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FODDER YIELD AND NUTRITIVE QUALITY OF HAULM FROM DUAL-PURPOSE COWPEA CULTIVARS FOR DRY SEASON LIVESTOCK FEEDING IN NIGERIA

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ABSTRACT

The availability of high quality forage, especially during the dry season remains a major challenge to ruminant livestock production in Nigeria and many parts of West Africa. This study was conducted to evaluate forage yield and nutritive quality of haulm from selected dual purpose cowpea (*Vigna unguiculata* L. Walp.) cultivars in the humid rain forest zone of Nigeria. The forage and pod yields of twenty cultivars were evaluated at the Teaching and Research Farm of the Federal University of Technology, Owerri, Imo State, Nigeria. Subsequently, five dual-purpose cultivars, namely IT04K-334-2, IT07K-293-3, IT04K-194-3, IT04K-405-5, IT06K-147-2, were selected based on forage and pod yields from previous trial, for determination of chemical and fibre compositions. The results revealed significant ($P<0.05$) differences in pod and forage yields among the twenty cowpea cultivars, with yields ranging from 0-1.5 t ha^{-1} and 0.1-4.5 t ha^{-1} for pod and forage, respectively. Cultivars IT07K-293-3, IT04K-405-5, IT06K-147-2, IT07K-194-3, IT04K-334-2, IT04K-267-8 and IT04K-339-1 recorded the highest fodder yields of at least 2715 t ha^{-1}, with crude protein contents ranging from 10.49% in IT07K-194-3 to 13 .57 % in IT04K-405-5. Cultivars IT07K-194-3, IT07K-293-3, IT07K-220-1-9, IT06K-147-2, IT07K-187-55IT04K-332-1 recorded the highest pod yields (>700 t ha^{-1}). There were significant ($P<0.05$) differences in crude protein, ether extract and non-fibre carbohydrates (NFC) contents among five cultivars selected from the top ten high yielding cultivars, based on mean ranking score. These selected cultivars are recommended as dual-purpose cowpea for the humid forest zone.

Key Words: Crude protein, ether extract, *Vigna unguiculata*

RÉSUMÉ

La disponibilité de fourrage de la haute qualité, en particulier pendant la saison sèche, reste un défi majeur pour l'élevage de ruminants au Nigeria et dans de nombreuses régions d'Afrique de l'Ouest. Cette étude a été menée pour évaluer le rendement de fourrage et la qualité nutritive des fanes de cultivars sélectionnés de niébé à double usage (*Vigna unguiculata* L. *Walp*.) dans la zone de forêt tropicale humide du Nigeria. Les rendements en fourrage et en gousse de vingt cultivars ont été évalués à la Ferme d'Enseignement et de Recherche de l'Université Fédérale de Technologie, Owerri, État d'Imo, Nigéria. Les cinq cultivars à double usage à savoir IT04K-334-2, IT07K-293-3, IT04K-194-3, IT04K-405-5, IT06K-147-2 ont été sélectionnés sur la base des rendements en fourrage et en gousse des essais précédents pour la détermination des compositions chimiques et des fibres. Les résultats ont révélé des différences significatives (P<0,05) dans les rendements des gousses et du fourrage parmi les vingt cultivars de niébé, avec des rendements allant de 0-1,5 t ha^{-1} et 0,1-4,5 t ha^{-1} pour les gousses et le fourrage respectivement. Les cultivars IT07K-293-3, IT04K-405-5, IT06K-147-2, IT07K-194-3, IT04K-334-2, IT04K-267-8 et IT04K-339-1 ont enregistré les rendements fourragers les plus élevés d'au moins 2715 t ha^{-1} avec des teneurs en protéines brutes allant de 10,49 % en IT07K-194-3 à 13,57 % en IT04K-405-5. Les cultivars IT07K-194-3, IT07K-293-3, IT07K-220-1-9, IT06K-147-2, IT07K-187-55IT04K-332-1 ont enregistré les rendements en gousses les plus élevés (>700 t ha^{-1}). Il y avait des différences significatives (P<0,05) dans les teneurs en protéines brutes, en extraits éthérés et en glucides non fibreux (GNF) parmi cinq cultivars sélectionnés parmi les dix premiers cultivars à haut rendement, sur la base du score de classement moyen. Ces cultivars sélectionnés sont recommandés comme niébé à double usage pour la zone de forêt humide.

