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Hydroponics Fodder Yield Characteristics of Selected Local Seeds in Southeastern Nigeria.

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ABSTRACT

This study aimed to produce hydroponic fodders from selected local seeds and characterize their subsequent growth. The research was conducted in two phases. The initial phase assessed the germination potential of seven local seeds: white and red sorghum (Sorghum bicolor), millet (Pennisetum glaucum), maize (Zea mays), fonio (Digitaria exilis), groundnut (Arachis hypogaea), and soybean (Gycine max). Forty-five seeds of each type were primed by soaking in water for 4 hours, then weighed and divided into three replicates (15 seeds/replicate) in a completely randomized design (CRD). Seeds were monitored every 24 hours for 96 hours, with 12-hourly moistening, to determine daily germination rate and weight changes. Based on superior germination, white sorghum, red sorghum, and millet were selected for the next phase. The second phase involved the production of hydroponic fodder. For each selected seed type, 2.5 kg were divided into five 500 g groups (T1 to T5). T1 served as the control (unsprouted seeds), while T2 to T5 were sprouted. The seeds were activated by soaking, drained after 4 hours, and left for 24 hours to hasten germination. They were then transferred to 12 x 16 x 1 (depth) in plastic trays with drainage in a randomized complete block design (RCBD), resulting in 15 trays (5 per seed type). The setup was housed in a naturally lit and airy room and irrigated three times daily for eight days to produce the fodder. Fodder yield characteristics and growth data were recorded on days 1, 4, 6, and 8. The results indicated that fodder weights were comparable up to the fifth day, after which the millet recorded a significantly higher ($p<0.05$) final weight than the sorghums. Millet fodder increased in weight by 280.8% of the initial 500 g seed weight, compared to 201.6% for white sorghum and 236.8% for red sorghum. Conversely, the sorghum seeds produced significantly taller ($p<0.05$) fodder than millet. In conclusion, both sorghum and millet seeds are suitable for hydroponic fodder production in southeastern Nigeria. Millet may be preferred for heavier fodder yield, while sorghum is advantageous for taller fodder growth.

Keywords: Hydroponics, Sprouted Seeds, Fodder, Sorghum, Millet.

Introduction

The global demand for high-quality, sustainable animal feed has spurred interest in alternative cultivation methods, particularly hydroponics. Hydroponics is a modern agricultural technique for growing plants in a controlled environment using mineral nutrient solutions dissolved in water, rather than traditional soil media.The Role and Benefits of Hydroponic Fodder Hydroponic fodder is produced by germinating and growing cereal grains or legume seeds for a short period (typically 7–10 days) within a designated growing room under specific environmental conditions (Naik *et al.*, 2015; Sriagtula *et al.*, 2021).

This method offers several significant advantages for

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livestock production :

Nutritional Enhancement: The process of sprouting dramatically increases the nutritional value of seeds, transforming dormant nutrients into more digestible and bioavailable forms, which is essential for improved animal growth and performance (Benincasa *et al.*, 2019). Sprouts are defined as the products obtained from seed germination and initial development in water or other media before being processed into feed (AACC, 2008).

Organic Production: Hydroponic fodder is often considered essentially organic, as its controlled production system inherently minimizes the need for herbicides, pesticides, and other agricultural chemicals (Girma and Gebremariam, 2018; Bari *et al.*, 2022).

Sustainable Feed Supply: Sprouting cereals and legumes provides a reliable and consistent source of feed, which is crucial for the food and fiber production economies reliant on meat, milk, egg, and skin output.

Addressing Feed Constraints in Nigeria

In developing nations like Nigeria, the livestock industry faces severe constraints, primarily due to inconsistent and insufficient feed supply. While the potential of hydroponic fodder is recognized globally, research efforts to generate relevant, locally specific data on sprouted fodder production systems in Nigeria remain sparse (Martins *et al.*, 2023). Existing limited studies in the country have primarily focused on the use of commercial seeds like rice, wheat, maize (Adebiyi *et al.*, 2018), and sorghum (Chana *et al.*, 2021a and b) for feeding ruminants and pigs. To make the hydroponic system practical and economically viable for local industry, there is an urgent need to evaluate the performance of indigenous local seeds. Critical information regarding the optimal seed choice, based on germination rates and subsequent fodder yield characteristics, is currently lacking.

Therefore, the objective of this study was to produce hydroponic fodders from selected local seeds and to determine the appropriate seed type for hydroponic fodder production by characterizing their respective growth performance. Such interventions are vital for sustaining the growth and development of the constrained livestock industry in Nigeria.

Materials and Methods

The study was conducted in two distinct phases: an initial screening of seven local seeds for germination potential, followed by the production and characterization of hydroponic fodder from the most promising candidates.

