Forage potentials of two cowpea (*Vigna unguiculata* L. Walp) varieties as influenced by varying irrigation frequencies and phosphorus application rates in Zaria

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Abstract

In Nigeria, the dietary energy and protein obtained from forages, particularly in the dry season, are generally too low to meet the nutrient requirements of ruminant livestock. Therefore, there is a clear need for alternative means of supplementing the year-round forage shortfall for livestock to improve productivity. A field experiment was conducted to evaluate the effects of irrigation frequencies and phosphorus application rates on forage quality of two cowpea varieties during dry season. The experiment was laid out in a 2×3×3 factorial arrangement in a split plot design with three replications. Treatments consisted of two cowpea varieties (SAMPEA 14 and 15), three irrigation frequencies (5, 10 and 15-days) and three phosphorus (P) rates (0, 20 and 40kg/ha), respectively. Chemical and mineral compositions were recorded. Results indicated that forage quality of the two cowpea varieties were affected ($P<0.05$) by some of the treatments during the two-year trial and the mean. Crude protein (CP) and crude fibre (CF) of forages were higher ($P<0.05$) in treatment with 20 kgP/ha and 40 kgP/ha compared to the control. SAMPEA 14 forage resulted in significantly higher ($P<0.05$) mean CP of 16.91% compared to SAMPEA 15 with 15.74%. The CP of SAMPEA 14 forage increased by 6.91% compared to SAMPEA 15 forage. Mean P increased by 11% with SAMPEA 14 compared to SAMPEA 15. Calcium and potassium were higher ($P<0.05$) in treatment with 5 days irrigation frequencies compared to 15 days irrigation interval. Phosphorus application rates showed an increasing trend ($P<0.05$) in P determined with 40 kgP/ha application level in 2018 dry season. It is therefore, concluded that, farmers should irrigate SAMPEA 14 using the 5-day irrigation frequency in combination with 20 kgP/ha of phosphorus application rate for optimum fodder quality.

Keywords: Irrigation, Phosphorus, Compositions, Varieties, Forage.

Introduction

In Nigeria, the major challenge of poor-quality livestock feeds (Franke *et al.*, 2011) for the smallholder farmer especially during the dry season could be addressed through irrigated forage production. The potential productivity of irrigated land generally exceeds that of unirrigated land, due to increased yields per crop and to the possibility of multiple cropping (Daniel,

2004). Shortages of feed resources often impose major constraints to animal production in the tropics and subtropics (Agregheore, 2002) especially during the dry season, where there are abundant crop residues which are of poor quality and cannot meet the animal nutrient requirements (Amodu *et al.*, 2008). In Nigeria, the dietary energy (2.4 Mcal/kgDM) and protein (5.6%) obtained

from these sources, particularly in the dry season, are generally too low to meet the nutrient requirements of ruminant livestock for maintenance (2.7 Mcal/kgDM and 11.6%CP) and production (2.9 Mcal/kgDM and 16.2%CP) (NRC, 1985). Therefore, there is a clear need for alternative and cheaper means of supplementing the year-round forage shortfall for livestock to improve productivity. Supplementation with legume-rich residues such as cowpea forage offers cheap sources of dietary protein and better feeding strategy in the dry season (Bayer, 1986) by meeting the nutrient needs of ruminant livestock. Among the factors responsible for low yield and quality of forages are the edaphic factors, particularly phosphorus (P) deficiency which is the most limiting soil fertility factor for cowpea production (IITA, 2003) which occurs as a result of either inherent low levels of P in the soils (Osodeke, 2005) or depletion of the nutrient through cultivation. In Nigeria, positive response of cowpea to application of P fertilizer has been reported by many authors due to its multiple effects on nutrition (Okeleye and Okelana, 1997). The Institute for Agricultural Research (IAR), Zaria with other collaborating institutes has the mandate to breed and release new cowpea varieties (SAMPEA 14 and 15) over a time with focus mostly on higher grain yield while forage quality is rarely a priority (Pande *et al.*, 2003). Therefore, there is need to investigate the suitable irrigation frequency, optimum fertilization levels and adopt improved varieties that could meet up demands of famers. This study was aimed at evaluating and comparing the influence of irrigation frequencies (5, 10 and 15 day) and phosphorus application rates (0, 20 and 40 kgP/ha) on forage yield quality of two cowpea varieties (SAMPEA 14 and 15) during 2018 and 2019 dry seasons.

