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COWPEA FOR A CHANGING ENVIRONMENT IN THE RAINFOREST OF SOUTH-SOUTH NIGERIA

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ABSTRACT

The introduction and use of appropriate cowpea varieties in south-south Nigeria may contribute to increased food security, especially in the context of the changing climate and desert encroachment in the country. In the context of evaluating diverse cowpea varieties for the changing environment, the present study involved the evaluation of 94 varieties of cowpea in 2013 and 2014 at Benin City in the rainforest of south-south Nigeria to identify varieties with the potential to contribute to grain or forage production and those with the potential for dual-purpose/multiple use. Grain yields of 0.5–2.0 t ha^{-1} and biomass (fodder) of 0.9–4.4 t ha^{-1} were obtained. Thirty-seven varieties that may contribute to grain production, 20 varieties that may contribute to biomass production and 13 varieties with potential for both grain and biomass production were identified. The observed potential to contribute to grain production, feed for livestock and crop residues for soil nitrogen improvement suggests cowpea may be a desirable option for use in mitigating the effect of climate change in the context of shift in crops and animals that can be produced in an environment that is changing.

Keywords: Climate change, cowpea, grain yield, biomass, south-south Nigeria

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp) is an important grain and fodder legume in Nigeria where its tolerance to moisture stress, heat and low soil fertility makes it suitable for cultivation in the savanna agro-ecological zone (IITA, 2009). Animals such as cattle, sheep and goats are mainly reared in this zone which uses cowpea fodder and haulms as feed. However, the environment is changing due to climate change (increase in heat and drought) and desert encroachment in the savanna and change in rainfall patterns in the rainforest with erratic and lesser rainfalls accompanied by gradual change in vegetation (Odjugo 2010; Idowu *et al.*, 2011). Growing period is shortening in the savanna due to climate change. Available arable land in northern Nigeria is getting smaller due to desertification.

Meanwhile, the late cropping season in the rainforest has potential for cowpea production. Climate change and desertification is presenting even a unique opportunity to grow cowpea in this zone. A consequence of climate change is a shift in animals and crops that can be grown in zones of traditional production. For example, in recent times the rainforest of Nigeria has experienced heightened herding activities with its attendant social/cross cultural challenges. Presently, hardly can one find a village in Edo state, for example, without Fulani nomads and their animals.

Even though cowpea is a major staple food for the people in south-south Nigeria, the price is very high because of cost of transportation from the northern to southern parts of the country. Price of the commodity could become cheaper if cowpea is grown in the region. In the region, there has also been a dearth of information on cowpea research and this has become very important in the face of the emerging challenges of climate change. Moreso, a fall in cowpea production in Nigeria will result in serious food security crisis in the whole of West and Central Africa because Nigeria does not only harbour all the agro-ecological zones; it is also the largest producer and consumer of cowpea in the region (IITA, 2009). As it happens to Nigeria so it happens to West and Central Africa. One way to avert this is for the breeder to breed for shorter duration cowpea for the savanna or for the agronomist to adapt cowpea varieties to the rainforest or both. Fortunately, there are many available genotypes of cowpea with diverse growth habits bred by the International Institute of Tropical Agriculture (IITA) (IITA, 2009). Some of these genotypes may have potential to grow and produce good

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grain and fodder yields in the rainforest of Nigeria. Cowpea adapted and grown in the rainforest will provide feed for the cattle; sheep and goat now found in the region as well as provide food for humans and improve the declining soil fertility of the rainforest occasioned by continuous cropping through crop residue generation and decomposition. Therefore, the objective of this study was to evaluate some varieties of cowpea for grain and biomass production potential in the rainforest as a way to mitigate the emerging threat of climate change on food security.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted in the late cropping seasons (late August – December) of 2013 and 2014, at the Teaching and Research Farm of the Faculty of Agriculture, University of Benin, Benin City (06^o 20 ‘E, 5^o 39’E; 78 m asl) in the Rainforest of South-south Nigeria. The soils are underlain by sands, clayey sands and discontinuous clay sequences of Benin Formation of the Niger Delta Basin classified as ultisols (Olatunji *et al*., 2014, Umweni *et al*., 2014). Rainfall is of high intensity and bimodal, beginning in March/April and ending in October/November with a dry little spell in August usually referred to as “August Break”. About 2025 mm of precipitation falls annually in Benin City with an average annual temperature of 26.1 °C (Climate-Data.org, 2016). The zone has a total growing period of 211 to 270 days (Ogeh and Ukodo, 2012). The period from the commencement of rain to the time of “August Break” is regarded as early cropping/growing season whereas the period from the break in August to the end of rains is regarded as the late cropping/growing season. The late cropping season was chosen for the experiment because it appears to be the most suitable for cowpea production in the Rainforest zone since it contains the months that present growing environments similar to those present in the savanna zones where cowpea is mainly grown. The rainfall and temperature during the years of trial together with the long-term rainfall and temperature are given in Table 1. Soil properties of the experimental site prior to start of the experiment are presented in Table 2.

