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IMPROVING GROWTH AND YIELD OF *KHARIF* SORGHUM (*Sorghum bicolor* L. Moench) WITH NANO NITROGEN FERTILISATION AND MOISTURE CONSERVATION PRACTICES

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ABSTRACT

A field experiment was conducted during the kharif seasons of 2024 and 2025 at the Soil Conservation and Water Management Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India, to evaluate the effect of nano nitrogen fertilization and moisture conservation practices on the growth and yield of sorghum (*Sorghum bicolor* L. Moench). The experiment was laid out in a split-plot design with three replications, comprising six fertility levels in the main plots and four moisture conservation practices in the subplots. Growth, biomass accumulation, and yield parameters were recorded at different crop growth stages. Application of 75% recommended dose of nitrogen (RDN) with 2 foliar sprays of 0.4% Nano N fertilizer (F_3) significantly improved crop performance over the control and other treatments. It recorded the highest plant height (159.76 and 162.01 cm at 60 DAS; 210.08 and 213.91 cm at maturity stage), grain yield (27.27 and 30.93 q ha^{-1}), stover yield (46.29 and 51.09 q ha^{-1}) and biological yield (73.56 and 82.02 q ha^{-1}) during 2024 and 2025, respectively. Among moisture conservation practices, Hydrogel @ 5.0 kg ha^{-1} combined with organic residue mulch @ 5 t ha^{-1} (M_3) produced superior results with grain yields of 27.39 and 30.45 q ha^{-1}, stover yields of 48.03 and 51.96 q ha^{-1}, and biological yields of 75.43 and 82.41 q ha^{-1} during the respective years. The study demonstrates that integrating 75% RDN with 2 foliar sprays of 0.4% Nano N fertilizer and Hydrogel @ 5.0 kg ha^{-1}plus organic residue mulch @ 5 t ha^{-1} enhances nitrogen use efficiency, conserves soil moisture, and significantly improves sorghum growth and yield under rainfed conditions, providing a sustainable nutrient and moisture management strategy for moisture-limited agro-ecosystems.

***Keywords* :** Sorghum, Nano N fertilizers, Hydrogel, Organic Residue Mulch, Yield and Yield attributes.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is the important crop in the country after rice, wheat maize and Pearl millets. Sorghum is not only staple food but it is also required to fulfil fodder requirement in order to make animal husbandry sector more viable. There is an urgent need to maintain well balanced and regular supply of more nutritious feed and fodder to animals in the state.

Sorghum, most popularly known in India as "Jowar" is often cross-pollinated crop and belongs to the family *Poaceae*. It is an important food, feed, fodder and ration for human, cattle and poultry. Its grain contains about 10-12 % protein, 3% fat and 70 % carbohydrate. Sorghum is the important crop in the country after rice, wheat maize and Pearl millets. Sorghum is not only staple food but it is also required to fulfil fodder requirement in order to make animal husbandry sector more viable. There is an urgent need to maintain well balanced and regular supply of more nutritious feed and fodder to animals in the state.

It is an important food, feed, fodder and ration for human, cattle and poultry. Its grain contains about 10-

12 % protein, 3% fat and 70 % carbohydrate. According to the USDA Production, Supply and Distribution Database, India's sorghum production during 2024–25 was estimated at about 6.0 million tonnes from nearly 4.0 million hectares with an average productivity of around 1.25 t ha^{-1}. State-wise sorghum statistics indicated that Maharashtra accounted for about 1.546 million hectares area with 1.690 million tonnes production, followed by Karnataka with 0.648 million hectares area and 0.815 million tonnes production. Gangaiah and Tara Satyavthi (2024). Rajasthan occupied nearly 0.642 million hectares with production of about 0.520 million tonnes. Uttar Pradesh recorded comparatively higher productivity of approximately 1622 kg ha^{-1}, whereas Andhra Pradesh reported the highest productivity of about 3459 kg ha^{-1} under irrigated conditions (Source: fas.usda.gov). India ranks fourth in total Sorghum production with 4.4 million tonnes grown in an area of 3.97 million hectares in 2023-24, where majority of Sorghum was produced during rabi season (source: *fas.usda.gov*). The *kharif* Sorghum (36.6%) was grown predominantly in Rajasthan (43.3%), Uttar Pradesh (15.6%), Haryana (10.1%) and Madhya Pradesh (9.8%), while rabi Sorghum (63.4%) grown in Maharashtra (63.5%), Karnataka (22%), Tamil Nadu (7.9%) and Andhra Pradesh (3.2%).Though the area under sorghum has declined from 18.6 Mha in 1969-70 to 3.995 Mha in 2024-25, its productivity has more than doubled (from 554 kg/ha to 1240 kg/ha) during the same period (Source: UPAG: Unified Portal for Agricultural Statistics, Ministry of Agriculture and Farmers Welfare), Government of India.

The reason for low productivity of this crop in agro-climatic zone IV a (Sub- Humid Southern Plain and Aravalli hills) seems to be non-adoption of proper agro techniques viz., using poor & old genotypes, inadequate use of fertilizer and inadequate plant population and plant protection measures. However, the production can be increased by adopting improved package including suitable genotype, optimum plant geometry and appropriate fertilization. Considering these facts, research efforts have been made to achieve substantial increase in sorghum productivity through evolving better genotypes development and dissemination of appropriate production technologies. But still a wide gap exists between realizable yield and yield obtained at the farmers' end.