Mots Clés : Protéine brute, extrait éthéré, *Vigna unguiculata*

INTRODUCTION

Seasonal fluctuations in livestock feed supply remains a major constraint to maximising the potential from the small holder livestock production system in Nigeria and other parts of west Africa (Ayantunde *et al*., 2005; Anele *et al*., 2011). Although forage is the cheapest and major nutritional component in the diets of ruminants, lack or almost complete absence of forage conservation leads to huge depreciation in quality, as forages that grow abundantly as natural pastures during the rainy season are allowed to mature and dry out by the onset of the dry season. This, in turn, leads to significant live weight losses and attendant production losses when the stuff is fed to animals, because such matured forages are generally deficient in vital nutrients such as protein, sulphur, minerals and vitamins (Kawas *et al*., 2010). For example, fresh cut of grass forage may contain 12-15 % crude protein before flowering; but this drops to <5% when the forage is subjected to lignifications due to over maturation (Anyanwu, 2017). In order to achieve high productive performance of ruminants, the feeding value of dry season feedstuffs needs to be improved through supplementation with on-farm produced forage legumes such as dual-purpose cowpea, which are rich in crude protein, and are capable of overcoming these nutritional deficiencies in the rumen.

Cowpea haulms fetch 50% or more of the grain price (dry weight basis) in many parts of Northern Nigeria, especially during the dry season (Larbi *et al*., 1999). In many parts of west Africa, the mature cowpea pods are harvested and the green haulms are cut; and rolled into small bundles containing leaves and vines. These bundles are stored on rooftops for use as feed supplement in the dry season; making cowpea a key component of crop-livestock systems.

Livestock economics emergent in Africa is largely in favour of crop residues utilisation than cultivated forages because of competition for land for human food production and estate development. Presently, there is an escalation of the resource conflict between the livestock sector and crop producers across the ecological zones of Nigeria. The move towards sedenterisation of pastoral livestock keepers would create a demand pull for crop residues. The objective of this work was to identify best bet dual-purpose cultivars of cowpea in the humid ecological zone of Nigeria for food and fodder production, useful during the dry season .

MATERIALS AND METHODS

This study was carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri, Imo State in Nigeria (5.48^o N, 7.03^o E). Imo State is located in the humid rainforest agro-ecological zone, with annual rainfall above 2220 mm (April to October). The mean monthly temperature ranges from 22.5 to 33.7^{o}C; while relative humidity in the rainy season (late March-October) and dry season (November-early March) ranges between 63 to 96 and 55 to 84%, respectively.

Twenty different cowpea cultivars were evaluated (Table 1), including the Kanannado the local cultivar from Kano (control). The study was laid out in a Randomised Complete Block Design, with three replications; in plots of 2 m x 4 m, with 1 m path between replicates.

The seeds of cowpea used for this trial were obtained from the International Institute of Tropical Agriculture (IITA) Cowpea Breeding Unit in Kano, Nigeria. The seeds were treated against weevil infestation in storage using

TABLE 1. Days to 50 % flowering of 20 cowpea cultivars in 2012 and 2013

S/N	Cultivar	2012	2013	Mean
01.	IT06K-147-1	60 ± 1.15	54 ± 1.73	57
02.	IT00K-335-45	50 ± 2.31	40 ± 0.58	45
03	IT07K-297-13	50 ± 2.88	38 ± 0.58	44
04.	IT07K-318-2	50 ± 1.73	45 ± 2.31	48
05.	IT04K-333-2	54 ±1.73	45 ± 1.15	50
06.	IT04K-332-1	50 ± 0.58	42 ±1.15	46
07.	IT07K-293-3	47 ± 1.73	47 ± 2.31	47
08.	IT07K-304-9	49 ± 2.31	47 ±0.58	48
09.	IT04K-405-5	58 ± 0.58	60 ±1.73	59
10.	IT06K-147-2	53 ±1.73	47 ±1.73	50
11.	IT04K-339-1	58 ±1.15	51 ± 1.73	55
12.	IT07K-187-55	43 ± 0.58	47 ± 1.15	45
13.	IT07K-194-3	41 ± 1.73	42 ± 1.15	42
14.	IT04K-334-2	48 ± 1.15	51 ± 2.31	50
15.	IT06K-139	48 ±0.58	54 ± 1.73	51
16.	IT04K-267-8	49 ± 2.31	54 ± 1.15	52
17.	IT07K-220-1-9	49 ± 1.15	47 ±1.15	48
18.	IT07K-292-10	45 ± 1.73	54 ± 1.15	50
19.	IT04K-227-4	46 ± 1.15	45 ±1.15	46
20.	Kanannado	58 ± 1.15	60 ±0.58	59
	Means	50.31± 0.71	48.5 ± 0.82	

Actellic 2 % dust. The seeds were planted at the spacing of 50 cm x 20 cm, at three seeds per hole; and later thinned to two plants per stand so that each line had 40 stands, equivalent to a plant population of 200,000 stands per ha. The plots were weeded manually at two and six weeks after planting.

