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The Effect of Nitrogen Fertilizer Source, Cultivar and Field Condition on the Growth Performance of Sorghum

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ABSTRACT

Nitrogen fertilizer sources respond differently under dryland and irrigated fields and that affects sorghum growth. This study was carried out during the 2018/19 and 2019/20 planting seasons at Molelwane farm, North West, South Africa. The objective of this study was to determine the effect of nitrogen fertilizer source, cultivar and field condition on the growth performance of sorghum.

The experiment was a 2x5x2 factorial arranged in a split-split plot experiment that was fitted into a randomized complete block design. The main plot factor was irrigation and dryland field conditions, the subplot factor was nitrogen sources (limestone ammonium nitrate, urea, ammonium sulphate, ammonium sulphate nitrate, and control) and the sub-sub plot was the cultivars (Titan and Avenger). The measured growth parameters included plant height, number of leaves, leaf chlorophyll content, leaf area and stem diameter. Nitrogen fertilizer source had no significant effect ($P>0.05$) on sorghum plant height and number of leaves during the 2018/19 and 2019/20 planting seasons. Even though no significant effects were observed during both planting seasons, the sorghum treated with urea and ammonium sulphate nitrate attained a higher plant height. Field conditions had a significant effect ($P<0.05$) on plant height and the number of leaves of sorghum plants for both planting seasons. Sorghum planted under dryland field conditions had taller plant and a higher number of leaves. In conclusion nitrogen fertilizer source like ammonium sulphate nitrate and urea significantly enhanced sorghum growth, with split application recommended to reduce nutrient loss. Cultivars such as Avenger and Titan perform well and should be chosen based on the environmental conditions. Effective practices including limestone ammonium nitrate application and moisture management, are essential for sustainable sorghum production, even in dryland conditions.

Keywords: field condition, cultivar, growth, nitrogen, sorghum.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] as a semi-arid crop requires a maximum temperature of around 32°C for both its vegetative and reproductive stages (Prasad et al., 2006). High temperatures tend to reduce the height that the sorghum plant reaches but have no effect on the leaf area and in fact increase the number of leaves on a sorghum plant (Prasad et al., 2008; Nguyen, 2014). High temperatures increase the leaf number, as well as the growth rate, and the appearance of the leaves, while concomitantly reducing the plant height, seed set, chlorophyll content and photosynthetic rate (Djanaguiraman et al., 2010; Singh et al., 2015). On the other hand, chilling temperatures reduce the growth rate of the sorghum plant and significantly reduce the number of leaves (Ercoli et al., 2004). Sorghum water requirements vary with the growing stages, and demand for water increases at an exponential degree up to the booting stage, but later begins to decline gradually (ARC-grain, 2008). Taking into consideration the soil and climate, the approximated water for optimal sorghum yields was found to be between 300-400 mm for every growing period (Araya et al., 2016). Drought stress on sorghum reduces leaf expansion, leaf number and leaf size (Muvata, 2012).

Nitrogen is an important nutrient for optimum growth and good yields (Olugbemi, 2017). The sorghum growth parameters respond positively to nitrogen fertilizer, no matter which source of nitrogen is applied (Sebetha and Modisapudi, 2019). Further

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reports have also indicated that as opposed to ammonium sulphate, LAN and urea bring positive results to the leaf area. Ahmad et al. (2007) also reported a positive response by the growth parameters, namely the number of leaves, internodes and plant height, when treated with urea, ammonium sulphate and ammonium nitrate. The highest plant height and largest stem diameter was recorded under the application of ammonium nitrate rather than ammonium sulphate in sweet sorghum (El-Lattief, 2011).

Late-maturing cultivars are photoperiod sensitive, but they can produce more assimilates for plant growth until panicle formation (Lafarge et al., 2002; Clerget et al., 2007). Sorghum cultivars are known to vary in their response to fertilizers (Sujathamma et al., 2015). Early maturing cultivars of sorghum can limit exposure to water stress under dryland condition without senesces (Baumdardt et al., 2005). Nitrogen fertilizer source like urea is commonly used in South Africa, however, urea has a major disadvantage because it is mostly lost through ammonia volatilization (Chen et al., 2008), causing a delay in growth of sorghum due to restricted nutrients that stimulates growth. Excessive moisture affects sorghum growth by remarkably reducing plant height, leaf number and photosynthetic processes (Zhang et al., 2016). The objective of the study was to determine the effect of field condition, nitrogen source and cultivar on the growth performance of sorghum.

