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Improvements in grain and fodder yield of cowpea (*Vigna unguiculata*) varieties developed in the Sudan savannas of Nigeria over the past four decades

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Abstract

A field study was conducted to determine the rate of genetic improvement in grain and fodder yields of cowpea genotypes developed in the Nigerian Sudan savannas from 1970 to 2004. Results showed that grain yield ranged from 568 kg/ha for an old variety TVX3236 to 1851 kg/ha for a recently released variety IT04K-321-2. The average rate of increase has been 28 kg/ha/year, which corresponds to a genetic gain of 3.6%. Fodder yield ranged from 1363 kg/ha for a variety released in 1976 (TVX1836-0131) to 3346 kg/ha for IT98k-476-8 released in 1998 corresponding to a genetic gain of 1.96%. This indicated that selection for dual-purpose cowpea varieties with increased fodder as well as grain yields has been successful. Total dry matter, fodder yield, harvest index, and 100-seed weight were significantly correlated with grain yield. The strong relationship between grain and fodder yields showed the success made in selecting for dual-purpose cowpea varieties.

Introduction

Cowpea is a leguminous crop of vital importance to the livelihood of millions of people in West and Central Africa. It provides nutritious grain and a less expensive source of protein for both rural poor and urban consumers (Inaizumi et al. 1999). In addition to food for humans, it is a valuable source of livestock fodder (Singh et al. 2003) making it very attractive to farmers. Because of its ability to tolerate drought, cowpea is well adapted to the semi-arid tropics. As a leguminous crop, cowpea improves soil fertility through its ability to fix atmospheric nitrogen (Sanginga et al. 2000). Together, these characteristics have made cowpea an important component of the cropping systems of the dry savannas of sub-Saharan Africa (Carsky et al. 2001). According to FAO statistics, cowpea is grown on an estimated worldwide area of 14 million ha. Some 8 million ha of cowpea are grown in West and Central Africa, especially in Burkina Faso, Cameroon, Mali, Niger, Nigeria, and Senegal. In Nigeria, the production trend of cowpea shows a significant improvement with an increase of some 440% in area planted and an increase of some 410% in yield over the period 1961 to 1995 (Ortiz 1998). According to Singh (2000), Nigeria produces about 2 million tons of cowpea on 5 million ha of land. The production trend would have moved upwards with the availability of more improved varieties and crop management practices. Despite the potential for further yield increases, cowpea production faces numerous problems including insect pest attack, *Striga gesneroides* parasitism, diseases, and drought.

Over the years, a great deal of progress has been made by IITA in breeding a range of high yielding cowpea varieties with combined resistance to major diseases, insect pests, and parasitic weeds and drought tolerance. Previously, from 1970 to 1988, cowpea research at the IITA concentrated primarily on developing and distributing grain-type cowpea varieties, which have been tested and released in many countries (Singh et al. 1997). Because of the importance of cowpea grain and fodder in West Africa, IITA began a systematic breeding program in 1989 to develop dual-purpose cowpea varieties (Singh et al. 2003). This program combined breeding for high yield potential for grain as well as fodder with resistance to major biotic and abiotic stresses. The general strategy is to develop a range of cowpea varieties differing in growth habit and maturity, seed type, and for sole crop and intercrop in different agroecologies (Singh et al. 2003). Since 1970, several cowpea lines have been developed and distributed to partnership institutions in Nigeria and over 60 other countries all over the world for evaluation and release (Singh 2000). Despite tremendous improvement in cowpea yield over the past 40 years, there is still a wide gap between what is obtained from the research station and that grown under on-farm conditions. However, farmers that grow the improved varieties under well-managed conditions usually obtain higher grain yields in the dry savannas of Nigeria. Ajeigbe et al. (2010 a, b) reported an over 300% increase in the value of produce when improved cowpea varieties are used in improved systems compared to local varieties under traditional systems. Although current yield increases for most crops have resulted from the impact of both genetic and improved crop husbandry, further improvement in yield may have to rely on genetic gains through improvement in crop productivity per hectare or increased genetic tolerance to pests and diseases (Francis 1991). This is because of high costs or non-availability of agrochemicals and reduction in soil quality (Cassman 1999).

