ISSN: 2504-9070

EVALUATION OF TROPICAL GRASS SPECIES FOR CLIMATE RESILIENCE UNDER VARYING WATERING REGIMES

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ABSTRACT

Changing rainfall patterns associated with climate change threaten pasture establishment and livestock production in the tropics, making the identification of moisture-stress-tolerant grasses essential for sustainable forage systems. This study evaluated the performance of Rhodes grass (*Chloris gayana*), Congo grass (*Brachiaria ruziziensis*), and Northern Gamba grass (*Andropogon gayanus*) under varying watering regimes to identify species with climate-resilient potential.
A 3 × 6 factorial experiment was arranged in a Completely Randomized Design with three replications, comprising three grass species and six watering intervals (0, 1, 2, 4, 7, and 14 days). Data were collected on percentage germination, plant height, root length, and fresh and dry shoot weight.
Results showed that Rhodes grass recorded the highest germination (36.67%) under daily watering, while weekly watering significantly ($P < 0.05$) enhanced root length (9.60 cm) compared with zero (2.00cm), four (8.77cm), and 14-day (8.99cm) intervals. Daily watering also produced the highest fresh shoot weights in Rhodes (22.33 g) and Northern Gamba grass (23.33 g), with Northern Gamba grass attaining the greatest dry shoot weight (13.33 g). Despite reduced watering frequency, Rhodes and Congo grasses maintained appreciable biomass and exhibited strong root development, indicating adaptive responses to moisture stress.
Based on the results, Rhodes and Congo grasses demonstrated superior resilience under water-limited conditions and are therefore well suited and recommended for pasture establishment in low-rainfall environments, supporting more stable and climate-resilient livestock production systems.
Keywords: Rhodes grass, Congo grass, Northern Gamba grass, Watering regimes and Fresh weight

INTRODUCTION

Nigeria is blessed with numerous livestock resources among which are 16 million cattle, 33 million sheep and 52.2 million goats (FAO, 2009). Livestock production in Nigeria is still dominated by the traditional Fulani herders. Under the existing extensive livestock production system, land areas for grazing and feeds availability are limiting factors in the area with high population of livestock in Nigeria (Muhammad and Abubakar, 2004). Animal's performance depends on the amount and quality of grass and its availability within the different month during the year (Hatam *et al.,* 2001).

Livestock production in Nigeria depends on natural and induced grasslands for the supply of forage and sustained productivity. However, provision of adequate feed has over the years, constituted a major challenge to the improved productivity of the animals (Olorunnisomo and Adewumi, 2015).

Some natural disasters such as flood, drought, heat wave, extreme cold, and hailstorm to mention a few, occasioned by climate change have affected every facet of life including agriculture. Agricultural activities such as livestock and crop production have received major blow because they are weather dependent.

Disparity in rainfall regime between the wet and dry season results in predictable fluctuations in forage supply across the different vegetational zones of Nigeria. The dry season presents a recurrent problem of feed shortage to grazing animals and resultant mass movement of cattle herds from the north to wet regions in the south (Nzeh, 2015). This seasonal migration is a major cause of serious and often fatal communal clashes between traditional cattle herdsmen and native crop farmers (Olorunnisomo and Adewumi, 2015).

The adverse effect associated with climate change has placed drought resistance as one of the most environmentally safe and economically viable means of producing forage for livestock. Forage plants are termed resilient when they have ability to grow or tolerate water deficient condition.

Identification of drought resistant grass species will serve as additional source to overcome the impact of climate change. Drought resistant grass species have comparatively better yield than susceptible ones. They ensure adequate forage for livestock all year round and discourage movement of herds from Northern to Southern part during dry season which often lead to avoidable death as experienced presently in Nigeria. Therefore, the objective of this study was to investigate the performance of different grass species under different watering regime

MATERIALS AND METHODS

Study Area

The research was carried out inside green house in the Department of Agricultural Technology, Federal College of Animal Health and Production Technology, Vom, Plateau State. Vom is situated on longitude, 8°791′ E and latitude 9°729′ N, at an elevation of approximately 1,280 m above sea level. The locality experiences a cool sub-temperate climate with mean temperatures ranging between 19 and 22 °C. Annual rainfall varies from 131.75 to 146 cm, with the peak precipitation occurring between July and August (Okafor *et al*., 2024).

