Plant Archives Vol. 26, Supplement 2, 2026 pp.720-725 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-2.081

INFLUENCE OF WEED MANAGEMENT AND NITROGEN FERTILIZATION ON GROWTH AND PRODUCTIVITY OF SORGHUM (*Sorghum bicolor* L.) IN SEMI-ARID RAJASTHAN

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(Date of Receiving : 01-03-2026; Date of Revision : 09-04-2026; Date of Acceptance : 04-05-2026)

ABSTRACT

A field study was carried out at Instructional Farm of S.K.N. College of Agriculture, Jobner, Rajasthan during *kharif* season of 2023 and 2024 to evaluate the effect of weed management and nitrogen levels on grain sorghum var. CSH-41. The experiment consisted of seven weed management treatments *viz*., weedy check, one HW at 20 DAS, two HW at 20 & 40 DAS, atrazine @ 500 g/ha (PE), atrazine @ 500 g/ha (PE) + one HW at 25 DAS, tembotrione @ 90 g/ha at 15-20 DAS, atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS, along with four nitrogen levels (0, 30, 60 and 90 kg N/ha), thereby making 28 treatment combinations. The experiment was laid out in split plot design, assigning weed control to main plots and nitrogen levels to sub plots. The treatments were replicated thrice. Among weed management treatments, results revealed that two HW at 20 and 40 DAS recorded significantly higher dry matter accumulation at 70 DAS (66.5 g/plant) and produced the highest grain (2985 kg/ha) and stover yields (8616 kg/ha). However, it remained statistically at par with atrazine @ 500 g/ha (PE) + one HW at 25 DAS, which also ensured effective weed control and superior crop performance. Plant height and dry matter accumulation at 35 DAS (11.2 g/plant) were significantly higher under atrazine (PE) + one HW at 25 DAS treatment. Nitrogen levels also significantly influenced crop growth and yield. Increasing nitrogen levels up to 90 kg N/ha resulted in significant improvement in plant height, dry matter accumulation, grain and stover yields. The application of 90 kg N/ha recorded the highest grain yield (2978 kg/ha) and stover yield (8592 kg/ha). The study highlights that integration of chemical and manual weed control along with optimum nitrogen application (90 kg N/ha) can effectively improve growth and productivity of grain sorghum under semi-arid conditions.

***Keywords*:** Sorghum, weed management, nitrogen levels, hand weeding, atrazine, tembotrione, crop growth and yield

Introduction

Sorghum (*Sorghum bicolor* L.) is a major cereal crop in the Poaceae family. It is an important *kharif* season crop grown mainly for grain, which is used as food for people and feed for animals. Sorghum is known as the “king of millets” and is the fourth most important cereal crop in India after rice, wheat, and maize. It is also called “*milo*” in many countries and is a major feed grain for cattle. In India, it is popularly known as “*jowar*.” Sorghum is often cross-pollinated crop. Sorghum is especially important for resource-poor, small, and marginal farmers in semi-arid regions. Because it can survive high temperatures and water stress, sorghum is widely grown in tropical and semi-arid regions of the world (Paterson *et al.,* 2009). Sorghum grain contains about 9.35% protein, 3.35%

fat, 72.41% carbohydrates, and 10.66% moisture. It is a good source of iron, zinc, phosphorus, and vitamin B-complex. Sorghum starch is gluten for, making it a good alternative to wheat flour for individuals suffering from 'celiac' disease. Sorghum grain is gluten-free, high in resistant starch, and has more and diverse phenolic compounds than many other cereals (Mukherjee *et al.,* 2024). India ranks fourth in total sorghum production with 4.0 million tonnes grown on an area of 3.65 million hectares during 2025-26. The *kharif* sorghum (36.6%) was grown predominantly in Rajasthan (43.3%), Uttar Pradesh (15.6%), Haryana (10.1%) and Madhya Pradesh (9.8%). In Rajasthan, the area under sorghum is estimated to be about 6.0-6.5 lakh hectares, with a total production of approximately 4.8-5.5 lakh tonnes and an average productivity of around 850-900 kg/ha during 2025-26. The main sorghum growing districts are Bhilwara, Udaipur, Chittorgarh, Dungarpur and Banswara (Anonymous, 2026). Weeds infestation is one of the important biotic constraints in sorghum cultivation because they compete with the crop for sunlight, water, nutrients, and space. This competition can reduce sorghum grain yield by 15% to 83%, depending on the variety of crop, the type and intensity of weed species, plant spacing, duration of weed growth, and environmental conditions. Mishra (1997) also reported that grain yield losses in sorghum due to weed competition range from 15% to 40%. Research clearly shows that the period between 30 to 45 DAS is the critical time when weeds cause the most damage. Therefore, effective weed control during this period is very important to ensure good growth and higher yield in sorghum.

