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# Comparative Analysis of Mulching and Weed Management Practices on Nutrient and Weed Dynamics of Kharif Sorghum (*Sorghum bicolor* L.)

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## ABSTRACT

The present field study was conducted to evaluate the effects of mulching and weed control methods on the nutrient and weed dynamics of Kharif Sorghum. The research was conducted in the Agronomy farm of Lovely Professional University in Phagwara, Punjab, during the summer of 2023. The experiment utilized a randomized block design with three replications. A total of six treatments were used, each with different amounts of treatment applied to assess the effects on the growth, yield, and weed characteristics of sorghum. The growth metrics, including plant height, leaf count, stem circumference, leaf area index, and chlorophyll content, saw significant improvement as a result of the amplified influence of mulching and weed management. Treatment T1, which excluded weeds, yielded the greatest plant height (134.69 cm), number of leaves (8.73), stem girth (10.14 cm) at harvest, leaf area index (7.78), and chlorophyll content (53.74) at 90 days after sowing (DAS). The T1 treatment, which was free of weeds, had the most favorable production characteristics. The grain yield was recorded at 2.15 $t.ha^{-1}$, the straw yield at 4.59 $t.ha^{-1}$, and the harvest index at 22.54%. The highest protein concentration was observed as 10.84% in T1 (Weed free) and 10.73% in T2 (Sugarcane trash). In addition, the characteristics of the weed, including the number of weeds, the effectiveness of weed management, and the weight of the weeds, were shown to be highest in dicots at 120 days after sowing (DAS). Treatment T1, which involved the complete removal of weeds, exhibited no weed population and achieved the maximum level of weed control effectiveness and dry weight. The study's findings indicated that the use of T1 (Weed-free) treatment had a substantial influence on different growth, yield, and weed characteristics. Effective management of essential inputs, such as cultivation, fertilizers, and weed management, is vital for improving overall productivity and stability.

## INTRODUCTION

The fifth-most significant cereal crop in the world is sorghum [*Sorghum bicolor* (L)], behind barley (*Hordeum vulgare* L), maize (*Zea mays* L), rice (*Oryza sativa* L), and wheat (*Triticum aestivum* L). Globally, 41 million hectares of land are used to cultivate sorghum, with 64.20 million tons produced in important production regions such as the Deccan plateau in central India, Northeast China, Sub-Saharan Africa, and the broad plains of North America (Głąb et al. 2017). Roughly sixteen percent of the world's sorghum crop is produced in India. As of 2010, this crop, which was one of India's primary staple foods and covered more than 18 million hectares in the 1950s only accounted for 7.69 million hectares (Hussain et al. 2021, Singh et al. 2019). The economic crisis poses a severe danger to the food security and farming systems of the country's dryland areas. A flexible crop, sorghum can be used for grain, feed, and, more recently, as a bioenergy source. Throughout Asia and Africa, sorghum grain is consumed by people or given to animals; the stalks are used as building materials or animal feed (Kumar et al. 2022).

Weed losses have significantly hindered the productivity of sorghum. The majority of the decrease in yield caused by weed competition happens within the initial six weeks after planting. During the crucial phase, the existence of weeds resulted in a reduction of 15-40% in crop production. Therefore, it is important to prioritize weed management during this period (Kandhro et al. 2015). To achieve effective weed control in sorghum, it is crucial to utilize all possible treatments and combine them into a comprehensive weed management strategy. The primary determinant of poor sorghum production, particularly in the rainy season, is the management of weed growth. Due to its larger row spacing and slower initial growth rate, sorghum has a severe weed infestation (Mishra & Patil 2014, Singh et al. 2019, Kandhro et al. 2015). Pesticides are rarely used in sorghum agriculture; instead, human weeding and machine inter-row cultivation are the main weed control techniques. Pre-emergence herbicides help provide early weed control during the wet season when it may not be possible to immediately hand weed or utilize mechanical inter-row cultivation (Abdul Rab et al. 2016, Kumar et al. 2016). To prevent weeds from growing between rows, it is recommended to use integrated weed control, which combines minimal hand weeding, sparing herbicide application, interculturing, and efficient agronomic techniques. One intercrop that could be utilized in place of manual weeding or pre-emergence herbicides is cowpeas (Dhaka et al. 2023). Dry conditions are typical for sorghum grain cultivation, potentially decreasing preemergence herbicide effectiveness due to low soil moisture. When facing such conditions, non-selective herbicides can be employed alongside herbicide-tolerant sorghum cultivars (Hussain et al. 2021). Hence, achieving effective weed control requires combining various integrated weed management practices systematically. Additionally, mulching materials are frequently utilized to support the growth of sorghum crops (Kumar et al. 2022). Recurring applications of the same herbicide can cause weed resistance, and herbicide-based weed control techniques leave behind residual toxicity. Organic mulching is a sustainable substitute for chemical control. Mulch made from a variety of crop wastes is used in this manner; it breaks down organically and enhances soil health. The goal of sustainable weed management is to reduce the detrimental effects of weeds on crop productivity while maintaining economically and environmentally sound agricultural methods. Recurring applications of the same herbicide can cause weed resistance, and herbicide-based weed control techniques leave behind residual toxicity. Organic mulching is a sustainable substitute for chemical control. Mulch made from a variety of crop residue is used in this manner; it breaks down organically and enhances soil health. Research into "mulching and weed management practices on nutrient and weed dynamics" is vital for developing methods that balance crop productivity with ecological sustainability. Such studies can lead to practices that enhance sorghum yield while promoting long-term soil health and environmental conservation. Ultimately, this research demonstrates how strategic mulching and management practices can improve soil nutrient levels and mitigate weed issues, thereby supporting more sustainable and productive Kharif Sorghum farming systems. The application of mulching and weed management techniques on the nutrients and weed dynamics of the kharif sorghum crop was the primary focus of the current study.

## MATERIALS AND METHODS

This study was carried out in the School of Agriculture, Lovely Professional University, Phagwara, Punjab, during the summer of 2022-2023. The farm is situated in the precise coordinates of 31.24° N latitude and 75.6909° E longitude, approximately 20 kilometers from the city of Jalandhar in the state of Punjab. Its altitude is 252 meters above mean sea level. The region is distinguished by soil with a texture ranging from sandy loam to clay and a pH level ranging from 7.8 to 8.5. The current site is inside the Trans-Gangetic Agro-climatic zone. The mean annual precipitation received amounts to 527.1 millimeters. The present investigation was carried out on sorghum to assess the effects of different techniques of weed management and mulching on the nutrient and weed dynamics of the crop.

### Experimental Design

The randomised block design (RBD) which composed of 6 treatments in 4 replications. The different treatments include T1: Weed free, T2: Sugarcane trash, T3: Vermicompost mulch, T4: Live mulch, T5: Parthenium extract, T6: Weedy check (control). The area for the plot was 550 $m^2$ with a size of 5×4 $m^2$ and 20 number of plots. The seeds were sowed at a spacing of 30*10cm, and sowing was done on April 7$^{th}$, 2023. Three irrigations were given after sowing. The other agricultural practices followed for sorghum were applied by the recommendations of commercial production.

### Experimental Data

The data for growth, yield, and weed attributes of the sorghum crop was recorded using three randomly chosen plants from each treatment after seed sowing. The growth features of the plants, including plant height (cm), number of leaves, stem girth (cm), leaf area index, and chlorophyll content, were measured. The growth parameters are measured at intervals of 30 days. The evaluation included the assessment of yield metrics such as grains per panicle, panicle length in centimeters, panicle girth in centimeters, test weight in grams, grain yield in tons per hectare, straw yield in tons per hectare, and harvest index as a percentage. The metrics studied for weed analysis were weed population, weed dry weight, and weed control efficacy.

### Statistical Analysis

The analysis of the data was done statistically by OPSTAT software. Results are presented in the form of the mean for different growth, weed, and yield attributes. A significant difference ($p<0.05$) among treatments was indicated by SPSS software version 24.

## RESULTS AND DISCUSSION

### Growth Parameters

**Effect of different levels of nutrients and weed dynamics on plant height (cm) at 30, 60, 90 DAS and harvest:** The growth parameters of sorghum, such as plant height, number of leaves, stem girth, leaf area index, and chlorophyll content, were significantly affected by the use of mulching and weed management practices. These practices influenced the nutrient and weed dynamics, and the effects were observed at 30-day intervals. The growth metrics exhibited a gradual increase as the influence of mulching and weed control

Table 1: Effect of different levels of nutrients and weed dynamics on plant height (cm) at 30, 60, and 90 DAS, and harvest.

