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GROWTH COMPONENTS AND FORAGE YIELD OF WYNN CASSIA (*Chamaecrista rotundifolia Cv.* Wynn) AS INFLUENCED BY VARYING LEVELS OF IRRIGATION VOLUME, FREQUENCY AND NATRON (*KANWA*) IN THE NIGERIAN SAVANNA

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ABSTRACT

A study was conducted to evaluate the effects of varying levels of irrigation volume, irrigation frequency and Natron (*Kanwa*) on growth components and forage yield of *Chamaecristarotundifolia*. The experiment was laid out in a split plot with 3×2×2 factorial arrangement, with three replications. Results indicated that stand count and growth components were affected (P<0.05) by all the treatments. Irrigation volume showed a significant (P<0.05) decreasing trend (25L>50L>100L) in all parameters measured across all growth stages. There were 55% and 56% increase (P<0.05) in stand count and plant height, respectively in treatments with the lowest irrigation volume (25L) compared to those with the highest (100L). Irrigation frequency followed a similar trend with 6 days having higher (P<0.05) values than 3 days while *Kanwa* application level at 40kg/ha had higher (P<0.05) values compared to 20kg/ha in all parameters measured. There were 48% and 42% increase (P<0.05) in fresh and dry forage yield, respectively with respect to the lowest irrigation volume as compared to the highest. Higher (P<0.05) fresh forage yield of 7% was recorded in treatment with 40kg/ha of Natron when *C. rotundifolia* was irrigated at 6 days irrigation interval. The dry forage yield was similar (P>0.05) between the treatments with Natron (*Kanwa*). All interactions were not significant (P>0.05), except the level of *Kanwa* and age of harvest of the forage (K×A) which was significant (P<0.05) on dry matter yield and number of leaves at the harvesting period. It was hence, concluded that all the treatments are paramount to the normal growth and forage yield of *C. rotundifolia*. However, farmers should irrigate *C. rotundifolia* using the minimum irrigation volume (25L) in combination with 40kg/ha of Natron (*Kanwa*) for better forage yield provided the irrigation interval does not exceed 6 days in the northern guinea savannah of Nigeria.

Keywords: *Chamaecrista*, growth components, irrigation, yield.

INTRODUCTION

Seasonal variations in feed quantity and quality cause fluctuations in animal nutrition and productivity throughout the year, especially during the dry season (Douglas *et al.,* 1991). Generally, legumes are considered as an appropriate option for alleviating nutritional constraints of livestock in the tropics (Humphrey, 1991). Wynn cassia (*Chamaecristarotundifolia*)also known asRound-leaf cassia has been identified as a promising material for 'fodder bank' production (Peters *et al*., 1994), apparently because of its prolific seeding habit and spontaneous seedling regeneration following the onset of rains (Tarawali, 1991). *C. rotundifolia* is a short-lived self-generating annual plant belonging to the *Fabaceae* family. It originated in North America, Caribbean and Tropical South America, but is grown in other parts of the world today (Cook *et al*., 2005). It is considered as one of the promising legumes for the sub humid regions of Nigeria (Tarawali, 1991;1994). The author reported dry matter production of 2.84t/ha per year and crude protein of 10.7% under rain fed condition.

Kanwa (Natron), generally referred to as *KanwarShanu*in the northern part of Nigeria, primarily known as a mineral supplement fed to traditionally managed cattle is used to improve soil fertility and providing better-quality foragepartially due to nutrients other than P and Cu at lower cost thanwith commercial N fertilizers(Mohamed-Saleem, 1984). In order to get available feeds for animals throughout the dry season, there is a need to undertake irrigation for the cultivation of forages for animals. Effective irrigation will influence the entire growth process from germination, nutrient utilisation, plant growth and regrowth which is a powerful impetus to forage production and use by providing high quality feed in the dry season. This study was therefore, designed to determine the effect of varying levels of irrigation volume , irrigation frequency and *Kanwa*rates on growth components and forage yield of *C. rotundifolia.*

MATERIALS AND METHODS

The experiment was conducted at the irrigation site of the Institute for Agricultural Research (IAR) Samaru- Zaria located on latitudes (11^0 and 11^0N) and longitudes (7^0 and 11^0E) at an altitude of 686m above sea level in the Northern Guinea savanna of Nigeria. The relative humidity is very high during the wet season and could reach about 70-80%, during the dry season the relative humidity falls to about 15-20% (Ovimaps, 2014). A composite soil sample was obtained from the experimental plots using a soil auger for routine analysis (Table 1). There was a total of 36 net plots measuring $1m^2$ with 0.5m inter-row path and watering channels.The entire plot was irrigated before sowing using flood irrigation applied after every three days, until irrigation treatment was imposed at 3 weeks after sowing. Soil moisture meter was used to measure volumetric water content. The plots received 18kgNPK fertilizer/ha as uniform dressing by broadcasting and were manually weeded using a hoe before sowing. Seeds and *Kanwa* rates were broadcasted in each plot at 15kg/ha. Data collection for agronomic studies began at four weeks after sowing when plant leaves were fully developed.

