



Effects of Irrigation Schedule and Phosphorus Fertilizer Rates on Forage Yield of Two Cowpea Varieties in Nigeria

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Abstract

A field experiment was conducted to evaluate the effects of irrigation schedule and phosphorus fertilizer rates on forage yield of two cowpea varieties during 2018 and 2019 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 2 cowpea varieties (SAMPEA 14 and 15), 3 irrigation schedule (5, 10 and 15-days) and 3 phosphorus (P) fertilizer rates (0, 20 and 40 kg/ha). Leaf area index, fresh forage yield and dry forage yield were recorded. Results indicated that Leaf area index (LAI), dry forage yield (DFY) and fresh forage yield (FFY) of two cowpea varieties were affected ($P<0.05$) by some of the treatments during the two years trial. SAMPEA 14 had higher ($P<0.05$) FFY (4.31 Vs 3.65 t/ha) and DFY (3.13 Vs 2.86 t/ha) compared to SAMPEA 15. There was 4% (0.12t/ha) increase in DFY of Sampea 14 compared to Sampea 15 over the two trial periods. The 15 day irrigation schedule had lower ($P<0.05$) LAI compared to the other irrigation schedules that were similar. A combined mean for FFY of 4.40 t/ha and DFY of 3.50 t/ha were recorded at irrigation schedule of 5 days interval. DFY increased by 46% (1.61t/ha) in the combined trial periods with respect to the 5 days irrigation schedule compared to the 15 days. The results also revealed that 20 kgP/ha fertilizer rate resulted in higher ($P<0.05$) FFY and DFY only when compared to the control. The DFY was 2.97 t/ha in combined trial periods which is an increase by 12% (0.37t/ha) with respect to 20 kgP/ha compared to the control. It was therefore, concluded that, farmers should irrigate SAMPEA 14 using the 5 day irrigation schedule in combination with 20 kgP/ha of phosphorus fertilizer for optimum fodder yield.

Keywords: Cowpea, forage, varieties, phosphorus, irrigation

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. Coker *et al.* (2014) emphasized the importance of cowpea forage as animal feed mainly during the dry season. The planting of dual-purpose legumes is currently gaining popularity in Nigeria (Inaizumi *et al.*, 1999). Apart from its grains that gave immediate economic returns, its fodder/haulm is also a good dry season feed supplement for livestock (Bala *et al.*, 2020). Cowpea (*Vigna unguiculata* L. Walp.) is balaaminu@gmail.com; agbala@abu.edu.ng; +2348068928548

gradually attaining economic importance in Nigeria, even though the bulk of the production is done in the semi-arid zone of Nigeria (Petu- Ibikunle *et al.*, 2008). The appreciating economic importance may be due to its food value and supplementary source of protein for animal use. 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 (Bala *et al.*, 2016).

Incorporation of promising legumes fodder such as cowpea haulms for livestock production will help to overcome the feed shortages. Cowpea haulm is the above ground part of cowpea without the pods which contains the grains (Inaizumi *et al.*, 1999). High yields of quality dry forage of up to 10t DM/ha have been recorded for cowpea under irrigation (Lemma *et al.*, 2009). While an average fodder yield of 0.5 t/ha in the world (Madamba *et al.*, 2006) and dry fodder yield of 0.23 t/ha by SAMPEA 14 cowpea variety (Bala *et al.*, 2018) had been obtained under rain fed conditions. Among the factors responsible for low yield 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. Cowpea has high P requirement, which simulate root and plant growth (Nkaa *et al.*, 2014). The Institute for Agricultural Research (IAR), Zaria with other collaborating institutes has the mandate to breed and release new cowpea varieties over a time with focus mostly on higher grain yield while forage yield and quality is rarely a priority (Pande *et al.*, 2003). SAMPEA 14 and 15 varieties of cowpea are high yielding, striga resistant, heat tolerant and drought resistant with maturity period of 70-78 days (IAR, 2015). This study was therefore, designed to determine the effects of irrigation schedule and phosphorus fertilizer rates on forage yield of two cowpea varieties.

