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Grain and fodder yields of early-maturity cowpea (*Vigna unguiculata* L. Walp) lines in Niger Republic

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ABSTRACT

Objective: In areas with short rainfall duration, the production of cowpea under rainfed conditions is affected by high incidence of terminal drought together with late season insects' infestation. The objective of the present work is to identify early maturing cowpea lines with high grain and fodder yields.
Methodology and results: Thirty-seven newly developed early maturing lines and three checks were evaluated at three research stations for grain and fodder yields. Data collected were subjected to anova and correlation analysis using R version 3.6.3. The genotypes and environments were highly significant for grain and fodder yields ($p > 0.001$). Significant differences were also observed with respect to genotype by environment interactions for all the traits except grain yield. Mean grain yield across locations is 407.6 kg/ha and the winning genotypes per site are IN17_104 with 889.3 kg/ha at Maradi, IN17_95 with 846.5 kg/ha at Tara and IN17_114 with 576.0 kg/ha at Magaria. In terms of fodder yield the mean is 2242.3 kg/ha and the best cultivars are IN17_58 at Magaria, TN5_78 at Maradi and IN17_143 at Tara with mean yield of 4663.0, 4885.0 and 3603.0 kg/ha. Mean number of days to 50 % maturity across the locations is 61.6 and ranges from 54.0 to 76.8. Grain yield is inversely related to fodder yield (-0.49) and days to 50 % maturity (-0.62).
Conclusions and application of results: Most of the top fodder yielding genotypes recorded lower grain yield. IN17_114 is the only line that was among the best performing lines with respect to both grain and fodder yields. However promising lines in terms of grain yield, fodder yield and early maturity were detected from the present results. Their registration as new improved varieties as well as their adoption by farmers may not only boost cowpea production in Niger but also improve the resilience of small-scale holders.
Key words: cowpea, early maturity, grain, fodder, yield

INTRODUCTION

Cowpea *(Vigna unguiculata)* is a multipurpose leguminous crop widely cultivated in the Sub-Saharan Africa (SSA). It is one of reliable sources of food, feed and income for small scale farmers of the semi-arid zones as it thrives well under harsh climatic conditions such as erratic rainfall and high temperature. With 5,725,433 hectares under cultivation, Niger accounts for about 40 % of total land allocated to cowpea production in the world. In terms of production, Niger is the second world largest producing country. It produced 2,386,735 tons in 2019 hence contributing to nearly 27 % of total world production (FAOSTAT 2021). The yield of 417 kg/ha recorded in the country is far below the world average. However, it can be significantly improved if some of the major production constraints such drought, low soil phosphorus fertility, insect and striga infestation are addressed. Drought spells in the Sahel region of West Africa, an area with the bulk cowpea production, is among the major causes of crop low yield especially when it occurred at seedling and/or flowering stage (Mahamat *et al.*, 2014). Souleymane *et al.*, 2017 claimed that the end of 2016 and 2017 rainy seasons in Niger were characterized by moisture and insect stresses. Similarly, Innocent *et al*., 2013 reported that greater density of bruchids, maruca, pod sucking bugs and thrips are recorded in late than early season. Early maturity allows the varieties to escape damage from terminal drought and late season insects (Ehlers and Hall, 1997). Nowadays, rainfall tend to start late, erratic at the onset or cease earlier than usual in SSA (Fatokun *et al.*, 2012). Early maturing cowpea cultivars are able to withstand dry environment because of its capacity to escape terminal drought. The development of early maturing varieties and their adoption by growers may help in boosting cowpea production in drier areas such as Niger. New early maturity lines were developed at the National Institute of Agricultural Research of Niger (INRAN) from four biparental populations. One hundred and forty-seven genotypes from the newly developed materials were evaluated for grain and fodder yields in 2020 minor season at Kalapaté research station. Promising lines were detected following that study and the present work is embarked on to assess its grain and fodder yields in three environments.