Table 1:Physical and chemical properties of the soil at the experimental site.

Properties	Soil
Physical properties (%)	
Clay	18.00
Silt	20.00
Sand	62.00
Textural Class	Sandy Loam
Chemical properties:	

pH (H_2O) 1:2:5	06.20
pH (0.01M $Cacl_2$)	05.20
Total Nitrogen (%)	00.11
Available Phosphorus (Mg/kg)	10.83
Organic carbon (%)	00.84
Exchangeable bases (Cmol/kg)	
Calcium (Ca^{++})	08.40
Magnesium (Mg^{++})	03.16
Potassium (K^{++})	00.61
Sodium (Na^{++})	00.61
Cation Exchange Capacity (CEC)	14.00
Exchangeble acidity (H+Al)	00.80

The *C. rotundifolia*forage was sampled at 4, 8 and 12 weeks post-emergence where five plants were randomly selected and tagged per plot for determination of various agronomic parameters (stand counts, plant height, number of leaves and branches using the standard procedure.The Leaf area indexwas obtained during the harvesting period by means of planimetrictechniques (Daughtry, 1990) using the Li-3100C planimeter (leaf area meter) which makes use of a fluorescent light source and a solid-state scanning camera to sense the area of leaves as they move through the instrument. The total fresh yield was estimated by cutting the cassia plants at 5cm above the ground from each plot at the harvesting period. Total fresh weight (Tot FW) of the material cut was weighed immediately using a hanging scale to determine the fresh fodder yield before a sub sample (FWss) was taken (200g). The samples wereoven dried at 65°C for 48hrs and reweighed (DWss) to give an estimate of the dry-matter production during this period using the formula below.

Dry matter (kg/ha) = Tot FW x (DWss / FWss) x 10 (Tarawali*et al*., 1995).

Where: Tot FW = total fresh weight from 1 m^2, FWss = fresh weight of the subsample and DWss = dry weight of the subsample all in grams.

DATA ANALYSIS

All data collected on growth components were subjected to analysis of variance (ANOVA) by Repeated Measures, while data on fresh and dry forage yields were analysedby General Linear Model (GLM), using the Statistical Analysis System (SAS, 2003). Treatment means were separated using Dunnet’s Test.

RESULTS

The result of the chemical analysis of the soil (Table 1) showed a soil pH of 5.20, total N (0.11%), available P (10.83%) and organic C content (0.84%).Table 2 showed the effects of varying levels of irrigation volume, frequency and *Kanwa* application on stand count and growth components of *Chamaecristarotundifolia* at 12 weeks after sowing (WAS). All treatments did not show significant difference (P>0.05) for leaf area index during the harvesting period. Irrigation volume showed a decreasing trend (25L > 50L > 100L) in all parameters measured. The stand count and plant height increased by 55% and 56%, respectively in treatments with the lowest irrigation volume (25L) compared to those with the highest (100L). Similarly, irrigation frequency followed a similar trend with 6 days having higher (P<0.05) values than 3 days in all parameters measured. However, for *Kanwa* application level, the results showed an increasing trend (P<0.05) in all the growth components with 40kg/ha application level having higher (P<0.05) values compared to 20kg/ha in all parameters measured.

Table 2: Effects of varying levels of irrigation volume, frequency and *Kanwa* on Stand count and growth components of *Chamaecristarotundifolia* at 12 weeks of age.

Treatments	Stand count (no)	Plant height (cm)	No. of leaves (no)	No. of branches (no)	LAI
Irrigation volume (L)					
25	4.30^{a}	15.92^{a}	25.40^{a}	3.30^{a}	0.04
50	3.31^{ab}	11.39^{b}	22.77^{b}	3.00^{b}	0.04
100	1.92^{b}	6.97^{c}	18.92^{c}	1.92^{c}	0.02
Irrigation (days)					
3	2.34^{b}	9.94^{b}	21.06^{b}	2.35^{b}	0.03
6	3.84^{a}	12.05^{a}	23.05^{a}	3.00^{a}	0.04
Kanwa (kg/ha)					
20	2.95^{b}	8.81^{b}	19.18^{b}	2.59^{b}	0.03
40	3.24^{a}	13.06^{a}	24.74^{a}	2.79^{a}	0.03
SEM	0.05	0.29	0.50	0.05	0.01

^{abc} Means with different superscripts along the column differed significantly (P < 0.05)
LAI = leaf area index SEM= Standard error of means