Atrazine is a selective, systemic herbicide of the triazine group, commonly used as a pre- and early post-emergence herbicide in maize and sorghum. It acts by inhibiting photosystem II (PS II) in the chloroplast by binding to the D1 protein, thereby blocking electron transport during photosynthesis. Atrazine is highly effective against broad-leaved weeds (dicots) such as *Amaranthus spp*., *Parthenium hysterophorus*, *Euphorbia spp*. and *Commelina benghalensis*. In the present study, atrazine significantly reduced weed density and dry matter, though its spectrum is narrower compared to combination treatments (Cooper *et al*., 2007). Tembotrione is a post-emergence triketone herbicide belonging to the 4-hydroxyphenylpyruvate dioxygenase (HPPD) inhibitor class that disrupts carotenoid biosynthesis in susceptible plants. After foliar application, it is absorbed through leaves and translocated via xylem and phloem to meristematic tissues, where it inhibits HPPD involved in plastoquinone and tocopherol synthesis (Krishnamurthy *et al*., 2021). Tembotrione is absorbed primarily through foliage and translocated throughout the plant, ensuring effective control of actively growing weeds. It provides broad-spectrum control of both grassy weeds such as *Echinochloa colona* and *Digitaria sanguinalis*, and broad-leaved weeds like *Amaranthus viridis* and *Commelina benghalensis* (Sharma *et al*., 2018). Nitrogen is one of the most important nutrients needed by plants, and is often the most limiting nutrient in modern crop production. Plants require nitrogen to make amino acids, proteins, and important pigments like chlorophyll. In the soil, nitrogen is available to plants in two main forms: nitrate (NO_3^-) and ammonium (NH_4^+). The form plants absorb depends on soil conditions. In well-aerated and cultivated soils, nitrate (NO_3^-) is usually the most common and easily available form of nitrogen. Soil moisture plays a key role in how efficiently plants use nitrogen. When soil is dry, nitrogen becomes less available to plants, which can greatly reduce crop yields. This is a major problem in drought-prone and rain-fed farming systems, where crops, including sorghum, often suffer from nitrogen deficiency even when fertilizers are applied (Thapa *et al.,* 2025).

Weed management and nutrient (especially nitrogen) management are very important for increasing the productivity of sorghum crops. Among all nutrients, nitrogen is one of the most important because it is required for the growth and development of plants. In many Indian soils particularly in low-fertility or coarse-textured soils such as sandy soils, nitrogen is often deficient which limits the crop growth. In a healthy plant, the concentration of nitrogen generally ranges between 1% and 5%, depending on the crop species or variety. Proper nitrogen management helps farmers get to better yield, better grain quality, and saves money and reduces the loss of nitrogen into the environment. Therefore, farmers should carefully decide how much nitrogen is needed for their field so that the sorghum crop can grow well without causing any harm to the environment (Shrivastava *et al.* 2024).

