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Study on Different Sources of Organic Manures in Comparison with RDF on Growth and Yield of Sorghum [*Sorghum bicolor* (L.) Moench]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2022 at Karunya Institute of Technology and Sciences, Division of Agronomy, Coimbatore, to study the different sources of organic manures in comparison with RDF on growth and yield of sorghum (*Sorghum bicolor* (L.) Moench). The experiment was laid out in a randomized block design with eight treatments and replicated thrice. The treatment consisted of T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%.

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Therefore from this experiment the results concluded that application of RDF 100% (Inorganic) significantly recorded maximum plant height (228.76 cm), total dry matter production (13485 kg ha^{-1}), leaf area index (LAI) (5.80), chlorophyll content (SPAD) (37.89), grain yield (3770 kg ha^{-1}) and straw yield (6600 kg ha^{-1}) respectively.

Keywords: RDF; vermicompost; farmyard manure; growth; yield.

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench), commonly known as jowar, is a significant staple crop with global importance. It holds a prominent position among cereal crops, ranking after wheat, rice, maize, and barley. Sorghum plays a crucial role in providing food for millions of people residing in semiarid tropics. Its cultivation covers a vast land area of 5.97 million hectares, resulting in a total production of 5.01 million metric tons and an impressive productivity rate of 1013 kg ha^{-1} [1]. In India, the main states for sorghum cultivation are Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat, Tamilnadu, Rajasthan, and Uttar Pradesh. Sorghum is preferred over other forage crops due to its remarkable resilience and adaptability to different soil and climatic conditions. It offers various advantages, including rapid growth, significant biomass accumulation, high dry matter content, and a wide range of adaptability, including the ability to withstand drought conditions.

Sorghum has a higher nutrient demand compared to other fodder crops, among the essential elements, nitrogen is highly mobile and is required throughout the entire growth period of a crop. Maximizing the utilization of applied nitrogen can be achieved by supplying it at the specific timing when the crop is in need of it. However, the excessive and unregulated use of chemical fertilizers has negatively impacted soil health and resulted in declining productivity. To address this issue, integrated nutrient management (INM) presents a potential alternative. INM not only ensures high productivity but also helps prevent soil degradation. In India, farmyard manure (FYM) and vermicompost are two important organic sources of nutrients.The presence of nutrients that are accessible for plants to absorb is a critical factor that affects crop production. When these nutrients are available in a balanced manner according to the plant's requirements, it promotes optimal growth. Naturally, mature manure has been extensively employed in the cultivation of various crops. It is recognized as an organic substance that enhances the physical, chemical, and biological properties of the soil. Additionally, manure aids in the formation of humus, which enhances the water-holding capacity of the soil and facilitates nutrient absorption by plant roots, thereby supporting plant growth and development. By combining the use of chemical fertilizers and organic manures, long-term fodder production can be achieved. This approach not only improves the efficiency of applied fertilizers in correcting secondary and micro nutrient deficiencies but also enhances overall fertilizer efficiency. Therefore the present study was undertaken with the view to study the different organic manures in comparison with RDF on growth and yield of sorghum.

2. MATERIALS AND METHODS

In order to achieve the pre-set objectives of the present investigation, a field experiment was conducted during *rabi* season of 2022 at the south farm of Karunya Institute of Technology and Sciences, Division of Agronomy, Coimbatore. The experimental site is located in the western agro-climatic zone of Tamilnadu and geographically located at $10^{o} 56^{1}$ N latitude and $76^{o} 44^{1}$ E longitude at an elevation of 474 above mean sea level. The soil composition of the experimental site was identified as clay. The initial nutrient status of the soil was low in available nitrogen (113 kg ha^{-1}), high in available phosphorous (62 kg ha^{-1}), and medium in available potassium (251 kg ha^{-1}) and organic carbon content was (0.69 %). The experiment was laid out in randomized block design (RBD) with three replications. The experiment consist of eight treatments T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%. The data was subjected to statistical analysis of the variance method [2].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height

The data on plant height (cm) at 30 DAS, 60 DAS, 90 DAS and at harvest stage of sorghum are presented in (Table 1 and Fig. 1). The periodical height of the plant was significantly influenced by different treatments at different growth stages and at the harvest of sorghum.