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| T1: Weed free | $69.72\pm1.58^a$ | $86.96\pm0.54^a$ | $112.61\pm0.19^a$ | $134.69\pm0.12^a$ |
| T2: Sugarcane trash | $68.25\pm1.72^b$ | $86.77\pm0.51^a$ | $112.51\pm0.22^a$ | $134.58\pm0.14^a$ |
| T3: Vermicompost mulch | $67.85\pm1.68^c$ | $86.46\pm0.31^a$ | $112.37\pm0.17^a$ | $134.49\pm0.17^a$ |
| T4: Live mulch | $67.13\pm1.64^c$ | $85.95\pm0.41^b$ | $112.06\pm0.55^a$ | $134.21\pm0.51^a$ |
| T5: Parthenium extract | $66.07\pm2.10^d$ | $85.71\pm0.44^b$ | $111.82\pm0.56^b$ | $133.77\pm0.52^b$ |
| T6: Weedy check (control) | $65.08\pm2.86^e$ | $85.12\pm0.73^b$ | $111.23\pm0.56^b$ | $133.37\pm0.08^b$ |
| CD | 1.83 | 0.47 | 0.42 | 0.34 |
| CV | 2.93 | 0.59 | 0.40 | 0.27 |
| SE[d±] | 0.88 | 0.22 | 0.20 | 0.16 |
| SE[m±] | 0.62 | 0.16 | 0.14 | 0.11 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

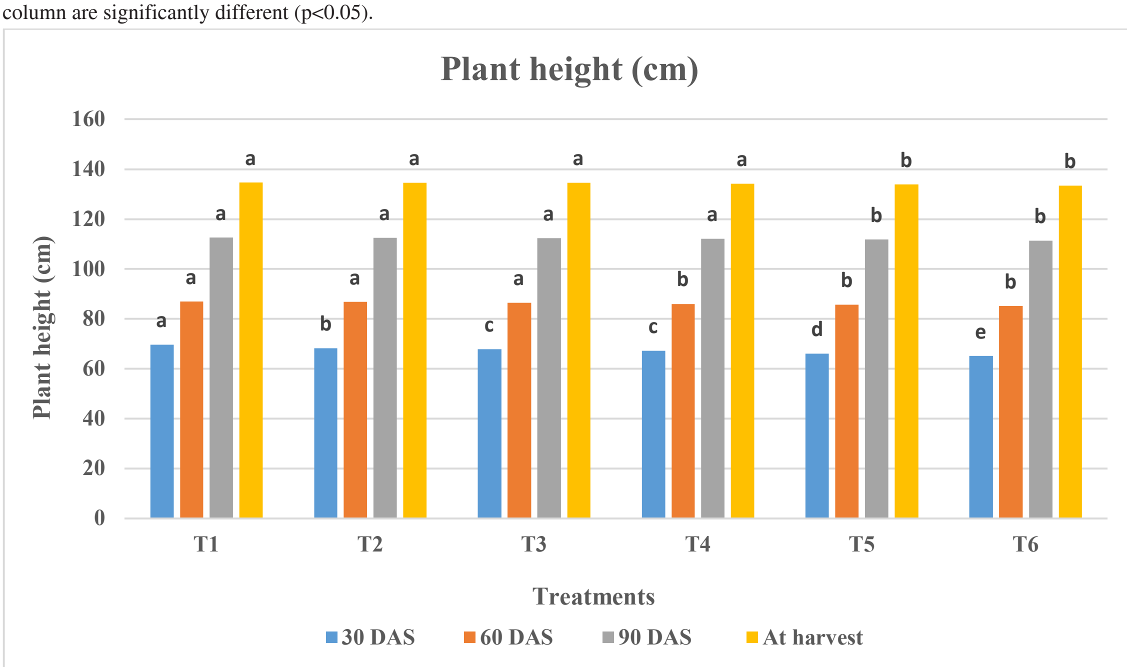


Fig. 1: Influence of different levels of nutrients and weed dynamics on plant height (cm) at 30, 60, and 90 DAS and harvest.

methods on nutrient and weed dynamics intensified, as seen in Table 1. Significant differences in plant height were observed across the different treatments at 30 days after sowing (DAS), 60 DAS, 90 DAS, and at harvest (Fig. 1). At the 30-day after sowing (30DAS) mark, the treatment T1, which involved keeping the plants free from weeds, exhibited the greatest plant height, measuring 69.72 cm. This height was statistically indistinguishable from the heights seen in treatments T2 and T3. The T6 Weedy check treatment exhibited the smallest plant height, measuring 65.08 cm. At 60 days after sowing (DAS), treatment T1 (Weed-free) had the greatest plant height of 86.96 cm, which was statistically comparable to treatments T2 and T3. The control treatment, T6, had the smallest reported plant height, measuring 85.12 cm. The plant height was measured at 112.61 cm in treatment T1 (Weed-free) and 112.51 cm in treatment T2 (Sugarcane trash) at 90 days after sowing (DAS). The treatment T1 (Control) had the smallest height, measuring 111.23 cm. Statistical analysis revealed that therapy T1 is comparable to treatments T2 and T3. Among the plants harvested, the tallest one measured 134.69 cm in height during the T1 treatment (Weed-free), and this height was not significantly different from the heights seen under the T2 and T3 treatments. The minimum observed plant height was 133.37 cm. The plant's increase in height is ascribed to the use of weed control strategies that improve nutrient availability, hence favorably affecting the plant's height parameter. Implementing effective weed management techniques and employing various mulching approaches enhance the growth characteristics of the crop. Similar results are followed by Bavalgave et al. (2017) in the sorghum crop.

**Effect of different levels of nutrients and weed dynamics on number of leaves at 30, 60, 90 DAS, and harvest:** The number of leaves is significantly influenced by the effects of mulching and weed control methods on the nutrient and weed dynamics of sorghum at 30, 60, and 90 days after

Table 2: Effect of different levels of nutrients and weed dynamics on number of leaves at 30, 60, 90 DAS, and harvest.

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| T1: Weed-free | 4.52±0.08[a] | 5.72±0.05[a] | 6.70±0.08[a] | 8.73±0.01[a] |
| T2: Sugarcane trash | 4.31±0.04[b] | 5.37±0.02[b] | 6.50±0.02[b] | 8.50±0.02[b] |
| T3: Vermicompost mulch | 3.92±0.01[c] | 4.91±0.01[c] | 5.92±0.02[c] | 7.91±0.01[c] |
| T4: Live mulch | 3.84±0.01[d] | 4.76±0.02[d] | 5.77±0.02[d] | 7.73±0.02[d] |
| T5: Parthenium extract | 3.75±0.03[e] | 4.65±0.01[d] | 5.65±0.02[e] | 7.57±0.04[e] |
| T6: Weedy check (control) | 3.72±0.03[e] | 4.33±0.02[e] | 5.40±0.01[f] | 7.47±0.02[f] |
| CD | 0.04 | 0.02 | 0.04 | 0.02 |
| CV | 1.14 | 0.57 | 0.76 | 0.29 |
| SE[d±] | 0.02 | 0.01 | 0.02 | 0.01 |
| SE[m±] | 0.01 | 0.01 | 0.01 | 0.00 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

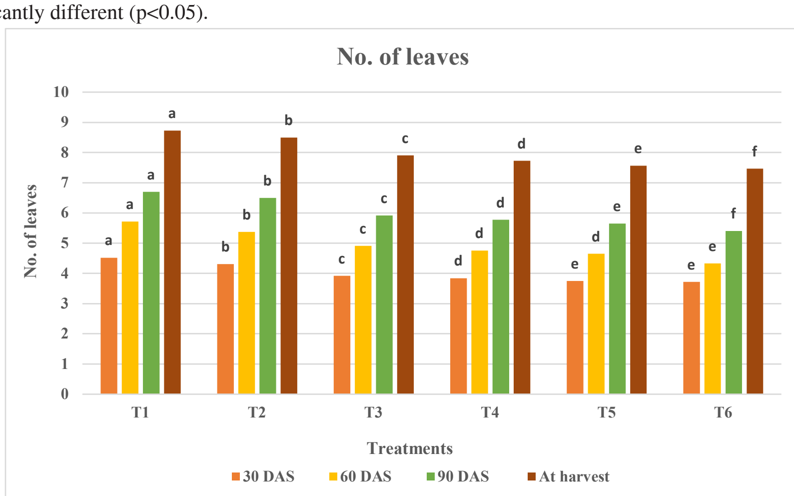


Fig. 2: Influence of different levels of nutrients and weed dynamics on the number of leaves at 30, 60 and 90 DAS, and harvest.