Amongst growth factors, adequate supply of chemical fertilizer, especially N and P, is considered to be of prime importance due to its profound impact on various aspects of growth and development, hence productivity of crop depends on the balanced use of fertilizer and plays a key role in modernization of Indian agriculture and in making the country self-sufficient in food grain production. It is estimated that almost 40 per cent of the total food grain output can be directly attributed to fertilizer use. Combined application of conventional and nano fertilizers helped to increase growth, growth attributes like number of leaves, leaf area, leaf area index, yield attributes, nutrient content, nutrient uptake and nutrient use efficiency of sorghum. Nutrient content and uptake also showed higher values for the same treatment along with the nutrient use efficiency indices. Krishnamurthy *et al.* (2023).

Since, the yield potential of a crop depends on its inherent capabilities along with extent to which it is being exploited through appropriate agro-techniques. Thus, there is a need to work out optimum combination of different growth factors so as to exploit the potential of these hybrid varieties under prevailing agro climatic conditions.

Therefore, keeping this fact in view, this study was undertaken an experiment entitled: "Improving Growth and Yield of *Kharif* Sorghum (*Sorghum bicolor* L. Moench) with Nano nitrogen Fertilisation and Moisture Conservation Practices." conducted at Soil Conservation and Water Management Farm of Chandra Shekhar Azad of Agriculture and Technology, Kanpur for experimental period of two consecutive *Kharif* season 2024 and 2025 with the following.

Materials and Methods

Experimental Site and Soil Characteristics

The field experiment was conducted during the *kharif* season of 2023-2024 and 2024-2025. The investigation was completed at the Soil Conservation & Water Management Farm of the Chandra Shekhar Azad University of Agriculture & Technology located in Kanpur district is situated in the sub-tropical region of Uttar Pradesh in part of Gangetic alluvium, lying between the river Ganga and Yamuna. It covers 115 km from North to South and 105 km from East to West. It lies between 25^0 26' and 26^0 58' North latitude and 79^0 31' and 80^0 34' East longitude. The elevation of the farm of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur is approximately 125.9 meters above Mean Sea Level. The average rainfall of the district is about 836 mm. The major portion of rainfall is received during the south west monsoon from the first week of July to the last week of November.

Experimental Design and Treatments

The experiment will be conducted using a Split Plot Design with 3 replications. While the full study has factors like fertility levels and moisture conservation practice this research conducted during *kharif* season 2024-2025. A total six fertility levels (Main plot) treatments were considered: F_1- Control, F_2-100 % RDN through urea, F_3-75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer, F_4-75 % RDN + 2 foliar spray of 2 % urea fertilizer**,** F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer, F_6-50 % RDN + 2 foliar spray of 2 % urea fertilizer. Four moisture conservation practices (Sub plot) treatments viz**.** M_1-Control, M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5 t/ha, M_3-Hydrogel @ 5.0 kg/ha + organic residue mulch 5 t/h and M_4- Kaolin @ 0.5 % at 45 DAS spray.

The recommended dose of N, P and K for sorghum was 120:50:40 kg/ha. Application of seventy-five percentage through recommended dose of nitrogen, twenty five percent as application through nano N fertilizers and along with urea spray. The total phosphorus and potassic fertilizers as per recommended dose of fertilizers, was applied as a basal application, while the rest of the nitrogenous doses were applied in equal proportions during the vegetative and head initiation stages.

Result and Discussion

Plant Height

At 30 DAS plant height was obtained under F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with 61.83 cm in 2024 and 62.55 cm in 2025, whereas the lowest plant height at 30 DAS was observed under F_1 control 56.80 cm in 2024 and 57.85 cm in 2025. However, the differences among fertility levels at 30 DAS plant height were non-significant.

Plant height 60 DAS and at maturity stage was significantly recorded influenced through fertility levels during both years (Table 2). At 60 DAS, the highest plant height was observed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with 159.76 cm and 162.01 cm during 2024 and 2025, respectively, while the minimum plant height was recorded under F_1- Control with 145.48 cm and 148.25 cm, respectively. At maturity stage, the highest plant height was recorded under F_3 with 210.08 cm and 213.91 cm, while the lowest was noticed under F_1 with 195.56 cm and 200.71 cm during 2024 and 2025, respectively Jadav *et al.* (2025), Mehta and Bharat (2019).

At 30 DAS highest plant height was obtained under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 59.84 cm in 2024 and 60.38 cm in 2025, whereas the lowest plant height at 30 DAS was observed under M_1 control 57.33 cm in 2024 and 58.19 cm in 2025. However, the differences among moisture conservation practices at 30 DAS plant height were result not significant. The plant height was significantly recorded by dissimilar moisture conservation practices during both years (Table 3). At 60 DAS, the maximum plant height was noted under treatment M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 153.87 cm in 2024 and 156.62 in 2025, whereas M_1-Control recorded the lowest values of 146.70 cm in 2024 and 148.83 cm in 2025, respectively. At maturity time, the maximum plant height was noted under treatment M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 206.08 cm in 2024 and 212.37 in 2025, whereas M_1-Control recorded the lowest plant height values noticed of 197.38 cm in 2024 and 203.63 cm in 2025, respectively. Soni *et al.* (2025), Srivastava *et al.* (2023).