MATERIALS AND METHODS

Forty genotypes were evaluated on three research stations i.e. Magaria (12° 59' N and 6° 56' E), Maradi (15°26‘N and 8°33‘E) and Tara (11° 53' N and 3° 20' E) during the rainy season of 2020. It consisted of 37 new inbred lines and three checks. The checks are TN5-78, IT90K-372-1-2 and UAM09-1055-6 obtained respectively from INRAN, International Institute of Tropical Agriculture (IITA) and University of Agriculture Makurdi (UAM). The 37 new lines were all developed at INRAN and are made up of one genotype from IT90K-372-1-2 ×TVNu 701 cross, 17 from N’Diambour x IT84S22-46-6, 18 from G150 x IT87D-1083 and one from G118 x IT87D-1083 (Table 1.). The experimental design was a 5 x 8 alpha lattice with three replications. The blocks and plots were respectively 2.5 and 2.0 m apart and each line was planted in 4 rows of 4 m long. Spacing was 0.5 and 0.8 m within and between rows. Planting was carried out on 14^{th}, 16^{th} and 25^{th} July at Maradi, Magaria and Tara. Two seeds were planted per hill and thinned to 1 plant three weeks after sowing. No fertilizer application was carried out. Weeds were controlled manually two to three times with hoes. Insecticides were sprayed at seedling, flowering and podding stages against aphids, thrips, maruca and *Clavigralla tomentosicollis.* Data were collected on days to first flower opening, days to 50 % flowering, days to 50 % maturity, pod yield per plot, grain yield per plot, fodder yield per plot, and number of striga shoots per plot. Data were subjected to analysis of variance (anova) and correlation with R version 3.6.3 statistical software.

Table 1. List of the genetic materials used in the study

S/N	Lines	Pedigree	Source
1	IN17-143	IT90K-372-1-2 ×TVNu 701	INRAN
2	IN17-94	N'Diambour x IT84S22-46-6	INRAN
3	IN17-115	N'Diambour x IT84S22-46-6	INRAN
4	IN17-72	N'Diambour x IT84S22-46-6	INRAN
5	IN17-97	N'Diambour x IT84S22-46-6	INRAN
6	IN17-56	N'Diambour x IT84S22-46-6	INRAN
7	IN17-47	N'Diambour x IT84S22-46-6	INRAN
8	IN17-65	N'Diambour x IT84S22-46-6	INRAN
9	IN17-52	N'Diambour x IT84S22-46-6	INRAN
10	IN17-42	N'Diambour x IT84S22-46-6	INRAN
11	IN17-31	N'Diambour x IT84S22-46-6	INRAN
12	IN17-92	N'Diambour x IT84S22-46-6	INRAN
13	IN17-23	N'Diambour x IT84S22-46-6	INRAN
14	IN17-53	N'Diambour x IT84S22-46-6	INRAN
15	IN17-124	N'Diambour x IT84S22-46-6	INRAN
16	IN17-68	N'Diambour x IT84S22-46-6	INRAN
17	IN17-28	N'Diambour x IT84S22-46-6	INRAN
18	IN17-114	N'Diambour x IT84S22-46-6	INRAN
19	IN17-50	G150 x IT87D-1083	INRAN
20	IN17-105	G150 x IT87D-1083	INRAN
21	IN17-35	G150 x IT87D-1083	INRAN
22	IN17-6	G150 x IT87D-1083	INRAN
23	IN17-74	G150 x IT87D-1083	INRAN
24	IN17-24	G150 x IT87D-1083	INRAN
25	IN17-90	G150 x IT87D-1083	INRAN
26	IN17-127	G150 x IT87D-1083	INRAN
27	IN17-91	G150 x IT87D-1083	INRAN
28	IN17-95	G150 x IT87D-1083	INRAN
29	IN17-69	G150 x IT87D-1083	INRAN
30	IN17-58	G150 x IT87D-1083	INRAN
31	IN17-33	G150 x IT87D-1083	INRAN
32	IN17-15	G150 x IT87D-1083	INRAN
33	IN17-79	G150 x IT87D-1083	INRAN
34	IN17-104	G150 x IT87D-1083	INRAN
35	IN17-111	G150 x IT87D-1083	INRAN
36	IN17-77	G150 x IT87D-1083	INRAN
37	IN17-03	G118 x IT87D-1083	INRAN
38	TN5-78		INRAN
39	IT90K-372-1-2		IITA
40	UAM09-1055-6		UAM

RESULTS

The genotypes and environments were highly significant for grain yield (p > 0.01), fodder yield (p > 0.001), days to 50 % maturity (p > 0.001), days to 50 % flowering (p > 0.001) and days to first flower opening (p > 0.001). Significant differences were also detected in terms of genotype by environment interactions (G x E) for all the traits except the grain yield (Table 2.).