Plant Materials and Experimental Layout

Ninety-four cowpea varieties obtained from the International Institute of Tropical Agriculture, Kano were evaluated in the study. The experiment was non-replicated having plot size of 3 m x 2 m with 0.75 m between plots. Plant spacing was 0.75 m between rows and 0.20 m within rows and there were four rows per plot.

Cultural Practices

The field was cleared of vegetation manually, using cutlass. On 02 September 2013 and 01 September 2014, seeds of cowpea were sown at the rate of three seeds per hole at a depth of 5 cm and later thinned to two plants per hill at two weeks after sowing. Neither organic nor inorganic fertilizers were applied as the soil was deemed relatively fertile. Plants were sprayed against insect pests at the beginning of flowering using Uppercott (30 g cybermethrin/230 g dimethoate per litre) at the rate of one litre per hectare. This was repeated at 10 days interval until when it was two weeks to harvesting. Spraying with fungicide (Z-force mancozeb 80% wp. Family: ethylene bidithiocarbamate EBDC manufactured by Jubali Sino agro chemical industry LTD, China) was done at 10 weeks after sowing to control fungal disease. Weeding was carried out using a hand hoe at two weeks after sowing and just before flowering to keep the plots weed-free.

Data Collection

The time of 95% pod maturity (i.e., when 95% of the pods in a plot had turned brown) was recorded. Number of branches and number of peduncles in a net plot (the two central rows) of a plot were determined and calculated as no. m^{-2}. Mature pods in a net plot were harvested, counted and threshed; pod counts from the net plot were calculated as no. m^{-2} while the seeds were weighed and seed weights calculated as kg ha^{-1} with adjusted moisture at 15%. Above ground biomass (leaf and stem) was assessed at harvesting. Plants within the net plot were cut at 10 cm above the ground and oven dried at 65^{o}C until constant weight was achieved. Weights of biomass were calculated as kg ha^{-1}.

Data Presentation and Analysis

Mean of the two-year data collected was subjected to correlation analysis, using the PRINCORR procedure of SAS programme (SAS, 2011). This was done to explore the relationship among the attributes. Two criteria were used to select promising varieties: high grain yield and high biomass based on the objectives of the study. To achieve this, frequency distributions were constructed for grain yield and biomass. Good biomass would help to identify varieties that may contribute to cowpea residue for soil improvement or livestock production while good grain yield would bring to light those varieties good for grain production; those suitable for dual purpose would also be identified. Frequency distributions were done by dividing the range for each variable by seven, which was the chosen number of class intervals using the empirical relationship suggested by Sturges (1926) as a guide and as stated below:

$K = 1 + 3.3log_{10}n$; where k is number of classes and n is total number of observations.

RESULTS AND DISCUSSION

Growing Conditions

Mean rainfall during the experimental period (September - December) was 542 mm with a mean temperature of 27ºC (Table 1). Soil samples collected before establishing the trial had a pH (H_2O (1: 1) of 4.5, organic carbon content of 9.3 g kg^{-1}, total nitrogen (Kjeldahl) of 1.07 g kg^{-1}, Olsen phosphorus (P) content of 19.64 ug g^{-1} and potassium content of 10.0 mmol (+) kg^{-1} $soil^{-1}$ (Table 2). These conditions provided an adequate environment for the cowpea crop to germinate, emerge, establish, grow and produce good yield. However, as with cowpea elsewhere, insect pests were serious problems. But more damaging without apparent control measure was the Quelea (*Quelea quelea*) birds that fed on the immature pods. However, the damage occurred most along border plots. Such damaged plots where excluded from the analysis and study which reduced the number of tested varieties from 94 to 75.