Number of Leaves/ Plant

Number of leaves/plant 30 DAS was not significantly recorded influenced by fertility levels during both years (Table 3). At 30 DAS, the highest number of leaves/plants was observed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with 6.72 and 7.39 during 2024 and 2025, respectively, while the minimum number of leaves/plants was recorded under F_1- Control with 6.01 and 6.24, respectively.

Number of leaves/plant 60 DAS and at maturity stage was significantly recorded influenced by fertility levels during both years (Table 3). At 60 DAS, the highest number of leaves/plants was observed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with 15.18 and 16.21 during 2024 and 2025, respectively, while the minimum number of leaves/plants was recorded under F_1- Control with 9.94 and 10.88, respectively. At maturity stage, the highest number of leaves/plants was recorded under F_3 with 12.47 and 13.76, while the lowest was noticed under F_1 with 7.39 and 8.07 during 2024 and 2025, respectively Udapudi *et al.* (2024)

Number of leaves/plant 30 DAS was not significantly recorded influenced by moisture conservation practices during both years (Table 3). At 30 DAS, the highest number of leaves/plants was observed under treatment M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 6.51 and 7.10

during 2024 and 2025, respectively, while the minimum number of leaves/plants was recorded under M_1-Control with 6.01 and 6.44, respectively. The number of leaves/plants was significantly recorded by dissimilar moisture conservation practices during both years (Table 3). At 60 DAS, the maximum number of leaves/plants was noted under treatment M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 13.95 in 2024 and 14.58 in 2025, whereas M_1-Control recorded the lowest values of 10.04 in 2024 and 11.56 in 2025, respectively. At maturity stage, the maximum number of leaves/plants was noted under treatment M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with 11.22 in 2024 and 11.44 in 2025, whereas M_1-Control recorded the lowest number of leaves/plant values noticed of 8.62 in 2024 and 9.87 in 2025, respectively Sree *et al.* (2024).

Fresh weight/plant (gram)

At 30 DAS, the maximum fresh weight/plant was noticed under F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with (57.30 gram) in 2024 and (58.34 gram) in 2025, whereas the lowest fresh weight/plant was observed under treatment F_1- control (50.70 gram) in 2024 and (51.73 gram) in 2025. However, the differences among fertility levels at the 30 DAS were non-significant. Fresh weight/plant 60 DAS and at maturity stage was significantly recorded influenced by fertility levels during both years (Table 3). At 60 DAS, the highest number of leaves/plants was observed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with (321.07 and 325.41gram) during 2024 and 2025, respectively, while the minimum fresh/plants was recorded under F_1- Control with (285.72 and 288.43), respectively. At maturity stage, the highest fresh weight/plant was recorded under F_3 with (822.34 and 827.84 gram), while the lowest was noticed under F_1 with 792.87 and 796.85 during 2024 and 2025, respectively Anil *et al.* (2023).

At 30 DAS, the maximum fresh weight/plant was noticed under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with (58.42 gram) in 2024 and (59.49 gram) in 2025, whereas the lowest fresh weight/plant was observed under treatment M_1-Control (51.02 gram) in 2024 and (52.05 gram) in 2025. However, the differences among moisture conservation practices at the 30 DAS were non-significant. At 60 DAS, the maximum fresh weight/plant was noticed under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with (321.30 gram) in 2024 and (324.83 gram) in 2025, whereas the lowest fresh weight/plant was observed under treatment M_1-Control (283.72 gram) in 2024 and (285.08 gram) in 2025. However, the differences among moisture conservation practices at 60 DAS were significant. At maturity stage, the highest fresh weight/plants were recorded under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with (819.53 gram) and (825.86 gram) during 2024 and 2025, while the lowest was noticed under M_1-Control with (790.25 gram) and (792.90 gram) during 2024 and 2025, respectively. However, the differences among moisture conservation practices at maturity stage were significantly Ekinci *et al.* (2014).

Dry weight/plant (gram)

At 30 DAS, the maximum dry weight/plant was noticed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with (9.87 gram) in 2024 and (11.04 gram) in 2025, whereas the lowest dry weight/plant was observed under treatment F_1- control (8.89 gram) in 2024 and (9.25 gram) in 2025. However, the differences among fertility levels at 30 DAS were non-significant. At 30 DAS, the maximum dry weight/plant was noticed under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with (9.65 gram) in 2024 and (10.50 gram) in 2025, whereas the lowest dry weight/plant was observed under treatment M_1-Control (8.97 gram) in 2024 and (9.75 gram) in 2025. However, the differences among moisture conservation practices at 30 DAS were non-significant

Dry weight/plant 60 DAS and at maturity stage was significantly recorded by different fertility levels during both years (Table 3). At 60 DAS, the highest dry weight/plant was observed under treatment F_3-75% RDN + 2 foliar sprays of 0.4% Nano N fertilizer with (57.39 and 58.97 gram) during 2024 and 2025, respectively, while the minimum dry weight/plant were recorded under F_1- Control with (51.58 and 53.05 gram) during both years respectively. At maturity stage, the highest dry weight /plant was recorded under F_3 with (316.27 and 321.38 gram), while the lowest was noticed under F_1 with (283.66 and 289.13 gram) during 2024 and 2025, respectively Kundu and Chhabra (2023), Abera *et al.* (2020).

