



Effects of Cultivar and Harvesting Time on Growth Components and Chemical Composition of Hydroponic Sorghum Fodder

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Abstract

The study was conducted to evaluate the growth components and chemical composition of four varieties of local sorghum [Red chakalari (V1), White chakalari (V2), Kaura (V3) and Jigari (V4)] seeds grown in an improvised hydroponic medium at three different harvesting periods (8, 12 and 16 days). The experiment was conducted as a 4×3 factorial arrangement in a randomized complete block design (RCBD). The results of hydroponic sorghum fodder (HSF) production showed significant ($P<0.05$) difference in germination percentages across the varieties, in the following ascending order V1 (red chakalari) >V2 (white chakalari) >V4 (jigari) >V3 (kaura). While the means yield and height at different harvesting periods were not statistically ($P>0.05$) affected among the varieties. However, individual yields showed significant ($P<0.05$) variation across the varieties and between the different harvesting periods with 8th day sprout having the highest yield followed by 12th day and lastly 16th day harvest. Nonetheless, chemical composition were inconsistent among the varieties but V4 recorded the highest crude protein value (14.05%) at 8th day post-harvest while organic and dry matter were superior at 12th day harvest in V3. It was concluded that HSF at 8th day harvest was the best in growth parameters of the plant and nutrient contents and all the varieties can be grown as fodder for livestock feeding.

Key words: Hydroponic, Sorghum, Biomass and Yield

Introduction

Animal production is a very important sector of the economy of any nation and is crucial in ensuring food security for the people (Bamaiyi, 2013). Livestock have been known for ages to meet the animal protein requirement of man and many other benefits they provide for farmers and the national economy. Kamuanga *et al.* (2004) reported that West Africa had 25% cattle, 33% sheep, and 40% goats of the total livestock kept. Nigeria has a livestock population of 41.3 million sheep, 72.5 million goats and 19.5 million cattle (Bourn *et al.*, 2007). However, inadequate feeding particularly during the dry season is the major obstacle to animal production in Nigeria in which animals survive mainly on range vegetation of low nutritive value.

Forage is the most common ruminant's feed and its production in Nigeria increases from Sahel to Southern Guinea Savanna and seasonal fluctuations in forage availability were more common in Sudan Savanna than the Guinea Savanna (Abubakar *et al.*, 2012). The Sudano-Sahelian zone is the traditional home of most of

Nigeria's ruminant livestock and is faced with great climatic and seasonal variation (Abubakar *et al.*, 2012). It is characterized by short duration of rainfall and a long dry season in which only few standing hays, browse plants and shrubs survive and are thus sparse. Therefore, feeding of livestock especially during dry season has always been a problem.

To alleviate this problem, introduction and implementation of innovative agricultural techniques are required to improve forage productivity and yield. Hydroponics is the cultivation of plants without using soil and the system fosters rapid growth, stronger yield and superior quality fodder (Mooney, 2005). It is also a system with continuous production without season influence and use of extensive land (Christidiana, 2018). The hydroponic fodder system is characterized by short growth period using cereal seeds, moisture with or without nutrient solution in a greenhouse within 6 to 8 days (Fazaeli *et al.*, 2012). The fodder has extraordinary protein, vitamins, fibre and mineral contents (Boue *et al.*, 2003). Therefore, this

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technology is an important agricultural technique currently used in many countries (Turdo *et al.*, 2003) which gives a guarantee for sustainable forage production. The objective of this study was to evaluate the growth parameters and nutrients composition of four varieties of hydroponic sorghum fodder at different harvesting periods.

Materials and Methods

Study Area

The experiment was carried out at the Livestock Teaching and Research Farm of the University of Maiduguri. Maiduguri is situated at latitude 11° 51'N and longitude 13° 09'E at an altitude of 354 m above sea level (Encarta, 2007), which falls within the semi-arid zone of West Africa. The area is characterized by short period of rainy season (3-4 months) from June to September with annual rainfall ranging from 500 to 600 mm. Long period of dry season (8-9 months) October to May were also observed annually. Ambient temperatures are high (38-44°C) in the months of March to May whereas low temperatures are recorded in December and January ranging from 15-19°C (Weather and climate, 2016). Relative humidity is low in the month of March (30%) and high in the month of August (80%).

Construction of Hydroponic Unit

A Growth Room (local greenhouse) was built with cemented floor, walls of nets and roofed with aluminum sheets surrounded by trees which provide additional cooling and ventilation to the room. The hydroponic unit was constructed with metal frame having a dimension of 3.5m length, 1.5m height and width of 0.75m consisting of 4 shelves. Each shelf contained 7 aluminum planting trays. The planting trays had a length of 70cm, a width of 45cm and 6cm depth. The trays also had holes at the bottom to allow drainage of excess water in order to prevent waterlogging. There was a horizontal spacing of 5cm between each tray on the shelves and each shelf has a vertical spacing of 30cm. The unit was installed in the growth room.