Phase I: Local Seed Selection and Germination Study

Seed Acquisition and Preparation

Seven common seed types were purchased from wholesalers in the local market in Imo State. The seeds—white sorghum, red sorghum (Sorghum bicolor), millet (Pennisetum glaucum), maize (Zea mays), fonio (Digitaria exilis), groundnut (Arachis hypogaea), and soybean (Gycine max)—were collected, labeled, and used within two weeks.

Experimental Setup

Forty-five (45) wholesome seeds of each type were randomly selected.

Priming: The initial weight of the seeds was determined. They were then soaked (primed) in clean bore-hole water for four hours to activate germination (FAO, 2014). The weight was recorded again immediately after soaking.

Design: The 45 soaked seeds were divided into three replicates of 15 seeds per replicate and arranged in a Completely Randomized Design (CRD).

Germination: Each replicate was placed in a small plastic cup fitted with a perforated cover to allow for air exchange. Seeds were allowed to germinate for 96 hours.

Moistening: The seeds were moistened regularly every 12 hours using a spray can, ensuring they remained moist without being submerged in excess water.

Data Collection

Observations were recorded every 24 hours over the 96-hour period to determine: Daily Germination Rate and Final Germination Rate.

Changes in Weight: Calculated by subtracting the initial dry weight from the final 96-hour weight of the setup. Based on the superior germination results, three seeds—white sorghum, red sorghum, and pearl millet—were selected as candidate seeds for the full fodder production experiment.

Phase II: Hydroponic Fodder Production and Growth Characterization
This phase involved the large-scale production of fodder using the three selected seeds and the determination of their sprouting yields and growth characteristics.

Seed Preparation and Experimental Design

Two and a half (2.5) kilograms of each selected seed type were purchased, and foreign materials (stones, chaff, etc.) were manually removed.

Treatment Groups: The prepared seeds were divided into five 500 g portions, labeled T1 through T5 . T 1 served as the unsprouted control and was spread on a plastic tray kept on a workbench.T2 to T5 were used for the sprouting experiment.Replication and Design: Each treatment (T1 to T5) was replicated three times. The study comprised 5 treatments and 3 replicates, utilizing a Randomized Complete Block Design (RCBD).

Sprouting and Tray Setup

Pre-Sprouting: The T2 to T5 seeds were transferred to plastic buckets with perforated lids, soaked in water for 4 hours for priming, and then the water was drained. The seeds remained in the buckets for an additional 24 hours to accelerate germination.

Fodder Trays: The germinating seeds were transferred to properly labeled plastic trays, each measuring approximately 12 in ×16 in with a depth of 1 in. One end of each tray was perforated to allow for excess water drainage.

Total Setup: This setup resulted in 15 trays (5 trays/ seed type × 3 replicates). The experiment was conducted in a naturally lit and airy room.

Irrigation: The seeds were irrigated with bore-hole water three times daily for a period of 8 days to produce the hydroponic fodder.

Data Collection and Statistical Analysis

Measurements were taken over the 8-day production period:

Weight: The weight of the tray contents was determined daily using an electronic weighing scale before the first daily watering.

Height: The height of the fodder shoots was measured daily in millimeters using a measuring tape. Measurements were taken at three representative points on each tray, and the average was recorded as the daily height value.

These weight and height values were used to calculate growth and yield characteristics at 0–24 hours (initial sprouting), 4 days, 6 days, and 8 days of growth.

Data generated were subjected to Analysis of Variance (ANOVA) using the SPSS (2012) statistical package. Where significant differences were identified, means were separated using the Least Significant Difference (LSD) method.

Results and Discussion

The results are presented in two major sections, corresponding to the two phases of the study: the initial seed screening for germination potential, and the subsequent growth characterization and yield analysis of the selected hydroponic fodders.

Germination and Initial Sprouting Characteristics of Local Seeds (Phase I)
The first phase evaluated seven local seeds to identify the best candidates for hydroponic fodder production, focusing on their germination rates and initial weight changes.

Germination Rate
The germination rates of the seven local seeds over three days are presented in Table 1

On Day 1, white sorghum recorded a significantly higher germination rate (84.43%) compared to all other seeds ($p<0.05$). Red sorghum and fonio also exhibited significantly superior germination to millet, groundnut, maize, and soybean. Notably, maize and soybean recorded 0.00% germination on the first day, indicating a slower initial activation or lag phase compared to the cereals.