Dry weight/plant 60 DAS and at harvest stage was significantly recorded under different moisture conservation practices during both years (Table 3). The maximum dry weight/plant noticed under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with (57.04 gram) in 2024 and (58.60 gram) in 2025, whereas the lowest dry weight/plant was observed under treatment M_1-Control (51.85 gram) in 2024 and (53.42 gram) in 2025. At maturity stage, the highest dry weight/plants were recorded under M_3-Hydrogel @ 5.0 kg ha^{-1} + organic residue mulch @ 5 t ha^{-1} with

(314.28 gram) and (319.42 gram) during 2024 and 2025, while the lowest dry weight was noticed under M_1-Control with (285.70 gram) and (291.14 gram) during 2024 and 2025, respectively**.** Ravi et al. (2023), Choudhary *et al.* (2023)

Yield

The grain, stover and biological yield (qha^{-1}) of sorghum were noted significantly influenced by fertility levels during both years (Table 5). Among fertility levels, F_3 -75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer produced the highest grain yield (27.27 and 30.93 qha^{-1}), stover yield (46.69 and 51.09 and qha^{-1}) and biological yield (73.56 and 82.02 qha^{-1}) during 2024 and 2025, respectively. The lowest grain yield (13.51 and 14.56 qha^{-1}), stover yield (27.33 and 29.68 qha^{-1}) and biological yield were recorded under F_1- Control (40.85, 44.25 qha^{-1}) during 2024 and 2025, respectively Sahu *et al.* (2022), Gangwar *et al.* (2022), Vivek *et al.* (2020).

The highest grain, stover and biological yield (qha^{-1}) of sorghum were recorded Superior influenced by different moisture conservation practices under the treatments M_3 -Hydrogel @ 5.0 kg/ha + organic residue mulch 5t/ha with (27.39 and 30.45 qha^{-1}) during 2024 and 2025, respectively, whereas the lowest grain, stover, and biological yield recorded under M_1-Control with (15.71 and 16.74 qha^{-1}). Similarly, the highest stover yield was obtained under M_3 with (48.03 and 51.96 qha^{-1}) while the lowest was recorded under M_1 with (28.96 and 32.75 qha^{-1}) during 2024 and 2025, respectively. The highest biological yield was obtained under M_3 with (75.43 and 82.41 qha^{-1}) while the lowest biological yield was recorded under M_1 with (44.13 and 49.50 qha^{-1}) during 2024 and 2025, respectively Khan *et al.* (2022), Arya *et al.* (2022).

Table 1: Effect of fertility levels and moisture conservation practices on plant height (30, 60 DAS and at maturity stage) of sorghum.

Treatments	Plant height (cm)					
	At 30 DAS		At 60 DAS		At maturity stage	
	2024	2025	2024	2025	2024	2025
(A) Fertility levels: -6 (Main plot)						
F_1- Control	56.80	57.85	145.48	148.25	195.56	200.71
F_2- 100 % RDN through urea	58.02	58.92	147.98	149.98	199.61	206.61
F_3- 75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	61.83	62.55	159.76	162.01	210.08	213.91
F_4- 75 % RDN + 2 foliar spray of 2 % urea fertilizer	60.72	61.63	155.72	158.55	208.90	213.18
F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	59.67	60.00	152.53	154.88	206.73	211.73
F_6- 50 % RDN + 2 foliar spray of 2 % urea fertilizer	58.03	59.17	149.59	151.91	203.70	209.06
SE (d)	1.07	1.08	2.73	2.78	3.71	3.81
CD at 5%	NS	NS	6.16	6.28	8.38	8.60
(B) Moisture Conservations:-4 (Subplot)						
M_1- Control	57.33	58.19	146.70	148.83	197.38	203.63
M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5t/ha	59.84	60.38	153.54	155.97	206.08	210.55
M_3- Hydrogel @ 5.0 kg/ha + organic residue mulch 5t/ha	59.90	60.81	153.87	156.62	206.95	212.37
M_4- Kaolin @ 0.5 % at 45 DAS spray	59.63	60.69	153.26	155.62	205.98	210.26
SE(d)	0.79	0.81	2.03	2.06	2.70	2.76
CD at 5%	NS	NS	4.13	4.19	5.50	5.63

Table 2: Effect of fertility levels and moisture conservation practices on No. of leaves/plant at 60 DAS and at maturity stage of sorghum.