Table 3 showed the effects of varying levels of irrigation volume, frequency, *Kanwa*, age of maturity and their interactions on plant height and number of leaves of *Chamaecristarotundifolia* at 4, 8 and 12WAS.Irrigation volume showed a decreasing trend (P<0.05) in order of 25L> 50L> 100L in all the parameters measured at all age intervals. Plant height increased from 33% at 4WAS to 56% at 12WAS with respect to the lowest irrigation volume (25L) as compared to the highest irrigation volume (100L). Similarly, irrigation frequency followed a similar trend with 6 day irrigation interval having higher values compared to 3 days interval. Plant height was similar (P>0.05) between treatments at 4WAS. However, for *Kanwa* application level, number of leaves was similar (P>0.05) between treatments at 4WAS. Plant height and number of leaves increased by 54% and 52%, respectively in treatment with 40kg/ha compared to 20kg/ha during the harvesting period. All the interactions on plant height and number of leaves showed no significant (P>0.05) differences between the treatments except the interaction between K×A which was significant (P<0.05) for number of leaves up to 12WAS.

Table 3: Effects of varying levels of irrigation volume, frequency, levels of *Kanwa*, age of maturity and their interactions on Plant height and number of leaves of *Chamaecristarotundifolia* at 4, 8 and 12WAS.

	Plant height (wks)			Number of leaves (wks)		
Treatments	4	8	12	4	8	12
Irrigation volume (L)						
25	1.87^a	6.53^a	15.92^a	5.77^a	12.40^a	25.40^a
50	1.34^b	5.64^b	11.39^b	5.10^b	12.31^a	22.77^b
100	1.26^c	4.09^c	6.97^c	4.85^c	10.31^b	18.92^c
Irrigation (days)						
3	1.52	4.61^b	9.94^b	5.06^b	11.53	21.06^b
6	1.56	5.98^a	12.05^a	5.42^a	11.68	23.05^a
Kanwa (kg/ha)						
20	1.46^b	4.18^b	8.81^b	5.53	8.47^b	19.18^b
40	1.61^a	6.36^a	13.06^a	4.94	14.42^a	24.74^a
SEM	0.03	0.13	0.29	0.08	0.31	0.50
Interaction						
V×A	NS	NS	NS	NS	NS	NS
K×A	NS	NS	NS	*	*	*
F×A	NS	NS	NS	NS	NS	NS
V×K× F× A	NS	NS	NS	NS	NS	NS

[abc] Means with different superscripts along the column differed significantly (P<0.05) SEM = **Standard error of means** V = Volume K = *Kanwa*F = Frequency A = Age of plant

Table 4 showed the effects of varying levels of irrigation volume, irrigation frequency and *Kanwa* application on fresh and dry matter yield of *Chamaecristarotundifolia* at 12WAS. Irrigation volume showed a decreasing trend (P<0.05) in order of 25L> 50L> 100L in all the parameters measured. The fresh forage yield increased by 48% with respect to the lowest irrigation volume (25L) as compared to the highest irrigation volume (100L). Similarly, irrigation frequency followed a similar trend with 6 day irrigation interval having higher values compared to 3 days interval. However, for*Kanwa* application level, there was 7% higher (P<0.05) fresh forage yield in treatment with 40kg/ha compared to 20kg/ha. The dry forage yield was similar (P>0.05) between the treatments. All the interactions on fresh and dry matter yield showed no significant differences (P>0.05) between the treatments except the interaction between K×A which was significant on dry matter yield.

Growth components and forage yield

Table 4: Effects of varying levels of irrigation volume, frequency and *Kanwa* on fresh and dry forage yields of *Chamaecristarotundifolia* at 12 weeks of age.

Treatment	Fresh forage Yield (t/ha)	Dry forage Yield (t/ha)
Irrigation volume (L)		
25	3.94[a]	3.05[a]
50	3.38[b]	2.36[b]
100	2.06[c]	1.77[c]
Irrigation (days)		
3	2.68[b]	1.76[b]
6	3.76[a]	2.84[a]
Kanwa (kg/ha)		
20	3.15[b]	2.32
40	3.37[a]	2.34
SEM	0.05	0.04
Interaction		
V×A	NS	NS
K×A	NS	*
F×A	NS	NS
V×K× F× A	NS	NS

[abc] Means with different superscripts along the column differed significantly ($P<0.05$)
SEM **= Standard error of means** V = Volume K = *Kanwa*F = Frequency A = Age of plant

DISCUSSION

The result of chemical analysis of the soil of the experimental field (Table 1) shows that the legume (*C. rotundifolia*) was established on a relatively acidic soil whose reaction presupposes that nutrients may not be readily available for plant uptake (Jones, 2003). Total N, available P and organic C content showed that the soil was low in these important chemical nutrients which were required for good growth and quality of forage plants. The low level of these nutrients is responsible for the poor productivity of crops, especially forage plants on tropical soils (Mohammed-Saleem, 1972). This justified the application of *Kanwa* which enriched the nutrient pool and thereby enhancing the quality of the soil to increases productivity of forage in the tropics.