Plant breeders have been able to measure breeding progress by growing varieties developed and released over a long period of time in the same environment (Tefera et al. 2009). Evaluation of genetic improvement and the associated changes in agronomic and physiological traits determining grain yield in crops may help identify traits of potential value for future breeding. This kind of study has been undertaken for several major crops. For example, Tefera et al. (2009) reported that grain yield potential of early maturing soybean increased from 1117 to 1710 kg/ha during two decades of breeding in the Nigerian savannas. Fodder yield also showed an annual increase of 22.8 kg per ha per year. Specht et al. (1999) reported that soybean yields in the United States increased by 31.4 kg per ha per year from 1972 to 1997. In Canada, a study on 41 early maturing soybean varieties representing seven decades of breeding showed a yield improvement of 0.5% per year with an associated decrease in protein content and improvement in lodging tolerance (Voldeng et al. 1997). Kamara et al. (2004) reported a genetic gain of 0.41% per year for maize varieties released from 1970 to 1999 in the Nigerian savannas. The increase was associated with an increase in total biomass and kernel weight and reduction in plant height and days to flowering. No direct comparisons of grain yield potential and other agronomic traits have been made for cowpea varieties developed in the Nigerian Sudan savannas over the past four decades. Therefore, this study was carried out to determine the rate of genetic improvement in grain and fodder yields and associated agronomic and physiological changes.

Materials and Methods

The field experiments were conducted under rain-fed conditions in 2007 and 2008 at IITA experimental station at Minjibr (12^o 10'42N, 8^o 39' 33E, Alt. 453m) in the Sudan savanna of northwest Nigeria (Table 1). A bulk soil sample was taken at the beginning of the trial and analyzed for particle part analysis, N, P, K, and pH. Daily rainfall and minimum and maximum temperature were also recorded.

Thirty-one medium-late maturing cowpea varieties (Table 2) representing cowpea varieties developed for the Nigerian Sudan savannas from 1970 to 2004 were evaluated in this study. These were best performing varieties selected to represent each decade. In both years, the trial was laid out in a randomized complete block design with four replications. For all treatments, prior to planting, each field was disc-harrowed and ridged. The planting distance was 0.75 m between rows and 0.25 m between plants. Three seeds of the cowpea varieties were sown and later thinned to two plants per stand at two weeks after planting. Immediately after planting, paraquat (1:1-dimethyl- 4, 4'-bipyridinium dichloride) was applied at the rate of 276 g a.i. L^{-1} to control weeds. This was followed by hoe weeding three weeks later. Fertilizer at 15 kg each of N, P and K was applied in the form of NPK 15:15:15 a week after planting. A standard formulation, cypermethrin + dimethoate (Best Action) at the rate of 30 g +250 g a.i. L^{-1} was used to control insect pests at flower bud formation, flowering, and podding stages to control insect pests and this was delivered with a knapsack sprayer.

Data were collected on days from sowing to when 50% of the number of plants per net plot reached flowering and to when 95% of the pods reached maturity. Mean number of pods per plant, and total dry matter (leaf, stem, grain, and threshed pod) per plant were all taken from a 10-plant sample within the two central rows for each plot when the crop reached physiological maturity. Harvest index was calculated by dividing grain weight per plant by total dry matter per plant. Mean hundred seed weight was recorded for each plot. Grain yields were determined from all plants harvested from two net 4-m-long central rows when the first flush of pods was mature and dry, and was reported on a 100% dry matter basis in kg/ha. Similarly, fodder yield was based on all plants that were harvested from the two net central rows for each plot, sun dried to constant weight, and calculated as kg/ha.