By Day 3, white sorghum retained the highest rate (88.89 %), but millet ($73.33%) and fonio (80.0%) had reached comparable germination percentages, forming a group significantly superior to the groundnut ($17.89 %) and soybean (42.22 %) seeds. This suggests that the cereal grains (sorghum, millet, fonio) are inherently better suited or the rapid, short-duration germination required by hydroponic systems due to their dormancy characteristics and ease of water uptake. Changes in Seed Weight During Germination

As expected, groundnut, soybean, and maize, being larger seeds, recorded the highest initial weights. Following the three-day germination period, all seeds, with the exception of fonio (0.00% change), exhibited a net reduction in weight. This weight reduction is attributed primarily to the metabolic breakdown of stored reserves (carbohydrates, fats, and proteins) to fuel the respiratory and developmental processes necessary for initial sprout

Table 1: Germination rate of local seeds (%)

Days	White sorghum	Red sorghum	Millet	Maize	Fonio	Groundnut	Soya bean	SEM
1	84.43a	51.11bc	42.22c	0.00d	55.56b	6.00d	0.00d	7.10
2	88.89a	60.00b	64.45b	37.78c	66.67b	17.89c	28.89c	5.60
3	88.89a	64.44bc	73.33abc	55.56cd	80.00ab	17.89e	42.22d	5.46

Means with different letters in the same row are significantly different (p< 0.05)

Table 2: Shows Initial weight and the percentage change in weight of the seven seeds after three days of germination.

Weight	White sorghum	Red sorghum	Millet	Maize	Fonio	Groundnut	Soya bean
Final(g)	10.77	10.23	10.03	16.67	10.00	21.50	15.57
Original(g)	11.70	10.70	10.30	23.40	10.00	32.10	17.00
%Wt change	7.94	4.39	2.62	2.62	0.00	3.30	8.41

Note: Percentage weight change represents the percentage reduction in seed weight after 3 days.

growth. Soybean (8.41%) and white sorghum (7.94%) recorded the highest percentage weight reduction, indicating high metabolic activity during the initial sprouting phase.

Based on the combination of superior and rapid germination rates (Table 1) and observable signs of metabolic efficiency, white sorghum, red sorghum, and millet were selected as the candidate seeds for the full hydroponic fodder production experiment (Phase II). The use of sorghum (Chana *et al.,* 2021a & b) and millet (Caceres *et al.,* 2014; Makange, 2017) in hydroponic or sprouting systems is well-documented, supporting their selection.
Hydroponic Fodder Yield Characteristics (Phase II)

The daily weight increase of the hydroponic fodders produced from the three selected local seeds over an eight-day period is presented in Table 3.
All three seeds demonstrated a progressive and continuous increase in weight throughout the 8-day cultivation period, which confirms that the local seeds are highly responsive to the hydroponic environment, with weight gain primarily attributed to water uptake and new biomass accumulation .

Table 3: Daily weight increase of the hydroponic produced from the three selected local seeds

Day	White Sorghum	Red Sorghum	Millet	SEM
0	500	500	500	
1	651.7ab	675.00a	633.75b	6.51
2	760.33	777.00	806.67	9.65
3	859.67	883.67	866.67	9.91
4	1109.67	1242.33	1433.67	69.62
5	1350.50b	1401.50b	1807.00a	85.44
6	1427.00b	1529.00b	1834.50a	65.56
7	1491.00c	1541.00b	1853.00a	71.63
8	1508.00c	1684.00b	1904.00a	72.45

Means with different superscript in the same row are significantly different ($p < 0.05$)

The initial weight on days 1 through 4 was statistically similar across the seed types, with only minor differences observed on Day 1 where red sorghum was marginally higher ($p<0.05$). However, a significant divergence in growth pattern emerged from Day 5 onwards.

From Day 5 until the final measurement on Day 8, millet fodder consistently recorded a significantly higher ($p<0.05$) weight compared to both white and red sorghum fodders. By the end of the experiment (Day 8), millet reached a final weight of 1904.00(g)

Fodder Yield and Discussion

The final increase in weight (total yield) relative to the initial 500(g) seed batch was calculated:

Millet: Increased by 280.8(g), Red Sorghum Increased by 236.8(g), White Sorghum: Increased by 201.6(g). This finding demonstrates that millet is the superior choice for maximizing biomass yield under these experimental conditions. This significant difference is likely due to the inherent morphological and physiological differences between the seeds, specifically millet's high density of seeds per unit area, resulting in a dense, compact root mat (or "matting ability") which efficiently traps and retains moisture, accelerating biomass development. While millet produced heavier fodder, the results indicated that the sorghum seeds produced significantly taller ($p<0.05$) fodder than millet seed (as noted in the Abstract). This morphological divergence—millet prioritizing weight/density and sorghum prioritizing height—suggests different applications in livestock feeding. Taller fodder might be preferred for manual cutting and specific feeding presentations, while heavier, denser fodder offers better overall nutritional return per unit of floor space.