Table 3: Effect of different levels of nutrients and weed dynamics on stem girth (cm) at 30, 60 and 90 DAS, and harvest.

| Treatments | 30 DAS | 60 DAS | 90 DAS | At harvest |
|---|---|---|---|---|
| T1: Weed-free | 6.67±0.09[a] | 7.65±0.04[a] | 9.26±0.04[a] | 10.14±0.02[a] |
| T2: Sugarcane trash | 6.40±0.03[b] | 7.53±0.04[b] | 9.12±0.05[b] | 10.04±0.02[b] |
| T3: Vermicompost mulch | 5.92±0.02[c] | 7.46±0.05[c] | 8.91±0.06[c] | 9.83±0.05[c] |
| T4: Live mulch | 5.79±0.02[d] | 6.93±0.01[d] | 8.81±0.02[d] | 9.70±0.02[d] |
| T5: Parthenium extract | 5.71±0.03[d] | 6.78±0.02[e] | 8.68±0.03[e] | 9.52±0.04[e] |
| T6: Weedy check (control) | 5.61±0.02[e] | 6.71±0.02[e] | 8.61±0.04[e] | 9.42±0.02[f] |
| CD | 0.04 | 0.03 | 0.04 | 0.03 |
| CV | 0.83 | 0.48 | 0.50 | 0.41 |
| SE[d±] | 0.02 | 0.01 | 0.02 | 0.01 |
| SE[m±] | 0.01 | 0.01 | 0.01 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

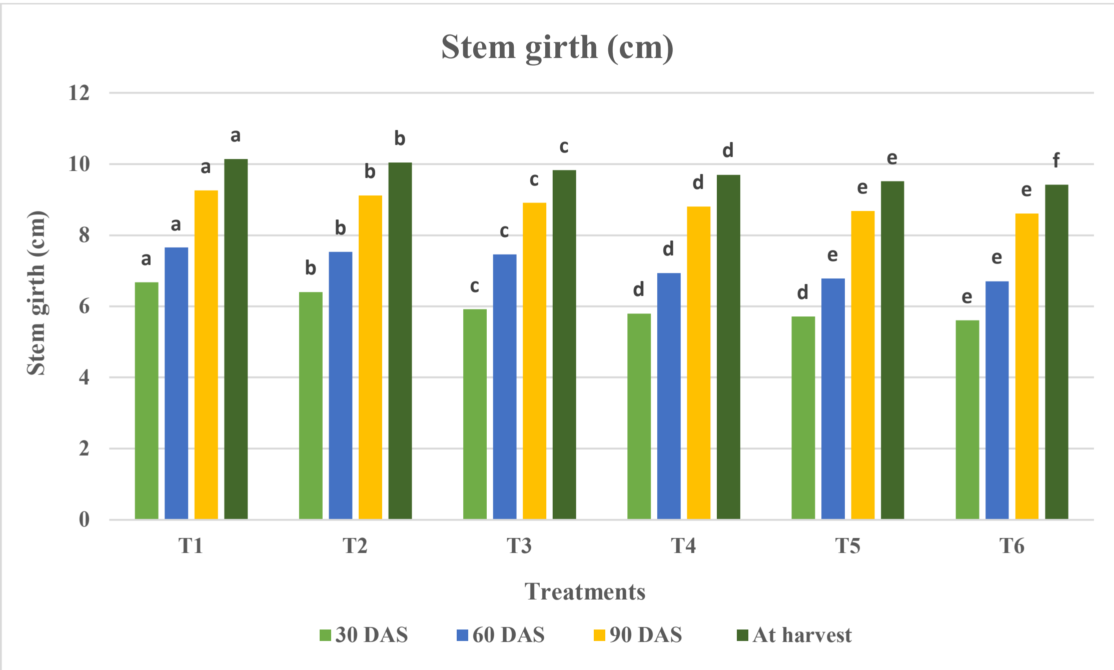


Fig. 3: Influence of different levels of nutrients and weed dynamics on stem girth (cm) at 30, 60, and 90 DAS and harvest.

sowing (DAS) and at harvest (Table 2 and Fig. 2). At the 30-day after sowing (30DAS) stage, treatment T1 (Weed free) had the highest reported leaf count of 4.52. This result has statistical similarity to the values seen in treatments T2 and T3. However, the treatment T6 Weedy check (Control) exhibited the shortest plant height, measuring 3.72. At 60 days after sowing (DAS), treatment T1 (Weed free) had the highest leaf count, measuring 5.72. This result is statistically comparable to the number of leaves observed in treatments T2 and T3. Conversely, the control treatment T6 had the fewest amount of leaves, specifically 4.33. T1 (Weed free) had the greatest leaf count, at 6.70 leaves, at 90 DAS. Subsequently, there were 6.52 leaves observed in T2, specifically in the context of Sugarcane garbage. The minimum number of leaves, 5.40, was recorded in T6 (Control). Treatment T1 (weed-free) had the greatest number of leaves, followed by treatments T2 and T3 at the time of harvest. The higher prevalence of foliage is directly correlated with the existence of nutrients in the root area, which improves the absorption of nutrients in their consumable state. Consequently, this improves the plant's metabolic processes, resulting in a rise in leaf output and other growth characteristics. Kumar et al. (2022) investigated comparable outcomes in the growth characteristics of sorghum crops.

## Effect of Different Levels of Nutrients and Weed Dynamics on Stem Girth (cm) at 30, 60, 90 DAS and Harvest

The stem girth is significantly influenced by different nutrient levels and weed dynamics in sorghum at 30, 60, and 90 days after sowing (DAS) and at harvest (Table 3). At the 30-day after-sowing (30DAS) stage, treatment T1 (Weed-free) had the biggest stem girth of 6.67 cm, which was statistically equivalent to treatments T2 and T3. Conversely, the treatment T6 Weedy check (Control) had the smallest plant height, measuring 5.61 cm. At 60 days after sowing (DAS), treatment T1 (Weed-free) exhibited the greatest stem girth of 7.65 cm, which was statistically comparable to treatments T2 and T3. The control treatment, T6, had the smallest stem circumference, measuring 6.71 cm. At 90 days after sowing (DAS), the stem girth measurement was 9.26 cm in T1 (Weed free), which was the highest, and 9.12 cm in T2 (Sugarcane trash), which was the second highest. In T6 (Control), the stem girth measurement reached its minimum value of 8.61 cm (Fig. 3). At harvest, the stem with the largest circumference was found in T1 (Weed free), whereas the smallest circumference was seen in T6 (Control). The increase in stem diameter is closely correlated with the availability of nutrients in the root zone. This promotes the assimilation of nutrients in a readily usable form, resulting in enhanced metabolic activities inside the plant. As a result, there is a clear increase in the circumference of the stem and other related characteristics. Kumar et al. (2022) and Bavalgave et al. (2017) reported similar results.

## Effect of Different Levels of Nutrients and Weed Dynamics on Leaf Area Index at 30, 60, and 90 DAS

At 30 days after sowing (DAS), the leaf area index (LAI) was highest in T1 (Weed-free) with a measured value of 2.56, while the lowest LAI was found in T6 (Control) with a value of 1.77. At 60 days after sowing (DAS), treatment T1 (weed-free) exhibited the highest Leaf Area Index (LAI) of 4.90, which was statistically comparable to treatments

Table 4: Effect of different levels of nutrients and weed dynamics on leaf area index at 30, 60, and 90 DAS.

| Treatments | 30 DAS | 60 DAS | 90 DAS |
|---|---|---|---|
| T1: Weed-free | $2.56±0.14^{a}$ | $4.90±0.06^{a}$ | $7.78±0.03^{a}$ |
| T2: Sugarcane trash | $2.44±0.13^{b}$ | $4.70±0.04^{b}$ | $7.71±0.03^{a}$ |
| T3: Vermicompost mulch | $2.30±0.12^{c}$ | $4.36±0.07^{c}$ | $7.57±0.07^{b}$ |
| T4: Live mulch | $1.94±0.03^{d}$ | $3.92±0.02^{d}$ | $6.95±0.01^{c}$ |
| T5: Parthenium extract | $1.83±0.04^{e}$ | $3.80±0.06^{e}$ | $6.86±0.01^{d}$ |
| T6: Weedy check (control) | $1.77±0.02^{f}$ | $3.66±0.04^{f}$ | $6.78±0.03^{e}$ |
| CD | 0.09 | 0.04 | 0.03 |
| CV | 4.94 | 1.26 | 0.53 |
| SE[d±] | 0.04 | 0.02 | 0.01 |
| SE[m±] | 0.03 | 0.01 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

