Examining the Impact of Various Nitrogen Concentrations on the Productivity of Diverse Sorghum Genotypes in the Context of Pakistan's Climatic Conditions

ABSTRACT

Pakistan ranks among the nation's most vulnerable to the ongoing and anticipated impacts of climate change. Cropping in Pakistan is bearing various climate challenges like temperature extremes drought flood heavy rains hails wind storms increase in Co_2, greenhouse gases and CFCs.Sorghum (*Sorghum bicolor* L. Moench) is a predominant crop in arid regions. A field experiment involving six sorghum cultivars and three distinct nitrogen levels was conducted at the Faculty of Agriculture, Gomal University, Dera Ismail Khan during the Kharif season of 2017. The cultivars, nitrogen levels, and their interactions had a significant influence on plant height (cm), leaf area (cm^2), crop growth rate (gm^{-2} day^{-1}), panicle elongation (cm), number of grains per panicle, grain weight (g), biomass production (kg ha^{-1}), and economic yield (kg ha^{-1}). The sorghum genotype JS-263, with an NPK dose of 120:75:60 kg ha^{-1}, exhibited the highest grain yield and yield-related parameters. This high-yielding sorghum cultivar and optimal nitrogen level could be utilized for enhanced yield and productivity.

Keywords: Sorghum;nitrogen;nutrient;kharifseason;NPK; climate change.

INTRODUCTION

The escalating demand for food and feed has sparked significant interest in the evolving climate scenario for sustainable agriculture. The choice of crop and its cultivation is intrinsically linked to nutrient availability, which serves as the cornerstone for achieving maximum productivity on a sustainable basis. Sorghum (Sorghum bicolor (L.) Moench) constitutes 43% of all major food staples with respect to animal and human consumption [1]. Among cereals, Sorghum (Sorghum bicolor L. Moench) provides food, forage, sugar, and biofuel (ethanol) globally [2]. It is primarily cultivated in extremely arid regions due to its drought resistance. Sorghum is transformed into a variety of products worldwide [3] making its production and utilization of paramount importance [4].It is cultivated in Pakistan during 2022 on 59 thousand hectare and produce 49 thousand tonnes grain production while there is decrease in production from previous year 2021 is 23.4% [5].The suboptimal field and environmental conditions result scanty growth and successively low productivity of agronomic crop including sorghum [6]. Therefore, plant breeders are needed to design improved varieties acquiring some acceptable agronomic and physiological characters for acquisition of professional aims [7] to secure satisfactory economic returns under uncertain conditions [8]. The acceptability and adjustability of advanced breeding lines of sorghum for a specific cultivated area should be experienced to recommend the variety exhibits higher productivity with sustainability [9], [10], [11].

Dera Ismail Khan situated in the semi-arid zone of Khyber Pakhtunkhwa, (Pakistan) situated on 71.07 longitude and 31.57 latitude and 500 m over the ocean level and arranged along the bank of Indus River [12]. The crop production in arid region becomes critical due to irrigation water scarcity, soil salinity and sodicity. Secondly, extremely high temperature of arid and semi-arid region tends to increase evapotranspiration and prevent removal of salts from soil surface and ultimately threat to sustainable productivity of major crop [13]. Arid and semiarid climate impact on plant functional traits including morphology, photosynthesis and respiration which results in shorter growth cycle and less accumulation of biomass before seed [14]

Sorghum serves both household and industrial consumption. The practice of continuous cropping and reliance on inherent soil fertility by subsistence farmers has led to the depletion of soil nutrient status. A significant constraint to sorghum production is low soil fertility, resulting from farmers' reliance on native soil fertility due to limited or no access to agricultural inputs [15].

