1: Average Weekly Meteorological data of Hisar district throughout the experimental crop growing season (July - September, 2023)

Fertilizers were applied as per the respective treatment specifications. Organic manures were manually incorporated into the soil in accordance with the nutrient requirements of each treatment. Yield attributing parameters were recorded at crop maturity. Additionally, three plants were randomly selected per plot to record data on plant height, number of leaves, dry matter accumulation, and leaf-to-stem ratio. The leaf area index (LAI) was determined by collecting foliage samples from the plant canopy, measuring the green leaf area, and dividing it by the ground area occupied by each plant. The weight of harvested green fodder from each plot was taken in situ (kg/plot) and then converted into q/ha. A random green fodder sample of 500 g was collected from each plot at the time of harvest, sun-dried, and then oven-dried to a constant weight. Based on these sample weights, the dry fodder yield was calculated and expressed in q/ha. The recorded data were statistically analyzed using analysis of variance (ANOVA). Data were analyzed using OPSTAT statistical software, available on the 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 treatment.

Results and Discussion

Growth Parameters

Data in Table 1 reveals that among organic sources, plant population at harvest did not differ significantly and an average of 10.70 plants per metre row length was recorded. The highest plant height (275.67 cm) was recorded in RDF at harvest which was on at par with vermicompost @ 7.5 t ha^{-1}. The increased plant height observed with the application of RDF could be attributed due to rapid release of nutrients from inorganic fertilizers. Similar findings were noted by Satpal *et al*. (2020) [18] and Kaur and Satpal (2019) [10]. Leaf area index (LAI) was significantly higher in RDF (6.79) and was statistically at par with vermicompost @ 7.5 t ha^{-1} and Biochar @ 7.5 t ha^{-1}. This likely led to enhanced nutrient availability and uptake, which in turn promoted protoplasm synthesis, cell division, cell expansion, and overall vigorous plant growth (Kashyap and Bainade, 2022) [9]. Number of leaves increased with the advancement of crop age and the application of different nutrient sources, both organic and inorganic, had a significant effect on the number of leaves per plant. Among the treatments, (RDF) recorded the highest number of leaves per plant (14.94) at harvest. This treatment was statistically comparable to Vermicompost @ 7.5 t ha^{-1}. The increase in the number of leaves per plant may be attributed to the higher availability of nitrogen, a key component of chlorophyll. Enhanced plant height, resulting from better nutrient availability, likely led to an increased number of nodes per plant, thereby contributing to a greater number of leaves (Srivani *et al*., 2022) [21]. Treatment T_2 (RDF) recorded the highest dry matter accumulation values (130.71 g) at harvest. These values were statistically at par with those recorded under treatment Vermicompost @ 7.5 t ha^{-1}, but significantly higher than those of all other treatments throughout the crop cycle. It is a cumulative outcome of plant growth, photosynthetic efficiency, and the balanced availability of essential macro and micronutrients. The increase in dry matter accumulation can be attributed to the synergistic effects of increased plant height and leaf number, which together expand the assimilating surface area. These findings align with those reported by Chaudhary *et al*. (2018) [2] and Oberoi and Kaur (2020) [13].

Table 1: Growth of forage sorghum as influenced by different nutrient sources

Treatments	Plant population at harvest	Plant height (cm) at harvest	No. of leaves per plant at harvest	Leaf area index at harvest	Dry matter accumulation (g/plant) at harvest
Control	10.0	192.48	10.68	4.80	92.00
RDF (75:30:30) NPK kg ha^{-1}	11.3	275.67	14.94	6.79	130.71
FYM @ 5 t ha^{-1}	10.6	196.00	11.31	5.18	95.81
FYM @ 10 t ha^{-1}	10.7	223.11	12.65	5.72	108.12
FYM @ 15 t ha^{-1}	10.8	240.67	13.37	6.13	116.74
Vermicompost @ 2.5 t ha^{-1}	10.2	217.67	12.60	5.67	102.36
Vermicompost @ 5.0 t ha^{-1}	10.7	258.33	14.10	6.44	125.54
Vermicompost @ 7.5 t ha^{-1}	11.2	271.88	14.78	6.74	130.47
Biochar @ 2.5 t ha^{-1}	10.8	207.38	11.92	5.38	98.50
Biochar @ 5.0 t ha^{-1}	10.9	223.89	12.71	5.84	111.32
Biochar @ 7.5 t ha^{-1}	10.5	245.67	13.40	6.65	119.82
S.Em (±)	0.4	3.61	0.21	0.06	1.23
CD (P=0.05)	NS	10.59	0.60	0.18	3.59

Green and dry fodder yield

Data in respect of green and dry fodder yield of forage sorghum as influenced by organic sources of nutrients is presented in Table 2. Fodder yield is a key criterion for assessing the effectiveness of various treatments, as their ultimate impact is reflected in the yield produced. Fodder yield depends on growth parameters such as plant height, number of leaves, and dry matter accumulation. Both green and dry fodder yields were significantly influenced by the different organic nutrient source applied. The highest green fodder yield (521.30 q/ha) and dry fodder yield (137.80 q/ha) were recorded under (RDF), which was statistically comparable to Vermicompost @ 7.5 t ha^{-1}. The lowest green fodder yield (285.15 q/ha) was observed in the control treatment, which was significantly lower than all other treatments receiving nutrients through either inorganic or organic sources. The green fodder yield under vermicompost was 13.29% and 17.05% higher than the highest yields recorded with biochar and FYM, respectively. This indicates that vermicompost is a more efficient organic nutrient source compared to FYM and biochar, likely because it provides nutrients more rapidly to the plants. Vermicompost demonstrated greater effectiveness and efficiency as an organic nutrient source, producing yields comparable to the RDF treatment. These findings are supported by the research of Gangaiah *et al*. (2021) [6], Nabi *et al*. (2021) [12], Satpal *et al*. (2020) [18], Singh *et al*. (2015b) [19], Duhan (2013) [5], and Jat *et al*. (2013) [8].

Table 2: Influence of various organic nutrient sources on green and dry fodder yield of sorghum crop

Treatment	GFY (q ha^{-1})	DFY (q ha^{-1})
T_1: Control	285.15	75.20
T_2: RDF (75:30:30) NPK kg ha^{-1}	521.30	137.80
T_3: FYM @ 5 t ha^{-1}	363.45	87.25
T_4: FYM @ 10 t ha^{-1}	410.60	108.50
T_5: FYM @ 15 t ha^{-1}	445.37	115.70
T_6: Vermicompost @ 2.5 t ha^{-1}	378.85	101.50
T_7: Vermicompost @ 5.0 t ha^{-1}	485.30	124.25
T_8: Vermicompost @ 7.5 t ha^{-1}	510.20	130.75
T_9: Biochar @ 2.5 t ha^{-1}	392.40	90.50
T_{10}: Biochar @ 5.0 t ha^{-1}	425.45	112.20
T_{11}: Biochar @ 7.5 t ha^{-1}	460.16	118.27
S.Em (±)	5.80	3.76
CD (P=0.05)	17.01	11.02

Conclusion

Based on one year of research, it can be concluded that the application of RDF (75:30:30 NPK kg ha^{-1}) resulted in significantly higher green and dry fodder yields compared to all other treatments, except vermicompost applied at 7.5 t ha^{-1}, with which it was statistically at par. Among the organic sources, vermicompost proved to be a more effective alternative than FYM and biochar, not only in terms of fodder yield but also in enhancing growth parameters such as plant height, number of leaves, leaf area index, and dry matter accumulation. Furthermore, vermicompost contributed to improved soil nutrient status, making it a superior organic nutrient source.

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