Data were collected on the number of days to 50% flowering, pod and forage yields (dry matter yields), as well as proximate analysis. Days to 50 % flowering were recorded on plot basis as the mean number of days taken to achieve a 50 % flowering from the date of planting. At physiological maturity, pods of the various cultivars were weighed separately. The harvesting of pods began two weeks after first flowering, 60 days after planting for the extra-early; and 70 days after planting for the early maturing cultivars. Since the pods ripened at different times, 2-3 hand-pickings were carried out as soon as the pods changed colour from green to light yellow, brown or pink, to prevent shattering and damage to pods and seeds by insects and rodents. Periodic hand picking was carried out for each plot, three times a week and each harvest was bulked with the previous harvest from the same plot. The hand picking was discontinued at the cessation of fruiting and pod formation The harvested pods were then spread evenly on a tray under the sun for proper drying. Subsequently, they were removed and stored indoors after sun drying sufficiently to moisture content of about 15 %.

Harvesting of the forage took place following the decline in fruiting and cessasion of pod formation (within 90 days after planting), by manually cutting the two middle rows while the vines were still green. Total forage yield was estimated by extrapolating yield of the herbage materials on dry matter basis from the two middle rows, into metric tonnes per hectare. A subsample of fresh stuff was oven dried for dry matter determination.

After each plot harvest, three grab samples from each plot were bulked together from where a representative sample was taken by hand for dry mater determination. A grab sample is obtained by using the palm to grab a sample of the forage. The samples from the five selected cultivars namely, IT04K-334-2, IT07K-293-3, IT04K-194-3, IT04K-405-5, IT06K-147-2, after oven drying, were processed for chemical analysis by grinding to a particle size of 1mm according to the procedure of A.O.A. C (1995).

Proximate analysis involved the determination of dry matter, crude protein, crude fibre, ether extract and ash contents according to A.O.A.C. (1995). Crude protein was estimateded as N x 6.25. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analysed according to Goering and Van Soest (1991). Cellulose was estimated as the difference between ADF and ADL; while hemicellulose was calculated as the difference between NDF and ADF.

All the data collected were subjected to Analysis of Variance in accordance with the General Linear Model procedure of SAS (2002). A cluster analysis dendogram based on the pod and forage yield data produced five distinct clusters (Fig. 1).

RESULTS

Days to 50% anthesis (flowering). The number of days to 50% flowering ranged from 41 in cultivars IT07K-194-3 to 60 in cultivar IT06K-147-1 in 2012; and 38 in cultivar IT07K-297-13 to 60 in cultivars IT04K-405-5 and Kanannando cultivar in 2013 (Table 1). Cultivars IT07K-194-3 and IT07K-297-13, IT00K-335-45, IT07K-187-55, IT04K-227-4, IT04K-332-1 and IT07K-293-3 achieved 50% flowering within 47 days. Overall, about 50% of the cultivars acheived 50% flowering within seven weeks (49 days); while 15% achievd 50 % flowering after eight weeeks (56 days).

Forage biomass yield. Forage biomass yield was significant across years and cultivars (Table 2). The forage biomass yield ranged from 0.2 t ha^{-1} (IT00K-335-45) to 6.59 t ha^{-1}