Sorghum, belonging to the family Gramineae (Poaceae), is a renowned crop of arid and semi-arid regions where water scarcity and heat stress pose major constraints in crop production. Sorghum serves as an excellent alternative cereal feed crop in areas with limited water availability [16]. As a C_4 crop, Sorghum can withstand both irrigated and intense heat conditions, showing resistance to drought, waterlogged, and saline conditions [17]. The main challenges include the unavailability of sorghum genotypes tolerant to drought and heat, deficiency of sorghum hybrid, poor crop management, and minimal use of fertilizers. Nitrogen is the next limiting factor for plant growth after water. Sorghum cultivars may exhibit varied responses to synthetic fertilizers, particularly nitrogen fertilization [18], and various nutrients can enhance sorghum yield. The cultivars can also contribute significantly to boosting its yield and production. Hugar et al. [19] reported that sorghum cultivars display significant differences in grain yield, thousands grain yield, and number of grains per panicle. Azrag*et al.*[9] stated that the grain yield of sorghum can be increased with the application of nitrogen. Moghimi and Eman (2015) [21] evaluated the effect of diverse N-doses on different sorghum cultivars, indicating that all nitrogen levels significantly increased plant height, leaf area index, biological, and grain yield. We have to enhance the grain production of sorghum for speedy growth of population in Pakistan with all biotic and abiotic stresses for food security in climate change scenario. The primary objective of the study was to identify the high-yielding sorghum cultivar and optimal nitrogen level for enhanced yield and productivity of sorghum under the agro-ecological conditions of Dera Ismail Khan, Pakistan.

MATERIALSANDMETHODS

LocationandExperimental Layout

This study was conducted at the Research Farm of the Faculty of Agriculture, Gomal University, Khyber Pakhtunkhawa, Dera Ismail Khan, Pakistan (31.8626°N, 70.9019°E) during the Kharif season of 2017. The mean maximum temperature ranged from 36°C to 50°C in June. The experimental soil was characterized as hard clay with a pH of 8.5, nitrogen content of 0.023%, phosphorus content of 6.8%, and low organic matter content (0.45%), indicative of an arid climate. The experimental design employed was a split plot. The sorghum cultivars were allocated to the main plots, while the nitrogen levels were randomized in the subplots. Each subplot, measuring 10m² (2 × 5), contained six rows of sorghum with a row-to-row and plant-to-plant distance of 60 cm and 30 cm, respectively. The soil was thoroughly prepared and leveled with a laser land leveler to create an optimal seedbed. A recommended seed rate of 30 kg ha^{-1} was used for planting. The cultivars included in the study were Desi sorghum, Js-263, Pak SS2, Dera Jawar, Giza-3, and T-3- dadu, while the nitrogen levels studied were 40, 80, and 120 kg ha^{-1}. The entire dose of phosphorus (60 kg ha^{-1}) was incorporated into the soil during the planting operation. Nitrogen was applied in two equal splits according to the different levels studied. The first half of the nitrogen was applied at the time of sowing, while the remaining half-dose of nitrogen was supplied with the first irrigation. All other agronomic practices were carried out in accordance with local recommendations. A total of four irrigations were applied throughout the growing season.

MethodologyforDataCollection

For the purpose of data collection, twelve plants were randomly selected from the inner lines of each treatment. These plants were used to measure both physiological and morphological characteristics. These characteristics included leaf area (cm^2), measured at two distinct growth stages (60 days and 90 days post-sowing), plant height, crop growth rate (g m^{-2} day^{-1}), green pigments (specifically, chlorophyll content measured in µgcm^{-2}), panicle length (cm), number of grains per panicle, 1000-grain weight (g), biomass production (kg ha^{-1}), and grain yield (kg ha^{-1}).

Statistical Analysis

The data were subjected to statistical analysis using a software package specifically designed for statistical computations. The technique employed was Analysis of Variance (ANOVA), and the means were differentiated using the Least Significant Difference (LSD) test at a 5% level of probability [10].

