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Phenotypic variability of some varieties of pepper (*Capsicum* spp) in the forest-savanna transition zone of Edo State, Nigeria

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ABSTRACT

Description of the subject. The phenotypic variability of some varieties of pepper (*Capsicum* spp) was carried out in Research Farm, Ambrose Alli University Ekpoma. This is to determine the different growth performance of varieties of pepper in south- south geopolitical zone in Nigeria.
Objectives. The study aims to evaluate the phenotypic variability of certain improved varieties of pepper (Atarodo "scotch bonnet", Atawewe "bird eye", Tatashe "red pepper" and Shombo "cayenne pepper".) in the Edo State region of Nigeria.
Methods. The experiment was Randomized Complete Block Design replicated four times. Data collected were subjected to Analysis of Variance at $P<0.05$. The genetic variability were analyzed using Genetic model (Heritability), Genetic gain and Genetic advance.
Results. Plant height and number of leaves at 3, 6 and 9 WAP differed significantly. However at 6 WAP there was no significant difference for number of leaves. There was no significant difference for the number of branches/plant. Petiole length, leaf area and stem girth varied significantly. Days to 50% flowering, 50% maturity, fruit length, fruit width, fruit weight and fruit yield were significantly different. Days to 50 % flowering and maturity, fruit length, fruit width and fruit yield (96.09 % and 4.02), (97.56 % and 3.08), (61.83% and 9.53), (75.32 % and 5.13) and (71.46 % and 2.41) recorded high values for heritability and genetic gain.
Conclusion. The Atawewe variety had the highest yield/ha and it is recommended for farmers in the locality.

Keywords: Pepper varieties, Phenotypic variability, Growth, Yield, Nigeria

1. INTRODUCTION

Pepper (*Capsicum* spp) belongs to the family *Solanaceae* and is originated from South and Central America. The crop is commonly called sweet pepper and is widely grown all over the world (Dagnoko *et al*., 2013). The genus *capsicum* has five domesticated species which are *C. annuum, C. frutescens, C. pubescens, C. baccatum, C. chinense* (Dangnoko *et al.*, 2013). Among these five, *Capsicum annuum* L. is the most widespread and economical important. The total area devoted to pepper worldwide is estimated at 4 million hectare with an average annual increase of 5% (Weiss, 2002). According to FAO (2016), the estimated world's production of peppers is put at 21.3 million tonnes from a harvested area of 1.6 million hectares. The major pepper producing countries include Brazil, china, Mexico and Turkey which produce about 70% of the total world population (Adeola *et al*., 2011).

The world fresh chilli and sweet pepper production was 27.6 million tons in 2010, to which West Africa contributed 888,400 tons. Nigeria and Ghana are among the biggest West African contributors. They are ranked 8th and 13th respectively (FAO, 2016). There are many local cultivars grown in West Africa. Nigeria alone has more than 200 selections of pepper (Idowu *et al*., 2012) Nigeria has a good soil and weather that can readily support the growth and production of pepper (Adaigho *et al.*, 2018). Nigeria

is known to be one of the major producers of pepper in the World accounting for about 50% of Africans production (Mohammed *et al.,* 2013*)*. In Nigeria, pepper is massively produced from the Northern States even though it grows well in the South West States and to a lesser extent in the South Eastern States. The bulk productions of pepper is found in the savanna zone and derived savanna areas of the south western Nigeria (Dias *et al*., 2013)

Capsicum spp which exhibits considerable morphological variation is a highly heterogeneous plant species (Walsh and Hoot, 2001). A good assessment of the qualitative and quantitative traits is highly important to study the extent of variation of traits of pepper germplasm. Although qualitative and quantitative characters are expected to jointly establish the phenotype, the latter is more important to the plant breeder than the former given its importance in crop improvement (Mohammed *et al*., 2013). Phenotypic characters such as fruit weight, fruit colour, fruit shape and plant height have been used to distinguish between pepper genotypes and classify them into groups (Weerakoon and Somaratne, 2010). Hence the knowledge of the phenotype given by morphological descriptors is important in giving correct species identification (Dias *et al*., 2013). It is very essential in bringing to light traits of agronomic importance especially quantitative traits for crop improvement (Geleta *et al*., 2005)