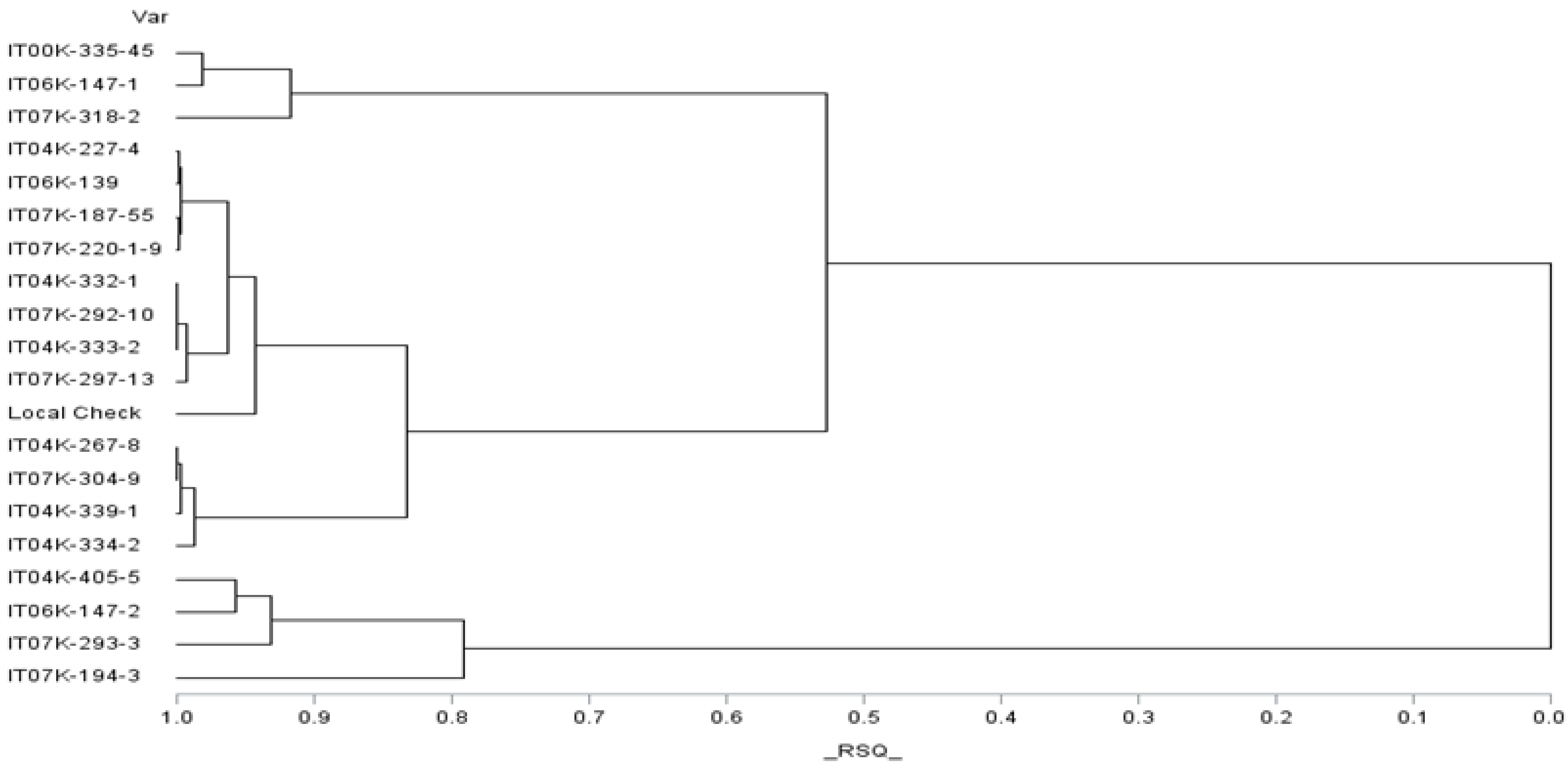

Figure 1. Cluster analysis of 20 cowpea cultivars based on forage and pod yields.

TABLE 2. Average forage yield (kg ha^{-1} DM) of 20 cowpea cultivars in 2012 and 2013 cropping seasons

S/N	Variety	2012	2013	Mean	SEM
1	IT06K-147-1	464.28	763.88	614.10	118
2	IT00K-335-45	204.16	62.50	133.30^{j}	39
3	IT04K-227-4	1709.72	2500.00	2104.90	430
4	IT04K-267-8	2240.62	3361.11	2800.90	358
5	IT04K-332-1	990.61	2597.22	1793.90	473
6	IT04K-333-2	1321.87	2347.22	1834.60	476
7	IT04K-334-2	2217.34	4027.77	3122.60	457
8	IT04K-339-1	2614.58	2816.66	2715.60	319
9	IT04K-405-5	5028.27	3229.16	4128.70	1087
10	IT06K-139	2774.03	1750.00	2262.00	395
11	IT06K-147-2	2803.59	4822.22	3812.90^{c}	896
12	IT07K-187-55	1508.33	2819.44	2163.90	369
13	IT07K-194-3	2567.42	4097.22	3332.30	454
14	IT07K-220-1-9	2004.58	2555.55	2280.10	382
15	IT07K-292-10	2281.25	1354.16	1817.70	279
16	IT07K-293-3	6591.66	2375.00	4483.30	1180
17	IT07K-297-13	887.03	2000.00	1443.50	266
18	IT07K-304-9	506.01	4833.33	2669.70	1256
19	IT07K-318-2	628.47	1305.55	967.00^{hij}	152
20	Kanannado	2116.02	1799.60	1957.80	187
	Mean	2072.99	2570.88		
	SEM	227.99	211.02		

SEM = Standard Error of the Means

(IT07K-293-3) in 2012; and from 0.06 t ha^{-1} in IT00K-335-45 to 4.82 t ha^{-1} in IT06K-147-2 in 2013. Sixty and 70% of the cultivars yielded at least 2 t ha^{-1} in 2012 and 2013, respectively. All cultivars, except IT00K-335-45, IT04K-332-1, IT06K-147-1, IT07K-297-13, IT07K-304-9, IT07K-318-2 and IT00K-335-45, IT06K147-1, yielded above 1 t ha^{-1} in 2012 and 2013, respectively.

