



GENETIC VARIABILITY AND INTERRELATIONSHIP BETWEEN GRAIN YIELD AND SOME MORPHOLOGICAL AND REPRODUCTIVE TRAITS OF ACHA (*DIGITARIA SPP.*) ACCESSIONS.

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ABSTRACT

Acha (*Digitaria exillis* Kippis. Stapf and *D. iburua* stapf L) belongs to the grass family, Poaceae and has been described as the oldest West African cereal and of great value to the natives. With its potentials, there has been a renewed interest in Acha cultivation and research. The present study focused on the evaluation of the genetic variability and interrelationship between grain yield and some morphological and reproductive traits of some Acha accessions collected from farmers in five villages (Mwel, Toff, Kuba, Mbar and Kulere Richa) Bokkos Local Government Area of Plateau State. The trial was conducted during the 2019 rainy season at the Federal College of Forestry Jos. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Analysis of variance revealed variability among the different accessions. Grain yield was positively and significantly correlated with plant height. Days to 75% seed germination, leaf width, stem girth, number of tillers per plant and spike length were positively correlated, and the correlation was not significant. The phenotypic variance was slightly higher than the genotypic variance, indicating the influence of the environment on these traits. Phenotypic Coefficient of Variance (PCV) was equally higher than the corresponding Genotypic Coefficient of Variance (GCV) for all characters evaluated showing that they all interact to some extent, except for plant height, stem girth and days to 75% panicle emergence. Broad sense heritability estimate coupled with genetic advance as percent mean was high for most of the characters studied indicating that these traits can be improved by selection, except for grain yield and stem girth which was low, indicating that selection will not be an appropriate method for improving these traits.

Keywords: *Digitaria Spp., Morphological and Reproductive Traits, Heritability, Genotypic and Phenotypic Variance, Genotypic and Phenotypic Coefficient of Variance*

INTRODUCTION

Acha (*Digitaria spp.*) has been a neglected and underutilized crop of West Africa. It is grown in an area covering from Senegal to Lake Chad (Cruz *et al.*, 2011). The crop is well adapted to local pedo-climatic conditions. Acha resists drought due to its C4 metabolism and take part in the maintenance of the environment by given a vegetative cover to ecologically sensitive and undervalued soils (Vall *et al.*, 2008; Cruz *et al.*, 2011). Poor in gluten, diabetics' patients, those suffering from overweight and breastfeeding women have been advised to take meals prepared from Acha (Vodouhe and Achigan Dako, 2006). It has also been reported to be rich in methionine and cysteine, the two essential amino acids for humans which is deficient in wheat, rice, maize and sorghum (km, 2013).

Acha is one of the ancient African crops, possibly the oldest West African crop as its cultivation seems to have started about 7,000 years ago (Gari, 2002). The first references to Acha as food are reported from the mid-14th century. Significant cultivation of Acha is in West Africa from Chad to Cape Verde, South Mali, in western Burkina Faso, eastern Senegal, Northern Guinea, in middle belt region of Nigeria as well as in the south of Niger, where the plant supplies the staple food for several million people. In some regions of Mali, Burkina Faso, Guinea and Nigeria, Acha is the most important or one of the main cereals. The White Acha has its main growing region in the highland plateaus of Nigeria, the second Acha-species *D. Iburu* or Black Acha is limited on the Jos-Bauchi Plateau in Nigeria and the northern regions of Togo and Benin (Gari, 2002).

Acha shows a wide range of diversity among the two main edible species and the wild relatives. *D. exilis* and *D. iburua* species exhibit tremendous inter and intra species variability in their morphology, physiology and anatomy. The *D. exilis* at maturity has a height that ranges from 30 to 75 centimeters; while *D. iburua* can grow to a height of 140 centimeters. Maturity of both species varies between two and a half months to six months. Vegetative traits, such as germination percent, tiller numbers, number of branches, plant height and leaf area as well as seed-related traits, such as number of days to 50% booting, number of days to 50% panicle emergence, straw weight at harvest and grain yield have all shown high levels of variability in experimental studies (Kwon-Ndung and Ochigbo, 2014).

Ali, *et al.*, (2007) has observed that genetic diversity plays an important role in the success of any breeding program and so, knowledge of genetic variability in available germplasm and genotypes is very useful for plant improvement all over the world, promoting the efficient use of genetic variations in breeding programs through supporting proper selection of cross combination among large sets of parental genotypes. This investigation thrives to

provide baseline information for the breeding of such traits

MATERIALS AND METHOD

This study was carried out at the research farm of the Federal College of Forestry, Jos, Plateau State located between latitude 09°55'N, Longitude 08°53'E and altitude 1,217m above sea level. The location has semi temperate climate with average daily temperature ranging from 18°C to 25°C with an annual average rainfall of 1775.1mm.