Analysis of variance and regression analysis were performed using PROC GLM and PROC REG in SAS, respectively (SAS Institute 2003). Year and replications were treated as random effects; varieties were treated as fixed effects. In order to determine the annual rate of genetic improvement for the period the varieties were released, linear regression analysis was used. The regression analysis was based on the mean values of each trait for each variety against the year of release for respective varieties. The ratio of genetic gain to the corresponding mean values of the oldest varieties was used to estimate the relative gain of breeding for the period 1974–2004 (Tefera et al. 2010). Simple correlation coefficients were estimated between grain yield and other traits.

Results and Discussion

Climate characteristics of the experimental site

In 2007, rains started in May, reached its peak in August, and ended in September with slight shower. A total of 864.4 mm of rain was obtained in 34 rainy days (Table1). While in 2008 the rains started in June, reached its peak in July, and ended in September with total rainfall of 698.3 mm in 41 rainy days. During the growth period, temperature ranged from a minimum of 23.05°C to maximum of 31.48 °C in 2007 and minimum of 22.45 °C to maximum of 41.31 °C in 2008.

Table 1. Rainfall and temperature at Mijibir during the trial period.

	2007				2008			
Month	Rainfall		Temperature		Rainfall		Temperature	
	(mm)	(no)	°C (max)	°C (min)	(mm)	(no)	°C (max)	°C (min)
Jan	0	0	25.53	15.06	0	0	26.44	16.02
Feb	0	0	34.21	23.36	0	0	28.74	17.71
March	0	0	34.58	22.03	0	0	36.08	21.89
Apr	0	0	40	25.57	0	0	37.63	26.43
May	67.5	3	32.8	26.56	0	0	38.69	28.19
Jun	162.6	8	30.62	23.73	102.5	7	36.38	26.45
Jul	249.2	10	31.48	23.44	313.9	10	29.97	23.18
Aug	376	12	28.74	23.05	209.1	12	28.71	22.45
Sept	9.1	1	30.97	23.17	68.3	12	29.8	23.82
Oct	0	0	31.03	24.29	0	0	41.31	22.99
Nov	0	0	33.03	23.72	0	0	32.03	23.03
Dec	0	0	33.17	21.35	0	0	30.68	21.77
Total	864.4				693.8			

Table 2. Cowpea varieties used for the evaluation.

Varieties	Growth habit	Year tested
IT00K-1207	Semi-determinate	2000
IT00K-1263	Determinate	2000
IT00K-227-4	Determinate	2000
IT03K-316-1	Determinate	2003
IT03K-351-9	Semi-determinate	2003
IT04K-217-5	Semi-determinate	2004
IT04K-223-1	Semi-determinate	2004
IT04K-321-2	Semi-determinate	2004
IT04K-332-1	Determinate	2004
IT81D-985	Spreading	1981
IT81D-994	Semi-determinate	1981
IT82D-889	Determinate	1982
IT84S-2246-4	Semi-determinate	1984
IT86D-1010	Determinate	1986
IT86D-719	determinate	1986
IT86D-721	Determinate	1986
IT87D-941-1	Determinate	1987
IT88D-867-11	Semi-determinate	1988
IT89KD-391	Semi-determinate	1989
IT90K-277-2	Semi-determinate	1990
IT97K-1101-5	Determinate	1997
IT97K-461-4	Determinate	1997
IT97K-494-3	Determinate	1997
IT97K-499-35	Determinate	1997
IT98K-131-2	Semi-determinate	1998
IT98K-476-8	Semi-determinate	1998
IT98K-506-1	Determinate	1998
IT98K-628	Determinate	1998
TVx 3236 (SUVITA 4)	Semi-determinate	1976
TVx 456-01F	Determinate	1975
TVx 66-24 (VITA 8)	Determinate	1975
TVx 1836-013J (VITA 10)	Determinate	1976
VITA 4 (TVu 1977-0D)	Semi-determinate	1974
VITA 5 (TVu 4557)	Semi-determinate	1974