RESULTSANDDISCUSSION

LeafArea(60DAS)

Leaves are often regarded as the photosynthetic apparatus of plants. The leaf area, as presented in Table 1, was significantly influenced by different sorghum cultivars and nitrogen (N) doses. However, the interaction between cultivars and N doses was not statistically significant. Despite this, visual differences among the various treatments were observed. Taking into account the treatments interaction, the leaf area of sorghum genotypes (at 60 DAS) ranged from 378.0 to 982.33 cm^2. These observed differences could potentially be attributed to varying levels of N. The cultivar JS-263 recorded the highest leaf area (839.77 cm^2), which was statistically comparable to the cultivar T-3-Dadu (741.22 cm^2). Similarly, the highest leaf area (781.22 cm^2) was recorded with an N application of 120 kg ha^{-1}. All cultivars exhibited good performance at the 120 kg ha^{-1} N level. This could be explained by the fact that N application enhances protein synthesis and cell mitosis, leading to an increase in cell size that subsequently boosts leaf length and width [22]. Our findings are in agreement with those of Pholsen et al. [23]. Akram et al. [24] and [25] also observed similar outcomes, concluding that higher N doses increase the leaf area.Perez et al. (2021) [26] explained about abiotic stresses like heat and temperature disturbed metabolism pathways of plants.Furthermore, the genetic variability among sorghum lines extends beyond plant height variation and also manifests in the number of leaves. Bello et al. (2007) [27] observed that different sorghum lines exhibited differences in the number of leaves. Specifically, the genotype SS 97-2(81) demonstrated a strong resistance to arid climates, allowing it to express its maximum genetic potential and produce a higher number of leaves (Faridullah et al. 2009) [28]. Ayub et al. (2010) [29] also noted significant differences in leaf count per plant, which can be attributed to variations in the genetic makeup of the sorghum cultivars.

LeafArea(90DAS)

Photosynthesis is a physiological process wherein the aerial green parts of plants synthesize food by capturing sunlight, absorbing CO_2 from the atmosphere, and drawing water from the soil. The leaf is the primary site where this process occurs. The total leaf area of a plant is a critical physiological attribute, as leaves are the primary source of food production that maintains the source-sink relationship and ultimately determines the grain yield and its components. Data on leaf area (cm^2) at 90 days after sowing (DAS) (Table 2) indicated significant diversity among different sorghum cultivars and nitrogen (N) levels. However, the interaction between cultivars and N levels was not statistically significant. The highest leaf area (cm^2) was recorded for the cultivar JS-263, followed by Pak SS-2. The highest leaf area (1637 cm^2) was observed with an N application of 120 kg ha^{-1} compared to other levels. Our findings, which demonstrate that increasing N levels increase leaf area, are supported by Akram et al. [30] and Khalid et al. (2010) [25]. In general, photosynthetic efficiency is dependent on the total leaf area per plant [31]. Naseer et al. [32] also highlighted the importance of leaf area, chlorophyll content, and mesophyll tissue in photosynthesis and the conversion of photosynthates into economically valuable components.Hussain et al., (2021) [33] also found at par results with our research. The high yielding varieties have more leaves area per m^2 and high photosyntheticefficiency which gave them ideal assimilation to sink resulted high grain yield.(Ghosh *et al.,* 2015) [34].

PlantHeight(cm)

The data presented in Table 3 reveal significant differences in the plant height among the six sorghum cultivars. Both the individual and interactive effects of the sorghum cultivars and nitrogen (N) levels were statistically significant. In this investigation, various Nitrogen concentration applied to sorghum enhanced plant growth length with an increase in nitrogen concentration. It showed direct relationship of plant growth with nitrogen supply.As the N application increased from 40 kg ha^{-1} to 120 kg ha^{-1}, there was a corresponding increase in plant height. The maximum plant height (357.90 cm) was observed with an N application of 120 kg ha^{-1}. The cultivars JS-263 and T-3-Dadu exhibited greater plant height compared to the other cultivars. Our results align with the findings of Miko and Manga [35], who reported positive effects of N on sorghum. The taller stature of JS-263 and T-3-Dadu can be attributed to their genetic traits and efficient utilization of available nutrients.