MATERIAL AND METHODS

Description of the experimental site

The experiment was conducted during the 2018/19 and 2019/20 planting seasons. The experiment was sited at North-West University research farm, Molelwane (25°48'S latitude and 45°38'E longitude and at a mean altitude above sea level of 1012 metres) outside Mafikeng city. The area receives rainfall of 571 mm, and it falls into a semi-arid region according to Kasirivu et al. (2011). The temperature of the region ranges from 7°C (minimum) to 37°C (maximum). Molope (1987) and Kasirivu et al. (2011) stipulated that the soil at the site belongs to the Hutton series with a sandy loam texture. According to the FAO-UNESCO (2006) the classification of the soil at Molelwane is categorized as a Ferric Luvisol. Table 1 shows the weather data that prevailed over the location during the course of this study.

Table 1. The mean temperature and rainfall data for Mafikeng for the duration of the experimental period

Site	Season	Climate data	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Mafikeng	2018/ 2019	Rainfall (mm)	5.2	5.2	90.6	30.2	113.4	36.2	122.8	7.2
		Max T (°C)	30.5	32.7	34.8	34.5	31.5	33.7	26.6	26.1
		Min T (°C)	13.1	15.9	19.6	18.9	17.5	17.1	13.7	8.4
	2019/ 2020	Rainfall (mm)	0.6	54.6	160.4	106.4	52.2	88.0	46.8	0.0
		Max T (°C)	33.6	33.3	30.2	30.7	31.1	28.4	25.8	25.7
		Min T (°C)	15.6	17.5	18.1	17.4	17.8	14.8	11.6	6.9

Source: South Celsius.

Max T (°C) = Maximum temperature in degrees Celsius; Min T (°C) = Minimum temperature in African Weather Service (SAWS), 2020; mm = millimetres.

Experimental design

The trial involved a 2x5x2 factorial fixed in a split-split plot design and was incorporated into a randomized complete block design. The main plots factor was irrigation and dryland field conditions distinctive of the site, while the subplots factor was nitrogen sources (LAN, urea, ammonium sulphate, ammonium sulphate nitrate, and control) and the sub-sub plots factor, was the cultivars (Titan and Avenger). There were a total number of 10 combinations of treatments per field condition which were replicated four times to give 40 experimental units.

Agronomic practices, chemical analysis and data collection

Pre-planting soil sampling was conducted at depths of 0-15 cm and 15-30 cm in a zigzag pattern using a soil auger, and the collected samples were sent to the Agricultural Research Council-Institute for Industrial Crops (ARC-IIC) laboratory for chemical and physical analysis. Soil chemical properties were analysed using standard procedures, including the 0.1N Potassium Sulphate extraction method with the Kjeldahl digestion procedure to determine N-NO_3 and N-NH_4, the Olsen sodium bicarbonate method to assess available phosphorus (P) as described by Bray and Kurtz (1945), and ammonium acetate extraction for exchangeable potassium (K). Soil pH was measured using the soil-water suspension method, and physical properties such as sand, silt, and clay percentages were determined using the texture-hydrometer procedure. Land preparation involved mouldboard ploughing, discing, and harrowing to remove residues, break surface crusts, and level the seedbed before planting sorghum cultivars Avenger and Titan sourced from Agricol Seed Company. Fertilizers, including lime ammonium nitrate, ammonium sulphate, ammonium sulphate nitrate, and urea for nitrogen, and phosphorus as a basal application, were applied at rates of 120 kg/ha and 60 kg/ha, respectively, with nitrogen split between banding at planting and side-dressing at knee height (37 DAP). Plots measured 5 m x 4 m, each accommodating six rows spaced 1 m apart with plants spaced 30 cm within rows, while spacing between plots and replications was maintained at 1 m and 2 m, respectively. Cultural practices included sowing three seeds per hole and thinning to one plant per stand, removing tillers to reduce nutrient competition, six weeding rounds per season, and pest control with Bulldock granules and liquid solutions to manage stalk borers during vegetative and grain-filling stages, while sorghum panicles were covered with monofilament bags to protect against birds. Irrigation was applied twice weekly using a sprinkler system, adjusted for rainfall, with supplementary irrigation measured at 17 mm/day using a rain gauge. Data collection involved tagging eight plants per plot to measure plant height at 70 days after planting (DAP), and leaf number, leaf area (length x breadth x 0.75), stem diameter with a Vernier caliper, and chlorophyll content with a CCM-200m Plus meter at 52 DAP, using the leaf area formula recommended by Stickler et al. (1961).