The observed data showed that the highest plant height (30.5, 155.5, 218.12 and 228.76 cm during *rabi* 2022) was recorded in RDF 100% (inorganic) (T_2) than other treatments. This was closely followed by Vermicompost 100% on N equivalent basis (29.3, 150.25, 212.51 and 226.27) (T_3).Among the other organic treatments, Farmyard manure 50% + Vermicompost 50% (29.19, 140.10, 205.68 and 218.52) (T_5) recorded highest plant height followed by Farmyard manure 100% on N equivalent basis (28.65, 135.22, 199.35 and 210.47) (T_4) respectively.In rest of the organic and inorganic combination treatments, higher plant height was recorded in RDF 50% + Vermicompost 50% (29.22, 145.01, 209.12 and 221.89) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (29.10, 139.30, 203.86 and 215) (T_8), RDF 50% + Farmyard manure 50% (28.69, 137.70, 199.50 and 211.24) (T_6). The lowest plant height was registered under absolute control (28.51, 133.86 196.45 and 206.26) (T_1). These similar results were supported by Mishra et al. [3] and Dereje et al. [4]

3.1.2 Dry matter production

The data on dry matter production (DMP) at 30 DAS, 60 DAS, 90 DAS and at the harvest stage of sorghum are presented in (Table 2 and Fig. 2). The treatments imposed had a significant influence on DMP at different growth stages and at the harvest on sorghum.

The observed data showed that the highest DMP (2134, 7164, 12459 and 13485 kg ha $^{-1}$ during *rabi* 2022) was recorded in RDF 100 % (inorganic) (T_2) than other treatments,. This was closely followed by Vermicompost 100% on N equivalent basis (1811, 6659, 11505 and 12625) (T_3). Among the other organic treatments, Farmyard manure 50% + Vermicompost 50% (1459, 6331, 11287, 12248) (T_5) recorded higher DMP followed by Farmyard manure 100% on N equivalent basis (1345, 5760, 10579 and 11645) (T_4) respectively. In the rest of the organic and inorganic combination treatments, higher DMP was recorded in RDF 50% + Vermicompost 50% (1642, 6451, 11409 and 12332) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (1432, 6203, 10953 and 12150) (T_8), RDF 50% + Farmyard manure 50% (1409, 6145, 10812 and 11979) (T_6). The lowest DMP was registered under absolute control (1242, 5991, 10441 and 11365) (T_1).

The observed data revealed that the both plant height and dry matter accumulation were progressively increased until the crop reaches its maturity. This may be due application of 100% RDF, which makes the soil enriched with more nutrients and by providing the vital elements needed for various metabolic processes, ultimately leading to plant development. Thus results in higher dry matter accumulation and plant height as inorganic fertilizer is readily available for crop growth. These similar results were supported by the findings of Sudhanshu [5] and Sujathamma et al. [6].

3.2 Physiological Parameters

3.2.1 Leaf area index

The data on leaf area index (LAI) at 30 DAS, 60 DAS, 90 DAS and at the harvest stage of sorghum are presented in (Table 3 and Fig. 3). The treatments imposed had a significant influence on leaf area index at different growth and at the harvest of sorghum.

The observed data showed that the highest leaf area index (LAI) (1.81, 4.73, 6.66 and 5.80 during *rabi* 2022) was recorded in RDF 100% (inorganic) (T_2) than other treatments. This was closely followed by Vermicompost 100% on N equivalent basis (1.75, 4.51, 5.65 and 5.72) (T_3).Among the other organic treatments, Farmyard manure 50% + Vermicompost 50% (1.64, 4.46, 5.36 and 5.43) (T_5) recorded higher leaf area index (LAI) followed by Farmyard manure 100% on N equivalent basis (1.31, 4.26, 4.76 and 4.98) (T_4) respectively.In the organic and inorganic combination treatments, higher leaf area index (LAI) was recorded in RDF 50% + Vermicompost 50% (1.67, 4.49, 5.45 and 5.62) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (1.61, 4.40, 5.22 and 5.37) (T_8), RDF 50% + Farmyard manure 50% (1.42, 4.36, 4.98 and 5.10) (T_6).

The lowest leaf area index (LAI) was registered under absolute control (1.28, 4.09, 4.90 and 4.93) (T_1).

The data on interactions revealed that the application of 100% RDF recorded higher LAI than any other treatments. Therefore increasing the rate of fertilizer application eventually raises the rate of LAI. It determines the crop's capacity for photosynthetic activity and Light interception and the power of the source/sink increase with a higher leaf area index. Therefore, a higher LAI correlates with increased photosynthetic activity, growth, and agricultural output. These similar results were supported by the findings of Elamin A. et al. [7].