Agronomic Performance

Time to maturity ranged from 61 to 99 days. Number of branches ranged from 1-33, number of peduncles from 25-222 and number of pods from 29-150 m^{-2}, respectively. Biomass and grain yield ranged from 875.8-4356.0 and 475.4-2023.0 kg ha^{-1}, respectively. Cowpea may be grouped into early (55-69 days), medium (70-85 days) and late (above 85 days) maturing varieties (Singh *et al*., 1997). Based on this, four varieties were early maturing, 68 medium maturing and three late maturing. According to Kamara *et al*. (2011), most early maturing, medium maturing and late maturing cowpea varieties have determinate, semi-determinate and indeterminate growth habits, respectively. While determinate cowpea varieties are grain-type cowpea, dual-purpose cowpea is either semi-determinate or indeterminate. In the context of providing fodder or generating crop residues, cowpea biomass can be a rich source of protein for animals or soil enrichment (IITA, 2009). Thus, cultivation of dual-purpose cowpea can be an attractive option for many farmers who would need to improve their impoverished soils occasioned by continuous cropping. With increasing number of herds migrating from the north to the south, cowpea fodder will help drive productivity and sustainability.

Relationship among Traits

Correlations between traits of the cowpea varieties studied are summarized in Table 3. Days to maturity was positively and significantly associated with biomass yield (r = 0.327, P = 0.0013) whereas it was negatively and significantly associated with grain yield (r = -0.238, P = 0.0211). This is why the medium and late maturing varieties had more biomass and less grain yields. There were significant and positive correlations between grain yield and biomass (r = 0.513, P < 0.0001); number of pods (r = 0.861, P < 0.0001); number of peduncles (r = 0.520, P < 0.0001) and number of branches (r = 0.475, P < 0.0001); between biomass and number of pods (r = 0.572, P < 0.0001); number of peduncles (r = 0.545, P < 0.0001) and number of branches (r = 0.524, P < 0.0001); between number of pods and number of peduncles (r = 0.614, P < 0.0001) and number of branches (r = 0.544, P < 0.001); and between number of peduncles and number of branches (r = 0.563, P < 0.001). These correlations indicate that grain yield depends on biomass, branch, and peduncle and pod production. Correlation between grain yield and yield components have been reported by several workers. Tamilselvam and Das (1994) studied correlation in cowpea and reported that seed yield per plant was positively correlated with number of branches and pods per plant.

Table 1: Rainfall and temperature at the experimental site for both long-term and 2013-2014 period

	Long-term†				2013				2014			
	Rainfall	Temperature (ºC)			Rainfall	Temperature (ºC)			Rainfall	Temperature (ºC)		
Month	(mm)	Min	Max	Av	(mm)	Min	Max	Av	(mm)	Min	Max	Av
Jan	9	21.1	31.7	26.4	29.0	24.0	32.0	28.0	21.5	24.7	32.4	28.6
Feb	44	21.8	32.7	27.2	33.0	24.2	32.8	28.5	6.7	24.5	32.5	28.5
Mar	109	22.3	32.6	27.4	105.5	23.9	33.1	28.5	108.7	24.3	32.9	28.6
Apr	164	22.9	32.1	27.5	113.2	23.4	31.9	27.7	132.7	23.6	32.1	27.9
May	199	22.4	31.6	27.0	231.9	23.2	31.9	27.5	154.6	23.3	32.3	27.8
Jun	267	21.8	29.4	25.6	358.6	23.0	30.4	26.7	208.5	23.3	31.2	27.3
Jul	331	21.2	27.8	24.5	274.3	22.7	28.6	25.7	139.0	22.9	29.2	26.1
Aug	247	21.2	27.8	24.5	255.3	22.5	28.1	25.3	437.2	22.4	28.6	25.5
Sep	338	21.7	28.2	24.9	257.7	23.2	29.3	26.3	246.0	23.3	30.3	26.8
Oct	233	21.8	30	25.9	225.0	23.6	30.6	27.1	116.6	23.1	30.3	26.7
Nov	62	21.8	31.6	26.7	106.6	22.8	31.4	27.1	125.0	23.1	31.6	27.4
Dec	22	20.5	31.6	26	6.5	20.9	33.1	27.0	0.6	23.7	33.8	28.8
Total	2025				1996.7				1697.1			