Data analysis

The data collected were subjected to analysis of variance (ANOVA) to compare the treatment means using the GENSTAT discovery 4th Edition (2012). Treatment means were separated using LSD at 5% level of probability and high factor relations were taken into account for the measured parameters. The correlations between the respective growth parameters were determined using the SSP programme (version:16). The significant level was corrected at 0.01 and 0.05.

RESULTS AND DISCUSSION

The effect of nitrogen fertilizer source, cultivar and field condition on sorghum plant height

As indicated in Table 2, the nitrogen fertilizer source and cultivar had no significant effect (P>0.05) on sorghum plant height during the 2018/19 and 2019/20 planting seasons. Even though no significant difference was observed among the respective nitrogen fertilizer sources, sorghum plants treated with urea and ammonium sulphate nitrate had higher plant heights of 117.32 and 115.87 cm, respectively, during the 2018/10 and 2019/2020 planting seasons. Sorghum plants treated with ammonium sulphate during the 2019/20 planting season, attained a height of 106.17 cm. Field condition had no significant outcome (P>0.05) on sorghum plant height throughout 2019/20 planting season, but gave a significant result (P=0.008) on plant height during the 2018/19 planting season. Sorghum planted under dryland field conditions recorded a significantly taller plant height of 118.63 cm as compared to those planted under irrigation field conditions. The interactions of treatment factors had no significant effect (P>0.05) on sorghum plant height during the 2018/19 and 2019/20 planting seasons.

The effect of nitrogen fertilizer source, cultivar and field condition on sorghum number of leaves

Nitrogen fertilizer source had no significant influence (P>0.05) on the number of leaves on the sampled sorghum plants during the 2018/19 and 2019/20 planting seasons (Table 2). Also, cultivar had no significant influence (P>0.05) on the number of leaves during the 2019/20 planting season but had a significant effect (P<0.001) on the number of leaves during the 2018/19 planting season. The sorghum cultivar, Avenger, had a considerably higher number of leaves (8.88) per plant as compared to the Titan sorghum cultivar that had 7.82. Field condition had no significant effect (P>0.05) on the number of leaves during the 2018/19 planting season but had a significant result (P<0.001) on the number of leaves during the 2019/20 planting season. Sorghum planted under dryland field conditions had a significantly larger number of leaves per plant (10.33) as compared to sorghum planted under irrigation field conditions. The interactions of treatment factors had no significant effect (P>0.05) on the number of leaves of sorghum during the 2019/20 planting season. During the 2018/19 planting season, the interaction of cultivar x field condition had a significant effect (P=0.004) on the number of leaves per sorghum plant.

The effect of nitrogen fertilizer source, cultivar and field condition on sorghum chlorophyll content

As indicated in Table 2, nitrogen fertilizer source had no significant effect (P>0.05) on leaf chlorophyll content during the 2019/20 planting season but had a significant effect (P=0.004) on leaf chlorophyll content during the 2018/19 planting season. Sorghum treated with ammonium sulphate, ammonium sulphate nitrate, limestone ammonium nitrate and urea had a significantly higher leaf chlorophyll content of 38.86, 40.69, 39.10 and 40.11ccl, respectively, as compared to sorghum without nitrogen fertilizer treatment. Even though there was no significant difference amongst the nitrogen fertilizer sources, sorghum treated with ammonium sulphate nitrate and urea had higher chlorophyll content levels of 40.69 and 40.11 ccl, respectively.

Cultivar had no significant effect (P>0.05) on the chlorophyll content of sorghum leaves during the 2018/19 and 2019/20 planting seasons. Field condition had a significant effect (P<0.05) on the chlorophyll content of sorghum leaves during the 2018/19 and 2019/20 planting seasons. Sorghum planted under dryland field conditions had a significantly higher chlorophyll content of 40.24 and 41.38 ccl during the 2018/19 and 2019/20 planting seasons, respectively, compared to chlorophyll content of 36.06 and 35.37 ccl of sorghum planted under irrigation field conditions. The interactions of treatment factors were not significant (P>0.05) on the chlorophyll content of sorghum leaves during the 2019/20 planting season, but the interaction of field condition x nitrogen fertilizer source had a significant effect (P=0.004) on the sorghum leaf chlorophyll content during the 2018/19 planting season.