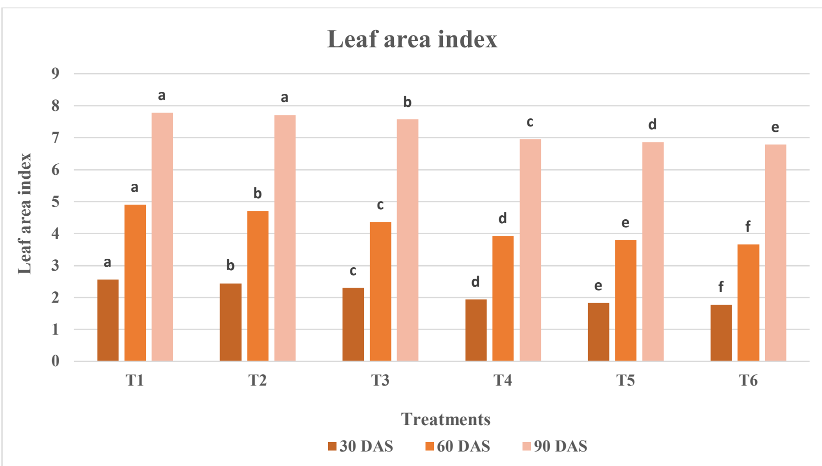


Fig. 4: Influence of different levels of nutrients and weed dynamics on leaf area index at 30, 60, and 90 DAS.

T2 and T3. The control treatment, T6, exhibited the lowest Leaf Area Index (LAI) value of 3.66. According to Table 4, the weed-free treatment (T1) had the highest leaf area index (LAI) of 7.78 at 90 days after sowing (DAS), whereas the control treatment (T1) had the lowest LAI of 6.78 (Table 4 & Fig. 4). Vijayakumar et al. (2014), undertook a comparable assessment and arrived at same findings. The rise in the leaf area index is ascribed to the crucial function of nutrients in aiding the transmission and movement of energy inside plants. Nutrients also play a crucial role in facilitating cell elongation and division.

**Effect of different levels of nutrients and weed dynamics on chlorophyll content (%) at 30, 60, and 90 DAS:** The chlorophyll content is significantly influenced by different levels of nutrient and weed dynamics of sorghum at 30, 60, and 90 DAS (Table 5). The highest chlorophyll level, at 34.73%, was found in T1 (Weed-free) at 30 DAS. T2 (Sugarcane trash) had the second-highest chlorophyll content at 34.52%, while the lowest chlorophyll content of 29.66% was reported in T6 (Control). The chlorophyll content at 60 days after sowing (DAS) was found to be 44.37% in T1 (Weed-free), which was the greatest, and 39.78% in T6 (Control), which was the lowest. At 90 days after sowing (DAS), the chlorophyll content was found to be 53.74% in T1 (Weed free), which was the greatest, and 48.59% in T6 (Control), which was the lowest (Table 5 and Fig. 5). The increase in chlorophyll concentration is believed to be attributed to the presence of nutrients. The nutrition and weed dynamics of sorghum have a vital role in the synthesis of chlorophyll and the promotion of photosynthetic activity, resulting in the production of ATP molecules. These results are in correspondence with the findings of Mishra and Talwar (2020) and Dixit et al. (2015) in sorghum.

## Yield Parameters

**Effect of different levels of nutrients and weed dynamics on yield parameters of sorghum:** Yield attributes including grains/panicle, panicle length (cm), panicle girth (cm), test

Table 5: Effect of different levels of nutrients and weed dynamics on chlorophyll content (%) at 30, 60, and 90 DAS.

| Treatments | 30 DAS | 60 DAS | 90 DAS |
|---|---|---|---|
| T1: Weed-free | 34.73±0.05[a] | 44.37±0.20[a] | 53.74±0.03[a] |
| T2: Sugarcane trash | 34.52±0.10[a] | 43.71±0.12[b] | 52.71±0.03[b] |
| T3: Vermicompost mulch | 34.29±0.11[a] | 43.52±0.09[b] | 52.46±0.05[b] |
| T4: Live mulch | 32.78±0.09[b] | 41.84±0.05[c] | 51.78±0.05[c] |
| T5: Parthenium extract | 31.43±0.04[c] | 41.60±0.18[c] | 49.73±0.01[d] |
| T6: Weedy check (control) | 29.66±0.04[d] | 39.78±0.04[d] | 48.59±0.05[e] |
| CD | 0.07 | 0.13 | 0.03 |
| CV | 0.24 | 0.33 | 0.07 |
| SE[d±] | 0.03 | 0.06 | 0.01 |
| SE[m±] | 0.02 | 0.04 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different (p<0.05).

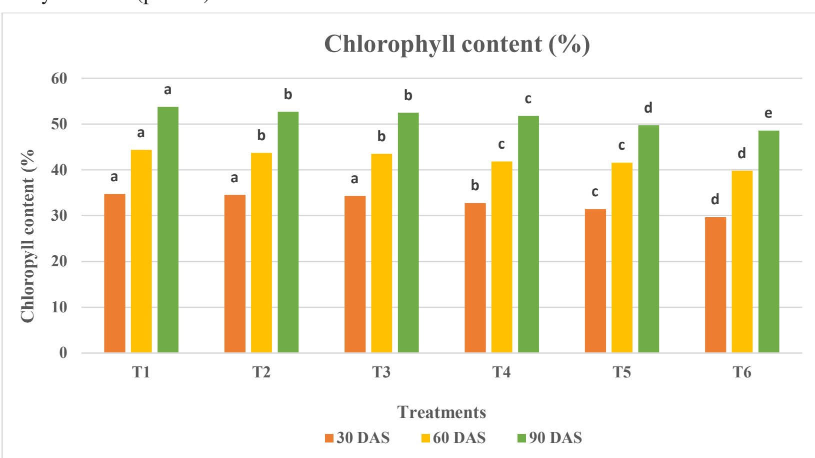


Fig. 5: Influence of different levels of nutrients and weed dynamics on chlorophyll content (%) at 30, 60, and 90 DAS.

Table 6: Effect of different levels of nutrients and weed dynamics on yield parameters of sorghum.

| Treatments | Grains/ panicle | Panicle length [cm] | Panicle girth [cm] | Test weight [g] | Grain yield [$t.ha^{-1}$] | Straw yield [$t.ha^{-1}$] | Harvest index [%] |
|---|---|---|---|---|---|---|---|
| T1: Weed-free | 525.97±1.62[a] | 27.35±0.26[a] | 17.47±0.25[a] | 38.77±0.08[a] | 2.15±0.02[a] | 4.59±0.05[a] | 22.54±0.02[a] |
| T2: Sugarcane trash | 523.45±1.05[b] | 26.99±0.35[b] | 17.28±0.38[a] | 38.51±0.10[a] | 2.06±0.02[a] | 4.49±0.03[b] | 22.41±0.04[a] |
| T3: Vermicompost mulch | 449.77±1.53[c] | 23.34±0.44[c] | 16.92±0.09[b] | 37.45±0.11[b] | 1.89±0.02[b] | 3.92±0.05[c] | 19.61±0.01[b] |
| T4: Live mulch | 447.62±1.57[d] | 22.01±0.51[d] | 15.83±0.37[c] | 37.32±0.13[b] | 1.76±0.01[c] | 3.81±0.07[d] | 18.59±0.05[c] |
| T5: Parthenium extract | 446.27±1.05[d] | 20.47±0.78[e] | 14.00±0.31[d] | 36.60±0.10[c] | 1.69±0.02[d] | 3.68±0.10[e] | 18.36±0.02[c] |
| T6: Weedy check (control) | 390.81±4.09[e] | 19.23±0.43[f] | 13.64±0.35[e] | 36.45±0.08[c] | 1.64±0.01[d] | 3.55±0.09[f] | 17.57±0.04[d] |
| CD | 2.14 | 0.58 | 0.33 | 0.09 | 0.01 | 0.06 | 0.03 |
| CV | 0.49 | 2.71 | 2.30 | 0.27 | 0.98 | 1.81 | 0.18 |
| SE[d±] | 1.02 | 0.28 | 0.16 | 0.04 | 0.01 | 0.03 | 0.01 |
| SE[m±] | 0.72 | 0.19 | 0.11 | 0.03 | 0.01 | 0.02 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