3.2.2 Chlorophyll content

Chlorophyll content of plant is an important parameter which directly affects the rate of photosynthesis and the treatments imposed had a significant influence on chlorophyll content at different growth stages and at the harvest of sorghum. The data on chlorophyll content at 30 DAS, 60DAS, 90DAS and at the harvest stage of sorghum are presented in (Table 4 and Fig. 4).

The observed data showed that the higher chlorophyll content (36.72, 60.16, 53.78 and 37.89) was recorded in RDF 100% (inorganic) (T_2) than other treatments. This was closely followed by Vermicompost 100% on N equivalent basis (34.49, 58.53,52.86 and 36.63) (T_3).Among the other organic treatment, Farmyard manure 50% + Vermicompost 50% (33.34, 54.38, 50.56 and 34.12) (T_5) recorded higher chlorophyll content followed by Farmyard manure 100% on N equivalent basis (30.30, 50.89, 47.83 and 31.53) (T_4) respectively. In rest of the organic and inorganic combination treatment, higher chlorophyll content was recorded in RDF 50% + Vermicompost 50% (33.87, 55.75, 51.53 and 34.54) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (32.81, 53.42, 50.28 and 33.75) (T_8), RDF 50% + Farmyard manure 50% (31.40, 52.12, 49.37 and 32.62) (T_6). Whereas the lowest chlorophyll content was registered under absolute control (29.26, 49.37, 46.37 and 30.87) (T_1).

3.3 Yield Parameters

3.3.1 Grain Yield

The data on grain yield of sorghum are presented in (Table 5 and Fig. 5). The treatments imposed had a significant influence on grain yield of sorghum.

The observed data showed that the highest grain yield (3770 kg ha^{-1} during *rabi* 2022) was recorded in RDF 100% (inorganic) (T_2) than other treatments. This was closely followed by Vermicompost 100% on N equivalent basis (3750 kg ha^{-1}) (T_3).Among the organic treatments, Farmyard manure 50% + Vermicompost 50% (3710 kg ha^{-1}) (T_5) recorded higher grain yield followed by Farmyard manure 100% on N equivalent basis (3398 kg ha^{-1}) (T_4) respectively. In rest of the organic and inorganic combination treatments, higher grain yield was recorded in RDF 50% + Vermicompost 50% (3747 kg ha^{-1}) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (3610 kg ha^{-1}) (T_8) and RDF 50% + Farmyard manure 50% (3550 kg ha^{-1}) (T_6). The lowest grain yield was registered under absolute control (3230 kg ha^{-1}) (T_1). As fertilizer levels rise, such advancements occurs. These similar results were supported by Sami et al. [8] and Sujathamma et al. [6].

3.3.2 Straw yield

The data on straw yield of sorghum are presented in (Table 5 and Fig. 6). The treatments imposed had a significant influence on straw yield of sorghum.

The observed data showed that the highest straw yield (6600 kg ha^{-1} during *rabi* 2022) was recorded in RDF 100% (inorganic) (T_2) than other treatments. This was closely followed by Vermicompost 100% on N equivalent basis (6598 kg ha^{-1}) (T_3).Among the organic treatments, Farmyard manure 50% + Vermicom post 50% (6550 kg ha^{-1}) (T_5) recorded higher straw yield followed by Farmyard manure 100% on N equivalent basis (6394 kg ha^{-1}) (T_4) respectively. In rest of the organic and inorganic combination treatments, higher straw yield was recorded in RDF 50% + Vermicompost 50% (6572 kg ha^{-1}) (T_7) which was followed by RDF 50% + Farmyard manure 25% + Vermicompost 25% (6490 kg ha^{-1}) (T_8) and RDF 50% + Farmyard manure 50% (6432 kg ha^{-1}) (T_6). The lowest straw yield was registered under absolute control (6234 kg ha^{-1}) (T_1). The increase in straw yield could also be attributed to its beneficial effects on the crop's vegetative and reproductive phases. The accumulation of dry matter and subsequent improvement in stover yield may have also been caused by an increase in photosynthetic rate. These similar results were reported by Dhingra et al. [9] and Jat MK. et al. [10].

Table 1. Influence of organic manures in comparison with RDF on plant height of sorghum

Treatments	Plant height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
T_1	28.51	133.86	196.45	206.26
T_2	30.50	155.50	218.12	228.76
T_3	29.30	150.25	212.51	226.27
T_4	28.65	135.22	199.35	210.47
T_5	29.19	140.10	205.68	218.52
T_6	28.69	137.70	199.50	211.24
T_7	29.22	145.01	209.12	221.89
T_8	29.10	139.30	203.86	215
SE(d)	2.404106	11.74193	16.91647	17.8391
CD (0.05%)	5.022393	24.52995	35.34004	37.26749

T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%.