Table 2. The effect of nitrogen fertilizer source, cultivar, and field condition on sorghum chlorophyll content, plant height, and the number of leaves during 2018/19 and 2019/20 planting season

Treatment factor	2018/19			2019/20		
	Plant height	Number of leaves	Chlorophyll content	Plant height	Number of leaves	Chlorophyll content
Nitrogen source						
AS	108.71	8.40	38.86	106.17	9.73	39.95
ASN	115.87	8.16	40.69	104.91	9.93	38.27
LAN	110.41	8.15	39.10	103.89	9.90	38.02
Urea	117.32	8.57	40.11	101.96	9.77	40.16
Control	108.76	8.51	31.99	98.66	10.45	35.47
LSD $_{(0.05)}$	14.68	0.55	4.79	7.78	0.58	3.47
Cultivar						
Avenger	115.64	8.89	37.17	101.14	9.78	39.23
Titan	108.79	7.82	39.13	105.10	10.12	37.53
LSD $_{(0.05)}$	9.28	0.35	3.04	4.92	0.37	2.19
Field condition						
Dryland	118.63	8.45	40.24	102.21	10.33	41.38
Irrigation	105.80	8.27	36.06	104.03	9.57	35.37
LSD $_{(0.05)}$	9.28	0.35	3.04	4.92	0.37	2.19
Interactions						
CxFC	NS	*	NS	NS	NS	NS
CxNS	NS	NS	NS	NS	NS	NS
FCxNS	NS	NS	*	NS	NS	NS
CxFCxNS	NS	NS	NS	NS	NS	NS

AS = ammonium sulphate, ASN = ammonium sulphate nitrate, LAN = lime ammonium nitrate

The effect of nitrogen fertilizer source, cultivar and field condition on sorghum stem diameter

As indicated in Table 3, nitrogen fertilizer source and cultivar had no significant effect (P>0.05) on sorghum stem diameter during the 2018/19 and 2019/20 planting seasons. Although the nitrogen fertilizer sources made no significant difference, sorghum treated with urea produced a larger stem diameter of 32.05 mm during the 2019/20 planting season. Field condition had a significant effect (P<.001) on sorghum stem diameter during the 2018/19 and 2019/20 planting seasons. During the 2018/19 planting season, sorghum planted under irrigated field conditions had a significantly larger stem diameter of 29.81 mm than sorghum planted under dryland field conditions. During the 2019/20 planting season, sorghum planted under dryland conditions had a significantly larger stem diameter of 32.71 mm compared to sorghum planted under irrigation field conditions. The interactions of treatment factors had no significant effect (P>0.05) on sorghum stem diameter during the 2018/19 and 2019/20 planting seasons.

The effect of nitrogen fertilizer source, cultivar and field condition on sorghum leaf area

Table 3 showed that the nitrogen fertilizer source had no significant effect (P>0.05) on sorghum leaf area during the 2018/19 and 2019/20 planting seasons. Even though there was no significant difference amongst the nitrogen fertilizer sources during the 2018/19 planting season, sorghum treated with ammonium sulphate nitrate produced a larger leaf area of 461.31cm. Furthermore, sorghum treated with ammonium sulphate during the 2019/20 planting season also produced a larger leaf area of 485.82 m. There was no significant difference (P>0.05) among the cultivars for leaf area during the 2018/19 planting season but was significantly different (P=0.003) for sorghum leaf area during the 2019/20 planting season. Sorghum cultivar Titan produced a significantly larger leaf area 480.77 cm than sorghum cultivar Avenger.

Field condition had a significant effect (P<0.05) on sorghum leaf area during the 2018/19 and 2019/20 planting seasons. Sorghum planted under dryland field conditions had a significantly larger leaf area of 493.25 and 528.86 cm^2 during the 2018/19 and 2019/20 planting seasons, respectively compared to sorghum planted under irrigation field conditions. The interactions of treatment factors for leaf area were not significantly different (P>0.05) in both planting seasons.