Materials and methods

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 686 m 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 from five different points of the field was obtained from the experimental plots using a soil auger at a depth of 15 cm before establishing the plots at the beginning of the experiment in 2018 and 2019 dry seasons at the Department of Soil Science, Ahmadu Bello University, Zaria (Table 1). Cowpea varieties (SAMPEA 14 and 15) were obtained from the Institute for Agricultural Research (IAR) Samaru-Zaria. Phosphorus fertilizer was procured from the open market in Samaru, Kaduna State. The source of phosphorus was Single Superphosphate (SSP, 18% P₂O₅) which was broadcasted on the experimental plots on the day sowing was carried out.

The experiment was laid out in a 2×3×3 factorial arrangement in a split plot design with three replications. The treatments consisted of combinations of two cowpea varieties (SAMPEA 14 and 15), three irrigation schedules (5, 10 and 15 days) and three phosphorus fertilizer rates (0, 20 and 40 kgP/ha). Cowpea varieties and irrigation schedule were assigned as the main plots, while the phosphorus fertilizer rates was placed in the sub-plot by incorporating into the soil before sowing. There were 54 net plots, each measuring 4 m² 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). The field was cleared and cultivated manually using 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 40 cm apart with 30 cm 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 7 weeks after sowing (flowering stage) to control insect pests.

Data collection for agronomic studies began at 5 weeks after sowing (WAS) when plant leaves were fully developed. The plants were sampled at 5 and 10 WAS where five plants were randomly selected and tagged per plot for determination of leaf area index using the standard procedure (Tarawali *et al.*, 1995). The parameters measured are as follows:

- a) Leaf area index; leaf area was obtained during the harvesting period by calculating the product of the total length and width of the longest leaf of the 5 tagged plants in each plot using the formula;

$$\text{Leaf Area} = \text{Total leaf length} \times \text{width} \times k$$

Where k is a coefficient for

$$\text{Dry matter (kg/ha)} = \text{TFW} \times (\text{DWss} / \text{FWss}) \times 10$$

Where: TFW = Total fresh weight from 1 m² in g

FWss = Fresh weight of the subsample in g

DWss = Dry weight of the subsample in g

Data collected were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM), Procedures of Statistical Analysis System (SAS) version 9 (SAS, 2003). Treatment means were separated using Dunnett's test at the 5% level.

The following model was used for the analysis:

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

Where:

Y_{ijk} = Individual observations based on ijk^{th} classification μ = Overall mean

A_i = Effect of i^{th} varieties

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

B_j = Effect of j^{th} irrigation schedule

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

C_k = Effect of k^{th} fertilizer rate

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

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

Treatment effects on leaf area index (LAI), fresh forage yield (FFY), dry forage yield (DFY) of two cowpea varieties during

cowpea = 0.76
(Musa *et al.*, 2016)

Then the leaf area index was obtained as the ratio of the leaf area to ground surface area.

- b) Fresh and dry forage yields; the fresh and dry forage yields (cowpea haulms) which comprise of the vine, leaves and roots without the pods were determined by uprooting the plant from each plot at 10 weeks after sowing. Total fresh weight (TFW) of the material cut was weighed immediately using a hanging scale to determine the fresh forage yield. A sample of 150–200 g fresh material (FWss) was weighed, oven dried at 65°C for 48hrs to a constant weight and reweighed (DWss) to give an estimate of the dry-matter production during this period using the formula below by Tarawali *et al.*, 1995.

2018 and 2019 dry seasons are presented in Table 2. There were no significant difference ($P > 0.05$) in LAI of the two cowpea varieties in the two trial periods at all ages. The non significant differences in