Experimental Design

The experimental design used for the experiment was 3 x 6 factorial, laid out in Completely Randomized Design (CRD) with three replications. Factor A comprised three grass species (Rhodes, Congo and Northern Gamba) while Factor B comprised six watering regimes (0, 1, 2, 4, 7 and 14 day(s)) which made up 18 treatment combinations. The watering regimes were selected to represent a gradient of soil moisture conditions that commonly occur in tropical pasture systems under both normal and climate-stressed environments

Sourcing of Seeds, Potting, Planting and Management

Seeds of Rhodes, Congo, and Northern Gamba grasses were obtained from the same seed lot derived from the previous year's harvest at the Dagwom Farm, National Veterinary Research Institute (NVRI), Vom. Formal laboratory seed viability or germination tests were not conducted prior to sowing; however, seeds were visually

ISSN: 2504-9070

inspected to remove damaged seeds. Black polybags were filled with 3 kg of topsoil and treated with a pre-emergence herbicide (atrazine) to minimize early weed interference. Ten seeds of each grass species were sown per polybag and irrigated with 50 ml of water according to the assigned watering regimes, except for the zero-watering control, which received no irrigation throughout the experiment. All pots were maintained under uniform environmental and management conditions.

Data Collection and Statiscal Analysis

Days to 50% germination were determined as the number of days required for half of the seeds sown in each pot to emerge. Plant height was measured with a measuring tape from the soil surface to the apical meristem. Root length was assessed at harvest by carefully uprooting the grasses with a hand trowel to prevent root damage, followed by gentle washing under running water to remove adhering soil. Each plant was then separated at the root–shoot junction using a sharp knife. Root length was measured from the crown to the tip of the longest primary root using a meter rule. Fresh shoot weight was recorded using a sensitive electronic balance. Dry shoot biomass was obtained by placing the fresh shoots in labeled paper bags and oven-drying them at 65 ± 2 °C to constant weight for 48 to 72 hours.

Data collected were subjected to Analysis of Variance (ANOVA) using DSAASTAT, Ver.1.101 add-in version 2011 (Onofri, 2007) and the significant means were separated using Least Significant Difference (LSD) at 5% level of probability.

RESULTS

Germination and Plant Height

Watering regime had a significant ($P < 0.05$) effect on all measured parameters (Table 1). The highest germination (30%) occurred under daily watering, while the control showed almost no emergence (1.11%). Plant height followed a similar trend, peaking at 9.82 cm under the daily watering interval and declining progressively with longer intervals.

Germination differed significantly ($P < 0.05$) among the three grass species (Table 2). Congo grass recorded the highest germination (26.11%), followed closely by Rhodes grass (23.83%), whereas Northern Gamba grass showed markedly lower germination (11.67%). Plant height varied significantly ($P < 0.05$) among the grass species (Table 2). Rhodes grass produced the tallest shoots (7.91 cm), closely followed by Congo grass (7.35 cm), while Northern Gamba grass exhibited the shortest height (4.56 cm).

The interaction of watering frequencies and grass species significantly ($P < 0.05$) influenced germination percentage and plant height (Table 3). Two grass species recorded their highest germination when watered daily; Rhodes grass (36.67%) and Northern Gamba grass (20%), while Congo grass recorded highest germination (36.67%) rate when irrigated at weekly intervals. Daily irrigation recorded the most heights on the three grass species, with Rhodes grass reaching 11.33 cm, followed by Congo grass (9.73 cm) and Northern Gamba grass (8.40 cm).

Root Length, Fresh and Dry Shoot Weight

Application of water at two days interval produced the tallest root (7.16 cm), but decreased significantly under seven and 14-days (6.18 and 5.67 cm) watering intervals (Table 1). Fresh and dry shoot weights were heaviest under daily watering (21.66 g and 10.33 g, respectively), with substantial reductions observed as watering intervals increased. The lowest biomass values occurred at 14 days (10.89g and 4.22g) watering regime, indicating strong growth suppression under moisture stress.

ISSN: 2504-9070

Root length, fresh and dry shoot weights differed significantly (P < 0.05) among the grass species (Table 2). Rhodes grass developed the longest roots (7.37 cm), whereas Congo grass (5.49 cm) and Northern Gamba grass (3.93 cm) produced progressively shorter roots. Congo grass produced the heaviest fresh biomass (14.11 g), followed by Rhodes grass (13.78 g), while Northern Gamba grass yielded the lightest (12.33 g). Northern Gamba grass surprisingly showed the heaviest dry matter yield (7.28 g), exceeding Congo grass (4.95 g) and Rhodes grass (5.78 g).