Table 3. The effect of nitrogen fertilizer source, cultivar, and field condition on sorghum stems diameter and leaf area during 2018/19 and 2019/20 planting seasons

Treatment factor	2018/19		2019/20	
	Stem diameter	Leaf area	Stem diameter	Leaf area
Nitrogen source				
AS	26.51	418.14	29.73	485.82
ASN	26.33	461.31	30.71	448.84
LAN	26.54	413.75	30.56	466.56
Urea	26.50	460.20	32.05	457.33
Control	25.23	416.03	30.96	446.07
LSD $_{(0.05)}$	1.60	66.70	2.46	39.89
Cultivar				
Avenger	26.61	449.92	30.99	441.08
Titan	25.83	417.89	30.61	480.77
LSD $_{(0.05)}$	1.01	42.12	1.56	25.23
Field condition				
Dryland	22.63	493.25	32.71	528.86
Irrigation	29.81	374.55	28.90	392.99
LSD $_{(0.05)}$	1.01	42.12	1.56	25.23
Interactions				
CxFC	NS	NS	NS	NS
CxNS	NS	NS	NS	NS
FCxNS	NS	NS	NS	NS
CxFCxNS	NS	NS	NS	NS

The correlation between sorghum growth variables during the 2018/19 planting season

Table 4 indicates the nature of the correlations between the respective variables as follows:

Plant height showed a positive and medium correlation with chlorophyll content (r=0.35). Number of leaves had a positive and medium correlation between stem diameter (r=0.30) and (r=0.40), respectively. Stem diameter also had a positive and small correlation between leaf number (r=0.30) and chlorophyll content (r=0.23), respectively. Chlorophyll content had a positive and medium correlation with plant height (r=0.35); however, a small correlation was observed between chlorophyll and stem diameter (r=0.23). Leaf area had a positive and medium correlation with leaf number (r=0.40). Leaf number was significantly negatively correlated with chlorophyll content. Chlorophyll content was also significantly correlated with leaf number.

Table 4. The correlation between sorghum growth variables during 2018/19 planting season

	Chlorophyll content	Plant height	Number of leaves	Stem diameter	Leaf area
Chlorophyll content	1.00				
Plant height	0.55	1.00			
Number of leaves	-0.28	0.43	1.00		
Stem diameter	-0.21	-0.58	-0.09	1.00	
Leaf area	0.54	0.9	0.34	-0.76	1.00

0.1 = weak correlation, 0.1-0.3 = small correlation, 0.3-0.5 = medium correlation, 0.5-1.0 = strong correlation, 0.8-0.9 = very strong correlation.

The correlation between sorghum growth variables during the 2019/20 planting season

As indicated in Table 5, plant height had a positive and medium correlation with chlorophyll content (r=0.421). Plant height showed a negative and correlation with leaf number. However, plant height showed a positive and weak correlation between stem diameter (r=0.153) and leaf area (r=0.196). Leaf number showed a positive and medium correlation with stem diameter (r=0.330). Leaf number showed a positive and a weak correlation with leaf area (r=0.205). Lastly, leaf number showed a significantly negative correlation between plant height and chlorophyll content. Stem diameter had a positive and medium correlation with leaf number (r=0.003), chlorophyll content (r=0.447) and leaf area (r=0.472). Stem diameter also had a positive but a weak correlation with plant height (r=0.153). Chlorophyll content had a positive and medium correlation with plant height (r=0.421), stem diameter (r=0.447) and leaf area (r=0.529). Furthermore, chlorophyll content was negatively and significantly correlated with leaf number. Leaf area showed a positive and medium correlation with stem diameter (r=0.472) and chlorophyll content (r=0.529). Leaf area showed a positive and weak correlation between plant height (r=0.196) and leaf number (r=0.205).

Table 5. The correlation between sorghum growth variables during 2019/20 planting season

	Chlorophyll content	Plant height	Number of leaves	Stem diameter	Leaf area
Chlorophyll content	1.00				
Plant height	0.17	1.00			
Number of leaves	-0.02	-0.51	1.00		
Stem diameter	0.65	-0.50	0.57	1.00	
Leaf area	0.74	0.12	0.53	0.65	1.00

0.1 = weak correlation, 0.1-0.3 = small correlation, 0.3-0.5 = medium correlation, 0.5-1.0 = strong correlation, 0.8-0.9 = very strong correlation.

Plant height

The taller plant height attained by sorghum treated with urea and ammonium sulphate nitrate might be ascribed to the fact that the ammonium form found in both fertilizer sources is readily available at the early vegetative stage, which promotes increase in the number of internodes, in turn resulting in increased plant height. This agrees with the results of Siam et al. (2008), who observed a remarkable increase in the plant height of maize when fertilized with a nitrogen source containing ammonium and sulphur as essential nutrients for plant growth. Fageria et al. (2011) also reported an increase in plant height for rice treated with urea.