leaf area index (LAI) of cowpea varieties in the two trial periods due to effect of irrigation schedule and P fertilizer rates at all ages may be possible that, irrigation schedule and P fertilizer rates are not major factors affecting the LAI. In 2019, SAMPEA 14 had higher ($P < 0.05$) FFY (4.31 and 3.65 t/ha) and DFY (3.13 and 2.86 t/ha) compared to SAMPEA 15. There was 4% (0.12t/ha) increase in DFY of Sampea 14 compared to Sampea 15 when the trial periods were combined (Figure. 1). The higher fresh forage yield (FFY) and dry forage yield (DFY) of the two varieties of cowpea in the 2019 trial could be due to more favourable environmental conditions for forage yield in that year. The difference in FFY and DFY of the two years (combined mean) might be due to genetic difference between the cowpea varieties (Ewansiha and Tofa, 2016), with SAMPEA 14 proving to be more adaptable to the growth conditions than Sampea 15. This observation supports an earlier report by Dowsell *et al.* (1996) that plants respond differently to environmental factors based on their genetic makeup and adaptation to new ecology, in terms of yield potential and maturity periods. Other authors, Ayaz *et al.*, 2004; Kamara *et al.*, 2010 have reported differences in the performance of some cowpea varieties. The high forage yield of SAMPEA 14 indicates its potential for forage production and can be used in filling some of the forage-gap for ruminant livestock in particular.

There was no significant difference ($P > 0.05$) in LAI during the sampling periods, except at 10 WAS in 2019 and the combined years for irrigation schedule. The 15 day irrigation schedule resulted in lower ($P < 0.05$) LAI, when compared to other irrigation schedules that had similar LAI. LAI is a measure of the size of photosynthetic or assimilatory system of plant. LAI is considered to be mainly concerned with accumulation and partitioning of photosynthetic part of the plant which has an economic role in the

final production of biomass (Ishiaku *et al.*, 2016). The significant increase in LAI at 5 day irrigation schedule compared to 15 days might be due to reaction of cowpea to moisture stress which leads to reduction in leaf area through changing leaf orientation and closing the stomata (Campos *et al.*, 1999; Ogbonnaya *et al.*, 2003). The FFY and DFY during the years and their mean, decreased significantly ($P < 0.05$) with increase in irrigation from 5 to 15 days intervals. A combined mean for FFY of 4.40 t/ha and DFY of 3.50 t/ha were recorded at irrigated level of 5 days interval. DFY increased by 46% (1.61t/ha) in the combined trial periods with respect to the shortest irrigation schedule compared to the longest irrigation schedule (Figure. 2). It was reported that shorter irrigation schedule favoured vegetative yield (Etissa *et al.*, 2014). Generally, the performance of the cowpea varieties in the present trial are as good as the dry matter production of cowpea forage that ranged from 0.5 tDM/ha to over 4 tDM/ha under favourable conditions (Heuzé *et al.*, 2015). The DFY obtained is higher than 0.23 tDM/ha cowpea haulm yield from SAMPEA 14 variety of cowpea under rain-fed condition (Bala *et al.*, 2018), but lower than 8.75 tDM/ha biomass yield of improved cowpea reported by Anele, (2010). The variation might be due to the differences in soil type and conditions under which the crop was grown (Bala *et al.*, 2016). It may therefore seem reasonable to suggest that, irrigation at every 5 days favours the crop vegetative growth which directly leads to higher fodder yield. Limited moisture might have hindered crop from growing to its full capacity, thereby affecting its productivity (Lemma *et al.*, 2009).

LAI of cowpea plant was not significantly ($P > 0.05$) affected by phosphorus (P) fertilizer rates in both trial periods. The results also revealed that 20 kg/ha phosphorus (P) fertilizer rate resulted in more FFY and DFY, although there was no

significant difference compared with 40 kgP/ha in both trials. The DFY produced 2.97 t/ha in the combined trial periods which is an increase by 12% (0.37t/ha) with respect to 20 kgP/ha compared to the control (Figure. 3). The significant increase in forage yields with 20 kgP/ha might be due to the growth-promoting role of P fertilizer which has been reported previously by Waraich, (2015). From this study, it can be suggested that P fertilizer at 20 kgP/ha could be the optimum for economical FFY and DFY as further application of P may not increase yield. This contradicts the findings of Kumar *et al.* (2012) who reported significant increase in green and dry fodder yield of cowpea with increase in P₂O₅/ha level from 0 - 60

kg/ha in their experiment. The clear response to P fertilizer observed in terms of forage yield confirms that P is an important nutrient element needed for high forage yield of cowpea as compared to the control. The Lower foliage recorded in the control may be due to the fact that, plants possess several adaptive mechanisms to cope with P deficiency, including slow changes at the morphological, physiological, biochemical and molecular levels (Zhang *et al.*, 2014). P is critical to cowpea yield because it is reported to stimulate growth which is attributed to increased leaf area (Nkaa *et al.*, 2014; Abaidoo *et al.*, 2016; Nziguheba *et al.*, 2016). The interaction effects of the treatments were not significant (P>0.05) in all the parameters measured in both years.