Table 2: Level of significance of factors with respect to traits under study

SOV	Gyield	Fyield	MAT50	DAF50	DAF
Genotype	92801**	6227461***	138.7***	214.5***	152.94***
Environment	883768***	37496518***	833.3***	501.8***	116.92***
Replications	368506***	5263146***	36.3***	30.3***	20.44**
Block	66077	2506480**	17.5**	8.6*	9.45*
G x E	52160	1775850**	20.9***	15.4***	8.46*
Residual	49279	1082181	8	4.6	5.71

SOV: sources of variations, Gyield: grain yield per ha, Fyield: fodder yield per ha, MAT50: days to 50 % maturity, DAF50: days to 50 % flowering, DAF: days to first flower appearance.

The distribution of grain yield by environments indicated that Magaria recorded considerably lower mean compared to Tara and Maradi (Fig.1).

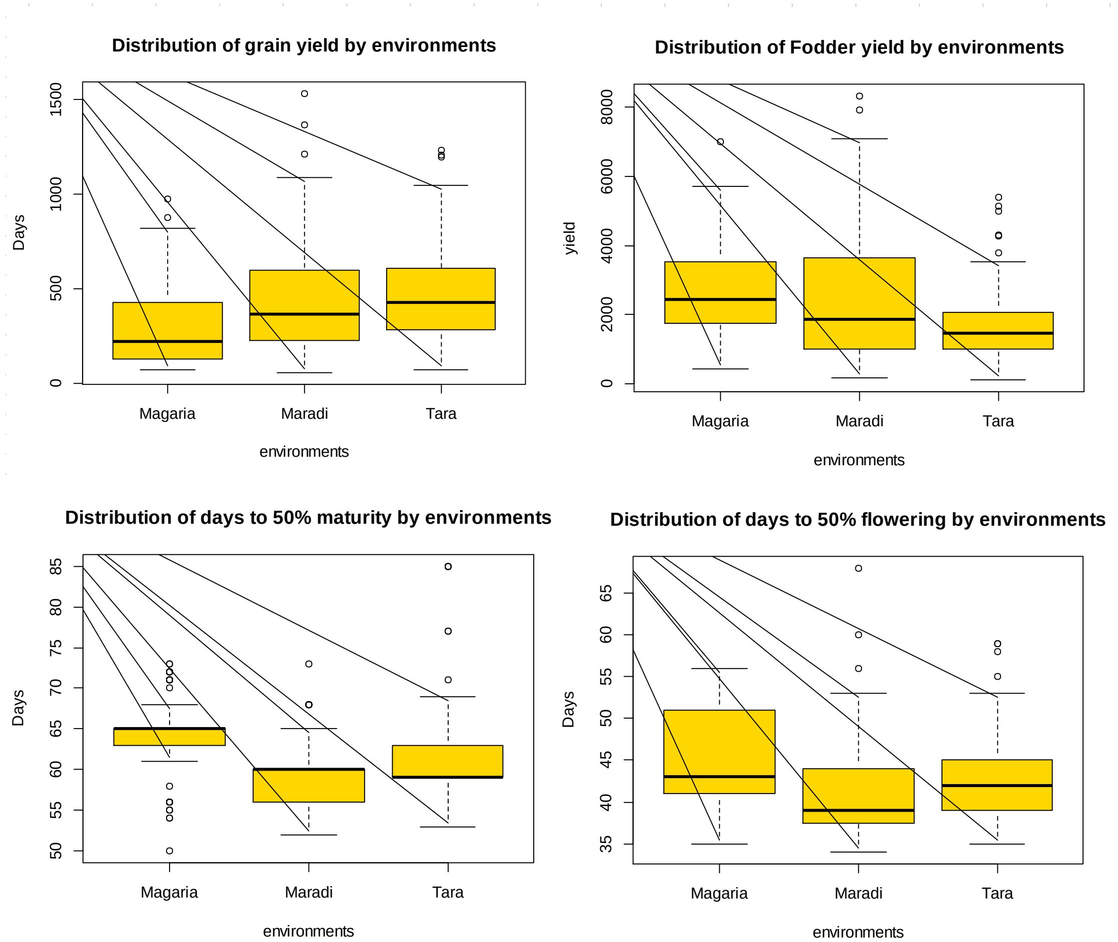

Fig.1: Distribution of grain yield, fodder yield, days to 50 % maturity and days to 50 % flowering according to environments