In this study (Table 2), the stand count and growth components of *Chamaecristarotundifolia* at the harvesting period was consistently decreasing with increase in irrigation volume. This might be attributed to the inadaptability of *C. rotundifolia* under waterlogged condition (Tanko, 2014). The lower stand count observed in the higest level of irrigation volume can be explained by the fact thatlegumes vary widely in their ability to become established, produce and persist in different soils, climatic, pests or diseases and management conditions (Miller *et al.,* 1988). Other contributing factors may include the level of seedbed preparation (Skerman*et al.,* 1988) and activities of harvester ants. However, Miller *et al.,* (1988) reported that stand count of one plant legume per square meter is adequate.

Similarly, irrigation frequency followed a similar trend with 6 days having higher values than 3 days in all parameters measured. Delaying irrigation interval from 6 – 12 weeks was observed to produce statistically higher values for growth and yield parameters in high water table areas (Cook *et al*., 2005). In general, *C. rotundifolia* used in this study adapted well to the moisture stress imposed due to irrigation frequency, thereby affecting the growth components.

The increasing trend with 40kg/ha application level compared to 20kg/ha in all parameters measured, infers that the response to *Kanwa*was linear up to the highest level of application (40kg/ha) in the study. This indicated that it can complement or replace inorganic fertilizer for *C. rotundifolia* production. It also implies that fertilizer application is required to replenish soil nutrients which pastures remove when grazed or cut (Ogedegbe*et al.,* 2014).

In this study (Table 3), the plant height and number of leaves of *C. rotundifolia* at 4, 8 and 12 weeks after sowing shows a decreasing trend as irrigation volume was increased at all stages of growth. Hazrat*et al*. (2004) reported that plant height generally depends on internodes expansion, which caused an increase in height with increase in water depth, resulting in a taller plant. Plant structural and functional characteristics changes continuously with relative age (Ninemets, 2004). However, for *Kanwa* application level, number of leaves increased at 40kg/ha level of application compared to 20kg/ha during the harvesting period. Many reports have shown that higher leaf proportion is a desirable attribute in forage species, as leaves have higher nutritive quality in addition to being generally more digestible, thereby eliciting higher animal intake (Minson, 1990). The interaction between the level of *Kanwa* and age of harvest of the forage (K×A) for number of leaves, implies that *Kanwa* rates resulted in more number of leaves of *C. rotundifolia*than irrigation volume, irrespective of irrigation frequency at all growth stages.

The fresh and dry forage yield increased with respect to the lowest irrigation volume compared to the highest (Table 4). Soil moisture level is an important determinant of plant's survival in an area and its final productive performance (Gilberto and Ladaslav, 2013). This might lead to upward movement of water from the capillary spaces in the soil into the root zone which could affect the performance parameters of the legume. Barnes and Addo-Kwafo (1996) reported that *C. rotundifolia* produced more dry matter in the dry season than other legumes. The implication under irrigation is that, the increase in dry matter of *C. rotundifolia* can furnish sufficiently large quantities of herbage for ruminant livestock production due to sufficient moisture in the soil. Total yield of any crop per unit land area depends on the number of plants per unit's area. Generally, the performance of the legume in the present trial was as good as the dry matter production of 2.84t/ha per year reported by Tarawali, (1991; 1994) but lower than the DM yields of up to 7,000 kg/ha that was recorded in Southeast Queensland, Australia (Strickland *et al*., 1985) under rain - fed conditions. The variation is ascribable to differences in soil type, initial stand counts, ecology and condition under which the crop was grown. The interaction between K×A for dry forage yield implies that *Kanwa* rates resulted in more number of leaves of *C. rotundifolia*than irrigation volume, irrespective of irrigation frequency at the harvesting period.

CONCLUSION

It can be concluded from this study that farmers should irrigate *Chamaecristarotundifolia* forage using the minimum irrigation volume (25L) in combination with 40kg/ha of Natron (*Kanwa*) for better growth components and forage yield provided the irrigation interval does not exceed 6 days in the Northern Guinea savannah of Nigeria, rather than the conventional method of irrigating their crops daily. Also, farmers should use available natural resources such as Natron (*Kanwa*) to improve the soil fertility to provide forage of higher biomass at lower cost than with commercial fertilizer. This will help to save the extra cost of labour and waste of resources, thereby increasing farm output.

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