Materials and Methods

A field experiment was conducted during *kharif* seasons of 2023 and 2024 at Instructional Farm of S.K.N. College of Agriculture, Jobner, Rajasthan. Geographically, Jobner is situated 45 km west of Jaipur. The physiographic location of the experimental farm is 26^0 5' North latitude and 75^0 28' East longitude with an altitude of 427 meters above mean sea level. This region falls under agro-climatic zone IIIa (Semi-Arid Eastern Plain Zone) of Rajasthan. The region receives higher rainfall during July and September months from South-West monsoon with an annual range of 400-500 mm. As weather and climatic condition influences the growth, yield and quality of crop as well as biotic phase of soil during the growing season. Soil of experimental site was sandy loam in texture and slightly alkaline in reaction (pH 8.31 and 8.22) and low in available nitrogen (129.73 and 132.45 kg/ha), medium available phosphorus (15.21 and 14.58 kg/ha) and available potassium (149.77 and 148.63 kg/ha) during both the years *i.e*., 2023 and 2024, respectively. The experiment comprised seven weed control treatments *viz.*, weedy check, one HW at 20 DAS, two HW at 20 & 40 DAS, atrazine @ 500 g/ha (PE), atrazine @ 500 g/ha (PE) + one HW at 25 DAS, tembotrione @ 90 g/ha at 15-20 DAS, atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS and four levels of nitrogen (0, 30, 60 and 90 kg/ha) thereby making 28 treatment combinations that were laid out in split plot design and replicated three times.

Sorghum variety "CSH-41" was sown at the seed rate of 12 kg/ha on 12.07.2023 and 10.07.2024, during *kharif*-2023 and 2024, respectively at 45 x 15 cm spacing. Before sowing, field was thoroughly ploughed and levelled. The crop was recommended dose of fertilizer 80:40:40 NPK kg/ha with N in two equal split doses at the time of sowing and top dressed at the time of first irrigation. Pre-emergence herbicides were applied within two days after sowing. Post-emergence herbicides were applied at 15-20 and 20-25 DAS. All the herbicides were used after making the spray volume of 500 l/ha. Data on various crop growth and yield attributing characters were statistically analysed as per the standard procedure outlined by Panse and Sukhatme (1985). Harvest index (%) was calculated by using the formulae as suggested by (Singh and Stoskopf, 1971).

$$\text{HI (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Weed flora

The experimental field was infested by grassy and broad-leaved weeds during both the years. Survey of the experimental field carried out during investigation revealed that the weedy check plots of sorghum were heavily invaded immediately after crop emergence by annual dicot weeds chiefly *Amaranthus spinosus*, *Amaranthus viridis* and *Trianthema portulacastrum*. Other dicot weeds noted to infest the experimental field were *Phyllanthus niruri*, *Digera arvensis*, *Euphorbia hirta*, *Boerhavia diffusa* and *Verbesina encelioides*. Among monocot weeds, *Cyperus rotundus*, *Dactyloctenium aegyptium* and *Commelina benghalensis* appeared to be prominent species, though their population was comparatively low (Kaushik and Shaktawat, 2005).

Effect on plant height

It is evident from the data presented in table 1 indicated that all the weed control treatments resulted significant improvement in plant height of sorghum at all the stages than weedy check treatment. Weed management practices significantly influenced crop growth, with atrazine @ 500 g/ha (PE) + one HW at 25 DAS and atrazine fb tembotrione @ 90 g/ha (20–25 DAS) proving most effective and statistically at par with two HW (20 & 40 DAS). These treatments ensured effective control of grasses and broad-leaved weeds, resulting in better crop-weed competition and enhanced plant height. They improved plant height by about 8-21% at 70 DAS and 5-14% at harvest over weedy check, while atrazine fb tembotrione alone recorded 15.3% and 11.8% increase, respectively. Tembotrione alone showed moderate improvement (12.2% and 8.7%) and remained at par with one HW and atrazine @ 500 g/ha (PE). Nitrogen levels also significantly affected plant growth, with plant height increasing up to 30 kg N/ha at 35 DAS and 60 kg N/ha at later stages. Application of 60 kg N/ha enhanced plant height by 5.5-5.7% at 70 DAS and 13.1-15.1% at harvest over lower levels and control. It remained at par with 90 kg N/ha, which recorded maximum plant height (171.5 and 192.8 cm) with 17-18% increase over control. Increase in overall growth of crop at all stages of observation was mainly due to significant reduction in weed competition, which otherwise would have interfered with the crop for incident solar radiation, nutrients and moisture. The superiority of these treatments was because of better control of all categories of weeds which resulted in reduced weed competition with crop. Results so obtained are in close conformity with the finding of Gupta *et al.* (2023) and Anuranj *et al.* (2025)