Mean grain yield of genotypes across locations ranged from 207.7 to 636.2 kg/ha while the grand mean is 407.6 kg/ha. The lines that recorded the highest and lowest mean grain are respectively IN17_79 and IN17_06. Mean grain yield of top performing genotypes and the checks are shown in Table 3 below. IN17_104 with 889.3 kg/ha recorded the highest grain yield at Maradi while the best performing lines at Tara and Magaria were IN17_95 and, IN17_114 with respectively 846.5 and 576.0 kg/ha. The checks TN5_78, IT90K372_1_2 and UAM09-1055_6 yielded 319.6, 277.7 and 239.8 kg/ha, respectively. IN17_79, IN17_95, IN17_91 and IN17_114 whose mean grain yield are respectively of 636.2, 623.6, 606.0, 554.9 kg/ha, expressed good level of stability since they were among the winning genotypes across the three locations. Despites being the second top grain producer, IN17_95 harboured the highest number of striga shoots per plot. Its mean striga shoots per plot is 12.8 and ranged from 4.3 at Magaria to 18.7 at Maradi. Other top performing genotypes highly infested by striga are IN17_91 and IN17_74 with respectively 10.0 and 8.4 mean striga shoots per plot. Among the winning cultivars, IN17_31 is however the only one with zero striga shoots per plot.

Table 3: Mean grain yield (kg/ha) of top performing lines and the checks

Lines	Magaria	Maradi	Tara	Mean
IN17_79	413.0	736.5	759.1	636.2
IN17_95	460.1	509.6	846.5	623.6
IN17_91	431.1	740.6	646.2	606.0
IN17_104	304.7	889.3	521.2	571.7
IN17_114	576.0	510.1	578.5	554.9
IN17_28	302.6	808.4	459.9	551.3
IN17_74	135.2	548.8	602.7	512.8
IN17_24	419.8	466.4	560.6	500.1
IN17_97	354.7	686.8	391.0	477.5
IN17_31	293.6	641.0	474.3	469.6
TN5_78	133.1		444.0	319.6
IT90K372_1_2	427.3	36.0	308.4	277.7
UAM09_1055_6	357.4	217.8	215.3	239.8

Lower fodder yield was recorded at Tara compared to Maradi and Magaria as shown by the boxplot in Fig.1. Mean fodder yield is 1624.0, 2397.0 and 2710.0 kg/ha at Tara, Maradi and Magaria, respectively. It varied from 788.2 to 3826. Kg/ ha while the overall mean is 2242.3 kg/ha. High yielding potential was observed in the best performing genotypes as each of the top 10 cultivars recorded above 3 tons mean fodder yield per hectare (Table 4). However, one of the checks, TN5_78 with a mean of 3296.1 kg/ha is among the high yielding lines. In contrast the two other checks, UAM _1055_6 and IT90K372_1_2, produced significantly less forage yield in comparison to the new high yielding lines. In fact, the fodder yield of UAM _1055_6 is as low as 969.7 kg/ha. Different cultivar won at different environment as the winning genotypes are IN17_58 at Magaria, TN5_78 at Maradi and IN17_143 at Tara with mean yield of 4663.0, 4885.0 and 3603.0 kg/ha. The best performing line is IN17_42 although it did not win in any environment. Its mean fodder yield across environments is 3826.1 kg/ha while it recorded 4460.0, 3728.0 and 3290.0 kg/ha at Magaria, Maradi and Tara. Among the top yielding genotypes, only TN5_78 and IN17_111 had up to 8 mean striga shoot per plot.