The ten (10) Acha accessions used for this investigation were collected from local farmers in five villages (Mwel, Toff, Kuba, Mbar and Kulere Richa) Bokkos Local Government Area of Plateau State. These accessions were sown in a Randomized Complete Block Design (RCBD) with three replicates. Experimental plot measured (3×2) m². All cultural practices were carried out throughout the growing season. Number of days to 75% seed germination, plant height, leaf length, leaf width, stem girth, number of leaves per plant, number of tillers per plant, days to 75% panicle emergence, spike length, number of spikes per panicle, number of seeds per centimeter of raceme, 1000 seed weight and grain yields were assessed. Data collected was subjected to analysis of variance and mean were separated using the Duncan Multiple Range Test (DMRT). The genotypic coefficient of variance and genetic advance were calculated according to Chaudhary and Prasad, (1968). Broad sense heritability was calculated using the formula according to Falconer (1996) and expected genetic advance was computed by the formula described by (Johnson *et al.*, 1955).

RESULTS AND DISCUSSION

The present investigation revealed high variability among both the morphological and reproductive characters considered in the ten Acha accessions (table 1 and 2). These results agree with the work of Kwon-Ndung and Ochigbo, (2014), that vegetative traits, such as germination percent, tiller numbers, number of branches, plant height and leaf area as well as seed-related traits, such as number of days to 50% booting, number of days to 50% panicle emergence, straw weight at harvest and grain yield all show high levels of variability in experimental studies. Martins, (1992) also reported high level of variability among some randomly collected Acha accessions assessed at Samaru, Zaria.

Table 1: Vegetative Characters of Ten (10) Acha Accessions Grown in Jos.

Accession	Plant Height (cm)	Leaf Lengths (cm)	Leaf Width (cm)	Number of Leaves Per Plant Stand	Stem Girth (cm)	Number of Tillers/Plant Stand	Days to 75% Seed Germination
A	55.2667 e	7.64667 e	0.556667 d	5.60000 bcd	0.580000 d	10.4000 c	4.33333 de
B	79.6000 ab	27.8333 b	1.19333 a	5.83333 bcd	1.71667 b	6.20000 d	7.66667 a
C	55.1000 e	9.83000 de	0.796667 b	5.53333 bcde	0.613333 d	17.7000 ab	5.00000 cd
D	70.1000 cd	10.6300 d	0.653333 cd	5.26667 bcde	0.940000 c	10.9000 c	4.00000 e
E	66.1000 d	17.6333 c	0.670000 cd	7.36667 a	0.613333 d	9.13333 c	4.33333 de
F	84.4400 a	11.9333 d	0.643333 cd	5.96667 bc	0.746667 cd	19.5667 ab	4.33333 de
G	76.3000 bc	9.91000 d	0.620000 d	4.56667 e	0.636667 d	16.9000 b	5.66667 bc
H	67.5667 d	9.74667 de	0.743333 bc	4.86667 de	0.563333 d	20.5000 a	6.33333 b
I	54.5000 e	32.9667 a	1.25000 a	6.13333 b	2.43667 a	5.00000 d	8.33333 a
J	78.5033 ab	11.6733 d	0.653333 cd	5.06667 cde	0.743333 cd	11.5000 c	4.33333 de
CV (%)	6.7	8.8	8.8	10.7	14.3	12.8	10.0

** = significant at 1% probability level, * = significant at 5% probability level

Any two means having a common letter within the same column are not significantly different at the 1% and 5% level of significance according to Duncan Multiple Range Test (DMRT)

Table 2: Reproductive Characteristics of the Ten Different Acha Accessions Grown in Jos.

Accession	Days to 75% panicle emergence	Number of spikelet per panicle	Spike length (cm)	Thousand (1000) seed weight (g)	Number of seeds per centimeter length of raceme	Weight of the seed (grain yield) kg/ha
A	92.0000 f	3.26667 c	9.24000 e	0.850000 b	15.9333 e	787.00 d
B	93.6667 f	6.76667 a	11.5700 bcd	1.41667 a	24.5000 b	2169.67 abc
C	122.333 b	3.46667 bc	11.0167 cd	0.756667 b	24.5333 b	1770.67 abcd
D	106.000 d	3.93333 bc	10.8133 cd	0.860000 b	19.6333 c	2556.00 ab
E	121.333 b	4.46667 b	12.6667 a	0.783333 b	27.0000 a	1270.33 cd
F	101.000 e	5.93333 a	12.3300 ab	0.783333 b	17.3000 de	1492.67 bcd
G	114.667 c	4.30000 bc	11.8567 abc	0.790000 b	25.3667 ab	2444.67 abc
H	117.000 c	3.50000bc	10.5567 d	0.756667 b	18.5667 cd	2849.00 a
I	130.667 a	6.83333 a	11.1867 cd	1.25667 a	23.9333 b	1959.00 abcd
J	101.667 e	4.26667 bc	12.3167 ab	0.770000 b	15.9667 e	2517.00 ab
CV (%)	1.4	13.0	5.6	12.1	5.4	36.20