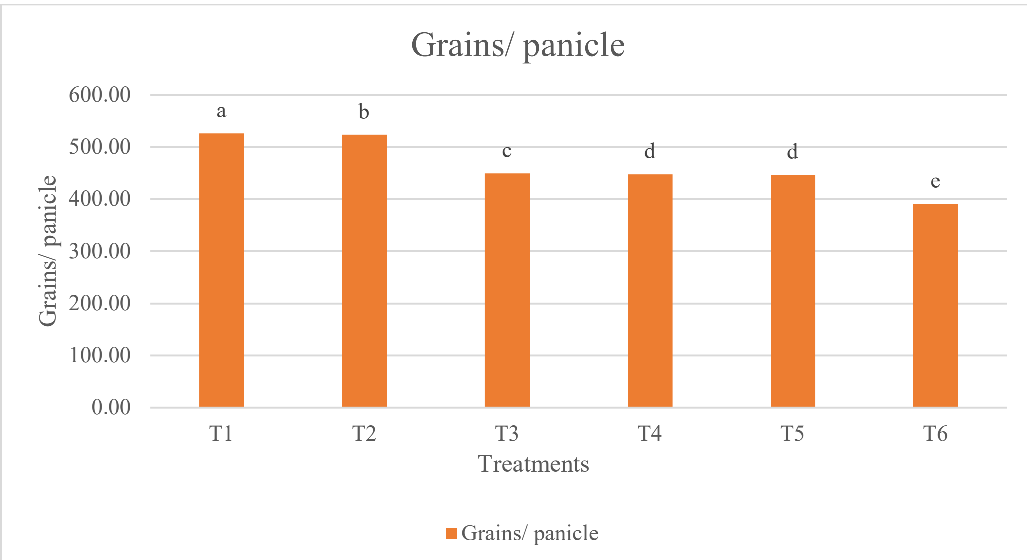


Fig. 6: Influence of different levels of nutrients and weed dynamics on grains per panicle of sorghum.

weight (g), grain yield ($t.ha^{-1}$), straw yield ($t.ha^{-1}$), and harvest index (%), are presented in Table 6 and Fig. 6. The grains per panicle were found to be highest in Treatment T1 (Weed free) at 525.97 and lowest in T6 (Control) at 390.81. The acquired results are comparable to the findings of Ajaykumar (2023). The availability of nutrients and the dynamics of weed growth are responsible for the rise in the number of grains per panicle. The length of the panicles was maximum in T1 (Weed free) at 27.35 cm, followed by T2 (Sugarcane waste) at 26.99 cm, and lowest in T6 (Control) at 19.23 cm (Fig. 7). The highest reported panicle girth was 17.47 cm in T1 (Weed-free), while the lowest was 13.64 cm in T6 (Control). Applying various fertilizers and managing weed growth increased the production characteristics of sorghum by increasing the length and thickness of the panicles. Bajwa et al. (2023) and Kumar et al. (2023) similarly documented similar findings to those described here. The test weight was highest in T1 (Weed-free) at 38.77 g, followed by T2 and T3 treatments. The lowest weight was seen in T6 (Control) at 36.45 g (Fig.8). The highest grain yield was recorded in treatment T1 (Weed free) at a rate of 2.15 $t.ha^{-1}$, followed by treatments T2 and T3 ( Fig. 9). The lowest yield was seen

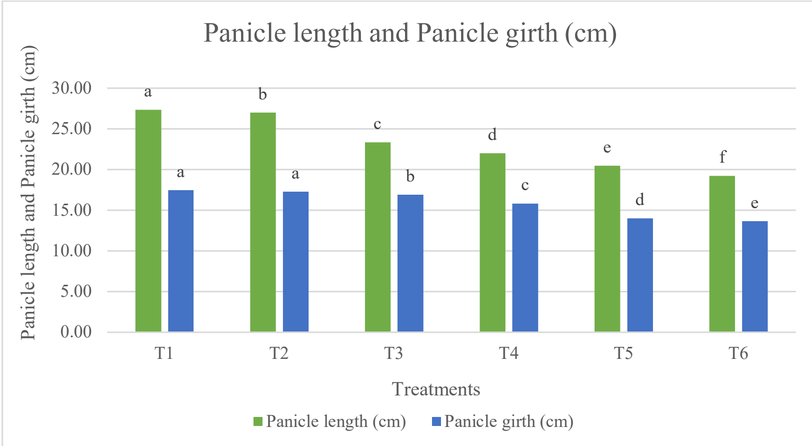


Fig. 7: Influence of different levels of nutrients and weed dynamics on panicle length (cm) and panicle girth(cm) of sorghum.

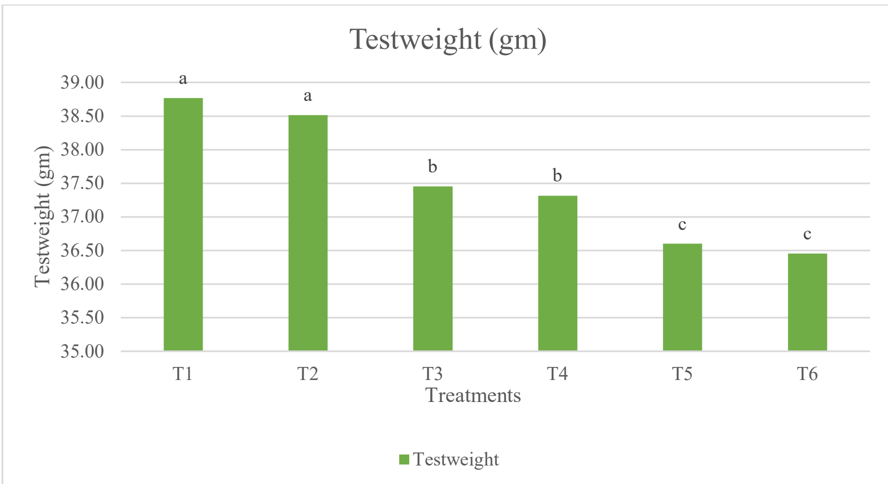


Fig. 8: Influence of different levels of nutrients and weed dynamics on test weight (g) of sorghum.

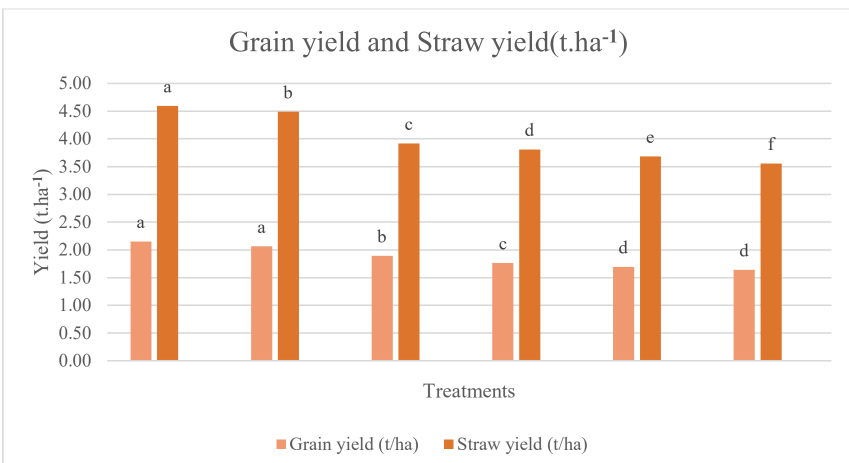


Fig. 9: Influence of different levels of nutrients and weed dynamics on grain yield($t.ha^{-1}$) and straw yield ($t.ha^{-1}$) of sorghum.

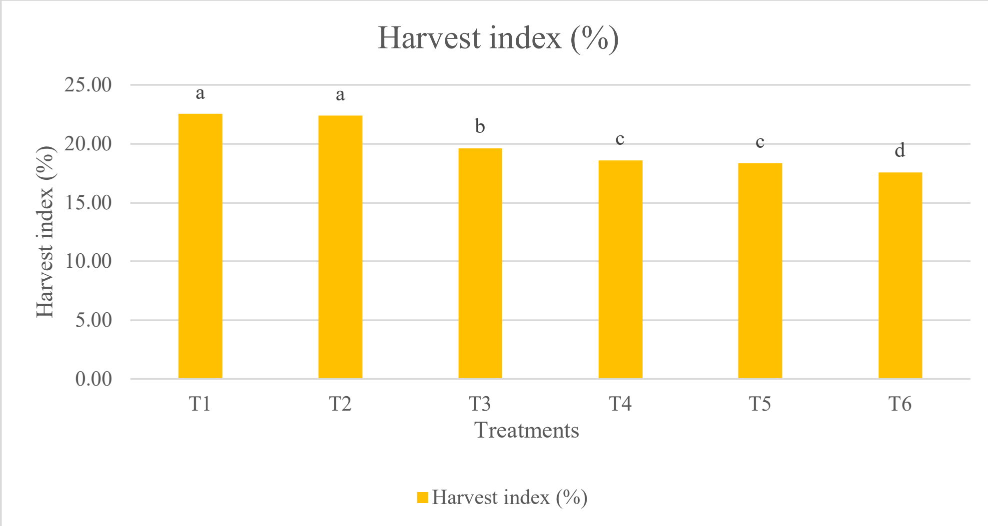


Fig. 10: Influence of different levels of nutrients and weed dynamics on harvest index(%) of sorghum.