SorghumGrowthRate($gm^{-2}day^{-1}$)

Growth, a fundamental characteristic inherent to all living organisms, is quantified in plants by assessing the increase in fresh weight, dry weight, and leaf volume. Growth parameters, such as leaf area index (LAI) and crop growth rate (CGR), are crucial for the photosynthesis and other physiological functions of sorghum plants, which in turn influence the grain yield and dry matter production. These parameters vary physiologically among different lines or cultivars under the agro-climatic conditions of a specific area.

As delineated in Table 4, significant variations in the crop growth rate (expressed in gm m^{-2} day^{-1}) were observed across different nitrogen levels and cultivars. The sorghum cultivar JS-263 exhibited the highest Crop Growth Rate (CGR) of 13.71, closely followed by T-3- Dadu. This maximum CGR was observed with a nitrogen level of 120 kg ha^{-1}. The superiority of the sorghum cultivar JS-263, particularly in terms of its maximum leaf area and plant height, was noteworthy. Comparable results were obtained by Olubemi and Ababyomi [36] through the application of varying doses of nitrogen in sorghum.Per3z *et al.,* (2021) [26] told the role of major nutrient like Nitrogen and salinity in the growth of plants. They concluded that water movement and nutrients changed metabolic and physiological activities of plant and Nitrogen enhanced the plant growth rate.

Table1.Leaf area(cm^{-2})ofsorghumcultivarsasinfluencedbydifferentnitrogenlevels(60 DAS)

	Nitrogenlevels			
Cultivars	**40kg ha^{-1}**	**80kgha^{-1}**	**120 kgha^{-1}**	**Mean**
DesiSorghum	413.7 ^{NS}	626.3	822.67	622.33 bc
Js-263	702.0	835.0	982.33	839.77 a
Pak SS2	378.0	636.0	716.67	576.89 bc
DeraJawar	424.0	593.0	575.0	530.66 c
Giza-3	435.0	669.0	709.0	604.33 bc
T-3-Dadu	553.0	789.0	881.67	741.22 ab
Mean	484.28c	692.38 b	781.22 a	

Meanssharingthesamelettersarenon-significantat5%levelofprobability.$LSD_{0.05}$
Cultivars=203.56
Nitrogen levels =77.29NS=Non-significant

Table2.Leaf area(cm^{-2})ofsorghumgenotypesasinfluencedbyN-doses(90 DAS)

Nitrogenlevels

Cultivars	40kgha^{-1}	80kgha^{-1}	120kgha^{-1}	Mean
DesiSorghum	968.7^{NS}	1033.7	1505.3	1169.2b
Js-263	1530.7	1965.3	2022.7	1839.5 a
Pak SS2	1302.0	1469.0	2070.0	1614.6 a
DeraJawar	902.0	1109.7	1446.3	1152.4b
Giza – 3	837.3	1047.0	1187.7	1024.0b
T-3-Dadu	939.0	1183.7	1594.7	1239.1b
Mean	1079.9 c	1301.2b	1637a	

Means with alike letters are in-significant at 5% level of probability.$LSD_{0.05}$
Cultivars = 296.07Nitrogen levels = 151.24NS=Non-significant

Table3.Plantheight(cm)ofsorghumcultivarsasinfluencedbynitrogendoses

	Nitrogenlevels			
Cultivars	40kgha^{-1}	80kgha^{-1}	120kgha^{-1}	Mean
DesiSorghum	200.6 h	267.74 e	287.59 d	251.98 d
Js-263	194.26 h	247.08 f	258.54 ef	333.30 a
Pak SS2	267.88 e	293.29 d	313.31 c	291.50 b
DeraJawar	228.14g	267.89 e	287.52 d	261.18 c
Giza – 3	267.72 e	289.24 d	318.79 c	291.91 b
T-3-Dadu	296.45 d	342.99 b	357.90 a	330.19 a
Mean	242.50 c	284.70 b	303.94 a	