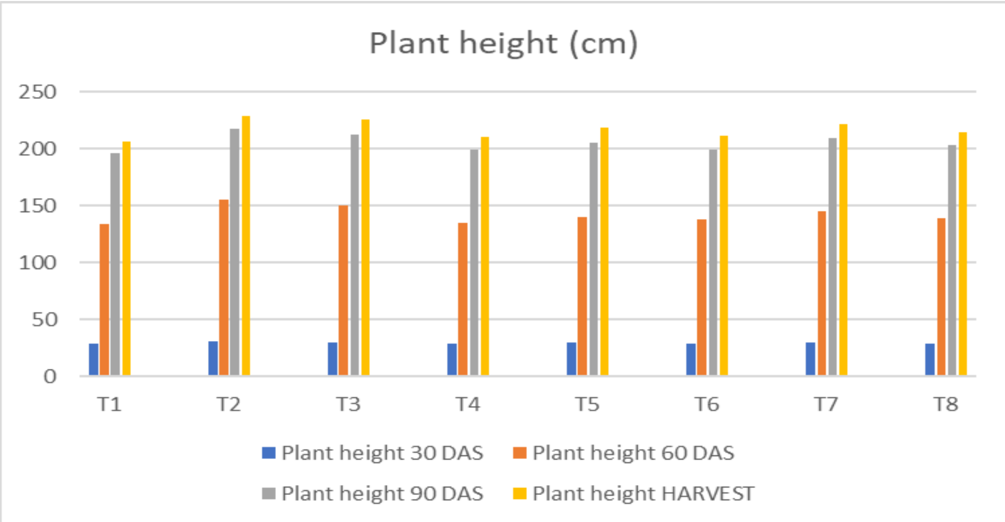

Fig. 1. Influence of organic manures in comparison with RDF on plant height of sorghum

Table 2. Influence of organic manures in comparison with RDF on dry matter production of sorghum

Treatments	Dry matter production (kg ha^{-1})			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
T_1	1242	5991	10441	11365
T_2	2134	7164	12459	13485
T_3	1811	6659	11505	12625
T_4	1345	5790	10579	11645
T_5	1459	6331	11287	12248
T_6	1409	6145	10812	11979
T_7	1642	6451	11409	12332
T_8	1432	6203	10953	12150
SE(d)	146.6207	526.0488	926.1824	1012.409
CD (0.05%)	306.3038	1098.963	1934.878	2115.014

T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%

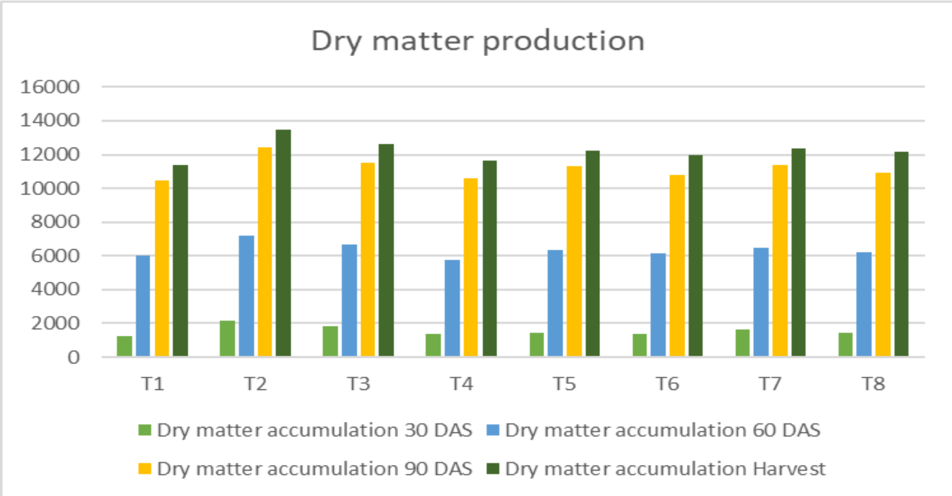

Fig. 2. Influence of organic manures in comparison with RDF on dry matter production of sorghum

Table 3. Influence of organic manures in comparison with RDF on leaf area index of sorghum