Variance analysis

Year and varietal effects were significant for all the traits measured. Year × variety interactions were significant for all the traits except for harvest index which showed no significant interaction between year and variety (Table 3). The significant year × variety interaction was due to the differences in rainfall between the two years. Rainfall during the growing period of cowpea (Table 1) was higher in 2007 than in 2008 both in amount and distribution. The rainfall differences may have caused cross ranking of the cowpea varieties between the two years. The significant year effect for virtually all traits indicated the sensitivity of the varieties to environmental factors that prevailed in the different years. Tefera et al. (2009) reported similar year × variety interactive effects for most traits measured in soybean in the Guinea savanna of Nigeria. Some of the varieties evaluated have been reported to be tolerant to drought (Singh 2000) suggesting that they will perform better in a year of low rainfall.

Table 3. Mean squares of 8 traits of cowpea varieties representing four decades of breeding in the Nigerian Sudan savannas.

Source of variation	df	Days to flowering	Days to maturity	Pod (No./ plant)	Hundred seed weight	Total dry matter (No./plant)	Grain yield (kg/ha)	Fodder yield (kg/ha)	Harvest index
Year	1	833.15***	2394.61***	89.18**	497.35***	6289.40***	105299.01[ns]	1033735.21**	0.007**
Variety	30	117.86***	264.61***	45.55***	33.79***	794.29***	608187.04***	1615147.00***	0.012***
Year x Variety	29	11.82***	61.58***	33.68***	4.33**	540.15***	65638.61**	1519372.85***	0.005
Error	142	1.69	3.76	13.40	2.36	153.11	36605.94	1519372.85	0.001
CV%		2.82	2.65	27.05	9.49	20.98	15.04	20.49	9.63

**Mean squares significant at < 5% probability level
***Mean squares significant at < 1% probability level
[ns]Mean squares not significant at 5% probability level

Mean performance of grain and fodder yields

Average grain yield ranged from 567.6 kg/ha for the variety released in 1976 (TVX3236) to 1850.8 kg/ha for variety released in 2004 (IT04K-321-2) (Table 4). Grain yield showed an increase from old to new varieties during the four decades of cowpea breeding at IITA and this increase was significantly associated with year of release (Figure 1). Average grain yields of varieties released in the 2000s are 106% higher than that of varieties released in the 1970s. The average rate of increase in grain yield was 28.2 kg/ha/yr (Fig. 1) corresponding to 3.6% (Table 5) annual genetic gain in yield. This gain is higher than the 0.41% reported for maize (Kamara et al. 2004) and the 2.2 and 1.99% reported for early and late maturing soybeans, respectively (Tefera et al. 2009; 2010) for the savannas of northern Nigeria. This gain is also higher than the 1% gain reported for soybean in USA (Wilcox et al. 1979) and the 0.5% reported for soybean in Canada during seven decades of breeding (Voldeng et al. 1997). The result suggests that significant progress has been made in breeding cowpea for higher grain yield in the Nigerian savannas.

Fodder yield ranged from 1363 kg/ha for TVX1836-013J released in 1976 to 3346 kg/ha for IT98K-476-8 released in 1998. There were significant differences in fodder yield among varieties and eras of release. Generally modern varieties showed higher fodder yield in comparison to older varieties. Differences in fodder yield between the 1990 and 2000 were however, not significant. There was gain of 30.9 kg/ha/ yr (Fig. 2) with a genetic gain of 1.96% (Table 5). Top yielding varieties produced higher fodder yields (Table 4) suggesting that efforts in breeding dual-purpose cowpea varieties at IITA have been a success.

Table 4. Physiomorphological and yield characteristics of 31 cowpea varieties developed over the past 40 years.