Meanswith alikelettersarein-significantat5%levelofprobability.$LSD_{0.0}$
Cultivars = 3.84Nitrogen levels = 7.22Interaction= 14.95

Chlorophyll Content (µ gm cm-2)

Chlorophyll content of sorghum were investigated through SPAD photometer.In process of photosynthesis, chlorophyll pigments absorb radiant visible energy (light) and convert this energy into chemical energy (sinha,2014) [37]. Photosynthesis is also a sensitive process to nutrients and water supply Ehsen et al.,(2017) [38]. Chlorophyll and nitrogen are intrinsically linked, as nitrogen is a primary constituent of chlorophyll. This relationship is logical given that nitrogen is a key component in the composition of chlorophyll, the structure of chloroplasts, and the accumulation of chlorophyll [39]. Data presented in Table 5 illustrate the significant influence of varying nitrogen doses on chlorophyll content. The maximum chlorophyll content was observed with a nitrogen dose of 120 kg N ha^{-1}. This finding is corroborated by Zaidi et al. [40], who reported an increase in leaf chlorophyll content following nitrogen application, given its essential role in chlorophyll synthesis in plants. The cultivar T-3-Dadu exhibited the highest chlorophyll content (38.41 µ g cm^{-2}), followed by Pak SS 2 (36.47 µ g cm^{-2}). Our results align with those of Al-Fageh (2004) [41], who asserted that chlorophyll content is influenced by both nitrogen dose and genotype. Hameed et al. [42] posited that the photosynthetic efficiency of a plant is contingent upon leaf area, chlorophyll content, and the proportion of mesophyll tissue present in leaves.

Panicle Length (cm)

The successful grain production of sorghum is based on the performance triangle of genetic, environment and nutrition.Menkar and Ejeta (2023) [43] registered that profound variation were seen among sorghum cultivars in yield, maturity,vegetative growth under variated environmental condition. The measurement of panicle length is a critical aspect of grain production, influencing both the number of grains per spike and grain weight. Significant variations in panicle length were recorded in response to nitrogen application (Table 6). The longest panicle was observed in the cultivar T-3- Dadu (37.33 cm), followed by JS-263 (33.84 cm). The longest panicle (30.60 cm) was measured with a nitrogen application of 120 kg ha^{-1}. In the interaction of cultivars and nitrogen levels, T-3- Dadu demonstrated significant superiority over other treatments. These results are supported by Miko and Mango [35] and Hasan and Bibinu [36], who reported the longest panicle length with high nitrogen dose application.

Number of Grains $Panicle^{-1}$

The data presented in Table 7 reveal significant differences in the number of grains per panicle among various sorghum cultivars and nitrogen levels, as well as their interactions. The cultivar JS-263 was found to be superior in this regard, producing 2187 grains per panicle, compared to other cultivars. The highest number of grains (1525 grains per panicle) was observed with a nitrogen level of 120 kg N ha^{-1}. The cultivar JS-263, when treated with 120 kg N ha^{-1}, produced the highest number of grains (2315 grains per panicle). These findings align with those of Mutava et al. [37], who reported significant differences among various sorghum cultivars.

1000-grain Weight (g)

As indicated in Table 8, the weight of 1000 grains was significantly influenced by different cultivars and nitrogen levels. The cultivar Giza-3 exhibited the heaviest 1000-grain weight (24.55 g), followed by Desi Sorghum (24.44 g) and JS-263 (24.11 g). The maximum 1000-grain weight (25.88 g) was recorded at the highest nitrogen level. This could be attributed to the availability of nitrogen, which is essential for grain accumulation. Our findings corroborate those of Sami et al. [38].