Materials and methods

Experimental site

A field experiment was conducted at the irrigation site of the Institute for Agricultural Research (IAR) Samaru, Zaria. Samaru is located on latitude 11° 10' N and longitude 7° 36' E at an altitude of 686m above sea level in the Northern Guinea Savanna of Nigeria (GPS, 2018) during the 2018 and 2019 dry seasons. The relative humidity is very high during the wet season and could reach about 70-80% with the highest maximum temperature of about 30 °C. During the dry season, the relative humidity falls to about 15-20% (IAR, 2018). A composite soil sample was obtained from the experimental plots using a soil auger at a depth of 15cm before establishing the plots in the beginning of the experiment in 2018 and 2019 dry seasons at the Department of Soil Science, Ahmadu Bello University, Zaria (Table 1).

Experimental design and treatments

The experiments were laid out in a 2×3×3 factorial arrangement in a split plot design with three replications as illustrated in Appendix 1. The treatments consisted of combinations two cowpea varieties (SAMPEA 14 and 15), three irrigation frequencies (5, 10 and 15 days) and three phosphorus application rates (0, 20 and 40 kgP/ha), respectively. Cowpea varieties and irrigation frequency were assigned as the main plots, while the phosphorus application rates was placed in the sub-plots by incorporated into the soil before sowing. There were 54 net plots, each measuring 4m² with 1m inter-row path and watering channels. Irrigation was carried out at 3 day intervals by the use of surface flooding before the actual irrigation treatment commenced at 3 weeks after sowing (WAS).

Forage establishment and management

Cowpea *seed* varieties (SAMPEA 14 and 15) were obtained from the Institute for

Table 1: Physical and chemical properties of the soil sample from the experimental site during 2018 and 2019 dry seasons

Properties	2018	2019
<i>Physical properties (g/kg)</i>		
Clay	100	160
Silt	160	180
Sand	740	660
Textural Class	Sandy loam	Sandy loam
<i>Chemical properties:</i>		
pH (H ₂ O) 1:2:5	6.70	5.94
pH (0.01M CaCl ₂)	5.80	5.91
Total Nitrogen (%)	0.14	0.33
Available Phosphorus (mg/kg)	16.10	22.00
Exchangeable bases (Cmol/kg)		
Ca ⁺⁺	4.60	6.00
Mg ⁺⁺	0.77	0.58
K ⁺⁺	0.34	0.43
Na ⁺⁺	0.43	0.73
Exchangeable acidity (Cmol/kg)		
H+Al	6.70	5.60

Agricultural Research (IAR) Samaru-Zaria. Phosphorus fertilizer was procured from the local market in Samaru, Kaduna State. The source of phosphorus was Single Superphosphate (SSP, 18% P₂O₅). The field was cleared and cultivated manually using hand hoes before planting operation was carried out. All the 54 experimental plots received a uniform 20 kgNPK/ha. Two seeds of the cowpea varieties were sown per hole in rows at 40cm apart with 30cm plant spacing within the rows. The field was maintained weed-free throughout the experimental period. Insecticide formulation consisting of 100 mL of lambda cypermethrin in 10L of water was applied with a knapsack sprayer at seven **weeks after sowing** (flowering stage) to control insect pests.

Data collection and chemical analysis

The dry forage yields were determined by uprooting from each plot at 10 weeks after sowing. The forage from the cowpea varieties were sun-dried, chopped and subsamples were milled with a hammer mill fitted with a 3 mm sieve for analyses of chemical composition using the method described by AOAC (2005) **at** the

Biochemistry Laboratory, Animal Science Department, Ahmadu Bello University, Zaria. While, the determination of mineral composition was done with an Atomic Absorption Spectrometer (Pye Unicam model SP 102) at Soil Science Department, Ahmadu Bello University, Zaria.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using Anova by General Linear Model (GLM), Procedures of Statistical Analysis System (SAS) version 9 (SAS, 2003).