Table 7: Effect of different levels of nutrients and weed dynamics on protein content (%) of sorghum.

| Treatments | At harvest |
|---|---|
| T1: Weed-free | 10.84±0.05[a] |
| T2: Sugarcane trash | 10.73±0.03[ab] |
| T3: Vermicompost mulch | 10.51±0.03[ab] |
| T4: Live mulch | 9.83±0.02[c] |
| T5: Parthenium extract | 9.74±0.03[d] |
| T6: Weedy check (control) | 9.65±0.03[e] |
| CD | 0.07 |
| CV | 0.24 |
| SE[d±] | 0.03 |
| SE[m±] | 0.02 |

in treatment T6 (Control) at a rate of 1.64 $t.ha^{-1}$. The highest straw yield was seen in treatment T1 (Weed-free) at a rate of 4.59 $t.ha^{-1}$, while the lowest yield was observed in treatment T6 (Control) at a rate of 3.55 $t.ha^{-1}$ (Table 6). The increased crop output can be due to the enhanced plant growth and yield characteristics affected by the nutrients and diverse weed control strategies. Thakur et al. (2016) and Kumar et al. (2023) achieved similar results. The significant increase in grain and straw production seen in response to diverse treatment combinations can be attributed to enhanced nutrient absorption, which is then distributed to various plant parts. The Harvest index reached its highest value in T1 (Weed-free) at 22.54%, followed by T2 and T3 treatments. The lowest value was found in T6 (Control) at 17.57% (Fig. 10). Various fertilizer inputs and weed management measures

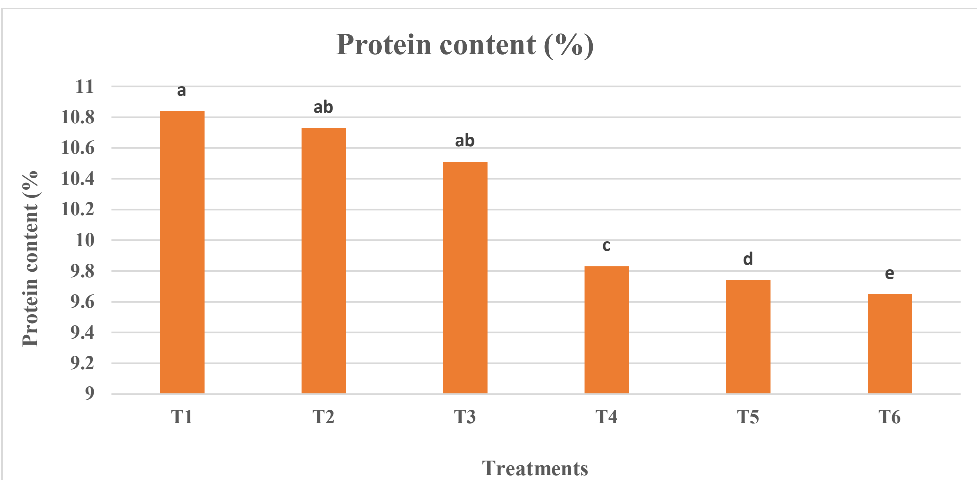


Fig. 11: Influence of different levels of nutrients and weed dynamics on protein content (%) of sorghum.

resulted in a better harvest index value. Similar findings are observed by Thakur et al. (2016).

## Quality Parameters

**Effect of different levels of nutrients and weed dynamics on protein content (%) of sorghum:** The protein content is significantly influenced by different levels of nutrient and weed dynamics of sorghum at harvest (Table 7). The maximum protein content was recorded as 10.84% in T1 (Weed-free), followed by 10.73% in T2 (Sugarcane trash), and the lowest was observed as 9.65% in T6 (Control). The presence of nutrients is thought to be the cause of the rise in protein content. Variations in the nutrient and weed dynamics of sorghum are crucial for the formation of protein( Table 7 and Fig. 11). The crude protein content of sorghum showed significant improvement with all the above nutrient-management practices over the control. The augmentation of protein content in grain sorghum results in an elevation of the prolamin percentage and an improvement in nutritional quality. Environmental variables, such as location, chemical fertilizers, plant population, and chemical treatments, have an impact on the protein content and amino acid pattern. These results align with the discoveries made by Mishra & Talwar (2020) and Dixit et al. (2015) in the field of sorghum.

## Weed Parameters

**Effect of different levels of nutrients and weed dynamics on the weed population of sorghum:** The weed population is significantly influenced by different levels of nutrient and weed dynamics of sorghum at 30, 60, 90, and 120 DAS (Tables 8 and 9). At 30 DAS, the maximum weed population was recorded as 8.33 in dicots, followed by monocots and

Table 8: Effect of different levels of nutrients and weed dynamics on weed population of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | |
| T1: Weed-free | 0.00±0.00$^{d}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ |
| T2: Sugarcane trash | 1.00±0.96$^{c}$ | 4.67±1.26$^{d}$ | 3.33±2.50$^{c}$ | 3.67±1.09$^{d}$ | 5.33±1.26$^{b}$ | 0.33±0.96$^{d}$ |
| T3: Vermicompost mulch | 2.67±2.22$^{b}$ | 6.00±0.96$^{b}$ | 6.00±1.73$^{b}$ | 5.33±1.30$^{b}$ | 5.33±1.26$^{b}$ | 1.00±0.96$^{c}$ |
| T4: Live mulch | 1.33±1.26$^{c}$ | 5.00±1.29$^{c}$ | 2.33±0.50$^{d}$ | 3.00±0.83$^{d}$ | 3.33±0.50$^{d}$ | 3.00±2.22$^{b}$ |
| T5: Parthenium extract | 1.33±0.82$^{c}$ | 4.67±1.50$^{d}$ | 2.33±1.83$^{d}$ | 4.33±1.48$^{c}$ | 4.00±0.96$^{c}$ | 1.00±0.82$^{c}$ |
| T6: Weedy check (control) | 6.33±1.71$^{a}$ | 8.33±2.08$^{a}$ | 8.00±2.16$^{a}$ | 8.00±3.56$^{a}$ | 9.33±4.93$^{a}$ | 8.33±5.85$^{a}$ |
| CD | 1.86 | 1.61 | 2.10 | 3.13 | 3.32 | 3.50 |
| CV | 95.01 | 36.35 | 61.74 | 83.24 | 78.67 | 165.54 |
| SE(d±) | 0.89 | 0.77 | 1.00 | 1.50 | 1.59 | 1.67 |
| SE(m±) | 0.63 | 0.54 | 0.71 | 1.06 | 1.12 | 1.18 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different (p<0.05).

Table 9: Effect of different levels of nutrients and weed dynamics on weed population of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 90 DAS | | | 120 DAS | | |
| T1: Weed free | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{e}$ | 0.00±0.00$^{d}$ |
| T2: Sugarcane trash | 5.33±1.41$^{c}$ | 6.00±0.96$^{c}$ | 0.33±0.58$^{d}$ | 4.67±1.26$^{d}$ | 5.67±0.96$^{c}$ | 1.00±0.82$^{b}$ |
| T3: Vermicompost mulch | 6.00±1.96$^{b}$ | 6.33±0.82$^{c}$ | 0.67±0.82$^{c}$ | 7.00±1.29$^{b}$ | 6.33±0.82$^{b}$ | 0.67±0.82$^{c}$ |
| T4: Live mulch | 4.33±3.11$^{d}$ | 5.00±0.96$^{d}$ | 0.00±2.52$^{e}$ | 4.33±1.71$^{d}$ | 4.00±0.82$^{d}$ | 2.33±0.96$^{b}$ |
| T5: Parthenium extract | 5.67±1.50$^{c}$ | 7.33±0.82$^{b}$ | 1.33±0.50$^{b}$ | 5.00±1.29$^{c}$ | 5.00±0.82$^{c}$ | 1.33±0.50$^{a}$ |
| T6: Weedy check (control) | 8.67±0.96$^{a}$ | 12.00±1.29$^{a}$ | 2.33±0.58$^{a}$ | 9.00±1.71$^{a}$ | 11.67±1.41$^{a}$ | 2.33±0.58$^{a}$ |
| CD | 2.09 | 1.00 | 0.60 | 1.43 | 1.30 | 0.96 |
| CV | 44.99 | 17.65 | 83.08 | 30.89 | 25.88 | 81.69 |
| SE[d±] | 1.00 | 0.48 | 0.28 | 0.68 | 0.62 | 0.46 |
| SE[m±] | 0.70 | 0.33 | 0.20 | 0.48 | 0.44 | 0.32 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different (p<0.05).