The general progressive change in sprouted seeds is consistent (Martins *et al.,* 2025; Sharma *et al.,* 2015). The successful production of fodder from both sorghum and millet confirms that both species can be utilized for hydroponic fodder production in southeastern Nigeria. However, millet seed offers a clear advantage for maximizing fresh weight yield, whereas sorghum is more suitable when fodder height is the primary consideration.

The weight of all fodders increased progressively throughout the experiment, aligning with existing

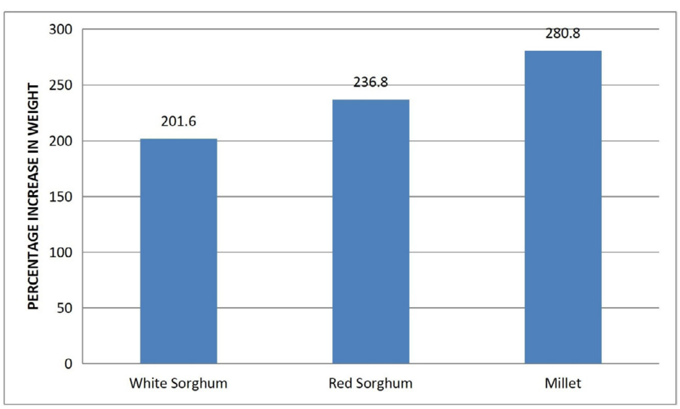

Figure 1: Shows percentage increase in weight.

literature (Chana *et al.*, 2021b). However, the critical divergence occurred from Day 5 onward, where millet fodder recorded a significantly higher ($p<0.05$) final weight than both sorghum types. By Day 8, millet reached 1904.00(g) from an initial 500(g) seed batch, corresponding to a 280.8% increase in fresh biomass. This performance surpassed red sorghum (236.8%) and white sorghum (201.6%).

The superior yield of millet for fresh weight suggests a higher density of growth, likely due to a more efficient development of the root mat and higher moisture retention capacity per unit area compared to the sorghum varieties. This high yield confirms the report by Kide *et al.* (2015) that the hydroponic method effectively produces high yields of biomass. While millet excelled in biomass accumulation (weight), the sorghum varieties demonstrated a significant advantage in vertical growth (height) (Table 4). White sorghum consistently produced the tallest fodder throughout the 8-day period, reaching 120.00 (mm) on the final day, significantly taller ($p<0.05$) than red sorghum (80.00) and substantially taller than millet 58.00 (mm).

Millet: Optimal for maximum fresh weight and dense feed volume per tray, prioritizing energy and nutritional yield.

Sorghum: Optimal when taller fodder is desired, potentially for easier harvesting or specific feeding presentations, consistent with heights reported by Chana *et al.* (2021b) and Murthy *et al.* (2017). Martins *et al.,* 2024 observed a successful production of high-yield, mineral-rich biomass from both millet and sorghum, this confirms their potential for supporting the constrained livestock industry in southeastern Nigeria. The millet seed, despite producing shorter fodder.

Murthy *et al.,* (2017) however reported a height of 10.8 cm for the 5th day sorghum fodder produced under a low-cost greenhouse production system. Although the millet seeds produce fodder that were shorter in length, the percentage increases in weight within 8 days of sprouting suggest that they will serve as better seeds for hydroponics fodder production. Sorghum seeds have however been reported to produce high concentrations of the cyanogenic

Table 4: Daily increase in height (mm) of fodder production the three selected local seeds.

Days	White Sorghum	Red Sorghum	Millet	SEM
1	4.75a	4.25a	2.00b	0.43
2	21.67a	16.00b	10.00c	1.63
3	31.67a	25.33b	18.33c	1.82
4	40.67	40.67	35.00	1.56
5	43.50b	50.00a	39.50	1.41
6	66.00a	62.00a	52.00b	2.34
7	93.50a	77.00b	54.00c	4.91
8	120.00a	80.00b	58.00c	7.78

Means with different superscript in the same row are significantly different ($p< 0.05$)

glucosides, dhurrin and amygdalin among other anti-nutrients in the immature leaves, with the levels decreasing with the plant age (Nyirenda 2020). There is therefore the need for caution when using sorghum seeds for hydroponic fodder production.

Conclusions and Recommendations

In conclusion, both sorghum and millet seeds are suitable for hydroponic fodder production in southeastern Nigeria. Millet may be preferred for heavier fodder yield, while sorghum is advantageous for taller fodder growth.

White sorghum, red sorghum and millet seeds should be used in hydroponic fodder production for year round feeding of livestock in Nigeria.
The technology should be adopted for quality fodder production during the drought periods characterized by feed scarcity in Northern Nigeria.

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