The following model was used for the design:

$$Y_{ijk} = \mu + A_i + B_j + C_k + (AB)_{ij} + (BC)_{jk} + (AC)_{ik} + (ABC)_{ijk} + e_{ijk}$$

Where:

Y_{ijk} = Any observation μ = Overall mean

A_i = Effect of varieties

$i = 1, 2$ (SAMPEA 14; SAMPEA 15)

B_j = Effect of level j of irrigation frequency

$j = 1, 2, 3$ (5 days; 10 days; 15 days)

C_k = Effect of application rate k of Phosphorus

$k = 1, 2, 3$ (0 kgP/ha; 20 kgP/ha; 40 kgP/ha)

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AB_{ij} = Effect of the ij^{th} interaction of $A \times B$

BC_{jk} = Effect of the jk^{th} interaction of $B \times C$

AC_{ik} = Effect of the ik^{th} interaction of $A \times C$

$(ABC)_{ijk}$ = Effect of the ijk^{th} interaction of $A \times B \times C$

e_{ijk} = Random error

Results and discussion

The effect of irrigation frequency and phosphorus (P) application rates on **chemical compositions** of two varieties of cowpea forage during 2018 and 2019 dry seasons are presented in Table 2. There was non-significant ($P > 0.05$) difference in the all the determined chemical components of the two varieties of cowpea forage during the trial periods, except for crude protein (CP) during the mean years. SAMPEA 14 forage resulted in significantly higher ($P < 0.05$) mean CP of 16.91% compared to SAMPEA 15 with 15.74%. The CP of SAMPEA 14 forage increased by 6.91% compared to SAMPEA 15 forage. The differences in CP might be linked to the genetic make-up of the varieties (Ewansiha *et al.*, 2014), with SAMPEA 14 cowpea haulm proving to be better in quality than SAMPEA 15 cowpea forage. Protein content of cowpea leaves varied within different genotypes (Afiukwa *et al.*, 2013). The **higher CP of SAMPEA 14 cowpea** forage obtained in this study, was higher than the 12.36% CP of cowpea forage reported by Yusuf *et al.* (2017) and a bit higher than the range of 8-13% CP reported by Norton, (2003) for legumes. The CP content of legumes tends to be higher in dry locations or seasons compared with locations or seasons with adequate rainfall (Ddamulira *et al.*, 2015; Sebetha *et al.*, 2015). Norton, (2003) observed that, feed with lower range of CP will not provide the required levels of ammonia for optimum rumen microbial activities; this may suggest that SAMPEA 14 cowpea forage could be a

material of high nutritional quality.

Irrigating cowpea at 5-day frequency showed a significant difference ($P < 0.05$) in CP of cowpea forages than irrigating at 10- and 15-day frequencies, except for CP in 2018. Higher ($P < 0.05$) crude fibre (CF) and acid detergent fibre (ADF) were recorded at longest irrigation frequency compared to the shortest. The CP and NDF were lower by 19.34% and 4.84%, respectively with respect to irrigation frequency of 15 days compared to irrigation frequency of 5 days. Higher values of CF and ADF recorded in the longest irrigation frequency compared to the lowest might be as a result of the plants level of maturity due to moisture stress (Bala *et al.*, 2016). It was reported that as the plant matured, even the leaves would become more fibrous and less digestible (Van Soest, 1982).

For P application rates, CP and CF were higher ($P < 0.05$) in treatment with 20 and 40 kgP/ha compared to the control. However, all the determined chemical components were the higher ($P < 0.05$) in treatment with 20 and 40 kgP/ha (Statistically similar) compared to the control during the mean years, except for EE and ash which were similar across the P application rates. The CP contents recorded in 20 kgP/ha application rates increased by 20.74% and 18.41% in 2018 and 2019 trials respectively as compared to the control. Higher value of CP recorded with P application compared to the control might be due to the applied P that enriched the soil with nutrients for plant uptake. According to Mamiro *et al.* (2011), the soil mineral content influences the mineral uptake of the plant which also affects the mineral available in leaves. Variations in the results of these trials in comparison with the results of previous authors might be due to geographical location, plant species and level of maturity at harvest. **All**