** = significant at 1% probability level, * = significant at 5% probability level

Any two means having a common letter within the same column are not significantly different at the 1% and 5% level of significance according to Duncan Multiple Range Test (DMRT)

Plant height as well as spike length showed positive correlation with grain yield and this implies that grain yield can be improved by simply increasing the plant height. Even though Nyam, (1996) reported a negative correlation between plant height and grain yield while investigating yield and yield components of some Acha accessions, this does not agree with the present study. Singh *et al.*, (2015) have also, reported a positive correlation between plant height and grain yield in rice.

Number of tillers per plant stand showed positive correlation with the grain yield though the correlation was not significant. The non-significant relationship may be as a result of the varietal difference since different accessions differ in their tillering ability.

Leaf length, thousand seed weight, number of leaves per plant, and number of seeds per centimeter length of raceme were negatively correlated (table 3).

Table 3: Correlation Coefficient Between Grain Yield and Other Morphological Characters.

	DSE	PH	LL	LW	NLPS	SG	NTPS	DPE	NSP	SL	NSCLR	TSW	GY
DSE													
PH	-0.148												
LL	0.800	-0.085											
LW	0.904	-0.160	0.924										
NLPS	-0.008	-0.200	0.471	0.234									
SG	0.810	-0.154	0.934	0.917	0.236								
NTPS	-0.368	0.232	-0.727	-0.565	-0.474	-0.695							
DPE	0.318	-0.484	0.269	0.271	0.204	0.223	0.060						
NSP	0.654	0.308	0.866	0.771	0.369	0.823	-0.486	0.023					
SL	-0.066	0.620	0.231	0.042	0.329	0.023	0.015	0.199	0.418				
NSCLR	0.413	-0.174	0.480	0.441	0.392	0.299	-0.263	0.585	0.291	0.362			
TSW	0.802	-0.015	0.886	0.902	0.224	0.892	-0.724	-0.090	0.796	-0.049	0.326		
GY	0.235	0.505	-0.024	0.115	-0.625	0.066	0.324	0.125	0.070	0.257	-0.079	-0.010	

Key:
DSE = Days to 75% Seed germination/ Emergence, **PH** = Plant Height (cm), **LL** = Leaf Lengths (cm), **LW** = Leaf Width, **NLPS** = Number of Leaves Per Plant Stand, **SG** = Stem Girth, **NTPS** = Number of Tillers Per Plant Stand, **DPE** = Days to 75% Panicle Emergence, **NSP** = Number of Spikelet Per Panicle, **SL** = Spike Length (cm), **NSCLR** = Number of Seeds Per Centimeter Length of Raceme, **TSW** = Thousand (1000) Seed Weight and **GY** = Weight of The Seed (Grain Yield) Kg/ha

A wide range of variance was observed for all the characters investigated. Phenotypic variance was higher than genotypic variance for the entire quantitative characters studied, which indicates the influence of environmental factors on these traits. This suggest that the accessions were either genotypically different or the genotype had a norm of reaction that spanned different traits.

Sivasubramanian and Madhavamenon (1973) categorised the value of GCV and PCV as low (0 – 10 %), moderate (10 – 20 %) and high (>20 %).

Table 4: Estimation of the Genotypic Coefficient of Variance, Phenotypic Coefficient of Variance, Heritability, Genetic Advance and Genetic Advance as Per Percentage Mean.