Year of first testing	Variety	Days to flowering	Days to maturity	Pod (No./ plant)	Hundred seed weight	Total dry matter (No./ plant)	Grain yield (kg/ha)	Fodder yield (kg /ha)	HI
1974	VITA4	44.75	69.50	17.87	12.10	77.00	733.00	1868.75	0.29
1974	VITA5	46.50	69.00	13.88	14.00	55.50	660.00	1275.00	0.34
1975	TVX456-01F	40.67	63.17	11.41	17.53	39.70	780.98	1449.72	0.34
1975	TVX66-24	48.80	70.80	10.78	13.60	38.86	747.88	1675.00	0.31
1976	TVX1836-013J	42.60	63.60	10.58	13.60	48.54	862.64	1363.33	0.39
1976	TVX3236	46.83	69.33	14.27	11.33	43.20	567.60	1724.17	0.24
	Mean	**45.03**	**67.57**	**13.13**	**13.69**	**50.47**	**725.35**	**1559.33**	**0.32**
	SE (7 D.F.)	1.22	1.35	1.14	0.87	5.88	41.50	94.44	0.02
1981	IT81D-985	58.40	86.80	10.42	17.52	63.40	1199.33	2247.33	0.35
1981	IT81D-994	54.38	86.00	6.64	16.83	59.31	1107.57	2078.85	0.35
1982	IT82D-889	42.25	63.75	14.85	13.60	65.28	1034.07	1714.58	0.37
1984	IT84S-2246-4	47.00	73.00	11.58	14.25	43.61	930.69	1532.50	0.38
1986	IT86D-1010	41.50	66.83	12.15	17.40	51.68	1137.02	1779.44	0.39
1986	IT86D-719	45.43	78.57	13.08	12.51	52.59	1093.03	2177.38	0.34
1986	IT86D-721	46.25	76.88	13.56	15.60	64.92	1200.96	1880.00	0.39
1988	IT88D-867-11	45.86	74.71	12.65	19.03	59.04	1111.37	1837.62	0.38
1989	IT89KD-391	51.75	76.13	11.57	18.90	50.94	1195.56	1973.13	0.38
	Mean	**48.09**	**75.85**	**11.83**	**16.18**	**56.75**	**1112.18**	**1913.43**	**0.37**
	SE (41 D.F.)	1.88	2.55	0.78	0.78	2.49	29.46	76.52	0.01
1990	IT90K-277-2	45.63	70.63	16.74	16.60	61.66	1651.62	2202.08	0.43
1997	IT97K-461-4	37.17	64.33	15.12	18.20	53.55	1412.02	2531.39	0.36
1997	IT97K-494-3	44.63	68.00	17.42	15.50	55.73	1587.22	2155.00	0.42
1997	IT97K-499-35	42.13	70.75	12.80	16.10	57.41	1548.96	2444.38	0.39
1998	IT98K-128-3	48.67	74.33	16.37	15.60	81.40	1408.93	3213.97	0.31
1998	IT98K-131-2	46.33	71.83	18.70	14.93	69.79	1442.22	1799.44	0.45
1998	IT98K-476-8	48.63	79.13	13.78	16.45	71.63	1560.11	3346.48	0.32
1998	IT98K-506-1	42.00	66.13	13.19	17.90	49.35	1356.13	2085.21	0.40
1998	IT98K-628	39.00	65.29	14.86	15.54	51.29	1408.65	2005.95	0.41
	Mean	**43.80**	**70.05**	**15.44**	**16.31**	**61.31**	**1486.21**	**2420.43**	**0.39**
	SE (41 D.F.)	1.35	1.58	0.67	0.37	3.60	34.02	178.27	0.02
2000	IT00K-1207	47.86	83.43	14.19	13.83	57.46	1370.21	2048.69	0.40
2000	IT00K-1263	44.60	72.20	13.80	17.68	55.17	1398.90	2146.00	0.40
2000	IT00K-227-4	45.57	73.43	12.40	18.29	62.05	1194.39	1604.29	0.42
2003	IT03K-316-1	46.13	77.00	14.53	18.15	70.83	1707.70	2832.92	0.38
2004	IT04K-217-5	52.17	81.33	8.90	21.60	63.67	1349.49	2015.83	0.41
2004	IT04K-321-2	49.38	81.25	15.80	18.25	83.90	1850.77	2800.21	0.39
2004	IT04K-332-1	43.14	70.57	15.49	15.14	61.00	1582.42	2619.52	0.38
	Mean	**46.98**	**77.03**	**13.59**	**17.56**	**64.87**	**1493.41**	**2295.35**	**0.40**
	SE (28 D.F.)	1.16	1.92	0.89	0.94	3.69	86.71	175.10	0.01
	Overall mean	46.00	72.83	13.53	16.05	58.69	1231.98	2078.33	0.37
	Overall SE (139 D.F.)	0.79	1.18	0.47	0.42	2.01	59.05	89.86	0.01