The interaction of watering frequencies and grass species significantly (P <0.05) influenced fresh and dry shoot weight (Table 4). Two grass species recorded their heaviest fresh biomass when watered daily; Rhodes grass (22.33g) and Northern Gamba grass (23.33g), while Congo grass recorded its heaviest fresh biomass (22.67g) when irrigated at two days intervals. Northern Gamba grass produced exceptionally high dry weights under daily and 4-day watering (17.33 g and 12.00 g), exceeding congo grass (7.00g) and Rhodes grass (8.33g).

The interaction of watering frequencies and grass species significantly (P <0.05) influenced root length (Table 5). Northern Gamba grass (9.07 cm) recorded the tallest root length when watered daily, while Rhodes and Congo grasses recorded tallest root lengths of 9.60 cm and 8.10 cm when irrigated seven and 14-days intervals respectively.

Table 1: Effect of Varying Watering Regimes on the Germination Percentage (%), Plant Height (cm), Root Length (cm), Fresh Shoot weight (g) and Dry Shoot weight (g) of Grass species at Eight Weeks after Sowing.

Watering regimes (days)	Germination Percentage (%)	Plant Height (cm)	Root length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)
0	1.11	0.89	0.67	0.89	0.56
1	30.00	9.82	7.14	21.66	10.33
2	23.33	8.98	7.16	21.11	8.44
4	23.33	7.69	6.78	13.11	7.33
7	23.33	6.80	6.18	12.78	5.11
14	22.11	5.47	5.67	10.89	4.22
LSD(P<0.05)	7.91	0.75	0.33	0.59	0.63

Table 2: The Germination Percentages, Plant Heights, Root Lengths, Fresh Shoot weights and Dry Shoot weights of Grass species at Eight Weeks after Sowing.

Grass species	Germination Percentage (%)	Plant Height (cm)	Root length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)
Congo grass	26.11	7.35	5.49	14.11	4.95
Northern Gamba grass	11.67	4.56	3.93	12.33	7.28
Rhodes grass	23.83	7.91	7.37	13.78	5.78
LSD(P<0.05)	5.59	0.53	0.24	0.42	0.45

Table 3: Interaction of Watering Regimes and Grass species on the Germination Percentages and Heights of Three Grass species at Eight Weeks after Sowing.

	Percentage germination (%)			Plant Height (cm)		
Watering regimes (days)	Congo grass	Northern Gamba grass	Rhodes grass	Congo grass	Northern Gamba grass	Rhodes grass

0	0	0	3.33	0	0	2.67
1	33.33	20	36.67	9.73	8.4	11.33
2	30	20	20	11.2	7.47	8.27
4	23.33	16.67	30	8.53	7.47	7.07
7	36.67	13.33	20	7.33	4	9.07
14	33.33	0	33.00	7.33	0	9.07
LSD(P<0.05)		13.7			1.3	

Table 4: Interaction of Watering Regimes and Grass species on the Fresh and Dry Shoot Weights of Three Grass species at Eight Weeks after Sowing.

	Fresh shoot weight (g)			Dry shoot weight (g)		
Watering regimes (days)	Congo grass	Northern Gamba grass	Rhodes grass	Congo grass	Northern Gamba grass	Rhodes grass
0	0	0	2.67	0	0	1.67
1	19.33	23.33	22.33	7.00	17.33	6.67
2	22.67	21.67	19.00	6.00	11.00	8.33
4	7.00	22.33	10.00	3.67	12.00	6.33
7	14.33	6.67	11.67	6.33	3.33	5.67
14	21.33	0.00	17.00	6.67	0.00	6.00
LSD (P<0.05)		1.03			1.09	

Table 5: Interaction of Watering Regimes and Grass species on the Root Length of Three Grass species at Eight Weeks after Sowing.

	Root length (cm)		
Watering regimes (days)	Congo grass	Northern Gamba grass	Rhodes grass
0	0.00	0.00	2.00
1	6.67	9.07	5.67
2	6.53	5.67	9.27
4	5.83	5.73	8.77
7	5.83	3.10	9.60
14	8.10	0.00	8.90
LSD (P<0.05)		0.58	

DISCUSSION

Germination

The percentage germination differed among the three grass species and were found to be very poor. This could be as a result of dormancy and short storage period of the seeds used for the trial. This agrees with Nerson (2002), who recommended extended storage periods, sometimes up to six months or longer, to increase coat permeability and raise germination percentages. Comparable interspecific variation in germination among tropical forage grasses has also been reported by Ishikawa *et al*. (2020), who attributed such differences to inherent seed dormancy mechanisms and maternal environmental effects.