Seeds Preparation, Planting and Irrigation

Four Varieties of sorghum (Red Chakalari, White Chakalari, Kaura and Jigari) were purchased from Maiduguri Gaboru market and used for the

experiment. Thirty six (36) aluminium planting trays were used, three (3) trays for each variety and at each harvesting time. The planting trays had capacity of growing 800 grams sorghum seed. Seeds were cleaned from debris and other foreign materials, weighed and washed thoroughly with clean water. It was soaked in water for 24 hours then rinsed with clean water before planting. The trays were stacked on the shelves and were irrigated twice daily (morning and evening) using knapsack sprayer. The sorghum fodder was harvested at 8, 12 and 16 days post planting. The following data were recorded: initial seed weight, germination percentage, plant height and total fresh fodder yield.

Chemical Analysis

Samples of the fodder were taken at each harvesting period, oven dried and ground in a hammer mill to pass through a 1mm sieve for determination of their chemical compositions on Dry Matter (DM) basis which include: Crude Protein (CP), Ether Extract (EE), Crude Fibre (CF), Ash and Nitrogen Free Extract (NFE) according to AOAC (2000). Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) were also determined as stated by Van Soest (1991) methods.

Statistical Analysis

Data collected were subjected to analysis of variance using General Linear Model of SAS (2000) and means were separated using Least Significant Difference (LSD).

Results and Discussion

The mean germination rates, means of yield and height of four different varieties of sorghum seeds at different harvesting time were presented in Table 1. The germination rates differed ($p < 0.05$) significantly across the varieties in the following ascending order V1 (red chakalari) > V2 (white chakalari) > V4 (jigari) > V3 (kaura). While the means of the three harvesting periods for yield (weight) and height of the fodders were not significantly ($p < 0.05$) different among the varieties. Growth components (yields and height) of HSF in this experiment was at its peak in 8 days post planting in all the four varieties and the 16th day had deteriorate as evidenced by their low

nutrient composition to sustained the plant. This supports the report of Christidiana (2018) who noted that biomass production of sorghum hydroponic fodder was significantly ($p < 0.05$) affected by variety and harvesting time.

The fresh yield of four varieties of HSF at different harvesting days of 8, 12 and 16 were also presented in Table 1. It ranges between 2550 to 3500g, 1766.7 to 3016.7g and 883.3 to 1833.3g for 8, 12 and 16 days harvest respectively from 800g of seeds sown each. The result showed significant ($p < 0.05$) difference across the varieties and the different harvesting periods with the highest in 8 days sprout followed by 12 days and lastly 16 days fodder. The present results were lower than the findings of Naik *et al.* (2013) who reported fresh yield of 8 to 10kg from 1kg locally grown maize seed in 7 to 10 days. Ghazi *et al.* (2011) also revealed that 1kg will produce 15 to 25kg fodder with planting period of 8 to 10 days. Improved sorghum seeds were used in the study of Christidiana (2018) who recorded fodder biomass of 25.51kg/m², 28.37kg/m² and 30.41kg/m² for KD4 sorghum variety and 27.95kg/m², 30.53kg/m² and 32.72kg/m² in Super-1 variety at harvesting time of 8, 12 and 16 days respectively. These differences is attributed to the differences in seed varieties, greenhouse condition (temperature and humidity), quality of seeds and irrigation water among others.

Chemical composition of four HSF varieties at different harvesting days.

Tables 2 and 3 shows the chemical compositions of harvested HSF varieties at 8 and 12 days post sowing respectively. There were changes in nutrient content of HSF with different harvesting periods and across the different varieties. Dry matter ranged recorded in this work at 8th day after sowing is in conformity with the report of Sneath and McIntosh (2003) who stated that various commercial hydroponics fodder producers claim yields of 6 to 10 times with dry matter percentages of 6.4 to 20. Furthermore, Naik and Singh (2013) postulated that maize hydroponic fodder produces 5 to 6 kg from 1kg seed with DM content of 11 to 14%. Similarly, Naik *et al.* (2015) also reported dry matter and organic matter contents of hydroponics fodder decrease

due to decrease in starch content. During sprouting, starch is catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis, so any decrease in the amount of starch causes a corresponding decrease in dry matter and organic matter. However, dry matter content at 12 days harvest of V1 and V2 increases with respective mean values of 14.12% and 24.75% while a decrease was observed in V2 and V4 at the same period. Similar trend were recorded in organic matter values. Hence, the changes might be as a result of varietal differences. Christidiana (2018) and Sneath and McIntosh (2003) reported that longer harvesting time decreases dry matter percentages and increases plant biomass.