Table 4: Mean fodder yield of top performing lines and the checks

Lines	Magaria	Maradi	Tara	Mean
IN17_42	4460.0	3728.0	3290.0	3826.1
IN17_58	4663.0	3996.0	2634.0	3764.3
IN17_143	2728.0	4565.0	3603.0	3632.0
IN17_92	3668.0	4544.0	2077.0	3429.6
IN17_52	3617.0	3541.0	3056.0	3404.5
IN17_04	3700.0	4829.0	1566.0	3365.2
TN5_78	2552.0	4885.0	2452.0	3296.1
IN17_35	2031.0	4343.0	3144.0	3172.8
IN17_69	2239.0	4725.0	2368.0	3110.9
IN17_114	3860.0	2815.0	2618.0	3097.8
IN17_111	4510.0	3149.0	1452.0	3036.9
IT90K372_1_2	1883.0	4291.0	1504.0	2559.2
UAM09_1055_6	1920.0	558.0	431.0	969.7

Mean number of days to 50 % maturity across the locations is 61.6 and ranges from 54.0 to 76.8. It is 59.3, 61.1 and 64.7 days after planting at Maradi, Tara and Magaria. About 14 genotypes among the new lines were able to reach maturity before 60 days after planting. The checks varieties were also early maturing with 62.8, 68.1 and 68.6 mean number of days to maturity for UAM09_1055_6, TN5_78 and IT90K372_1_2. However, the earliest maturing line, IN17_97 reached maturity at 54 DAP, that is two weeks before the two popular varieties TN5_78 and IT90K372_1_2. IN17_97 was the first genotype to reach maturity at all the locations with 53.0, 54.0 and 55.0 at Maradi, Tara and Magaria. Other extra-early maturing cultivars include IN17_56, IN17_104, IN17_90, IN17_114, IN17_95, IN17_28, IN17_31, IN17_65 and IN17_52 (Table 5).

Table 5: Mean number of days to 50 % maturity of top early maturing lines and the checks

Lines	Magaria	Maradi	Tara	Mean
IN17_97	55.0	53.0	54.0	54.0
IN17_56	56.3	56.0	56.0	56.1
IN17_104	58.3	53.7	57.0	56.3
IN17_90	58.0	56.0	57.0	57.0
IN17_114	60.0	56.3	55.0	57.1
IN17_95	58.7	58.0	58.0	58.2
IN17_28	62.0	55.0	58.0	58.3
IN17_31	63.7	55.0	57.0	58.6
IN17_65	62.6	58.5	56.8	58.9
IN17_52	63.7	54.0	59.0	58.9
UAM09_1055_6	68.3	61.0	59.0	62.8
TN5_78	-	-	68.1	68.1
IT90K372_1_2	71.3	65.5	69.9	68.6

The lines that were able to reach the stage of 50 % flowering before 40 days after planting include IN17_97, IN17_90, IN17_104, IN17_114, IN17_56, IN17_95, IN17_31, IN17_52 and IN17_28 (Table 6). Among the checks, UAM09_1055_6 which is the earliest variety reached mean 50 % flowering at 41.3 DAP while the mean number of days to reached 50 % flowering of TN5_78 and IT90K372_1_2 was 50.4 and 51.7. As in 50 % maturity, IN17_97 preceded all the lines in reaching 50 % flowering stage across the environments.

Table 6: Mean number of days to 50 % flowering of top early maturing lines and the checks

Lines	Magaria	Maradi	Tara	Mean
IN17_97	38.3	34.7	36.3	36.4
IN17_90	38.3	36.0	39.0	37.8
IN17_104	40.3	35.7	38.0	38.0
IN17_114	38.7	37.7	38.7	38.3
IN17_56	39.0	37.3	39.7	38.7
IN17_95	40.7	36.7	38.7	38.7
IN17_31	41.7	36.3	38.3	38.8
IN17_24	40.7	37.7	39.3	39.2
IN17_52	42.3	36.3	39.0	39.2

IN17_28	42.3	36.7	40.3	39.8
UAM09_1055_6	45.0	39.0	40.0	41.3
TN5_78	55.3	48.3	47.7	50.4
IT90K372_1_2	54.3	50.7	50.0	51.7

Flowers's setting has started very early, the mean number of days to first flower opening was 36.7 days after planting and it ranges for 32.1 to 47.1. Flower setting started earlier at Magaria than the two other locations. As illustrated in the table below, IN17_114, IN17_97 and IN17_, 03 recorded a mean of 30.0 and 30.7 days after planting to first flower opening at Magaria. The mean number of days to first flower opening of the checks is 36.9 for UAM09_1055_6; 44.9 for TN5_78 and 45.4 for IT90K372_1_2.