Pod yield. Table 3 presents pod yield of the study cultivars. About 65% of the twenty cultivars generated above 0.5 t ha^{-1} pod yield; with yields ranging from 0.0 t ha^{-1} for the Kanannado variety to 1.79 t ha^{-1} for IT07K194-3 in 2012; and from 0.0 t ha^{-1} for the Kanannado cultivar to 1.06 t ha^{-1} for IT07K-194-3 in 2013. Cultivars that recorded high pod yields included IT07K-293-3, IT06K-147-2, IT07K-194-3, IT07K-220-1-9 and IT04K-334-2 which fall into cluster 1 in the dendogram. Furthermore, there was no significant (P> 0.05) correlation between pod yield and forage yield (r=0.14). Table 4 shows the ranking of the various cultivars based on mean fodder and pod yields.

Proximate and fibre composition. Proximate analysis and fibre compositions of the selected cowpea cultivars are shown in Table 5. Forage dry weights (pods and vines) were statistically similar (P>0.05) across years and cultivars;. Crude protein was significantly (P<0.05) higher in the Kanannado cultivar

TABLE 3. Average Pod yield (kg ha^{-1} DM) of 20 cowpea cultivars in 2012 and 2013 cropping seasons

S/N	Variety	2012	2013	Mean	SEM
1	IT06K-147-1	0.00^h	187.00	187	62.50
2	IT00K-335-45	416.67	12.005	300.00	84.77
3	IT04K-227-4	791.60	416.67	604.16	99.04
4	IT04K-267-8	500.00	333.00	416.66	69.72
5	IT04K-332-1	437.00	875.00	700.00	211.39
6	IT04K-333-2	583.33	583.00	583.00	52.70
7	IT04K-334-2	750.00	375/00	562.50	135.97
8	IT04K-339-1	291.66	166.60	229.16	59.65
9	IT04K-405-5	166.60	333.00	250.00	55.90
10	IT06K-139	833.30	350.00	591.66	157.00
11	IT06K-147-2	1000.00	458.00	729.00^c	149.00
12	IT07K-187-55	1041.00	416.00	729.00	197.00
13	IT07K-194-3	1791.66	1062.00	1500.00	223.00
14	IT07K-220-1-9	1083.30	500.00	791.60	150.23
15	IT07K-292-10	666.60	625.00	645.83	142.00
16	IT07K-293-3	1208.33	583.00	895.83	189 .00
17	IT07K-297-13	666.00	416.60	541.66	100.34
18	IT07K-304-9	500.00	375.00	425.00	50.00
19	IT07K-318-2	708.33	566.00	637.50	88.68
20	Kanannado	0.00	0.00	0.00	0.0
	Mean	715.91	436.40		
	SEM	62.68	39.12		

SEM = Standard Error of the Means

(15.92%) than the improved cultivars under study. The highest value for ether extract (12.50%) was recorded in cultivar IT04K-405-5 and the lowest (10.50%) for cultivar IT07K-194-3. The non-fibre carbohydrates was highest (12.43 %) in cultivar IT07K-293-3 and lowest (6.40 %) in the Kanannado cultivar. There were no significant differences (P>0.05) in ash content among the cultivars.

The highest NDF and ADL constituents were recorded for cultivar IT04K-194-3 (Table 5). The highest ADF content was registered by cultivar IT06K-147-2 (50 %) and the lowest by cultivar IT04k-334-2 (36%). Contents of hemicellulose and cellulose were highest in cultivars IT04K-334-2 and IT06K-147-2, respectively.

DISCUSSION

Days to 50% flowering. The days to 50 % flowering among the cultivars in this study ranged from 38 to 60 days (Table 1) and the mature pods were ready for harvest 10 days thereafter. This confirms that these are extra-early maturing cultivars (Akundabweni *et al*., 1991). The days to flower were shorter than the range of 44-73 reported by Omokanye *et al*. (2003) who worked on similar cultivars. It can be inferred that the effect of day-length and season in the sub-humid and humid zones, may have been responsible for the differences in days to 50% flowering. According to Nuhu and Mukhtar (2013), day length had significant effect on phenology among all genotypes of cowpea studied in Kano, Northern Nigeria.