Effect on dry matter accumulation

Data pertaining to the effect of different weed control treatments on crop dry matter accumulation (Fig. 1) revealed that all treatments significantly enhanced dry matter at critical growth stages. At 35 DAS, pooled data indicated that atrazine @ 500 g/ha (PE) + one HW at 25 DAS and atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS recorded significantly higher dry matter accumulation of 11.2 and 10.9 g/plant, respectively, registering an increase of 21.6 and 18.5 per cent over weedy check. These treatments proved effective in early weed suppression, resulting in better crop growth. At 70 DAS, two HW at 20 and 40 DAS recorded the highest dry matter accumulation (66.5 g/plant), showing a marked increase of 32.7 per cent over weedy check and 17.9, 15.3 and 10.3 per cent over atrazine @ 500 g/ha (PE), tembotrione @ 90 g/ha at 15-20 DAS and one HW at 20 DAS, respectively. However, it remained statistically at par with atrazine @ 500 g/ha (PE) + one HW at 25 DAS, which also maintained significantly higher dry matter accumulation over other treatments. Nitrogen levels also significant influence on dry matter accumulation. Application of 60 kg N/ha recorded 10.6 and 64.0 g/plant at 35 and 70 DAS, which was 7.1 and 22.4 per cent higher over control, respectively. However, the maximum dry matter accumulation was recorded under 90 kg N/ha (10.8 and 65.0 g/plant at 35 and 70 DAS), which was 3.8 and 10.7 per cent higher than 30 kg N/ha and 9.1 and 24.3 per cent higher than control at respective stages. Overall, integration of effective weed management practices with higher nitrogen levels significantly enhanced dry matter accumulation at crucial growth stages of sorghum. The present findings are in close agreement with those reported by Krishnamurthy, *et al*. 2021 and Kumar *et al*. 2024.

Effect on grain yield, stover yield and harvest index

Data pertaining to effect of different weed control treatments on grain and stover yields of sorghum given in table 2 and fig. 2 clearly showed that all the treatments registered significant increase in grain and stover yields as compared to the weedy check during individual years as well as in pooled analysis. The pooled analysis of data revealed that two hand weedings at 20 and 40 DAS produced the highest grain yield (2985 kg/ha) and stover yield (8616 kg/ha) and was observed as the most superior treatment. It increased the grain yield by 218, 350, 442, 567 and 1068 kg/ha and stover yield by 9.4, 14.0, 20.4, 27.9 and 51.8 per cent over atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS, one HW at 20 DAS, tembotrione @ 90 g/ha at 15-20 DAS, atrazine @ 500 g/ha (PE) and weedy check treatments, respectively. In terms of percentage, grain yield improvement ranged from about 3.5 to 49.4 per cent over different treatments. However, it was found at par with pre-emergence application of atrazine @ 500 g/ha + one HW at 25 DAS, which recorded grain and stover yields of 2865 and 8252 kg/ha, respectively, and registered a corresponding increase of 3.5, 8.7, 12.6, 18.4 and 49.4 per cent in grain yield and 695, 1098, 1517 and 2577 kg/ha in stover yield over one HW at 20 DAS, tembotrione @ 90 g/ha at 15-20 DAS, atrazine @ 500 g/ha (PE) and weedy check treatments, respectively. Application of atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS also produced mean grain and stover yields of 2767 and 7876 kg/ha, respectively, and proved to be the most effective herbicidal treatment, showing about 38.8 per cent increase in stover yield and around 37.5 per cent increase in grain yield over weedy check. This was followed by one HW at 20 DAS (2635 and 7557 kg/ha), which recorded about 33.2 per cent higher stover yield over control. Tembotrione @ 90 g/ha at 15-20 DAS and atrazine @ 500 g/ha (PE) alone also improved grain yield by 32.7 and 26.1 per cent and stover yield by 1479 and 1060 kg/ha, respectively, over weedy check, but were comparatively less effective due to lower weed control efficiency. Nitrogen levels also significantly influenced both grain and stover yield. Increasing nitrogen levels progressively enhanced yield, with the highest grain yield (2978 kg/ha) and stover yield (8592 kg/ha) recorded at 90 kg N/ha. This level produced 157, 419 and 976 kg/ha higher grain yield and 5.2, 17.2 and 55.0 per cent higher stover yield over 60 and 30 kg N/ha and control, respectively, indicating the positive role of nitrogen in improving crop productivity. It may be due to better control of weeds initially by pre-emergence spray and after that late emerging weeds were controlled by post-emergence herbicides. The higher yield in these treatments might be due to more availability of nutrients and moisture as there was less competition between weeds and crop. Similar results were also found by Ganapati and Guggari (2018), Shrivastava, *et al.* (2024) and Santos *et al.* (2024). Harvest index remained non-significant under different weed control treatments and nitrogen levels during both the years as well as in pooled analysis.