The CP percentages of V1, V2 and V4 were decreased at 12 days as compared to 8 days. Naik *et al.* (2015) reported an increase in crude protein with corresponding decrease in dry matter. Therefore, the result of the current study was contrary with this statement. Hence, the CP contents obtained in this work were within the ranged values mostly reported for hydroponics cereal crops. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of the HSF's ranged between 38.12 to 44.36% and 22.20 to 29.04% respectively at 12 days post planting. Lesser range of NDF (37.14 to 44.69%) and ADF (20.83 to 31.32%) were recorded in 8 days after planting. The NDF range of values were in conformity with values (24.98 to 49.52%) reported by Zalalem and Gurmesa (2021) who studied different varieties of HSF, however, the ADF of the present study were higher than those reported (7.04 to 19.43%) by Zalalem and Gurmesa (2021). Ghazi and Al-Momani (2011) recorded lower values of ADF (14.3%) and NDF (29.6%) for hydroponic barley fodder, while Owens (2009) reported ADF values of <30-35% and NDF (<40-45%) in his findings, which were in conformity with the values obtained in the current study. Lower values of NDF and ADF in fodder were considered as good nutritional values because Sneath and McIntosh (2003) concluded that digestibility of forages decrease with increasing fibre content. However, increase in NDF and ADF values occur because of synthesis and accumulation of lignin which usually occurs

during the formation and thickening of secondary cell walls. Therefore, the rate of maturation and irrigation affect the accumulation of lignin (Carmi *et al.*, 2006). Furthermore, Dung *et al.* (2012) explained that fibre content is mostly derived from roots and seed husk due to the maturation

process and endosperm formation. The hemicellulose of the current study was at the range of 13.50 to 15.90% for V3 and V4, respectively.

Table 1: Height and yields (weight) of hydroponic sorghum fodder at different harvesting days

Parameters (%)	Varieties				SEM	LS
	V ₁	V ₂	V ₃	V ₄		
Germination rate (%)	77.36 ^a	68.56 ^{ab}	51.15 ^b	63.55 ^{ab}	63.55 ^{ab}	*
Means of Height (cm)	12.45	13.45	9.22	11.45	2.34	NS
Means of Yield (g)	2722.2	2782.3	716.7	2094.5	661.86	NS
HF8 (cm)	14.67 ^a	15.67 ^a	12.33 ^b	14.67 ^a	00.62	*
HF12 (cm)	13.67 ^a	13.67 ^a	09.00 ^c	11.00 ^b	00.59	*
HF16 (cm)	09.00 ^a	11.00 ^a	06.33 ^b	08.67 ^{ab}	00.99	*
WF8 (g)	3500.00 ^a	3500.00 ^a	2550.00 ^b	2866.70 ^b	188.93	*
WF12 (g)	2833.30 ^a	3016.70 ^a	1766.70 ^b	1766.70 ^b	270.89	*
WF16 (g)	1833.30 ^a	1833.30 ^a	0883.30 ^b	1650.00 ^a	185.22	*

V1 = Red Chakalari Variety, V2 = White Chakalari Variety, V3= Kaura Variety, V4= Jigari Variety, HF 8= Height of Fodder at Day 8, HF12 = Height of Fodder at Day 12, HF16 = Height of Fodder at Day 16, WF8 = Weight of Fodder at Day 8, YF12 = Weight of Fodder at Day 8, WF12 = Weight of Fodder at Day 12, WF16 = Weight of Fodder at Day 16, SEM = Standard Error of Mean, LS = Level of Significance, * = Significant (P<0.05), ^{a,b,c,d} = Means in the same row with different superscript are significantly different, NS = Not Significant.

Table 2: Chemical composition of varieties of HSF harvested at 8 days

Parameters (%)	Varieties			
	V ₁	V ₂	V ₃	V ₄
Dry matter	12.10	15.95	16.35	14.50
Organic matter	10.60	14.95	14.85	13.50
Crude protein	11.71	10.62	09.31	14.05
Neutral detergent fibre	42.06	37.14	41.08	44.69
Acid detergent fibre	27.67	20.83	26.30	31.32
Hemicellulose	14.39	16.31	14.78	13.37

V₁ = Red Chakalari Variety, V₂ = White Chakalari Variety, V₃ = kaura Variety and V₄ = Jigari Variety.

Table 3: Chemical composition of varieties of HSF harvested at 12 days

Parameters (%)	Varieties			
	V ₁	V ₂	V ₃	V ₄
Dry matter	14.12	12.18	24.75	14.01
Organic matter	13.12	10.68	23.75	13.01
Crude protein	04.57	05.99	10.28	12.10
Neutral detergent fibre	43.15	40.75	38.12	44.36
Acid detergent fibre	29.04	25.85	22.20	30.86
Hemicellulose	14.11	14.90	15.93	13.50

V₁ = Red Chakalari Variety, V₂ = White Chakalari Variety, V₃ = kaura Variety and V₄ = Jigari Variety.

Conclusion

This study concluded that HSF at 8th day harvest was the best in fodder yield, nutrient contents and height of the plants. Furthermore, all the varieties were suitable for hydroponic fodder in semi-arid environment and all the four varieties investigated in this study were recommended.

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