Treatments			No. of leaves/plant			
	At 30 DAS		At 60 DAS		At maturity stage	
	2024	2025	2024	2025	2024	2025
(A) Fertility levels: -6 (Main plot)						
F_1- Control	6.01	6.24	9.94	10.88	7.39	8.07
F_2- 100 % RDN through urea	6.10	6.66	10.63	13.14	9.39	10.39
F_3- 75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	6.72	7.39	15.18	16.21	12.47	13.76
F_4- 75 % RDN + 2 foliar spray of 2 % urea fertilizer	6.49	7.26	13.77	15.09	11.64	11.79
F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	6.32	6.96	12.24	13.64	11.22	11.24
F_6- 50 % RDN + 2 foliar spray of 2 % urea fertilizer	6.20	6.86	11.46	11.83	10.14	10.36
SE (d)	0.29	0.38	0.82	0.55	0.74	0.49
CD at 5%	NS	NS	1.85	1.26	1.68	1.11

(B) Moisture Conservations:-4 (Subplot)						
M_1- Control	6.05	6.44	10.04	11.56	8.62	9.87
M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5t/ha	6.40	7.05	12.95	13.91	10.91	11.21
M_3- Hydrogel @ 5.0 kg/ha + organic residue mulch 5t/ha	6.51	7.10	13.45	14.58	11.22	11.44
M_4- Kaolin @ 0.5 % at 45 DAS spray	6.28	6.98	12.41	13.80	10.74	11.22
SE(d)	0.22	0.28	0.61	0.54	0.55	0.32
CD at 5%	**NS**	**NS**	1.24	1.10	1.11	0.65

Table 3: Effect of fertility levels and moisture conservation practices on fresh weight /plant (gram) of sorghum.

Treatments	**Fresh weight/plant (gram)**					
	At 30 DAS		**At 60 DAS**		**At maturity stage**	
	2024	**2025**	**2024**	**2025**	**2024**	**2025**
(A) Fertility levels: -6 (Main plot)						
F_1- Control	50.70	51.73	285.72	288.43	792.87	796.85
F_2- 100 % RDN through urea	54.92	55.96	295.86	297.94	801.42	805.22
F_3- 75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	57.30	58.34	321.07	325.41	822.34	827.84
F_4- 75 % RDN + 2 foliar spray of 2 % urea fertilizer	56.35	57.38	317.79	321.54	820.49	824.27
F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	55.93	56.97	299.50	303.53	806.08	809.58
F_6- 50 % RDN + 2 foliar spray of 2 % urea fertilizer	54.95	56.16	297.29	299.85	800.41	805.76
SE (d)	4.19	4.35	10.49	10.96	13.71	14.66
CD at 5%	NS	NS	23.68	24.75	27.83	29.75
(B) Moisture Conservations:-4 (Subplot)						
M_1- Control	51.02	52.05	283.72	285.08	790.25	792.90
M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5t/ha	55.45	56.49	303.52	307.53	810.99	815.57
M_3- Hydrogel @ 5.0 kg/ha + organic residue mulch 5t/ha	58.42	59.46	321.30	324.83	819.53	825.86
M_4- Kaolin @ 0.5 % at 45 DAS spray	55.21	56.36	302.96	307.03	808.30	812.00
SE(d)	3.21	3.35	7.54	7.94	12.53	10.81
CD at 5%	NS	NS	15.36	16.17	25.56	22.01

Table 4: Effect of fertility levels and moisture conservation practices on Dry weight /plant (gram) of sorghum.

Treatments	**Dry weight/plant (gram)**					
	At 30 DAS		**At 60 DAS**		**At maturity stage**	
	2024	**2025**	**2024**	**2025**	**2024**	**2025**
(A) Fertility levels: -6 (Main plot)						
F_1- Control	8.89	9.25	51.48	53.05	283.66	289.13
F_2- 100 % RDN through urea	9.20	10.01	52.21	53.78	287.71	293.14
F_3- 75 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	9.87	11.04	57.39	58.97	316.27	321.38
F_4- 75 % RDN + 2 foliar spray of 2 % urea fertilizer	9.72	10.63	56.26	57.83	310.00	315.18
F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	9.53	10.43	54.88	56.46	302.44	307.70
F_6- 50 % RDN + 2 foliar spray of 2 % urea fertilizer	9.44	10.27	53.79	55.36	296.42	301.75
SE(d)±	0.72	0.65	0.98	1.01	5.44	5.53
CD at 5%	NS	NS	2.22	2.28	12.27	12.49
(B) Moisture Conservations:-4 (Subplot)						
M_1- Control	8.97	9.75	51.85	53.42	285.70	291.14
M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5t/ha	9.64	10.43	54.27	55.84	299.05	304.35
M_3- Hydrogel @ 5.0 kg/ha + organic residue mulch 5t/ha	9.65	10.50	57.04	58.60	314.28	319.42
M_4- Kaolin @ 0.5 % at 45 DAS spray	9.50	10.40	54.19	55.76	298.64	303.94
SE(d)±	0.55	0.49	0.72	0.74	3.99	4.06
CD at 5%	NS	NS	1.47	1.51	8.12	8.27

Table 5: Effect of fertility levels and moisture conservation practices on grain yield and stover yield of sorghum.