Table 7: Mean number of days to first flower opening of top early maturing lines and the checks

Lines	**Magaria**	**Maradi**	**Tara**	**Mean**
IN17_97	30.7	31.3	34.3	32.1
IN17_03	30.7	32.0	34.0	32.2
IN17_114	30.0	33.3	33.7	32.3
IN17_52	31.3	32.0	34.0	32.4
IN17_24	31.7	32.0	34.7	32.8
IN17_31	32.0	32.7	34.3	33.0
IN17_53	32.3	32.7	34.3	33.1
IN17_90	31.3	32.7	35.3	33.1
IN17_104	32.3	32.7	35.3	33.4
IN17_28	31.3	34.0	35.0	33.4
UAM09_1055_6	37.3	36.0	37.3	36.9
TN5_78	49.3	41.0	44.3	44.9
IT90K372_1_2	47.0	43.0	46.3	45.4

Grain yield was inversely related to fodder yield (-0.49), days to first flower appearance (-0.59), days to 50 % flowering (-0.63) and days 50 % maturity (-0.62). The relationship between grain yield and these traits is not only negative but also significant ($p > 0.001$). Among the traits recorded, the number of striga shoots per plot is the only one having significant and positive correlation with grain yield. The number of striga per plot is negatively related to Fyield, DAF, DAF50 and MAT50. Strong, positive and highly significant correlation was detected between days to 50 % maturity and days to 50 % flowering (0.93), days to first flower appearance and days 50 % maturity (0.90). Nearly perfect positive correlation (0.96) was detected between days to 50 % flowering and days to first flower appearance (Table 8).

Table 8: Correlation matrix between traits

	Fyield	MAT50	DAF50	DAF	Gyield	Striga
Fyield	1					
MAT50	0.44**	1				
DAF50	0.49***	0.93***	1			
DAF	0.37**	0.90***	0.96***	1		
Gyield	-0.49***	-0.62***	-0.63***	-0.59***	1	
Striga	-0.13	-0.18	-0.2	-0.13	0.31*	1

DISCUSSION

Cowpea varieties that reach maturity within 60-69 days after planting are classified as extra-early (Dugje *et al.*, 2009). The lines in the present study belong therefore to the extra-early maturity class since all matured before 70 DAP except two. However, the earliest cultivar, IN17_97 that matured within 54 days after planting, was not as early as Sanzi, a line which was reported (Owusu *et al.,* 2018) to attain 90 % maturity at 49.3 DAP. Nonetheless, IN17_97 is early maturing than all the improved varieties registered so far in the National catalogue of Niger. Three of the new lines (IN17_95, IN17_97 and IN17_31) are among the top performing genotypes in terms of both early maturity and grain yield. These genotypes have great yield potentials as they recorded significantly higher yield than the checks which are known to be high yield varieties. Greater grain yield would have been obtained if they were planted earlier as early planting results in higher yield according to Mirzaienasab and Mojaddam (2014) and Ezeaku *et al*. (2015). Apart from late planting, the absence of fertilizer application has also affected the yield performance of the lines in the present study. Early maturing varieties with mean grain yield ranging from 834 to 2291 kg/ha were however reported in Nigeria by Ewansiha *et al.,* (2018). Lines that produced up to 2000 kg/ha in 60 days were also reported in Senegal by Hall *et al.* (2003). Early maturing varieties could offer the opportunity of improving cowpea yield in farmers' fields as they can escape terminal drought which may cause up to 80 % yield loss (Agbicodo et al., 2009). It can also escape damage from insects (Innocent *et al.* 2013) and diseases (Ehlers and Hall, 1997) as well as striga damage according to Souleymane et al.,2017 who suggested the parasite damage occurred beyond 8 weeks DAP. The same authors further claimed that striga infestation may not significantly affect yield of extra-early cowpea varieties. Early maturing varieties are climate smart (Adeyanju and M. F. Ishiyaku, 2007) and could increase the resilience of small-scale farmers by providing them food early (Ehlers and Hall, 1997) when foodstuffs are not only scarce but have higher price in markets. It can be recommended to areas with short rainfall duration where crops are grown under rainfed system and the end of rainy seasons are characterized by moisture and insect stresses such as Niger republic. However, late season rains as it is the case sometimes in the Sahel may affect the quality as well as the viability of extra-early varieties grains, thus the necessity for farmers adopting such cultivars to possess some storage facilities to protect their harvest. Lines that combined early maturity and high fodder yield were detected in the present work. IN17_42 which the highest fodder yielding cultivar with a mean yield of 3826.1 kg/ha reached maturity at 60.8 days after planting. Also, IN17_114 and IN17_52 which matured before 60 DAP recorded more than 3 tons per ha mean fodder yield. Most of the top fodder yielding genotypes recorded lower grain yield. IN17_114 is the only line that was among the best performing lines with respect to both grain and fodder yields. The present findings are in agreement with Ewansiha *et al.,* (2018) who reported a local check with high fodder but low grain yields. They however detected seven high yielding genotypes in terms of grain and fodder whose grain and fodder yields ranged respectively from 1014 to1276 and 2408 to 3360 kg/ha. Early maturing cowpea varieties with high grain and fodder yields were also reported by Singh *et al.* (1997), Kamara *et al.* (2011) and Ewansiha and Osaigbovo, (2016). Cowpea varieties that produce high grain and forage are suited to the need of small-scale holders in the Sahel who usually grow crops and keep livestock at the same time. Owing to the prominence of cowpea grain and fodder in West Africa, IITA embarked on the development of dual-purpose cowpea since1989 (Singh *et al*., 2003). Dual-purpose cowpea cultivars help in reducing food and feed shortage, especially in areas prone to low rainfall, high temperature and low soil fertility. The strong, negative and highly significant relationship observed between grain yield and fodder yield is an indication that most of the lines evaluated in the present study did not produce together high grain and fodder yields. This can be attributed to their early maturity characteristic since it may be difficult for a genotype to combine early maturity, high grain yield and fodder yield. Our findings do not however corroborate with Ewansiha *et al*., (2018) who found significant positive correlation between grain and fodder yields. The positive and significant correlation between grain yield and striga shoots per plot observed in this work suggests that either top yielding lines are tolerant to striga or they escape its damage due to their short duration on the field. Also, the inverse relationship of grain yield and maturity pointed out that most of high yielding genotypes are different from those first to reach maturity. In other words, it means that selection for early maturity may negatively affect grain yield and vice versa, thus obstructing the development of extra-early high grain yielding varieties. Similar results were reported by Kamai *et al.,* (2014); Turk *et al*. (1980) and Ombakho and Tyagi (1987).