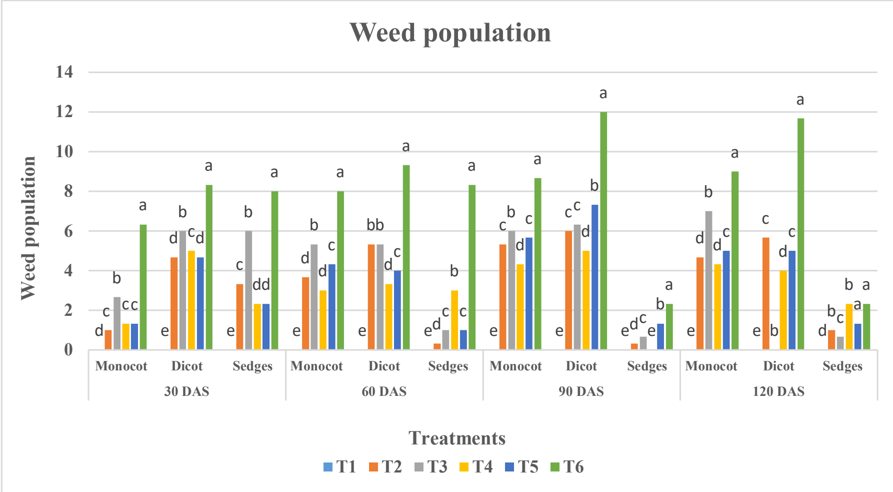


Fig. 12: Influence of different levels of nutrients and weed dynamics on the weed population of sorghum.

Table 10: Effect of different levels of nutrients and weed dynamics on weed control efficiency (%) of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | |
| T1: Weed-free | 100±0.11[a] | 100±0.07[a] | 100±0.05[a] | 100±0.47[a] | 100±0.06[a] | 100±0.06[a] |
| T2: Sugarcane trash | 64.27±0.06[b] | 66.38±0.06[b] | 63.59±0.04[b] | 73.59±0.04[b] | 75.38±0.05[b] | 72.41±0.02[b] |
| T3: Vermicompost mulch | 55.69±0.05[c] | 61.27±0.05[c] | 54.29±0.06[c] | 71.38±0.04[c] | 72.38±0.05[c] | 69.48±0.05[c] |
| T4: Live mulch | 52.58±0.04[d] | 59.49±0.04[d] | 51.49±0.03[d] | 69.48±0.04[d] | 71.53±0.07[d] | 67.58±0.04[d] |
| T5: Parthenium extract | 51.48±0.05[e] | 58.69±0.02[e] | 49.64±0.06[e] | 67.28±0.06[e] | 69.46±0.03[e] | 66.37±0.04[e] |
| T6: Weedy check (control) | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] |
| CD | 0.05 | 0.04 | 0.04 | 0.29 | 0.05 | 0.04 |
| CV | 0.11 | 0.09 | 0.11 | 0.52 | 0.09 | 0.07 |
| SE[d±] | 0.02 | 0.02 | 0.02 | 0.13 | 0.02 | 0.01 |
| SE[m±] | 0.01 | 0.01 | 0.01 | 0.09 | 0.01 | 0.01 |

Data is presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different (p<0.05).

Table 11: Effect of different levels of nutrients and weed dynamics on weed control efficiency (%) of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 90 DAS | | | 120 DAS | | |
| T1: Weed-free | 100±0.08[a] | 100±0.07[a] | 100±0.09[a] | 100±0.13[a] | 100±0.07[a] | 100±0.08[a] |
| T2: Sugarcane trash | 81.35±0.13[b] | 83.38±0.11[b] | 80.82±0.36[b] | 91.45±0.10[b] | 92.37±0.05[b] | 89.48±0.05[b] |
| T3: Vermicompost mulch | 79.59±0.09[c] | 81.33±0.05[c] | 79.34±0.11[c] | 89.74±0.03[c] | 91.35±0.10[c] | 88.59±0.04[c] |
| T4: Live mulch | 76.48±0.06[d] | 78.58±0.04[d] | 76.30±0.02[d] | 87.68±0.03[d] | 89.39±0.04[d] | 86.28±0.04[d] |
| T5: Parthenium extract | 75.35±0.03[e] | 77.31±0.06[e] | 75.17±0.05[e] | 86.21±0.09[e] | 88.48±0.03[e] | 85.38±0.06[e] |
| T6: Weedy check (control) | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] | 0.00±0.00[f] |
| CD | 0.07 | 0.07 | 0.20 | 0.10 | 0.07 | 0.04 |
| CV | 0.12 | 0.11 | 0.33 | 0.15 | 0.10 | 0.06 |
| SE(d±) | 0.03 | 0.03 | 0.09 | 0.05 | 0.03 | 0.02 |
| SE(m±) | 0.02 | 0.02 | 0.06 | 0.03 | 0.02 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different (p<0.05).

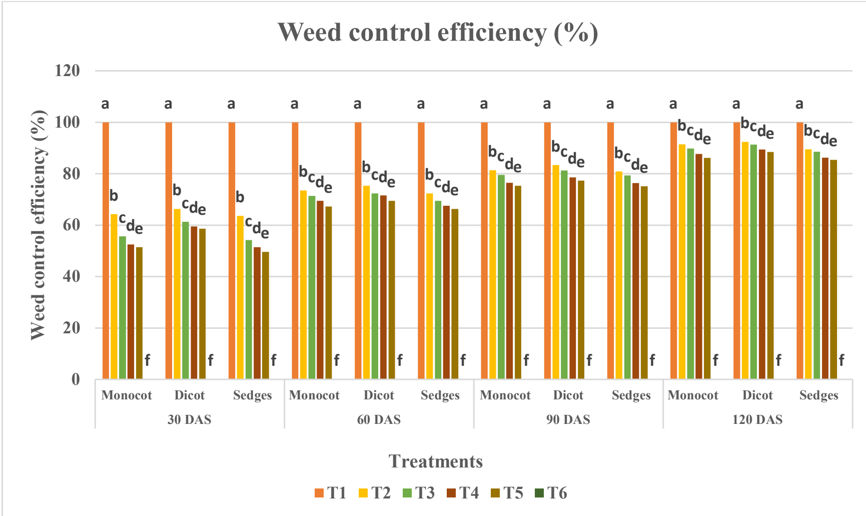


Fig. 13: Influence of different levels of nutrients and weed dynamics on weed control efficiency (%) of sorghum.

Table 12: Effect of different levels of nutrients and weed dynamics on weed dry weight (g) of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | |
| T1: Weed-free | 1.15±0.03[f] | 1.18±0.04[f] | 1.09±0.02[f] | 1.39±0.04[f] | 1.49±0.03[f] | 1.35±0.04[f] |
| T2: Sugarcane trash | 4.45±0.03[c] | 4.56±0.02[c] | 4.42±0.04[c] | 5.69±0.04[c] | 5.79±0.02[c] | 5.67±0.03[c] |
| T3: Vermicompost mulch | 4.28±0.04[d] | 4.36±0.03[d] | 4.24±0.05[d] | 5.44±0.02[d] | 5.46±0.02[d] | 5.43±0.06[d] |
| T4: Live mulch | 4.16±0.03[e] | 4.19±0.02[e] | 4.13±0.03[e] | 5.37±0.05[e] | 5.39±0.07[e] | 5.30±0.04[e] |
| T5: Parthenium extract | 4.52±0.08[b] | 4.69±0.02[b] | 4.50±0.08[b] | 6.27±0.06[b] | 6.34±0.05[b] | 6.19±0.04[b] |
| T6: Weedy check (control) | 5.48±0.03[a] | 5.56±0.03[a] | 5.35±0.04[a] | 6.67±0.04[a] | 6.71±0.03[a] | 6.61±0.03[a] |
| CD | 0.06 | 0.03 | 0.05 | 0.05 | 0.03 | 0.04 |
| CV | 1.67 | 0.83 | 1.58 | 1.07 | 0.75 | 0.89 |
| SE[d±)] | 0.02 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 |
| SE[m±] | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

Table 13: Effect of different levels of nutrients and weed dynamics on weed dry weight (g) of sorghum.