Treatments	**Grain yield (qha^{-1})**		**Stover yield (qha^{-1})**		**Biological yield (qha^{-1})**	
	2024	**2025**	**2024**	**2025**	**2024**	**2025**
(A) Fertility levels: -6 (Main plot)						
F_1- Control	13.51	14.56	27.33	29.68	40.85	44.25
F_2- 100 % RDN through urea	20.47	22.44	38.24	41.46	58.70	63.90

F_3- 75 % RDN + 2 foliar sprays of 0.4 % Nano N fertilizer	27.27	30.93	46.29	51.09	73.56	82.02
F_4- 75 % RDN + 2 foliar spray of 2 % urea fertilizer	24.81	28.09	42.81	47.69	67.62	75.79
F_5- 50 % RDN + 2 foliar spray of 0.4 % Nano N fertilizer	22.62	25.47	41.44	43.80	64.07	69.27
F_6- 50 % RDN + 2 foliar spray of 2 % urea fertilizer	21.79	24.36	38.51	44.03	60.31	68.40
SE(d)±	1.51	1.45	2.48	2.29	4.13	5.00
CD at 5%	3.40	3.29	5.60	5.17	9.33	11.29
(B) Moisture Conservations:-4 (Subplot)						
M_1- Control	15.17	16.74	28.96	32.75	44.13	49.50
M_2- Hydrogel @ 2.5 kg/ha + organic residue mulch 5t/ha	24.27	27.16	43.03	47.12	67.30	74.28
M_3- Hydrogel @ 5 kg/ha + organic residue mulch 5t/ha	27.39	30.45	48.03	51.96	75.43	82.41
M_4- Kaolin @ 0.5 % at 45 DAS spray	20.15	22.89	36.39	40.00	56.55	62.89
SE(d)±	1.32	1.40	2.20	2.02	3.27	3.62
CD at 5%	2.70	2.86	4.52	4.12	6.67	7.38

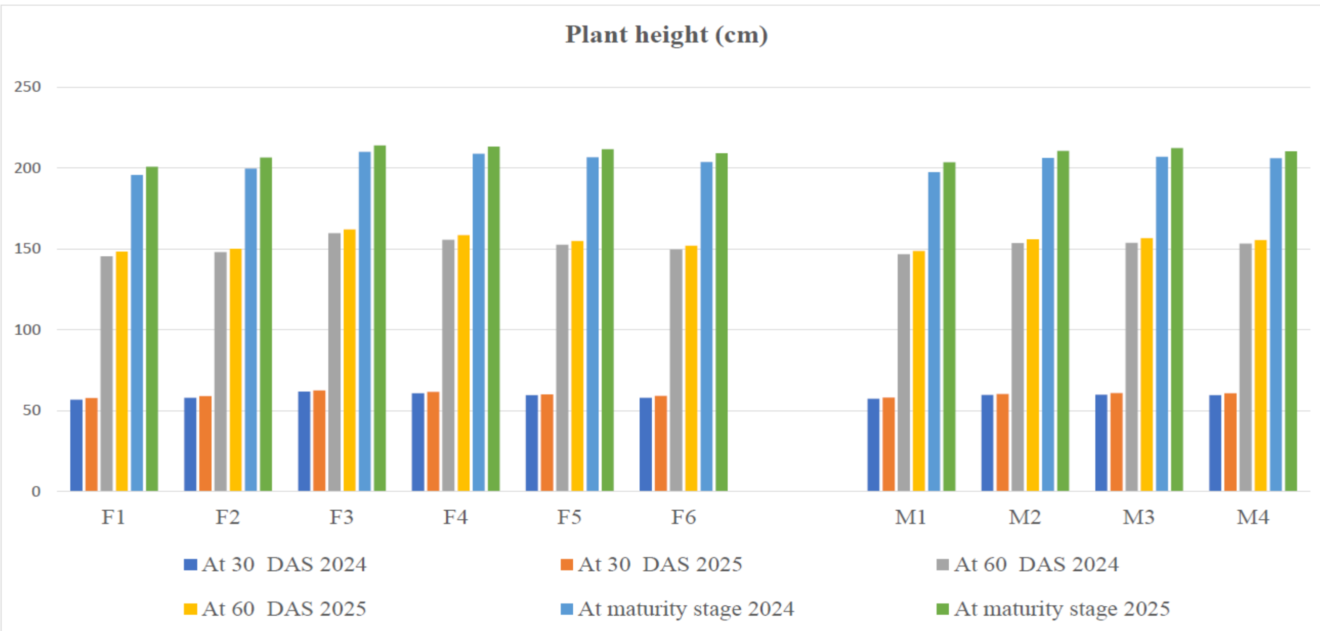

Fig. 1: Effect of fertility levels and moisture conservation practices on plant height (30, 60 DAS and at maturity stage) of sorghum.