Treatments	Leaf area index (LAI)			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
T_1	1.28	4.09	4.90	4.93
T_2	1.81	4.73	5.66	5.80
T_3	1.75	4.51	5.65	5.72
T_4	1.31	4.26	4.76	4.98
T_5	1.64	4.46	5.36	5.43
T_6	1.42	4.36	4.98	5.10
T_7	1.64	4.49	5.45	5.62
T_8	1.61	4.40	5.22	5.37
SE(d)	0.133732	0.358715	0.437399	0.435402
CD (0.05%)	0.279378	0.749387	0.913765	0.909594

T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%

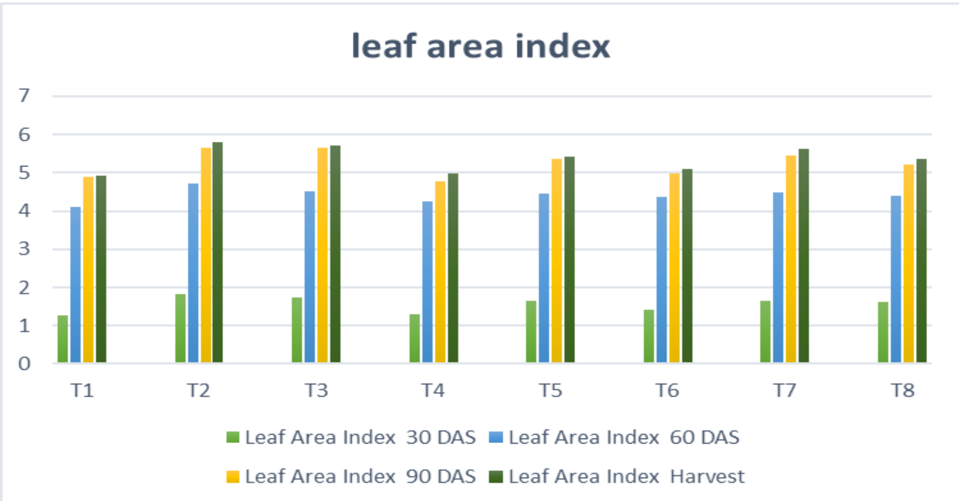

Fig. 3. Influence of organic manures in comparison with RDF on leaf area index of sorghum

Table 4. Influence of organic manures in comparison with RDF on chlorophyll content of sorghum

Treatments	Chlorophyll content (SPAD)			
	30 DAS	60 DAS	90 DAS	Harvest
T_1	29.26	49.37	46.37	30.87
T_2	36.72	60.16	53.78	37.89
T_3	34.49	58.43	52.86	36.63
T_4	30.30	50.89	47.83	31.53
T_5	33.34	54.38	50.56	34.12
T_6	31.40	52.12	49.37	32.62
T_7	33.87	55.75	51.53	34.54
T_8	32.81	53.42	50.28	33.75
SE(d)	2.686878	3.8443369	4.102671	2.849071
CD (0.05%)	5.61313	8.029143	8.570849	5.951965

T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%

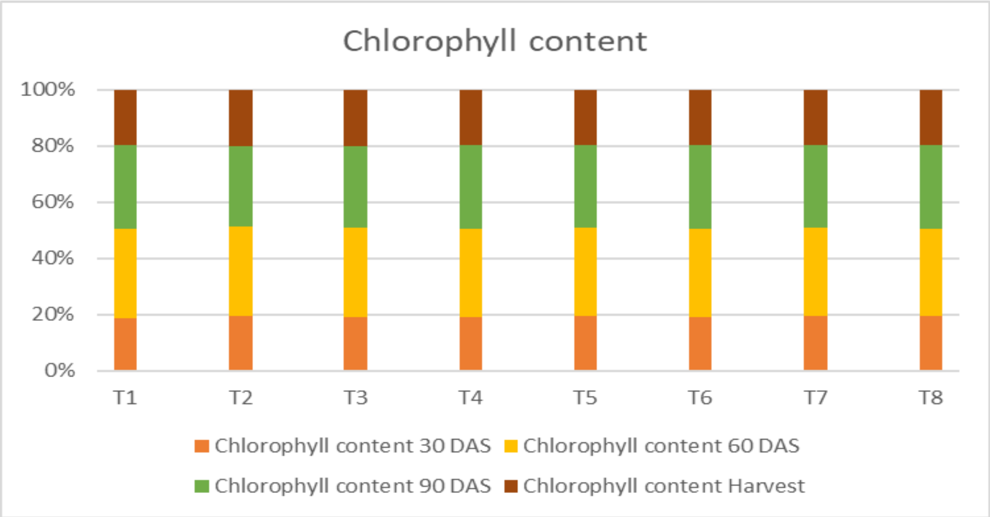

Fig. 4. Influence of organic manures in comparison with RDF on chlorophyll content of sorghum