This is important because of the increasing demand for cowpea fodder for animal feed in the dry savannas of West Africa. Tefera et al. (2009) also reported significant gains in breeding dual-purpose soybean varieties in the Guinea savannas of Nigeria. Due to the earlier emphasis on high grain yield, the improved varieties bred in the 1970s to early

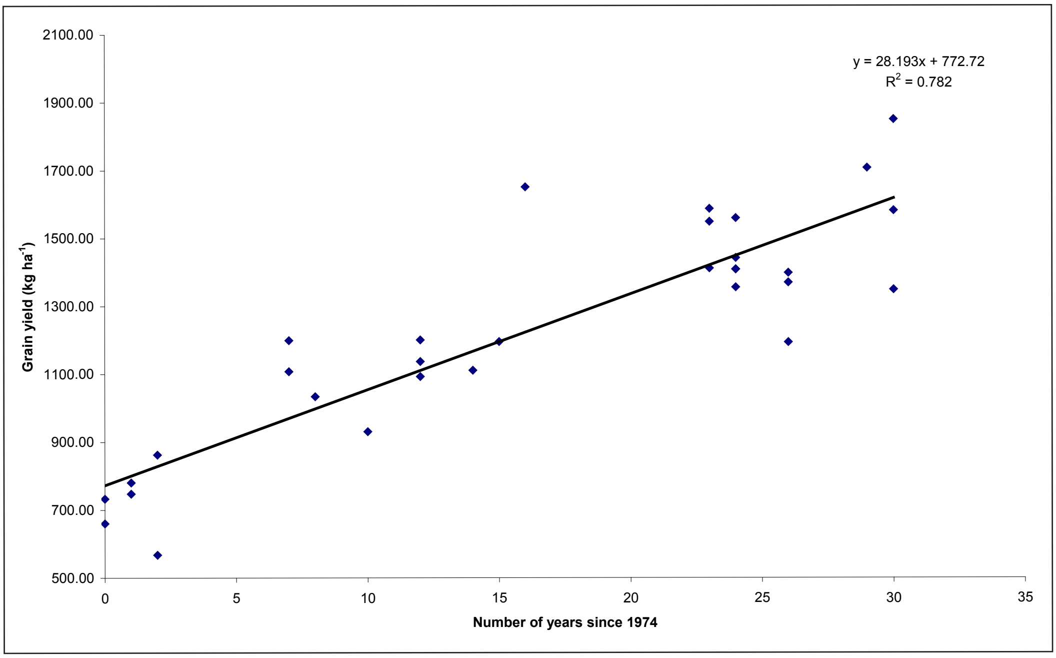

Figure 1. Relationship between grain yield of cowpea varieties and year of breeding (expressed as number of years since 1974).

Table 5. Relative genetic gain, coefficients of determination (R2), slope and regression coefficients (b) of grain and fodder yield from linear regression of the mean value of each character for each variety against the year of first testing for that variety.

Trait	Relative genetic gain (% per year)	R2	a	b
Grain yield	3.65	0.78	772.72	28.193**
Fodder yield	1.96	0.41	1575.4	30.873**

*significant at 5% probability level ($P < 0.05$), **significant at 1% probability level, ns = not significant.