† Data covered a period of 1982 -2012; source: Climate-Data.org (2016a)

Table 2: Physical and chemical properties of soil for the experiment prior to planting in 2013

Properties	Concentration
Sand	810 g kg^{-1}
Silt	40 g kg^{-1}
Clay	150 g kg^{-1}
pH (H_2O (1: 1)	4.5
Organic carbon content	9.3 g kg^{-1}
Total nitrogen (Kjeldahl)	1.07 g kg^{-1}
Olsen phosphorus (P) content	19.64 ug g^{-1}
Potassium content	10.0 mmol (+) $kg^{-1}soil^{-1}$

Kamara *et al.* (2011) reported that grain yield had a positive association with number of pods and fodder yield for determinate cowpea varieties and positive association with fodder yield for semi-determinate cowpea varieties. Manggoel and Uguru (2011) reported significant and positive relationship between grain yield and number of peduncles and number of pods. Ewansiha *et al.* (2015) reported marked and positive correlation between grain yield and number of branches, number of peduncles, number of pods and fodder yield in cowpea varieties. Based on these findings, breeding for higher number of branches, peduncles, pods or fodder yield will lead to higher yields. With more biomass, cowpea tends to become dual in purpose.

Selection of High Yielding and Dual-Purpose Varieties

Frequency distributions of biomass and grain yield are presented in Table 4. Based on the classes, varietal values were scored for biomass and grain yield as shown in Tables 4 and 5 (1 = very poor; 7 = outstanding). Based on biomass, 20 varieties having high biomass were selected. These varieties scored well to outstanding performance for biomass. These can be used as fodder-type cowpea. This is very pertinent in the south-south environment where herding is becoming an increasing trend. Alternatively, the selected varieties with potential for biomass can be used as a resource for improving the soil in crop residue generation. This is very important in situations where continuous cropping has resulted in impoverished soils or where bush fallow has become too short to be able to replenish the soil. Based on grain yield, 37 varieties were selected because they had high grain yield. These varieties scored good to outstanding performance for grain yield and hence can be used as grain-type cowpea. For dual-purpose use, 13 varieties with high grain plus high biomass yields were identified.

Figure 1 shows all the selected varieties for fodder, grain and dual-purpose use. These varieties are mostly medium maturing, meaning that they have enough time for biomass accumulation and short enough maturity to escape terminal drought. While such varieties have yield potential of at least 2 t ha^{-1} for grain and 2 t ha^{-1} for fodder (Singh *et al*., 2003) in the savanna, the present study recorded a mean of 1.4 t ha^{-1} grain yields and 2.8 t ha^{-1} biomass/fodder yields for the selected varieties.

Table 3: Correlation coefficients between traits of cowpea varieties grown in a Rainforest environment

Trait	Days to maturity	Number of branches	Number of peduncles	Number of pods	Fodder yield
Number of branches	-0.057				
Number of peduncles	0.088	0.563**			
Number of pods	-0.182	0.544**	0.614**		
Fodder yield	0.327**	0.524**	0.545**	0.572**	
Grain yield	-0.238*	0.475**	0.520**	0.861**	0.513**

*significant at 5% level of probability; **significant at 1% level of probability

Table 4: Frequency distributions and selection scores for cowpea varieties

Selection attributes	Variety value	Selection score*	Number of varieties	Remarks
Biomass (kg ha^{-1})	876.0-1394.0	1	18	Very poor
	1395.0-1913.0	2	24	Poor
	1914.0-2432.0	3	13	Fair
	2433.0-2951.0	4	11	Good
	2952.0-3470.0	5	6	Very good
	3471.0-3989.0	6	2	Excellent
	3990.0-4508.0	7	1	Outstanding
Grain yield (kg ha^{-1})	475.0-696.0	1	5	Very poor
	697.0-918.1	2	18	Poor
	919.0-1140.0	3	15	Fair
	1141.01362.0	4	18	Good
	1363.0-1584.0	5	6	Very good
	1585.0-1806.0	6	8	Excellent
	1807.0-2028.0	7	5	Outstanding