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 (%)</i>		
Clay	10	16
Silt	16	18
Sand	74	66
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

Table 2: Leaf area index, fresh forage yield and dry forage yield of two cowpea varieties as influenced by irrigation schedule and phosphorus fertilizer rates during 2018 and 2019 dry seasons.

Treatments	Leaf area index						Forage yield (t/ha)					
	5 WAS			10 WAS			Fresh forage yield			Dry forage yield		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
Variety (V)												
SAMPEA 14	1.51	2.28	1.89	2.00	2.88	2.44	2.99	4.31 ^a	3.65 ^a	2.59	3.13 ^a	2.86 ^a
SAMPEA 15	1.36	2.23	1.79	2.10	2.60	2.35	3.04	3.84 ^b	3.44 ^b	2.51	2.98 ^b	2.74 ^b
SEM	0.38	0.53	0.45	0.42	0.43	0.42	0.08	0.12	0.10	0.05	0.06	0.05
Irrigation schedule, days (I)												
5	1.57	2.38	1.97	2.30	3.37 ^a	2.83 ^a	3.70 ^a	5.10 ^a	4.40 ^a	3.03 ^a	3.98 ^a	3.50 ^a
10	1.52	2.40	1.96	2.08	2.81 ^a	2.44 ^a	3.15 ^b	3.77 ^b	3.46 ^b	2.87 ^b	3.16 ^b	3.01 ^b
15	1.23	1.99	1.61	1.77	2.05 ^b	1.91 ^b	1.99 ^c	3.36 ^c	2.67 ^c	1.76 ^c	2.03 ^c	1.89 ^c
SEM	0.38	0.53	0.45	0.42	0.43	0.42	0.08	0.12	0.10	0.05	0.06	0.05
Phosphorus rates, kgP/ha (P)												
0	1.18	2.04	1.61	1.70	2.32	2.01	2.72 ^b	3.75 ^b	3.23 ^b	2.44 ^b	2.76 ^b	2.60 ^b
20	1.46	2.41	1.93	2.15	2.89	2.52	3.08 ^a	4.46 ^a	3.77 ^a	2.70 ^a	3.16 ^a	2.97 ^a
40	1.68	2.32	2.00	2.30	3.01	2.65	3.24 ^a	4.02 ^a	3.68 ^a	2.79 ^a	3.27 ^a	3.03 ^a
SEM	0.38	0.53	0.45	0.42	0.43	0.42	0.08	0.12	0.10	0.05	0.06	0.05
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 in a subset with different superscripts within the column differed significantly (P<0.05) SEM = Standard error of means WA Weeks after sowing

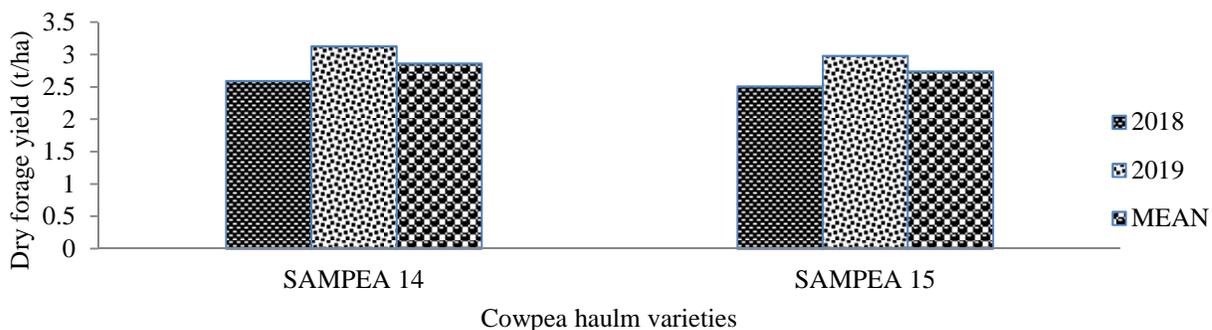


Figure 1: Trend in dry forage yield of cowpea as influenced by variety during 2018 and 2019 dry seasons.