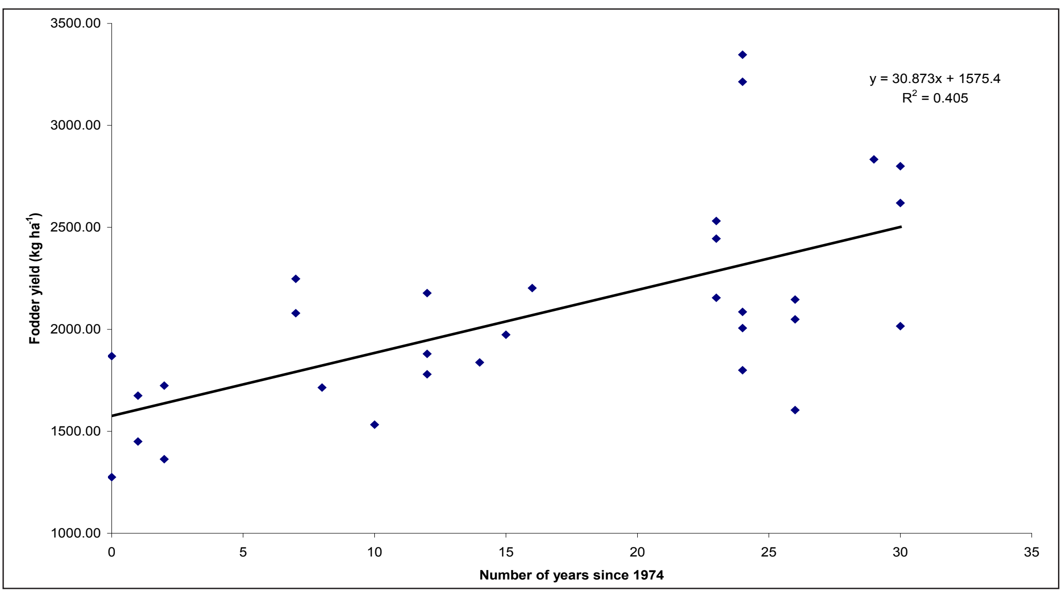

Figure 2. Relationship between fodder yield of cowpea varieties and year of breeding (expressed as number of years since 1974).

1980s were erect and were early-medium maturing (Singh and Sharma 1996). With good management and heavy pod load, these varieties shed most of their leaves. The grain yields of these varieties are therefore high but fodder yields are low (Singh et al. 2003) probably because they have a short growth period for biomass accumulation and a greater harvest index. To increase grain and fodder yields simultaneously, breeding emphasis shifted to developing intermediate maturing varieties (75–80 days) with semi-erect growth habit and canopy height of 30 cm or more. Such varieties which have been bred have enough time for biomass accumulation but short enough maturity to escape terminal drought. These varieties have yield potential of at least 2 t/ha grain and 2 t/ha fodder (Singh et al. 2003).

Mean performance of agronomic traits and association with grain yield

Significant differences were found among the cowpea cultivars for number of pods per plant, 100 seed weight, total dry matter, and harvest index (Table 4). There was no clear trend in days to flowering for all the varieties because early and late flowering varieties were found among both old and recent varieties. Three varieties (IT81D-985, IT81D-994, and IT89KD-391) released in the 1980s were found to be significantly late flowering. Among the recent varieties released in the 2000s, IT04K-217-5, IT04K-321-2 were found to be late flowering. Tefera et al. (2010) also reported that there was no consistent trend in days to flowering among old and new soybean varieties in the Nigerian Guinea savannas. There were significant differences between old and new varieties for days to maturity. Recent varieties had higher number of days to maturity than varieties released in the 1970s. For example, three varieties (IT04K-217-5, IT00K-1207, and IT04K-321-2) released in the 2000s were particularly late in maturity. This may be due to emphasis on dual-purpose cowpea varieties since late 1980s (Singh et al. 2003). Number of pods per plant did not show consistent change with era. For example, VITA 4, which was released in 1974 had number of pods not significantly different from that of 1T98K-131-2 released in 1998 which produced the highest number of pods per plant. One hundred seed weight was significantly lower in varieties released in the 1970s compared to the other eras. Seed weight of varieties released in the 1980s, 1990s, and 2000s did not however, differ significantly suggesting that no further progress was made in increasing seed weight after the 1970s.