* Score for all varieties: Table 5

Table 5: Maturity group, biomass, grain yield and scores* for selection of high yielding varieties

Variety	Days to maturity	Biomass (kg/ha)	Grain yield (kg/ha)	Score for biomass yield	Score for grain yield	Total
IT06K-121	61.0-67.0	1178.6	1094.5	1	3	4
IT07K-188-44		883.0	915.8	1	2	3
IT97K-461-4		1186.1	806.8	1	2	3
IT97K-499-39		875.8	618.3	1	1	2
Aloka Local	71.0-85.0	2003.1	1370.8	3	5	8
Danila		1596.5	1668.7	2	6	8
IAR-48		986.3	575.7	1	1	2
IT00K-1263		3169.0	1781.9	5	6	11
IT03K-130		1315.7	777.1	1	2	3
IT03K-316-1		2054.1	1162.2	3	4	7
IT03K-324-9		1210.0	1204.3	1	4	5
IT03K-335-9		1788.5	1068.8	2	3	5
IT03K-337-6		1238.0	1384.0	1	5	6
IT03K-351-1		2691.7	1789.8	4	6	10
IT03K-351-9		3418.5	1788.4	5	6	11
IT03K-378-4		1537.5	896.9	2	2	4
IT04K-227-4		1788.4	1187.6	2	4	6
IT04K-333-2		1133.5	1172.7	1	4	5
IT04K-516-1		2890.1	1391.8	4	5	9
IT06K-111		1426.8	965.9	2	3	5
IT06K-111-1		3591.1	1872.1	6	7	13
IT06K-121-3		1406.1	801.8	2	2	4
IT06K-133		1409.1	1128.8	2	3	5
IT06K-135		1250.7	747.5	1	2	3
IT06K-212-1		2449.5	1031.4	4	3	7
IT06K-270		1826.5	728.5	2	2	4
IT06K-275		1392.7	1144.8	1	4	5
IT06K-91-1		1354.3	769.7	1	2	3
IT07K-187-72		1525.9	1015.1	2	3	5
IT07K-194-3		1907.7	1598.2	2	6	8
IT07K-206-1-3		1077.3	1157.5	1	4	5
IT07K-211-1-8		2379.5	1936.7	3	7	10
IT07K-212-4-3		1288.9	1280.7	1	4	5
IT07K-216-7		3248.1	1257.4	5	4	9
IT07K-220-1-9		1814.7	1233.8	2	4	6
IT07K-244-1-1		1851.1	1297.5	2	4	6
IT07K-249-1-11		1293.3	857.1	1	2	3
IT07K-252-2-10		1698.9	1132.7	2	3	5
IT07K-260-5		2105.1	915.1	3	2	5
IT07K-281-2-7		2393.5	1400.4	3	5	8
IT07K-290-11		1567.8	1207.1	2	4	6
IT07K-291-69		2516.9	686.3	4	1	5
IT07K-292-10		1524.2	938.1	2	3	5
IT07K-293-18		2328.8	1412.1	3	5	8
IT07K-293-3		1879.1	875.6	2	2	4
IT07K-297-15		1944.4	937.5	3	3	6
IT07K-299-4		1372.6	713.2	1	2	3
IT07K-301-3		1252.3	1020.7	1	3	4
IT07K-302-20		2267.9	1446.2	3	5	8
IT07K-302-27		3739.2	1916.4	6	7	13
IT07K-303-1		2555.1	801.2	4	2	6
IT07K-311-1		2561.7	1246.7	4	4	8
IT07K-313-44		3018.1	1848.3	5	7	12
IT07K-318-2		1458.1	1061.6	2	3	5
IT81D-994		1876.1	1063.8	2	3	5
IT87D-941-1		2081.0	1061.1	3	3	6
IT90K-277-2		1819.3	1168.8	2	4	6
IT93K-452-1		2538.0	1328.3	4	4	8
IT97K-568-11		2191.5	1633.8	3	6	9
IT98K-1111-1		1765.3	1165.1	2	4	6
IT98K-1263		2025.5	1067.0	3	3	6
IT98K-131-2		2617.8	2023.2	4	7	11
IT98K-133-1-1		3450.0	1671.0	5	6	11
IT98K-205-8		2766.4	777.1	5	2	7
IT98K-409-4		2576.1	1264.9	4	4	8
IT98K-503-1		1308.3	990.7	1	3	4
IT98K-589-2		1627.5	773.2	2	2	4
IT99K-1060		2152.9	1305.1	3	4	7
IT99K-377-1		2395.8	866.5	3	2	5
IT99K-494-6		1623.7	1738.2	2	6	8
IT99K-529-2		1621.8	877.8	2	2	4
IT99K-573-2-1		1561.7	1159.8	2	4	6
IT04K-321-2	90.0-99.0	2663.1	555.5	4	1	5
IT89K-288		3365.5	475.4	4	1	5
IT98K-1103-13		4356.3	857.3	7	2	9