Table 2: Chemical composition of two varieties of cowpea haulm as influenced by irrigation frequency and phosphorus application rates during 2018 and 2019 dry seasons

2017 dry seasons			Chemical composition (%)																				
			Crude protein			Crude fibre			Ether extract			Ash			Nitrogen free extract			NDF			ADF		
			2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
TRT																							
VAR																							
SMP 14	16.85	16.96	16.91 ^a	25.46	27.64	26.55	1.68	1.73	1.70	4.49	5.48	4.98	51.59	50.67	51.13	61.03	59.95	60.49	32.90	32.24	32.90		
SMP 15	15.64	15.87	15.74 ^b	25.53	27.41	26.47	1.69	1.60	1.64	4.61	5.42	5.01	51.78	50.20	50.99	61.58	61.01	61.29	33.58	32.36	33.58		
SEM	0.61	0.55	0.59	0.72	0.63	0.67	0.67	0.22	0.44	3.87	0.89	2.38	1.07	1.21	1.14	0.40	0.46	0.43	1.09	0.83	1.09		
I (days)																							
5	16.74 ^a	17.08 ^a	16.91 ^a	24.05 ^c	25.54 ^c	24.79 ^c	1.65	1.65	1.65	4.97	5.34	5.15	50.03	44.62 ^b	47.32 ^b	60.33	61.75	61.04 ^a	32.11 ^b	31.03 ^b	32.11 ^b		
10	15.99 ^a	15.56 ^b	15.77 ^a	24.99 ^b	27.83 ^b	26.41 ^b	1.73	1.68	1.70	4.68	5.38	5.03	50.26	50.46 ^a	50.36 ^a	60.22	60.60	60.41 ^a	33.30 ^a	32.90 ^a	33.30 ^a		
15	14.33 ^b	14.72 ^c	14.52 ^b	27.45 ^a	29.21 ^a	28.33 ^a	1.68	1.67	1.67	4.15	5.62	4.88	51.76	51.23 ^a	51.49 ^a	61.00	59.10	60.05 ^b	34.34 ^a	32.97 ^a	34.34 ^a		
SEM	0.61	0.55	0.59	0.72	0.63	0.67	0.67	0.22	0.44	3.87	0.89	2.38	1.07	1.21	1.14	0.40	0.46	0.43	1.09	0.83	1.09		
P (kg/ha)																							
0	13.41 ^b	13.69 ^b	13.55 ^b	24.70 ^b	26.07 ^b	25.38 ^b	1.78	1.65	1.71	5.82	5.44	5.63	50.72	46.86 ^b	48.79 ^b	60.30 ^b	58.30 ^b	59.30 ^b	31.45 ^b	30.17 ^c	31.45 ^b		
20	16.92 ^a	16.78 ^a	16.85 ^a	25.89 ^a	27.99 ^a	26.94 ^a	1.70	1.67	1.68	5.96	5.53	5.74	49.17	51.97 ^a	50.57 ^a	60.72 ^b	61.30 ^a	62.01 ^a	33.69 ^a	32.67 ^b	33.69 ^a		
40	16.72 ^a	16.88 ^a	16.80 ^a	25.90 ^a	28.52 ^a	27.21 ^a	1.65	1.68	1.66	5.01	5.39	5.20	51.17	52.49 ^a	51.83 ^a	62.89 ^a	61.75 ^a	62.32 ^a	34.58 ^a	34.06 ^a	34.58 ^a		
SEM	0.61	0.55	0.59	0.72	0.63	0.67	0.67	0.22	0.44	3.87	0.89	2.38	1.07	1.21	1.14	0.40	0.46	0.43	1.09	0.83	1.09		
INT																							
V × I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
V × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
I × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
V × I × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		

^{abc} Means with different superscripts along the column differed significantly ($P < 0.05$). SEM = Standard error of means VAR = variety, SMP = SAMPEA, I = Irrigation frequency, P = phosphorus application rates, P-V = P-value, INT = Interactions, ADF = Acid detergent fibre, NDF = Neutral detergent fibre

Table 3: Mineral composition of two varieties of cowpea haulm as influenced by irrigation frequency and phosphorus application rates during 2018 and 2019 dry seasons.