The taller plant observed under dryland field conditions may be attributed to the amount of effective rainfall during the vegetative stage (Table 2). This observation corroborates the findings of Hlophe (2014), who opined that an uninterrupted water supply during the early stage of crop development significantly increases plant height. It was further reported that water stress at the late vegetative state does not have an effect on plant height.

Number of leaves

The Higher number of leaves per plant of sorghum cultivar Avenger may be attributed to its genetic superiority over Titan. Hadebe et al. (2017), also reported that significant difference in the leaf number may possibly be attributed to genotypic differences among the cultivars.

The higher number of leaves under dryland conditions may be attributed to the initial use of soil moisture that was available to promote leaf appearance relatively sooner-unlike sorghum plants that were exposed to constant soil moisture conditions leading to longer internodal distances and fewer leaves. Similarly, Stone and Schlegel (2006) indicated that irrigated sorghum plants have extended internodal distances which require a rather longer period of time to develop and also result in fewer leaves.

Chlorophyll content

The higher leaf chlorophyll content in sorghum plants treated with ammonium sulphate nitrate and urea could be due to the contribution of sulphur in ASN that helps promote protein synthesis and photosynthesis by increasing the absorption of nutrients. Furthermore, the ammonium form from ASN and urea is readily available for plant use during the early growth stage and it increases the leaf area surface for plants to absorb enough light and to maximize the process of photosynthesis. Khursheed and Mahammed (2015) discovered that the chlorophyll content of wheat treated with urea showed a remarkable increase. Chaturvedi (2005) reported that the vegetative growth of rice may be attributed to photosynthetic and chlorophyll processes which were intensified under applications of ammonium sulphate nitrate.

The higher leaf chlorophyll content under dryland field conditions may be due to the available moisture for plant absorption to maintain stomatal opening and sustain the photosynthesis process. According to Basu et al. (2004), the stability of the photosynthetic components could be attributed to the maintenance of positive leaf turgor under stress as a result of osmotic adjustment.

Stem diameter

The larger stem diameter of sorghum treated with urea may be as a result of its high level of solubility, which stimulates root growth and makes it easier for plant absorption and promotes cell division and elongation of the stem. This correlates with the findings of Sebetha and Modi (2017) who reported that maize treated with urea nitrogen fertilizer had significantly larger stem diameter of 2.0 cm. The effect of field conditions on stem diameter was not consistent during the 2018/19 and 2019/20 planting seasons. This is due to the availability of soil moisture which may be attributed to rainfall during the vegetative stage, allowing the plants to maintain stem turgor and thus to increase stem diameter.

Leaf area

The larger leaf area of sorghum treated with ammonium sulphate nitrate and ammonium sulphate may be attributed to the additional sulphur that promotes the absorption of other nutrients, resulting in wider leaf growth, thus allowing for better photosynthetic performance. Furthermore, the superiority of ASN could be attributed to the ammonium and nitrate forms, which improve protein synthesis, thus increasing the leaf surface area for the production of food through photosynthesis. This concurs with the findings of Kaleem Abbasi et al. (2015) and Ayub et al. (2000) who reported that as opposed to other sources, ammonium sulphate contributes most to leaf area increases.

The larger leaf area under cultivar Titan may be credited to the genetic make-up of the cultivar in extending the growth cycle and resulting in intensified vegetative growth under favourable conditions. This concurs with the results of Ahmad et al. (2003), who reported a significant difference in the leaf area of a maize cultivar which these authors attributed to the difference in genetic potential and the plant characteristics.

The higher leaf area under dryland field conditions may be attributed to the adaptive mechanisms of the plant such as the extraction of soil moisture at different depths by the roots, which in their turn assist with the absorption of enough water and nutrients to promote leaf growth and expansion. This correlates with reports by Wang et al. (2007), indicating that the root and leaf area index increase as the stress becomes more severe, thus implying that plants under stress develop more root to extract water from the soil.

CONCLUSIONS

This study concluded that nitrogen fertilizer sources such as urea and ammonium sulphate nitrate significantly enhance specific growth parameters of sorghum, including chlorophyll content, stem diameter, and leaf area. The cultivars Avenger and Titan demonstrated varied performance, influenced by genetic variability of traits and environmental conditions. Dryland field conditions proved advantageous for plant height and leaf chlorophyll content, highlighting the crop’s adaptability to water-limited environments. For sustainable sorghum production, particularly in semi-arid regions, strategic use of nitrogen fertilizers and selection of cultivar suited to prevailing environmental conditions is crucial.

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