Total dry matter per plant ranged from 38.86 g for TVX66-24 released in 1975 to 83.90 g for IT04K-321-2 released in 2004 (Table 4) indicating a significant improvement in total dry matter in the last 40 years. Several studies have reported a significant genetic gain in dry matter for grain crops (Kamara et al. 2004; Tollenaar 1991; Naylor et al. 1998). Moreover, De Bruin and Pedersen (2009) reported that new cultivars of soybean produced higher yields due to improved total dry matter accumulation, which is in agreement with the present study. Averaged across varieties, mean harvest index (HI) was significantly lower for varieties released in the 1970s than those of the other eras. HI ranged from 0.24 for an old variety (TVX-3236) to 0.45 for a new variety (IT98K-131-2) released in 1998. There were however, no significant changes in HI from 1980 to 2004 probably due to the emphasis on dual-purpose cowpea where breeders select for both grain and fodder yields. This suggests that increasing HI will be at the expense of fodder yield. The rate of increase of HI was therefore maintained at a low level. Tefera et al. (2009) reported modest changes in HI for soybean over a 16-year period of breeding in the Nigerian savannas because the breeders selected for both grain and fodder yields. According to Singh et al. (2003), cowpea breeders have shifted their focus to selecting for dual-type varieties since the late 1980s because of the increasing importance of cowpea for fodder.

Grain yield showed a positive and significant correlation with fodder yield, harvest index, total dry matter per plant, and hundred seed weight (Table 6). The strong association of grain and fodder yields indicated that improvement has been made for both traits. This strong association is also expected because cowpea breeders at IITA have been continuously selecting for dual-purpose cowpea since the late 1980s (Singh et al. 2003). The same trend has been observed in early and late maturing dual-purpose soybean varieties in the savannas of Nigeria (Tefera et al. 2009; 2010). The strong association of grain yield with total dry matter and HI suggests that grain yield improvement was partly due to improvement in dry matter and HI. Kamara et al. (2004) attributed genetic gain in grain yield of maize in the savannas of Nigeria to improvement in dry matter accumulation. Similarly, Tollenaar (1989) attributed genetic gain in Central Ontario maize hybrids to improvement in dry matter production but HI did not change between eras. The positive correlation of grain yield with HI may be due to the deliberate emphasis on breeding cowpea for both grain and fodder. Similarly Tefera et al. (2009) reported a positive correlation of soybean grain yield with HI in the Nigerian savannas also because of breeding emphasis on both grain and fodder yields.

Table 6. Mean values and correlation coefficients of traits with grain yield of cowpea varieties representing four decades of breeding in the Nigerian Sudan savannas.

	1974–2004	
Trait	Mean	Correlation coefficient (r)
Days to flowering	46.00	–0.011
Days to maturity	72.83	0.273
Grain yield	1231.98	–0.742**
Fodder yield	2078.33	0.587**
Harvest index	0.37	0.529**
Total dry matter per plant	58.69	0.498**
Hundred seed weight	16.05	0.348
Number of pods per plant	13.53	

*Correlation coefficients significant at 1% probability level.

Conclusion

A study of 31 medium to late maturing varieties of cowpea released in 1970–2004 showed that grain yield ranged from 568 kg/ha for an old variety TVX3236 to 1851 kg/ha for a recently released variety IT04K-321-2. The average rate of increase has been 28 kg/ha/year, which matches to a genetic gain of 3.6%. Fodder yield ranged from 1275 kg/ha for a variety released in 1974 (VITA5) to 3346 kg//ha for IT98K-476-8 released in 1998. The genetic gain in fodder yield was 1.96% which indicated that selection for dual-purpose cowpea varieties with increased fodder as well as grain yields has been successful. Total dry matter, fodder yield, harvest index, and 100 seed weight were significantly correlated with grain yield. The strong relationship between grain and fodder yields showed the success made in selecting for dual-purpose cowpea varieties.

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