Biological Yield (kgha-1)

Nagao *et al*., (1999) [39] predicted the role of nitrogen and enhancement in vegetative growth, biological yield and grain yield in crops by increment in photosynthesis through plant growth rate.Table 9 presents data regarding the biological yield (kg ha^{-1}), showing that the biomass production of sorghum was significantly influenced by nitrogen doses, sorghum cultivars, and their interactions. The highest biomass was produced by JS-263 with 120 kg N ha-1 (17378 kg ha^{-1}), while the overall highest biological yield (14293 kg ha^{-1}) was recorded at 120 kg ha^{-1} N. Among the different sorghum cultivars, JS-263 proved to be the best (16716 kg ha^{-1}), followed by Desi Sorghum (14327 kg ha^{-1}). It is thus suggested that the availability of nitrogen largely dictates the yield of sorghum [1]. Similar results were obtained by Ayub et al. [39], who found a higher biological yield with a high dose of nitrogen. The notably high biological yield of JS-263 was due to the maximum leaf area per plant, which increased the photosynthetic rate and consequently resulted in a high biological yield. Our results are in line with those of Rashid and Himayatullah (2003) [40] and Iqbal et al. [41].

Grain Yield (kgha^{-1})

Panicle length, grains panicle^{-1}, 1000 grains weight and seed set percent (fertility) are major yield contribution factors that contribute to grain yield of sorghum cultivars according to Arunkumar (2013) [42].The grain yield of sorghum is also dependent on genetic potential of sorghum cultivars. The maximum grain yield can be achieved by employing the best management system based on cultivars and the nutrients available to the crop. The grain yield of a cultivar is the most integrative trait, as it is affected by both known and unknown factors [43]. The data show that sorghum cultivars and nitrogen levels significantly affected the grain yield. The cultivar JS-263 produced the highest grain yield (3719 kg ha^{-1}), followed by Pak SS2. The highest nitrogen level (120 kg ha^{-1}) resulted in the highest grain yield (2675 kg ha^{-1}). The interaction of 120 kg N ha^{-1} with the cultivar JS-263 contributed to a higher grain yield (4287 kg ha^{-1}). Our results are supported by Ashiono et al. [44] and Rashid et al. [45], who recorded the highest grain yield with a high nitrogen level.

Table4.Cropgrowthrate(gm^{-2}day^{-1})ofsorghumgenotypesasinfluencedbynitrogendoses

	Nitrogenlevels			
Cultivars	**40kgha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**

DesiSorghum	6.16jk	6.55ijk	7.73h	6.81de
Js-263	12.49 c	13.95 b	14.69 a	13.71 a
Pak SS2	9.43g	10.37f	11.25 de	10.35 c
DeraJawar	6.89ij	7.61h	7.76h	7.42d
Giza – 3	5.87k	6.45jk	7.04hi	6.42e
T-3-Dadu	10.62 ef	11.09 ef	11.65 d	11.12 b
Mean	8.57e	9.32b	10.02 a	

Means with alike letters are in-significant at 5% level of probability.$LSD_{0.05}$
Cultivars =
0.65Nitrogen levels =
0.19Interaction= 0.48

Table5.ChlorophyllContent(μgcm^{-2})ofsorghumgenotypesasinfluencedbynitrogendoses

	Nitrogenlevels			
Cultivars	**40kg ha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**
DesiSorghum	33.70^{NS}	35.53	36.13	35.12 b
Js-263	31.36	39.20	37.30	35.96 b
Pak SS2	35.03	36.90	37.50	36.47 ab
DeraJawar	31.86	34.03	37.73	34.54 b
Giza – 3	29.03	30.56	30.93	30.17 c
T-3-Dadu	39.03	37.93	38.26	38.41 a
Mean	33.33 b	35.69 ab	36.31 a	

Means with alike letters are in-significant at 5% level of probability.$LSD_{0.05}$
Cultivars =
2.29Nitrogen levels =
2.56NS=Non-
significant