TABLE 4. Mean ranking of the cultivars based on mean fodder and pod yields in 2012 and 2013

S/N	Variety	Mean fodder yield	Mean pod yield	Mean ranking score	Ranking
1	IT07K-293-3	4483.3	895.83	1.5	1st
2	IT07K-194-3	3332.3	1500.00	2.5	2nd
3	IT06K-147-2	3812.5	729.0	3.5	3rd
4	IT07K-220-1-9	2280.1	791.6	6	4th
5	IT07K-187-55	2163.9	729.0	8	5th
6	IT04K-334-2	3122.6	562.5	8.5	6th
7	IT04K-405-5	4128.7	250.0	9.5	7th
8	IT06K-139	2262.8	591.7	10	8th
9	IT04K-267-8	2800.9	416.7	10.5	9th
10	IT04K-227-4	2104.9	604.2	10.5	9th
11	IT07K-304-9	2669.7	229.2	11	11th
12	IT07K-292-10	1817.7	645.8	11	11th
13	IT04K-332-1	1793.9	700.0	11	11th
14	IT04K-339-1	2715.8	229.2	12.5	14th
15	IT04K-333-2	1834.6	583.0	12.5	14th
16	IT07K-318-2	967.0	637.5	13	16th
17	IT07K-297-13	1443.5	541.7	15	17th
18	Kanannando	1957.8	0.00	16.5	18th
19	IT00K-335-45	133.0	300	18	19th
20	IT06K-147-1	614.0	187	19	20th

The cowpea cultivars evaluated in this study belong to the group of extra-early maturing (60 - 70 days) to production of dry grain (Timko and Singh, 2008), except for the Kanannado cultivar which flowered but produced no grain for the two years. This could be explained by the postulation of Adeigbe *et al.* (2011) that local unimproved landraces are photo-periodically sensitive and less productive than the improved ones. The difference in photo-period between Kano and Owerri may have influenced the flowering and seed setting. Thus, the local landrace Kanannando, would not be suitable as dual purpose cowpea for fodder production within this ecological zone. It therefore follows that the improved cultivars which recorded promising yields of both grain and fodder and which are not photo-periodically sensitive as the local counterparts, would fit-in as the best bet cultivars for the humid rain forest zone of Nigeria. Given its comparative advantage of abundant rainfall and the potential for high forage yields, the humid forest zone could serve as source of forage for dry season livestock feeding, especially to the Northern parts of Nigeria with huge feed deficits during the dry season.

In this study, all the improved cultivars produced matured pods within 14 days of 1st or 50% flowering (Table 1). This further suggest that improved dual purpose cowpea cultivars have great potential as fodder and grain source, given the very short growth cycle of these cultivars. In fact, two cycles of production are possible within the dry season if irrigation is available, thereby increasing the food supply and household income for small holder farmers. The fact that the yields recorded in this study are comparable to yields in other locations in Nigeria (1-6 t ha^{-1} reported by Omokanye *et al.* (2003) in Zaria, and 0-5 t ha^{-1} by IITA, (unpubished), further supports the adoption of the improved best bet cultivars

TABLE 5. Proximate composition and fibre fractions (DM) of selected cowpea cultivars

Cultivars	Proximate composition					Fibre fractions				
	DM	CP	EE	Ash	NFC	NDF	ADF	ADL	HEM	CELL
IT04K-334-2	86.00^{ab}	11.14^{c}	10.50^{b}	6.67	11.69^{ab}	60.00^{bc}	36.00^{c}	5.33^{b}	24.00^{a}	20.66^{b}
Kanannado	85.00^{ab}	15.92^{a}	11.00^{ab}	5.33	6.40^{c}	61.33^{b}	40.67^{b}	12.67^{a}	20.67^{a}	28.00^{b}
IT07K-293-3	89.00^{a}	10.49^{c}	11.5^{ab}	5.67	12.34^{a}	60.00^{bc}	42.67^{b}	10.67^{a}	17.33^{bc}	32.00^{b}
IT04K-194-3	88.00^{a}	11.14^{c}	10.50^{b}	6.00	7.39^{bc}	66.00^{a}	41.33^{b}	10.00^{a}	24.67^{a}	31.33^{b}
IT04K-405-5	86.00^{ab}	13.57^{b}	12.50^{a}	6.67	10.59^{abc}	56.67^{c}	44.00^{b}	12.67^{a}	12.67^{c}	31.33^{b}
IT06K-147-2	89.00^{a}	12.28^{bc}	11.50^{ab}	5.33	7.55^{bc}	63.30^{ab}	50.00^{a}	11.33^{a}	13.33^{c}	38.67^{a}
SEM										

^{abcd} = Means on the same column with different superscript are significantly (P<0.05) different

DM = Dry matter; CP = Crude protein; EE = Ether extract; NFC = Non fibre carbohydrates; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin; HEM = Hemicellulose; CELL = Cellulose for the emerging integrated crop-livestock systems in the humid rainforest zone of Nigeria.