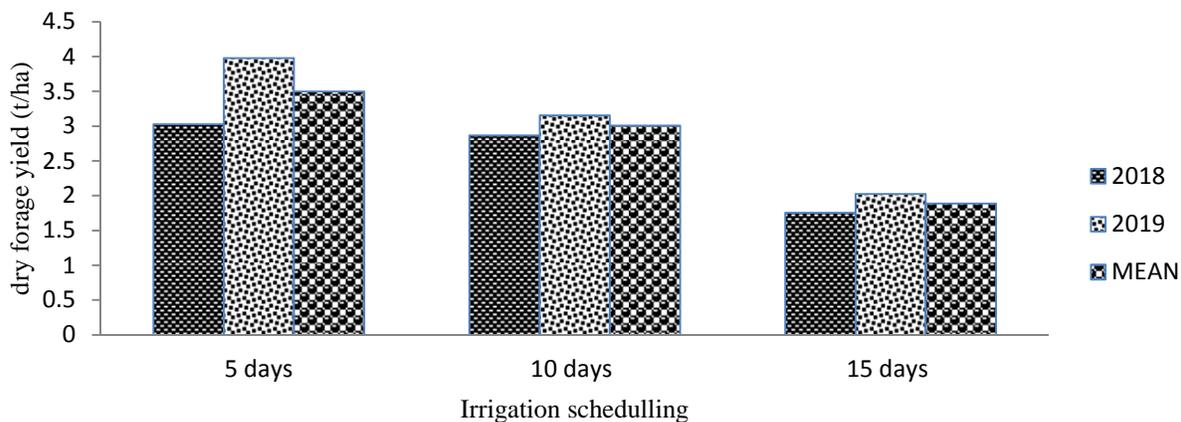


Figure 2: Trend in dry forage yield of two cowpea varieties as influenced by irrigation schedule during 2018 and 2019 dry seasons.

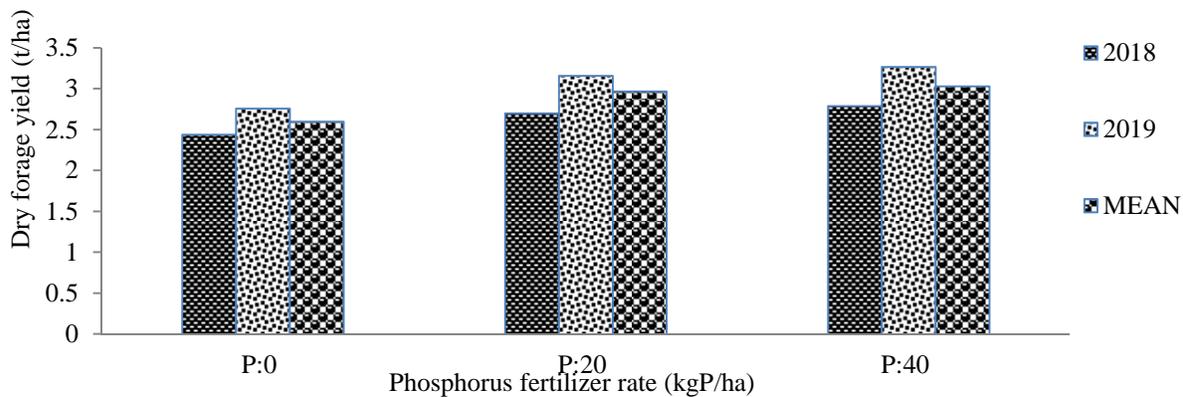


Figure 3: Trend in dry forage yield of two cowpea varieties as influenced by phosphorus fertilizer rates during 2018 and 2019 dry seasons.

Conclusion and recommendation

From this study, it can be concluded that SAMPEA 14 cowpea variety can be irrigated under 5 days irrigation interval in combination with 20 kgP/ha for better fodder yield to fill the forage-gap for livestock in Nigeria.

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