CONCLUSION AND APPLICATION OF RESULTS

Promising lines in terms of early maturity, grain and fodder yields were detected in the present work. Their registration as new improved varieties as well as their adoption by farmers may not only boost cowpea production in Niger but also improve the resilience of small-scale holders.

CONFLICT OF INTEREST

The author declares that he does not have any conflict of interest.

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REFERENCES

Adeyanju AO and Ishiyaku MF (2007). Genetic Study of Earliness in Cowpea (*Vigna unguiculata* L. Walp) Under Screen House Condition. International Journal of Plant Breeding and Genetics 1:34-37. https://doi: 10.3923/ijpbg.2007.34.37

Agbicodo EM, Fatokun C A, Muranaka S, Visser RGF and Linden Van Der CG

(2009). Breeding drought tolerant cowpea: Constraints, accomplishments, and future prospects," Euphytica, vol. 167, no. 3, pp. 353–370. https://doi 10.1007/s10681-009-9893-8

Dugje IY, Omoigui LO, Ekeleme F, Kamara AY and Ajeigbe H (2009). Farmers' Guide to Cowpea Production in West Africa. IITA. Ibadan. Nigeria. 20pp.

Ehlers JD and Hall A E (1997). Cowpea [Vigna unguiculata (L.) Walp.]. Field Crops Research 53: 187–204. https://doi.org/10.1016/S0378-4290(97)00031-2

Ezeaku I.E, Mbah BN and Baiyeri KP (2015). Planting date and cultivar effects on growth and yield performance of cowpea (Vigna unguiculata (L.) Walp). African Journal of Plant Science 9(11):439-448. https://doi 10.5897/AJPS2015.1353

Ewansiha SU, Iremirem GE, Fatokun CA and Boukar O (2018). Grain and fodder yields potential of new early maturing cowpea [Vigna unguiculata (L.) Walp.] genotypes in a rainforest agroecology. Samaru Journal of Agricultural Research 25: 45-58.