Treatments	Mineral composition (%)											
	Ca			P			K			Mg		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Variety (V)												
SAMPEA 14	0.73	0.65 ^a	0.69	0.50 ^a	0.58 ^a	0.54 ^a	0.28	0.55	0.41	0.15	0.22	0.18
SAMPEA 15	0.71	0.61 ^b	0.66	0.45 ^b	0.51 ^b	0.48 ^b	0.27	0.52	0.39	0.13	0.20	0.17
SEM	0.02	0.02	0.08	0.20	0.30	0.02	0.04	0.03	0.06	0.04	0.04	0.07
Irrigation interval, days (I)												
5	0.76 ^a	0.64	0.70	0.44 ^b	0.57	0.51	0.29	0.61 ^a	0.47	0.13	1.19	0.16
10	0.71 ^b	0.64	0.67	0.49 ^a	0.52	0.50	0.25	0.45 ^b	0.35	0.15	0.22	0.18
15	0.70 ^b	0.61	0.66	0.50 ^a	0.56	0.52	0.28	0.54 ^c	0.41	0.15	0.23	0.18
SEM	0.02	0.02	0.08	0.20	0.30	0.02	0.04	0.03	0.06	0.04	0.04	0.07
Phosphorus rates, kgP/ha (P)												
0	0.72	0.63	0.67	0.46 ^b	0.56	0.51	0.27	0.57	0.42	0.14	0.22	0.19
20	0.73	0.63	0.68	0.44 ^b	0.55	0.49	0.29	0.53	0.41	0.15	0.22	0.18
40	0.72	0.64	0.70	0.52 ^a	0.55	0.53	0.26	0.51	0.39	0.12	0.20	0.16
SEM	0.02	0.02	0.08	0.20	0.30	0.02	0.04	0.03	0.06	0.04	0.04	0.07
Interaction												
V × I	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V × I × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^{abc} Means with different superscripts along the column differed significantly (P<0.05) SEM = Standard error of mean

the interactions on chemical composition showed insignificant differences ($P>0.05$) between the treatments throughout the sampling years and the combined means.

Table 3 showed the effect of irrigation frequency and phosphorus (P) rates on mineral composition of two varieties of cowpea forage during 2018 and 2019 dry seasons. There was no significant difference ($P>0.05$) in the two cowpea varieties on all mineral elements measured in the trial periods except for calcium (Ca) in 2019 and phosphorus in both trial periods. SAMPEA 14 forage resulted in higher ($P<0.05$) Ca and P (0.65% vs 0.50%) compared to SAMPEA 15 (0.61% vs 0.45%) in 2019 dry season. Mean P increased by 11% with SAMPEA 14 compared to SAMPEA 15. The observed variations in the concentrations of minerals may be attributed to the differences in nutrient uptake from the soil (Zafar et al., 2007; Bala et al., 2016) and climate factor (George, 2005). Calcium and K were higher ($P<0.05$) in treatment with 5 days irrigation frequency compared to 15 days irrigation frequency. The Ca increased by 8% in treatments with the lowest irrigation frequency compared to the highest irrigation frequency. The decline in concentration of P in cowpea forage with decrease in irrigation frequency in 2018 is in agreement with the report of Etissa et al., (2014), that irrigation at lower frequencies favoured excessive yield. It may therefore seem reasonable to suggest that, irrigation at every 5 days may have enhanced availability within the forage due to efficient utilization of absorbed P.

However, phosphorus application rates showed an increasing trend ($P<0.05$) in P determined with 40 kgP/ha application level in 2018 dry season. The increase in P may be due to the fact that the cowpea forage might have been fortified with P application. The range of values for Ca, P and K and Mg in this trial were within the 0.3-0.8% for Ca, 0.3-0.8% for P and 0.25-0.6% for K range of

values recommended for growing bucks to enable them meet their mineral requirements (NRC, 2007).

Conclusion

From this study, it can be concluded that farmers should irrigate SAMPEA 14 using the shortest irrigation frequency of 5 days in combination with 20 kgP/ha of phosphorus application rate for optimum fodder quality to fill the forage-gap for livestock during the dry season in the northern Guinea savannah zone of Nigeria.

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