Pod yield. The range of pod yield of 0-1.5 t ha^{-1} is within the range of 0.5 -1.0 t ha^{-1} recorded by Omokanye *et al.* (2003) at Shika in Zaria; as well as 0.3- 0.4 t ha^{-1} reported by Anele (2010) at Abeokuta, This further proves that dual purpose cowpea production has great potential as a late rainy season crop in the humid forest zone of Nigeria. The values reported for pod yields were used to estimate the grain yield potential of the various cultivars since the number of pods and weight of pods were positively correlated with grain yield (Abayomi *et al.*, 2008; Ogunkanmi *et al.*, 2013). Hazra *et al.* (2007) reported that increase in pod length and pod number results in a corresponding increase in yield. The high pod yielding cultivars which had high forage biomass yields greater than 3 t ha^{-1} are recommended as dual purpose cultivars. Due to the enormous importance placed on cowpea grain as food crop, cultivars must show promising yields in both forage and grain yields to qualify as dual purpose cultivars. Cultivar IT04K-405-5, which recorded very high yield of fodder with high contents of crude protein, posseses large round seeds different from the popular edible cowpea in the market which may make it difficult for adoption by farmers. When averaged across the cultivars, there was a higher pod yield in the first year (0.7 t ha^{-1}) compared to the second year (0.4 t ha^{-1}). This pod yield pattern was inconsistent with the higher forage yield recorded in the second year (Table 3). This implies that fodder and pod yields may be sensitive to biotic and abiotic variables. According to Singh and Rachie (1985) several factors could contribute to differences in yields across years, among which could include insects and other pests, low or high soil pH, high exchangeable aluminum, low fertility, soil salinity, high temperatures, excessive or droughty water levels, inadequate management and poor plant protection, hydrological stress and their interactions. In addition, the higher rainfall in the first year (Fig. 2) might have positively influenced vegetative growth and seed formation because retained moisture in the soil might have resulted to a longer growing time and ultimately more flowering and the fruiting, compared to the succeeding year. The reduction in pod yield in the second year could

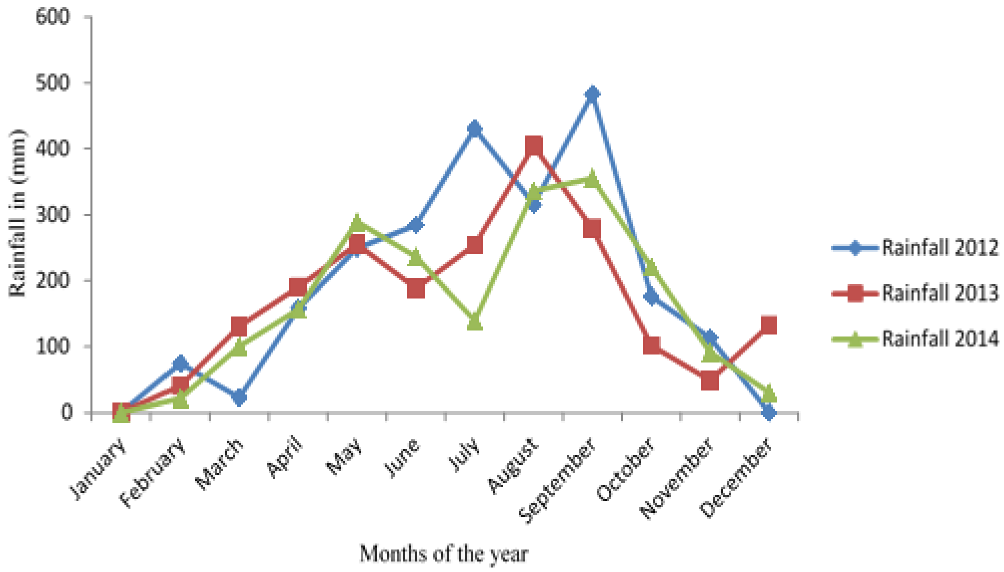

Figure 2. Rainfall data (mm) in Owerri in 2012, 2013 and 2014.

have been due to interaction of these biotic and abiotic factors. Overall, mean yields above 2 t ha^{-1} and 0.5 t ha^{-1} for both fodder and pod, respectively, are a good start which could be leveraged with fertiliser application. From the foregoing, it is recommended to apply a booster dose of super phosphate fertilizers due to the low available phosphorous in the soils within the study location (Table 6).