* Criteria for score: Table 4

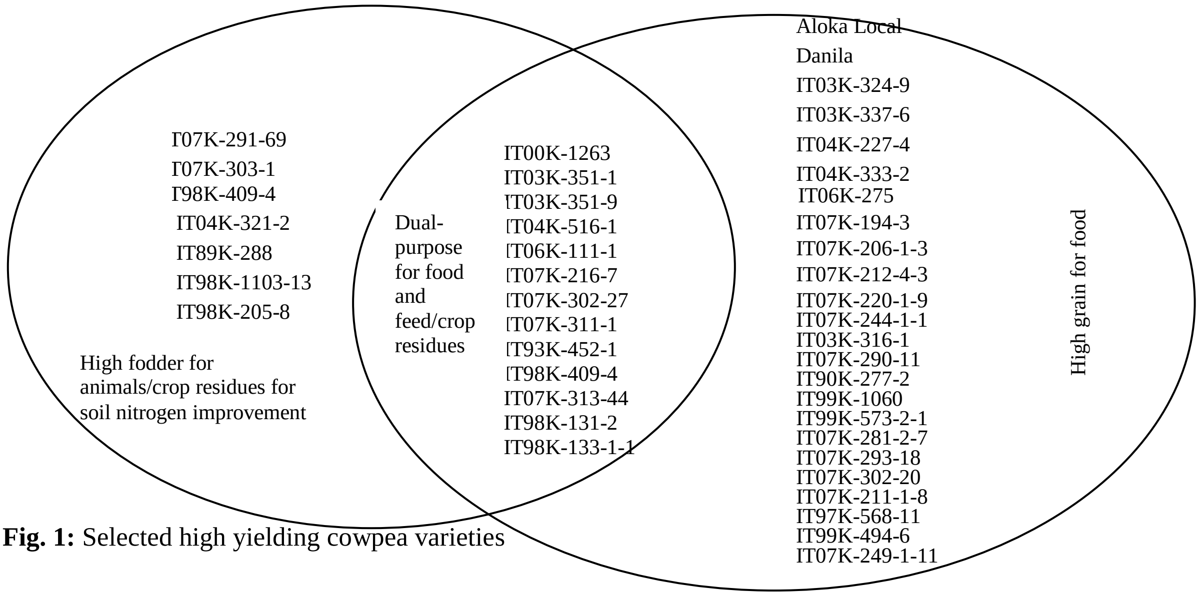

Fig. 1: Selected high yielding cowpea varieties

This implies that the selected varieties are well adapted to the rainforest and that the late growing season of south-south Nigeria may readily replace the Nigeria savanna in the context of changing environment due to climate change and desertification. This may be so because the growing environment in the savanna as typified by Minjibir in Kano, where the above yields were reported has similar rainfall and temperature as in Benin City during September-December when the present experiment was conducted. The long-term rainfall and temperature covering 30 years for Minjibir, Kano during July to October when cowpea is grown are 529 mm and 25.7^{o}C, respectively (Climate-Data.org, 2016b). This matches with the rainfall and temperature data for both long-term and current data (Table 1) for September to December in Benin City.

Thus, the application of these findings may help to mitigate the effect of climate change and desertification, ensure sustained food security especially when traditional crops may not be able to thrive in environments where they were once most adapted and grown.

CONCLUSION

Cowpea appears to have potential for use in the farming systems in the rainforest of south-south Nigeria where it can be grown for grain, fodder and soil improvement. A good number of the varieties were selected for their potential to contribute to high grain and fodder production while providing both grain and fodder. Further agronomic evaluations including planting date, plant population, insect pest infestation and diseases are warranted.

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