Parameters	Genotypic variance (δ^2g)	Phenotypic Variance (δ^2p)	GCV %	PCV %	H ² b %	Genetic Advance GA	GAM %
Days to 75% germination	2.027	3.061	26.5	32.6	66.2	2.389	44.5
Plant height	117.6	126.5	27.8	16.4	94.6	21.940	31.9
Leaf length	73.381	76.006	57.5	58.2	96.5	17.365	15.9
Leaf width	0.057	0.064	30.6	32.5	88.6	0.462	59.4
Stem girth	0.388	0.388	64.9	60.7	14.6	1.376	14.3
Number of leaves per plant	0.601	0.662	13.8	14.5	90.8	1.524	27.1
Number of tiller per plant	29.356	32.888	42.4	44.9	89.3	10.565	82.7
Days to 75% panicle emergence	161.92	188.05	20.6	12.5	77.2	77.006	69.9
Number of spikelet per panicle	1.7566	1.934	28.4	29.8	90.8	2.605	55.8
Spikes length	1.0188	1.1091	8.89	9.27	91.8	1.996	17.6
Number of seed per centimeter raceme	17.664	18.054	19.8	19.9	97.8	8.576	40.3
Thousand seed weight	0.0465	0.0722	23.9	29.8	64.4	0.357	39.6
Grain yield	0.0037	0.1177	0.003	0.017	3.20	0.023	0.001

GCV=genotypic coefficient of variance, PCV= phenotypic coefficient of variance, H²b = broad sense heritability, GAM =genetic advance as per percentage mean.

GCV was highest in stem girth, leaf length and number of tillers per plant with the values of 64.9, 57.5 and 42.4% respectively (table 4). Coefficient of variation studied indicated that estimates of phenotypic coefficient of variation (PCV) were higher than the corresponding genotypic coefficient of variation (GCV) for all the traits except plant height, stem girth, days to 75% panicle emergence that were slightly higher than the PCV. This indicates that they all interacted with the environment to some extent. Similar results were reported by Singh *et al.*, (2015); Bhadru *et al.*, (2012) and Paikhomba *et al.*, (2014) in rice. The higher estimate of phenotypic coefficient of variation (PCV) was obtained for almost all the characters corresponding to GCV and these characters could be used as selection indices for crop improvement. A comparison of estimates of GCV (%) with their corresponding PCV (%) for different traits revealed that in general, the GCV (%) were close to the estimates of PCV (%) for all characters indicating that they have been influenced by the environment, except for plant height and days to 75% panicle emergence that were least influenced by the environment.

Heritability estimate was high for all characters studied except for grain and stem girth which recorded low (table 4). The heritability percentage is categorized as low (0-30%), moderate (30-60%) and high (>60%) Robinson, *et al.*, (1949). High values of heritability in broad sense indicate that the character is less influenced by environmental effects. Similar results were reported by Chen, *et al.*, (1996), Satyanarayan and Kumar, (1995) and Ojo *et al.*, (2006). Similar results were also reported by Bihari *et al.*, (2004), Sankar *et al.*, (2006) for days to 50 per cent flowering. Kundu *et al.*, (2008) recorded high heritability for grain yield per plant in rice contrary to low heritability recorded in the present study.

Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates

REFERENCES

- Adilakshmi, D. and Girijarani, M. (2012). Variability, character association and path analysis in conventional hybrids in maize. *Mysore Journal of Agricultural Sciences*. 29(3): 213-218.
- Ali, M. L., Rajewski, J. F., Baenziger, P. S., Gill, K. S., Eskridge, K. M., and Dweikat, L. (2007). Assessment of genetic diversity and relationship among a collection of US sweet sorghum germplasm by SSR markers. *Molecular Breeding*, 21, 497-509.
- Ballogoun, V. Y. (2013). (post-harvest systems of quality processing of fonio and Derived products in Northern Benin. Doctoral thesis. Agronomic sciences. (Systèmes post-récolte, transformation, qualité du fonio et produits dérivés au nord du Bénin. Thèse de Doctorat unique. Faculté des Sciences Agronomique). Université d'Abomey- Calavi. Bénin. P 152.
- Bihari, P. K., Richharia A. K., Sahu, R. S. (2004). Genetic advance for yield attributes in aromatic rice. *Journal of Applied Biology*. 14: 1-5.
- Chaudhary, L. B., and Prasad B. (1968). Genetic variation and heritability of quantitative characters in Indian mustard (*Brassica Juncea*). *Indian Journal of Agricultural Science*, 38: 820-825.
- Chen ling, Cuishaoping, Chen, L., Cui, A. P and Sun, Y. B. (1996). Analysis of the gene effect on ear characters in maize. *Acta Agricultural Bareli Sinica*. 11(2): 28-32.

alone. Characters exhibiting high heritability may not necessarily give high genetic advance. High heritability should be accompanied with high genetic advance to arrive at a more reliable conclusion. High heritability coupled with high genetic advance as percentage mean was recorded for days to 75 percent panicle emergence and number of tillers per plant stand indicating that the high heritability observed is due to additive gene effects. Mass selection and progeny selection may be effective for the improvement of these characters. Adilakshmi and Girijarani, (2012) reported high heritability and high genetic advance as percent mean for 1000-seed weight and Madhaviatha *et al.*, (2005), for grain yield per plant in rice.