Daily watering encouraged higher germination of the grass species, whereas very low emergence occurred in the non-watered control. This indicates that adequate soil moisture is essential for imbibition and enzyme activation during germination. Reduced germination at longer intervals (seven to 14 days) likely resulted from intermittent soil desiccation, which impairs metabolic activity and radicle protrusion. These observations agree with reports that drought/osmotic stress reduces germination percentage in legumes and other species (Papathanasiou *et al*., 2022).

Plant Height

Daily watering markedly enhanced the heights of the grass species, whereas plant height declined progressively as watering intervals increased. This pattern indicates that shoot elongation is highly responsive to soil moisture availability. The reduction in height observed under the seven to 14-day watering intervals is likely due to diminished turgor pressure, restricted cell expansion, and lowered photosynthetic efficiency under moisture stress. Such moisture-induced limitations are consistent with the shorter shoots recorded. Similar observations were reported by Koech *et al*. (2016), who noted significant declines in vegetative growth and herbage accumulation under deficit or infrequent irrigation regimes.

Root Length

Root length of grass species peaked at the two-day watering regime, indicating that moderate moisture availability optimizes root elongation. Interestingly, plants subjected to the seven and 14-day watering regimes produced moderate root lengths, despite experiencing clear moisture limitations. This pattern reflects a typical drought-avoidance strategy in many grasses, where mild to moderate water deficit stimulates compensatory root elongation as plants attempt to explore deeper soil layers for available moisture. Kou *et al*. (2022) reported that root growth under moderate stress is often prioritized relative to shoot growth because of hormonal regulation, particularly elevated abscisic acid (ABA) and altered auxin transport, which promote root extension even when above-ground tissues are inhibited.

Specifically, irrigation at seven and 14 days intervals produced longer roots in Rhodes and Congo grasses respectively. This could be a survival mechanism used by the plants to circumvent water stress. Previous studies have shown similar species-specific differences, with Rhodes grass often producing deeper, more fibrous root systems compared with other tropical forages (Mwendia *et al*., 2017; Nunes *et al*., 2019). This result also aligns with Cook *et al*. (2005) and Heuze *et al*. (2016), who reported that Rhodes grass can withstand long dry period as a result of its long roots which can extract water to a depth of greater than 4 m.

Biomass (fresh and dry shoot weight)

Congo grass produced the heaviest fresh biomass, followed by Rhodes grass while Northern Gamba grass yielded the least. The superior fresh mass of Congo and Rhodes grasses is consistent with their greater shoot elongation and canopy development, which enhances total photosynthate accumulation. The relatively low fresh biomass of Northern Gamba grass reflects its shorter height and limited leaf development. Similar interspecific differences in fresh herbage yield among tropical grasses have been reported by Pereira *et al*. (2018), who noted that biomass output is strongly associated with early plant vigour and rapid leaf expansion.

Northern Gamba grass surprisingly showed the highest dry matter yield exceeding Congo and Rhodes grasses. The heavier dry matter proportion in Northern Gamba grass may be due to greater tissue structural density, higher fiber accumulation, or lower moisture content relative to the other species. Although Northern Gamba grass produced less fresh biomass, the higher dry matter suggests slower but more structurally robust growth. This finding is consistent with observations by Oliveira *et al*. (2021), who reported that some slow-growing grasses accumulate more structural carbohydrates, resulting in higher dry matter concentration despite reduced fresh weight.

Conclusion

Tropical grasses demonstrated clear species-specific responses to moisture stress. Rhodes grass and Congo grass showed superior climate resilience, maintaining acceptable growth and productivity under restricted watering. In contrast, Northern Gamba grass performed optimally only under frequent or moderate irrigation.

Recommendations

Rhodes and Congo grasses are recommended for cultivation in drought-prone or low-rainfall areas, as they sustain appreciable biomass production even under extended watering intervals. In contrast, Northern Gamba grass performs optimally under reliable or moderate irrigation, where its high dry matter yield can be fully realized. To ensure successful establishment, seeds of these grass species should either be stored for a minimum of six months or subjected to chemical scarification prior to sowing.

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