Table6.PanicleLength(cm)ofsorghumgenotypesasinfluencedbyN-doses

	Nitrogenlevels			
Cultivars	**40kgha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**
DesiSorghum	19.20 i	21.33 h	24.16fg	21.56e
Js-263	30.60 d	34.13 c	36.80 b	33.84 b
Pak SS2	25.33f	27.66e	31.33 d	28.11 c
DeraJawar	16.60 j	19.86 i	23.00g	19.82f
Giza – 3	21.33 h	24.00g	28.33e	24.55 d
T-3-Dadu	34.00 c	38.00 b	40.00 a	37.33a
Mean	24.51 c	27.50 b	30.60 a	

Means with alike letters are in-significant at 5% level of probability.$LSD_{0.05}$
Cultivars =
0.96Nitrogen levels =
0.39Interaction= 0.97

Table 7.Number ofGrains Panicle^{-1}ofsorghumgenotypesasinfluenced bynitrogendoses

		Nitrogenlevels		
Cultivars	**40kgha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**
DesiSorghum	876o	1081i	1697f	1218c
Js-263	1991c	2255 b	2315a	2187a
Pak SS2	1233g	1817e	1954 d	1668 b
DeraJawar	936m	1005 k	1149 h	1030 d
Giza – 3	818p	904n	965 l	895 f
T-3-Dadu	925 mn	1051j	1070j	1015e
Mean	1129c	1352 b	1525a	

Means with alike letters are in-significant at 5% level of
probability.$LSD_{0.05}$
Cultivars =
12.89Nitrogen levels =
9.40Interaction= 23.02

Table8.1000-grainweight(g) of sorghumgenotypesasinfluencedbynitrogendoses

		Nitrogenlevels		
Cultivars	**40kgha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**
DesiSorghum	23.00 cd	22.66 ef	27.66 a	24.44 a
Js-263	19.00 h	24.66 c	28.66 a	24.11 a
Pak SS2	21.00g	21.00g	24.66 c	22.22 b
DeraJawar	22.33 ef	23.00 ef	26.33 b	23.88 a
Giza – 3	22.00fg	23.33 de	28.33 a	24.55 a
T- 3-Dadu	14.00j	17.00i	19.66h	16.88 c
Mean	20.22e	21.94b	25.88a	

Means with alike letters are in-significant at 5% level of
probability.$LSD_{0.05}$
Cultivars =
1.58Nitrogen levels =
1.01Interaction= 2.48

Table9.Biologicalyield(kg ha^{-1})ofsorghumgenotypesasinfluencedbydifferentnitrogenlevels

		Nitrogenlevels		
Cultivars	**40kgha^{-1}**	**80kgha^{-1}**	**120kgha^{-1}**	**Mean**
DesiSorghum	13215 fg	14255 e	15512 cd	14327 b
Js-263	16085 c	16685 b	17378 a	16716 a
Pak SS2	13552 fg	14311 e	14951 d	14271 b
DeraJawar	12011ij	12951 gh	13768 ef	12910 c
Giza – 3	9992 k	10625 k	11692 j	10769 d
T-3-Dadu	9292j	10642 k	12458 k	10797 d
Mean	12357 c	13245 b	14293 a	

Means with alike letters are in-significant at 5% level of
probability.$LSD_{0.05}$
Cultivars =
533.29Nitrogen levels =
208.92Interaction=
511.75

Conclusion

Sorghum, recognized for its heat and drought resistance, may offer superior performance by providing both grains and fodder. Given the current market conditions, where the prices of major crops are not favorable and rainfall is deficient, sorghum could be an optimal choice in the context of climate change. The findings of this study suggest that breeding new high-yielding sorghum genotypes that respond well to nitrogenous fertilizer could be a viable option for farmers contending with heat and drought stress. In particular, the sorghum cultivar JS-263 demonstrated robust performance with a nitrogen dose of 120 kg ha^{-1} in this research.

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