Table 5. Influence of organic manures in comparison with RDF on grain yield and straw yield of sorghum

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	3230	6234
T_2	3770	6600
T_3	3750	6598
T_4	3398	6394
T_5	3710	6550
T_6	3550	6432
T_7	3743	6572
T_8	3610	6490
SE (d)	294.1638	524.9031
CD (0.05 %)	614.5347	1096.57

T_1 - Absolute control, T_2 - RDF 100% (Inorganic), T_3 - Vermicompost 100% on N equivalent basis, T_4 - Farmyard manure 100% on N equivalent basis, T_5 - Farmyard manure 50% + Vermicompost 50%, T_6 - RDF 50% + Farmyard manure 50%, T_7 - RDF 50% + Vermicompost 50%, T_8 - RDF 50% + Farmyard manure 25% + Vermicompost 25%.

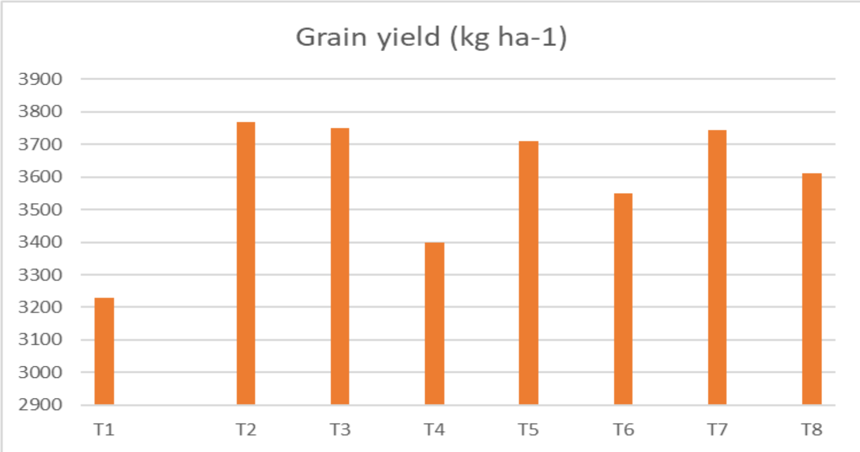

Fig. 5. Influence of organic manures in comparison with RDF on grain yield of sorghum

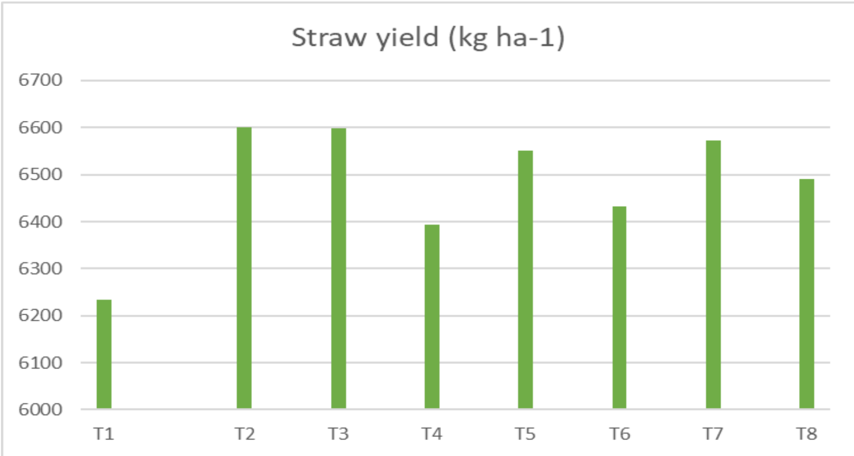

Fig. 6. Influence of organic manures in comparison with RDF on straw yield of sorghum

4. CONCLUSION

Based on the research findings, it was concluded that among the various treatments application of RDF through inorganic fertilizer significantly boosted the grain yield and straw yield of sorghum. Among organic treatments application of vermicompost on N equivalent basis significantly increased the growth and yield parameters. Therefore, the application of RDF with vermicompost and farmyard manure resulted in an improvement in the growth and yield of sorghum by improving the soil fertility status over the rest of the treatments.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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