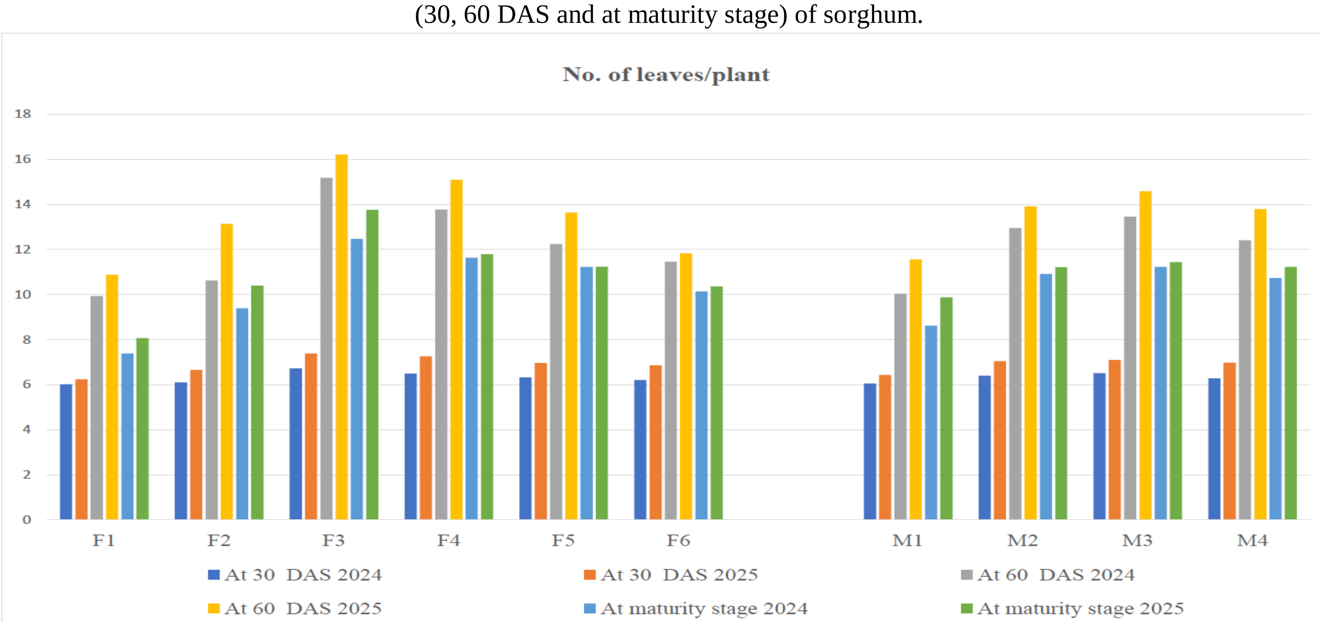

Fig. 2: Effect of fertility levels and moisture conservation practices on No. of leaves/plant at 60 DAS and at maturity stage of sorghum.

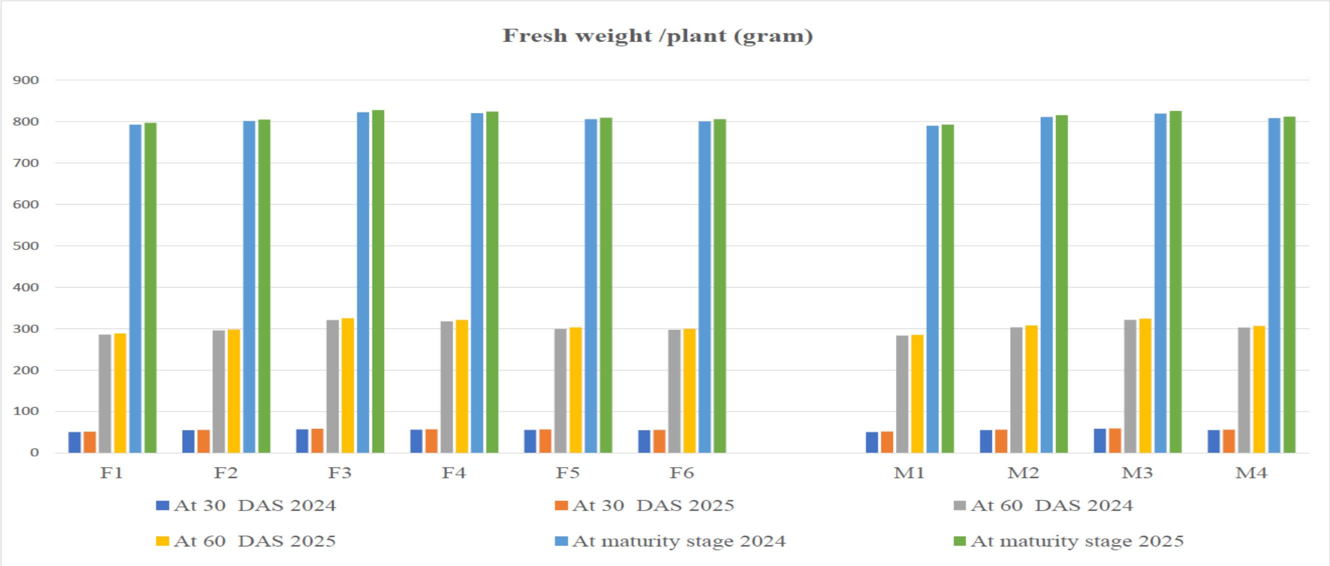

Fig. 3: Effect of fertility levels and moisture conservation practices on fresh weight /plant (gram) of sorghum.