Conclusion

Based on the two-year investigation on sorghum var. CSH-41, it can be concluded that effective weed management and optimum nitrogen fertilization significantly enhanced crop growth and productivity. Among the weed control treatments, two HW at 20 and 40 DAS recorded higher crop growth as well as grain yield (2985 kg/ha), closely followed by atrazine @ 500 g/ha (PE) + one HW at 25 DAS. With respect to nitrogen levels, application of 90 kg N/ha resulted in the highest growth parameters and grain yield (2978 kg/ha). Therefore, integration of timely manual and chemical weed control practices along with optimum nitrogen application (90 kg N/ha) is recommended for achieving higher crop growth and productivity of sorghum under similar agro-climatic conditions.

Table 1 : Effect of weed control and nitrogen levels on plant height of sorghum (cm) at different stages

Treatments	35 DAS			70 DAS			At harvest		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Weed control (main plot)									
W_0- Weedy check	33.6	38.1	35.9	136.8	149.9	143.3	164.4	167.2	165.8
W_1- One HW at 20 DAS	46.1	51.4	48.7	153.6	165.2	159.4	178.2	180.0	179.1
W_2- Two HW at 20 & 40 DAS*	43.5	49.3	46.4	160.7	172.0	166.4	183.7	191.1	187.4
W_3- Atrazine @ 500 g/ha (PE)	41.5	46.2	43.9	150.2	163.1	156.6	175.2	177.0	176.1
W_4- Atrazine @ 500 g/ha (PE) + one HW at 25 DAS	46.7	53.7	50.2	167.7	179.9	173.8	186.0	192.9	189.5
W_5- Tembotrione @ 90 g/ha at 15-20 DAS	41.8	47.7	44.7	155.0	166.6	160.8	179.6	181.0	180.3
W_6- Atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS	46.4	51.4	48.9	159.3	171.2	165.3	181.9	189.0	185.4
SEm±	1.33	1.30	0.93	4.39	4.33	3.08	4.33	4.78	3.22
CD (P =0.05)	3.80	3.71	2.71	12.53	12.36	8.99	12.38	13.64	9.41
CV (%)	10.76	9.32	-	9.82	8.98	-	8.41	9.06	-
Nitrogen levels (sub plot)									
N_0- Control	37.7	42.4	40.0	139.6	151.3	145.5	163.3	167.4	165.4
N_{30}- 30 kg/ha	42.7	48.8	45.7	152.6	164.8	158.7	175.0	178.8	176.9
N_{60}- 60 kg/ha	44.5	50.3	47.4	161.4	173.6	167.5	184.8	189.4	187.1
N_{90}- 90 kg/ha	46.4	51.5	49.0	165.5	177.6	171.5	190.6	194.9	192.8
SEm±	0.80	0.83	0.69	2.43	2.42	2.12	2.62	2.98	2.37
CD (P =0.05)	2.27	2.36	1.93	6.93	6.90	5.96	7.47	8.51	6.67
CV (%)	8.52	7.86	-	7.19	6.64	-	6.72	7.48	-

* Treatment was partially applied at 35 DAS

Table 2: Effect of weed control and nitrogen levels on grain, stover yields (kg/ha) of sorghum and harvest index (%)