Ewansiha SU and Osaigbovo AU (2016). Cowpea for a changing environment in rainforest of South-South Nigeria. Agro-Science 15 (1):23-24. https://doi 10.4314/as. v15i1.5

FAOSTAT 2021. http://www.fao.org › faostat

Fatokun CA, Boukar O and Muranaka S (2012). Evaluation of cowpea (Vigna unguiculata (L.) Walp.) germplasm lines for tolerance to drought. Plant Genetic Resources: Characterization and Utilization 10(3):171–176. https://doi.org/10.1017/S1479262112000214

Inocent EE, Mbah BN, Baiyeri KP and Uguru MI (2013). Productivity of grain cowpea (vigna unguiculata (l.) walp.) as influenced by season. genotype. insect pest management and cropping system in southeastern Nigeria. PhD thesis Department of Crop Science. University of Nigeria 270p. https://www.unn.edu.ng/publications/files/images/EZEAKU,%20EZEORAH%20INNOCENT.pdf

Kamai N, Gworgwor NA and Joshua WW (2014). Varietal Trials and Physiological Components Determining Yield Differences among Cowpea Varieties in Semiarid Zone of Nigeria", International Scholarly Research Notices, Hindawi Publishing Corporation, Article ID 925450, 7 pages. https://doi.org/10.1155/2014/925450

Kamara AY, Tefera H, Ewansiha SU, Ajeigbe HA, Okechukwu R, Boukar O and Omoigui L O (2011). Genetic grain yield and agronomic characteristics of cowpea cultivars developed in the Sudan Savannas of Nigeria over the past three decades. Crop Science 51: 1877-1886. https://doi.org/10.2135/cropsci2010.12.0698

Mahamat HH, Belko N, Cisse N, Sine B, Ndoye I and Fonceka D (2014). Évaluation au champ et en pot de huit génotypes de niébé par des paramètres physiologiques et agronomiques en réponse à différentes conditions hydriques. Journal of Applied Biosciences 77:6550 – 6563. http://dx.doi.org/10.4314/jab.v77i1.12

Mirzaienasab M and Mojaddam M (2014). The effect of planting date on yield and yield components of two red bean cultivars in azna weather conditions. Indian Journal of Fundamental and Applied Life Sciences 4 (3):417-422.

Ombakho GA and Tyagi AP (1987). Correlation and path coefficient analysis for yield and its components in cowpea (Vigna unguiculata (L.) Walp.). East African Agriculture and Forestry Journal, vol. 53, no. 1, pp. 23–27. https://doi.org/10.1080/00128325.1987.11663535

Owusu EY, Akromah R, Denwar NN, Joseph Adjebeng-Danquah JA, Kusi F and Mohammed H (2018). Inheritance of Early Maturity in Some Cowpea (Vigna unguiculata (L.) Walp.) Genotypes under Rain Fed Condition. Hindawi Advances in Agriculture Volume 2018, Article ID 8930259, 10 pages https://doi.org/10.1155/2018/8930259

Singh BB, Ajeigbe HA, Tarawali SA, Fernandez-Rivera S and Abubakar M (2003). Improving the production and utilization of cowpea as food and fodder. Field Crop. Res., 84 (1-2): 169-177. https://doi.org/10.1016/S0378-4290(03)00148-5

Singh BB, Chambliss OI and Sharma B (1997). Recent advances in cowpea breeding, pp 30-40 In Singh, B. B., Mohan Raj D. R., Dashiel, K. E. and Jakai, L. E. N. (eds.), Adavances in cowpea research. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Centre for Agricultural Sciences (JIRCAS), IITA, Ibadan, Nigeria.

Souleymane A, Ofori K, Danquah EY, Kumaga FK, Danquah A, Fatokun CA and Boukar O (2017) Selection of cowpea (vigna unguiculata (l). walp) for high yield under low soil phosphorus conditions. Thesis submitted to the University of Ghana, Legon in partial fulfilment of the requirements for the award of doctor of philosophy degree in plant breeding West Africa Centre for Crop Improvement College of basic and applied sciences, University of Ghana, Legon 216pp. http://ugspace.ug.edu.gh/handle/123456789/24704

Turk K J, Hall AE and Asbell CW (1980). Drought adaptation of cowpea. I. Influence of drought on seed yield. Agronomy Journal, vol. 72, no. 3, pp. 413–420, 1980. https://doi.org/10.2134/agronj1980.00021962007200030004x