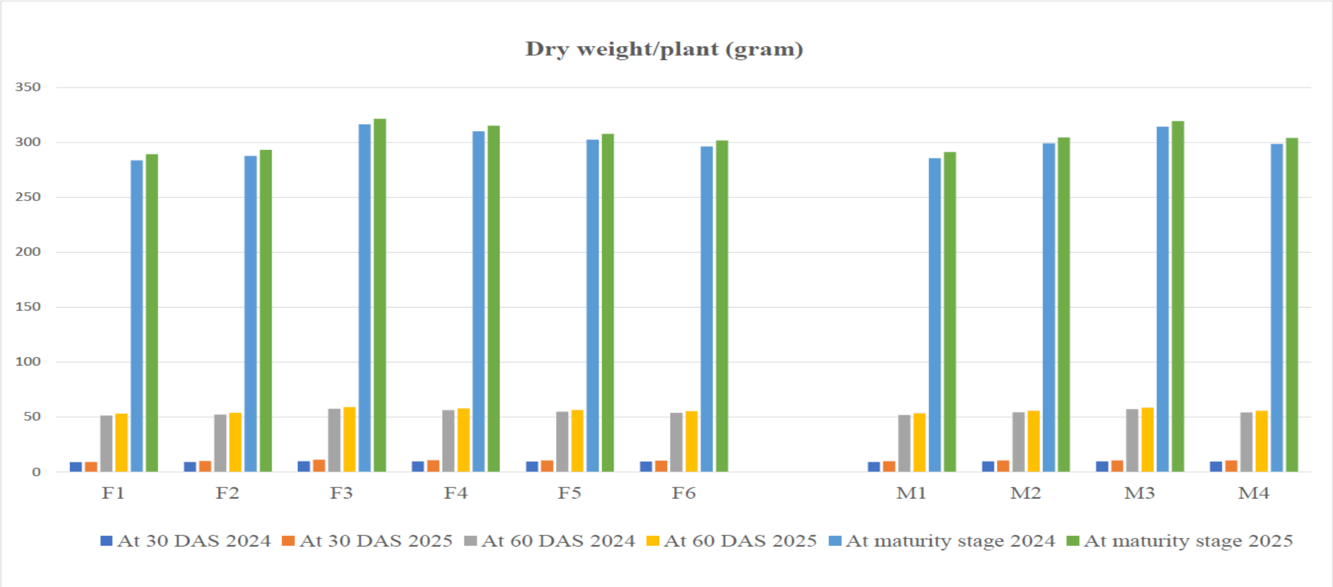

Fig. 4: Effect of fertility levels and moisture conservation practices on Dry weight /plant (gram) of sorghum.

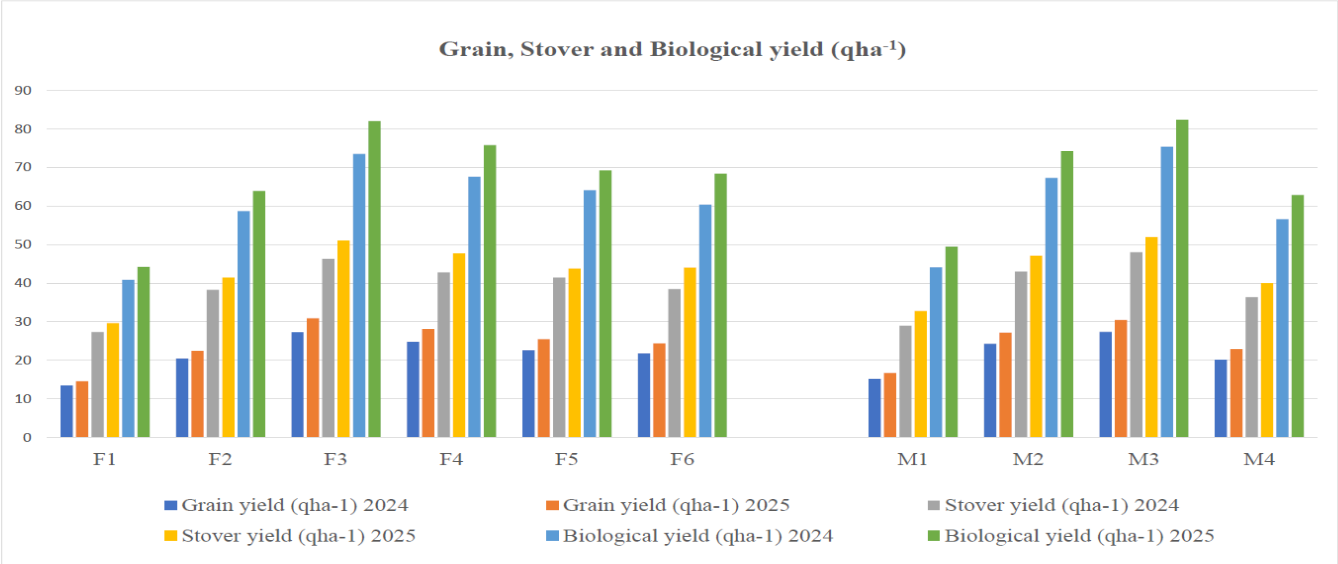

Fig. 5: Effect of fertility levels and moisture conservation practices on grain yield and stover yield of sorghum.

Conclusion

Integrated nano nitrogen fertilization and moisture conservation practices significantly improved the growth and yield of *kharif* sorghum under rainfed conditions. Application of 75% RDN with two foliar sprays of 0.4% Nano N fertilizer produced superior crop growth and yield. Hydrogel @ 5.0 kg ha^{-1} combined with organic residue mulch @ 5 t ha^{-1} effectively enhanced soil moisture availability and biomass production. Therefore, this integrated approach offers a sustainable and efficient strategy for increasing sorghum productivity in moisture-limited environments.

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