Treatments	Grain yield (kg/ha)			Stover yield (kg/ha)			Harvest index (%)		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
Weed control (main plot)									
W_0- Weedy check	1786	2049	1917	5247	6103	5675	25.51	25.31	25.41
W_1- One HW at 20 DAS	2476	2793	2635	7116	7997	7557	25.85	25.95	25.90
W_2- Two HW at 20 & 40 DAS	2818	3151	2985	7950	9281	8616	26.13	25.32	25.72
W_3- Atrazine @ 500 g/ha (PE)	2266	2571	2418	6220	7250	6735	26.92	26.39	26.65
W_4- Atrazine @ 500 g/ha (PE) + one HW at 25 DAS	2686	3043	2865	7689	8814	8252	26.04	25.83	25.93
W_5- Tembotrione @ 90 g/ha at 15-20 DAS	2391	2695	2543	6679	7629	7154	26.52	26.29	26.41
W_6- Atrazine @ 500 g/ha (PE) + tembotrione @ 90 g/ha at 20-25 DAS	2605	2929	2767	7299	8453	7876	26.49	26.03	26.26
SEm±	68	70	49	197	263	164	0.94	0.92	0.65
CD (P =0.05)	210	214	142	609	809	480	NS	NS	NS
CV (%)	9.72	8.78	-	8.91	10.07	-	8.49	9.66	-
Nitrogen levels (sub plot)									
N_0- Control	1863	2141	2002	5139	5951	5545	26.75	26.60	26.68
N_{30}- 30 kg/ha	2428	2690	2559	6955	7707	7331	25.90	25.92	25.91
N_{60}- 60 kg/ha	2646	2995	2821	7539	8802	8170	26.13	25.59	25.86
N_{90}- 90 kg/ha	2794	3162	2978	7909	9271	8592	26.05	25.39	25.72
SEm±	45	44	32	134	161	105	0.51	0.47	0.35
CD (P =0.05)	128	130	90	383	459	294	NS	NS	NS
CV (%)	8.42	7.57	-	7.69	9.28	-	7.19	8.38	-

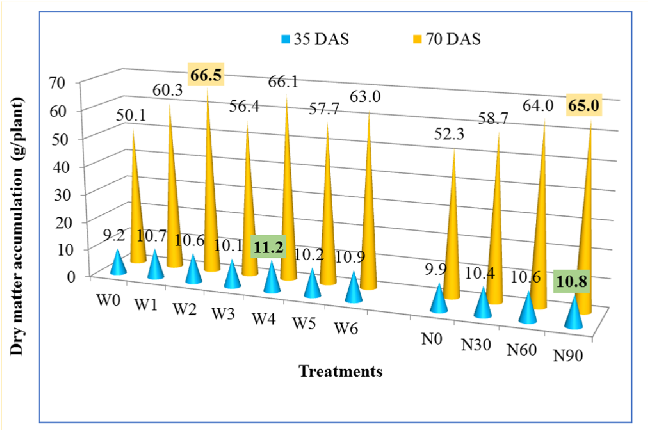

Fig. 1: Effect of weed control and nitrogen levels on periodical crop dry matter accumulation

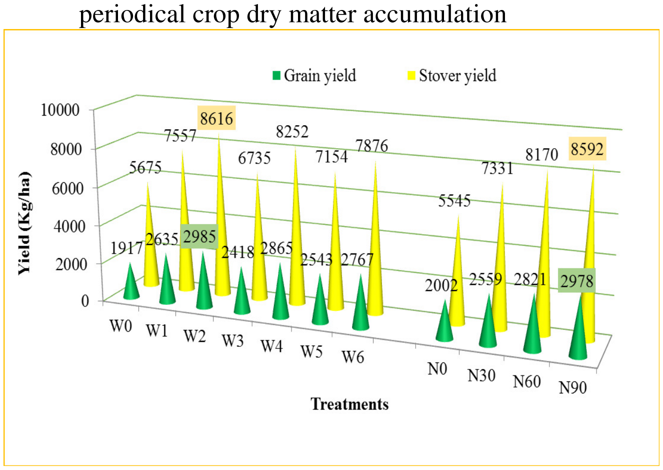

Fig. 2: Effect of weed control and nitrogen levels on grain yield and stover yield of sorghum

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