| Treatments | Monocot | Dicot | Sedges | Monocot | Dicot | Sedges |
|---|---|---|---|---|---|---|
| | 90 DAS | | | 120 DAS | | |
| T1: Weed-free | 1.78±0.04[f] | 1.82±0.04[f] | 1.69±0.02[f] | 1.94±0.03[f] | 1.96±0.02[f] | 1.89±0.03[f] |
| T2: Sugarcane trash | 6.79±0.03[c] | 6.82±0.03[c] | 6.71±0.03[c] | 8.48±0.04[c] | 8.59±0.04[c] | 8.49±0.03[c] |
| T3: Vermicompost mulch | 6.61±0.04[d] | 6.69±0.03[d] | 6.59±0.03[d] | 8.35±0.04[d] | 8.41±0.02[d] | 8.25±0.03[d] |
| T4: Live mulch | 6.49±0.03[e] | 6.52±0.03[e] | 6.47±0.03[e] | 8.17±0.05[e] | 8.25±0.04[e] | 8.14±0.02[e] |
| T5: Parthenium extract | 7.18±0.03[b] | 7.19±0.03[b] | 7.14±0.03[b] | 9.66±0.04[b] | 9.74±0.02[b] | 9.64±0.03[b] |
| T6: Weedy check (control) | 7.38±0.05[a] | 7.41±0.05[a] | 7.34±0.07[a] | 9.72±0.04[a] | 9.78±0.02[a] | 9.70±0.04[a] |
| CD | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 |
| CV | 0.73 | 0.81 | 0.82 | 0.62 | 0.42 | 0.51 |
| SE(d±) | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |
| SE(m±) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

Data are presented in the form of mean (n=3). CD = Critical difference, CV = Critical variance, SE = Standard error. Different superscripts present in the same column are significantly different ($p<0.05$).

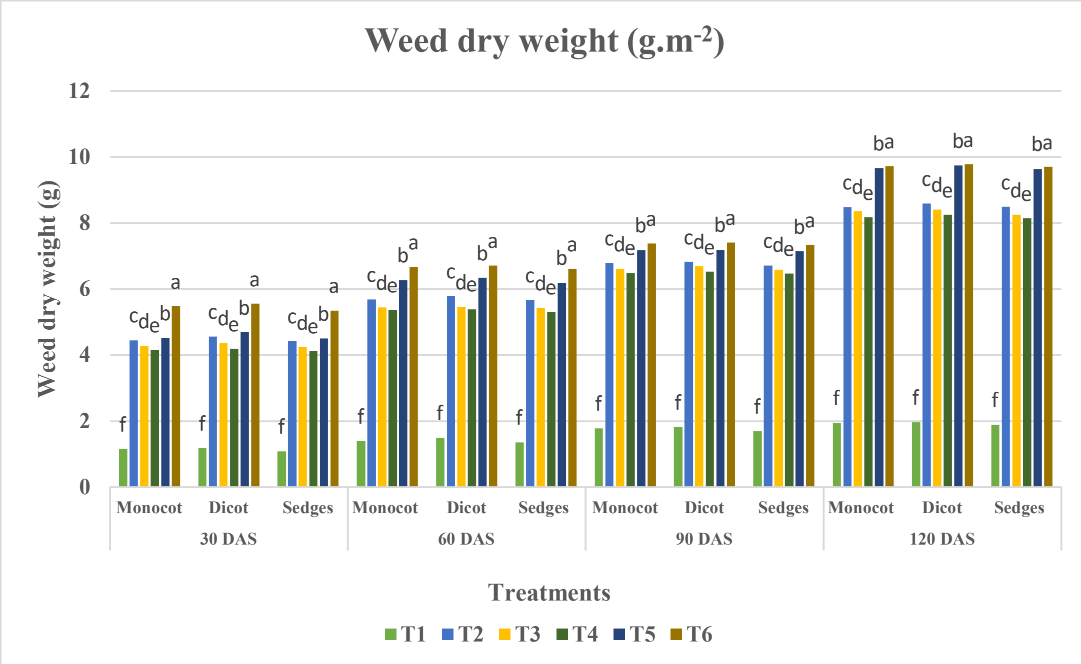


Fig. 14: Influence of different levels of nutrients and weed dynamics on weed dry weight (g.m$^{-2}$) of sorghum.

sedges in T6 (Control), and the lowest was observed as 0.00 in T1 (Weed-free). At 60 DAS, the highest weed population was reported as 9.33 in dicots, followed by sedges and monocots in T6 (Control), and the lowest was recorded as 0.00 in T1 (Weed-free). At 90 DAS, the highest weed population was examined as 12.00 in T6 (Control), and the lowest was recorded as 0.00 in T1 (Weed-free). At 120 DAS, the highest weed population was recorded as 11.67 in dicots, followed by monocots and sedges in T6 (Control), and the lowest was observed as 0.00 in T1 (Weed-free). The weed population was maximum in the control treatment as no treatment to control weeds was applied, and the lowest was observed in weed-free treatment (Tables 8 and 9, Fig. 12). These results are in correspondence with the findings of Singh et al. (2012) and Thakur et al. (2016) in sorghum.

**Effect of different levels of nutrients and weed dynamics on weed control efficiency (%) of sorghum:** The weed control efficiency is significantly influenced by different levels of nutrient and weed dynamics of sorghum at 30, 60, 90, and 120 DAS (Tables 10 and 11). At 30 days after sowing (DAS), the highest level of weed control effectiveness was recorded as 100% in dicots, followed by monocots and sedges in treatment T1 (weed-free). The lowest level of weed control effectiveness was found as 0.00% in treatment T6 (control). At 60 days after sowing (DAS), the weed control effectiveness was highest, reaching 100%, in dicots. Monocots and sedges followed with lower efficiency. This was observed in treatment T1, where the weeds were completely removed. The lowest weed control efficiency was recorded as 0.00% in treatment T6, which served as the control group. At 90 days after sowing (DAS), the weed control effectiveness was found to be 100% in treatment T1 (Weed-free), which was the highest observed. The lowest weed control efficiency of 0.00% was recorded in treatment T6 (Control). At 120 days after sowing (DAS), the weed control effectiveness was highest at 100% in dicots, followed by monocots and sedges in treatment T1 (weed-free). The lowest weed control efficiency was detected at 0.00% in treatment T1 (control). The weed control efficacy was highest in the treatment where no weeds were present, whereas the lowest efficacy was seen in the control treatment (Tables 10 and 11, Fig. 13). Ajaykumar (2023) found similar findings.

**Effect of different levels of nutrients and weed dynamics on weed dry weight (g) of sorghum:** The weed dry weight is significantly influenced by different levels of nutrient and weed dynamics of sorghum at 30, 60, 90, and 120 DAS (Tables 12 and 13). At 30 DAS, maximum weed dry weight was recorded as 5.56 in dicots followed by monocots and sedges in T6 (Control), and lowest was observed as 1.18 in T1 (Weed free). At 60 days after sowing (DAS), the dicots had the highest weed dry weight, measuring 6.71, followed by monocots and sedges in treatment T6 (Control). The lowest weed dry weight, measuring 1.49, was recorded in treatment T1 (Weed free). At 90 days after sowing (DAS), the weed dry weight was greatest in treatment T6 (Control) at 7.41, while the lowest weight was obtained in treatment T1 (Weed-free) at 1.82. The weed dry weight reached its peak at 120 DAS, with dicots having the highest recorded value of 9.78, followed by monocots and sedges in T6 (Control). The lowest weed dry weight was found in T1 (Weed free), with a value of 1.96 ( Tables 12 and 13, and Fig. 14). The primary reason for this was the improved management of weed development, which led to a reduction in the overall weight of weeds at the time of harvest. These data support the conclusions of Jat et al. (2016).

## CONCLUSIONS

In the present experiment, the effect of comparative analysis of mulching and weed management practices on nutrient and weed dynamics of Kharif sorghum on growth, yield, and weed parameters was studied. It was concluded from the results that the application of T1 treatment (Weed-free) followed by T2 (Sugarcane trash) and T3 (Vermicompost mulch) improves the growth, yield, and weed components of sorghum. Integrated weed management (IWM) involves integrating many tactics to reduce weeds. To accomplish effective weed control, integrated weed management requires systematic integration of several components. Mulching materials are commonly employed in the establishment of various plant and tree species. Mulches improve plant germination, survival, seedling transfer, and crop performance compared to unmulched treatments. Proper management of vital inputs, including tillage, fertilizers, and weeds, is crucial for improving overall production and stability. Weed control approaches for sorghum should be efficient, cost-effective, and ecologically friendly.

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