High heritability coupled with moderate genetic advance in percentage of mean was observed for plant height, days to 75 percent seed germination, leaf width, number of spikelet per panicle, number of seeds per centimeter length of raceme and 1000 seed weight indicating the role of both additive and non-additive gene effects for control of these characters. This result is in conformity with the report of Seyoum *et al.*, (2012) for plant height. However, panicle length had recorded high heritability coupled with low genetic advance in percentage of mean in the present investigation, which is similar to the findings of Singh *et al.*, (2012). High heritability and low genetic advance as percentage mean indicates that these characters were controlled by non-additive gene effects. Therefore, these characters could be improved through heterosis breeding programme

CONCLUSION

High heritability coupled with high genetic advance as percentage mean was observed for days to 75% panicle emergence and number of tillers per plant stand indicating additive gene effects, Mass selection and progeny selection may be recommended for the improvement of these characters. Since Panicle length had high heritability and low genetic advance, improvement could be through heterosis breeding.

- Cruz J. F., Béavogui F., Dramé, D. (2011). Le fonio, une céréale africaine. Quae, CTA, Presses agronomiques de Gembloux. P 175.
- Falconer, D. S. and Mackay, T. F. C. (1996). An Introduction to Quantitative Genetics. 4th edition., Prentice Hall, London.
- Gari, J. A (2002). "Review of the African millet diversity". FAO - Food and Agriculture Organisation of the United Nations. Rome. Italy.
- Johnson, H. W., Robinson, H. F. and Comstock R. E., (1955). Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*. 47:314 - 318.
- Kundu, A., Senapati, B. K., Bakshi, A and Mandal, G. S.2008. Genetic variability of panicle characters in tall aman rice. *Oryza*, 43 (40): 320 - 323
- Kwon-Ndung, E.H. and A.A. Ochigbo, (2014). Acha (fonio) genetic diversity, distribution and conservation in Nigeria. *New Approaches to Plant Breeding of Orphan crops in Africa. Vol. 8: Bern, Switzerland.*
- Madhavilatha, L., Reddi Sekhar, M., Suneetha, Y., and Srinivas, T. (2005). Genetic variability, correlation and path analysis for yield and quality traits in rice (*Oryza sativa L.*). *Research on Crops*, 6 (3): 527-534.
- Martins, R. I. (1992). Variability in some agronomic characters of thirteen cultivars of Acha *Digitaria exilis stapf B.* agriculture project. A.B.U Zaria.
- Nyam, D. D, (1996). Yield and yield components of some Acha *Digitaria spp* varieties. Unpublished M.Sc. thesis. University of Jos. Nigeria.
- Ojo, D. K., Omikunle, O. A., Oduwaye, O. A., Ajala, M. O and Ogunbayo, S. A. (2006). Heritability, association analysis in rice (*Oryza sativa L.*) treated with trichoderma harzianum. *Crop Research*, 44(1&2): 141-145.
- Robinson, H. F., Cornstock, R. E., and Harvey, P. H. 1949. Estimates of heritability and degree of dominance in corn. *Agronomy Journal*. 41:353-359.
- Sankar P. D, Sheeba A, Anbumalaramathi J (2006). Variability and character association of cultivars of rice (*Oryza sativa L.*). *Agricultural Science Digestive*, 26: 182-84.
- Satyanarayana, E., and Sai Kumar, R. (1995). Genetic variability and Per se performance of non-rice under submergence. *Crop Research*, 44(1 and 2): 146-151.
- Seyoum, M., Alamerew, S., and Bantte, K. (2012). Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice. *Journal of Plant Sciences*.7 (1): 13-22.
- Singh, P. K., Dhakad, B. K., Singh, H. B. and Singh, A. K. 2012. Genetic variability and characters in tall indica aman rice. *Oryza*, 45(4): 320-323.
- Sivasubramanian, S., and Menon, M. (1973). Heterosis and inbreeding depression in rice. *Madras Agricultural Journal*. 60:1339.
- Vall, É., Dembélé, K., Kanwé, A. (2008). Options for the development of the fonio project. In: improving the quality and competitiveness of the fonio sector in Africa by l' west (J.-F. Cruz, éd.) [CD-Rom], Cirad, Montpellier. P 40.
- Vodouhè, S. R., Achigan Dako, E. G. (2006). *Digitaria exilis* (Kippist) Stapf. In: PROTA 1- Cereal and pulses / (cereals and dried vegetable) Céréales et légumes secs. Brink, M., Belay, G. (Editors). [CD-ROM]. Prota, Wageningen, Pays-Bas.