Proximate analysis. The results of proximate analysis of bulked samples of the five selected cultivars, from the two seasons, indicate crude protein content of between 9 and 15 % (Table 5).This is far in excess of the minimum crude protein requirement of a ruminant animal for optimum growth (Van Soest, 1994). In the semi arid and arid regions of northern Nigeria, farmers stockpile leftover cereal crop residues at harvest, for dry season feeding. However, cereal stovers are generally nutritionally inadequate to produce high meat and milk yields, hence, the potential of cereal crop residues as animal feed can be enhanced when fed in combination with legume residues (Anyanwu, 2021). Therefore, cowpea haulms from the improved cultivars could supplement and supply the needed protein for optimum productivity. In recent times, there has been a growing demand for roughage feeds by scores of livestock marketers, who must feed their animals with high quality forages in order to maintain or improve their body condition until animals are sold. The values reported for crude protein in this study are in agreement with results reported in earlier studies (Grings *et al.*, 2010b), but lower than that reported by Anele *et al.* (2011) for improved cowpea varieties, and lower than those reported by Gebreyowhans and Gebremeskel (2014). Differences in the CP could be explained by a variety of factors such as environment (e,g, soil characteristics, rainfall), crop management (e.g. level of fertilisation, plant density, stage

TABLE 6. Physical and chemical characteristics of the composite soil samples taken from the experimental site at 0-15 cm depth in 2012 and 2013

Soil properties	2012	2013
pH ($CaCl_2$)	6.4	6.69
Total N (%)	0.066	0.092
Organic carbon (%)	0.638	0.838
Organic matter (%)	1.101	1.445
Plant available macro nutrients (cmol kg^{-1})		
Calcium	0.048	0.08
Magnesium	0.144	0.16
Aluminum	1.64	0.44
Hydrogen	0.12	0.16
Exchangeable sodium	0.093	0.108
Exchangeable potassium	0.014	0.012
Available phosphorus (Mg kg^{-1})	23.80	14.35
Particle size distribution (%)		
Sand	85.96	84.96
Clay	11.76	11.76
Silt	2.28	3.28
Textural class	Loamy soil	

of maturity at harvest, methods of harvesting, and storage) (Walli *et al*., 1994). The variation in nutritional qualities recorded in this study is in resonance with considerable variation observed in the quality of the various crop residues sold in the different markets (Anyanwu, 2021). Cowpea haulms and groundnut haulms are among the popular crop residues used in feeding ruminant livestock in parts of Nigeria; and have been reported to vary in quality depending on the harvest method, storage and proportions of plant materials included in the residue such as leaves, stems and residual pods (Myer, 2010). Among the legume crop residues, leaf shattering increases the proportion of stems and diminishes its nutritional value (Myer, 2010).

The lower value of crude protein of the forage from this study compared to other studies (Anele *et al*., 2011; Gebreyowhans and Gebremeskel, 2014) could be attributed to the fact that no fertiliser was applied to the crops in the two years of study. Fertiliser application, especially nitrogen fertilisers, increases the protein content of herbage which includes legumes (Humphreys, 1987). It could also be attributed to the lower nitrogen status of the soil at the study site (Table 6). In addition, the advanced stage of maturity of the cowpea haulm could have led to a reduction in crude protein content due to accumulation of fibrous carbohydrates. Crude protein values obtained in the present study were, however, higher than 7% reported by Van Soest (1994) as the minimum CP content required in ruminant diets for optimal activity of rumen micro-organisms. This supports the widely held belief by several authors that cowpea crop residue would be suitable as a feed supplement to low quality basal diets in the dry season in most production systems in West Africa (Omokanye *et al*., 2003; Akinlade *et al*., 2005; Grings *et al*., 2010).

The NDF content of the selected top yielding cultivars ranged from 56 to 68%, which is comparable with 56-61% reported by Anele (2011) in the wet season at Abeokuta. The cultivars recorded acceptable levels of fibre concentrations (Table 5) which are easy to degrade (Anele, 2011). The Kanannado cultivar recorded a higher amount of lignin, which was in agreement with results of higher crude protein content reported by (Anele, 2011) between improved and commercial cultivars. The fibre values among the improved cultivars were within the acceptable range required for optimal livestock production (Table 5).

CONCLUSION

This study has confirmed that the selected cultivars from cluster 1 namely, IT07K-293-3, IT04K-405-5, IT06K-147-2, IT07K-194-3 and cluster 2; IT04K-227-4 , IT06K-139 , IT07K-187-55, IT07K-220-1, are dual purpose cultivars, based on their higher yields of pod and forage. IT04K-334-2 in cluster 3 is also a promising dual purpose cultivar. Crude protein and fiber contents of the selected cultivars mentioned above are sufficient to supply additional nitrogen when used as supplemental feed during the dry season. Although the crude protein content in the Kanannado cultivar was relatively higher, it cannot be recommended because of zero yield of pod and lower digestibility.

The relatively high crude protein content of the various cultivars make them suitable as supplements to poor quality stovers especially during the dry season in the humid and sub-humid zones of Nigeria; which offers opportunity for the emergence of forage merchants and traders. The only limitation to producing dry crop residues free from mouldy growth is the high humidity and inadequate sunshine in the rainforest zone that makes sun drying difficult, especially in the rainy season. Nevertheless, entrepreneurs could devise ingenious low cost techniques to achieve proper drying and storage, since sale of cowpea hay could contribute substantial household income.

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