In Edo State, Nigeria, the production of pepper is low, this probably because of planting of the cultivation of low yielding varieties. It is a known fact that high yielding varieties out-yielded unimproved ones due to their genetic improvement. This, therefore, calls for an urgent need to identify the varieties with the best phenotypic characteristics suited for the study area. Thus, the study aims to evaluate the phenotypic variability of certain improved varieties of pepper (Atarodo "scotch bonnet", Atawewe "bird eye", Tatashe "red pepper" and Shombo "cayenne pepper". ") in the Edo State region of Nigeria

The study is intended to assess the growth and yield of pepper (capsicum spp) in Ekpoma, Edo State. The results from the study will reveal the best variety in Phenotypic variability of some varieties of pepper **(**Capsicum spp) in the forest-savanna transition zone**,** this will be useful to farmers making them to adopt the best variety for their pepper farm so as to achieve better production and better their standard of living with increased revenue from pepper farming. The finding will also be beneficial to extension service providers in terms of discerning the best variety to be used by pepper farmers. More so, it will be useful to government agencies in charge of policies making in agriculture as related to pepper production.

2. MATERIAL S AND METHODS

2.1. Experimental location

The field experiment was carried out at the Teaching and Research Farm, Faculty of Agriculture, Emaudo Annex, Ambrose Alli University, Ekpoma. Edo State located at latitude 6.45^0N and longitude 6.08^0E in a Forest/Savanna transition zone of South-South Nigeria. Edo state has a Tropical wet and dry or savanna climate with yearly temperature of 28.78°C (83.8°F) and it is -0.68% lower than Nigeria's averages. Edo typically receives about 183.49 millimeters (7.22 inches) of precipitation and has 265.91 rainy days (72.85% of the time) annually and at an elevation of 239.16 meters (784.65 feet) above sea level (Edo, NG Climate Zone, Monthly Weather Averages and Historical Data Report 2023)

2.2. Experimental materials

Four (4) varieties of pepper were used. The seeds were obtained from the Agricultural Development Program (ADP) Benin City, Edo state. These include: Atarodo (scotch bonnet), Atawewe (bird eye), Tatashe (red bell pepper) and Shombo (cayenne pepper).

2.3. Experimental layout

The experiment was a Randomized Complete Block Design (RCBD) with four (4) replications. The seeds before sowing were raised for four (4) weeks in a nursery bed prepared opposite the experimental site.

2.4. Land preparation and planting

The land for the experiment was cleared manually and the debris removed without burning. The total land area was $180m^2$ (9 m x 9 m). It was mapped and demarcated into plots given a total of 16 plots. Each plot size was 1m x 1m. The spacing was 50cmx50cm with a discard of 50cm within rows and between giving equivalent population density of 40,000 plants/ha. Two (2) weeks after transplanting NPK 15:15:15 was applied at the rate of 200kg/ha using ring method (Remison, 2005). Weeding was done manually using a hoe at the 3^{rd} and 7^{th} weeks after transplanting.

2.5. Data collection

Plant Height (cm): A meter rule was used for measurement. Height of four randomly selected

plants in each plot was measured from ground level to the apex of the plant and the mean value recorded. This measurement was taken at 3, 6 and 9 WAT

Number of leaves/plant: Leaves from four plants randomly selected in each plot were counted at 3, 6 and 9 WAT and the average value recorded.

Number of branches/plant: Branches from four randomly selected plants in each plot were counted at 3, 6 and 9 WAT and the average value recorded.

Total leaf area/plant (cm²): A meter rule was used to measure the longest length and widest breadth of the leaves for each plant and was multiplied by a constant 2.325 and multiplied by number of leaves/plant and the mean value recorded.

Petiole length: This was done by measuring the petiole length with a meter rule from four randomly selected plants and the average value recorded.

Stem girth (cm): A digital vernier caliper was used to measure the girth of the stem of four randomly selected plants per plot and the mean value recorded.

Days to 50% flowering: The date from sowing to when 50% of the plants open their first floral bud in each plot was recorded.

Days to 50% maturity: This was obtained when 50% of the fruit were fully matured, four stands in each plot were sampled and the mean value recorded.

Fruit Length (cm): Four fruits from each plot were sampled and the length of the fruit measured from the base to the tip of the fruit and the average value recorded.

Fruit width (cm): A digital vernier caliper was used to measure the broadest part of the fruit diameter from four randomly selected fruit per plot and the mean value recorded.

Fruit weight (g): A sensitive scale was used to take the fruit weight. The value was calculated in gram (g).

Fruit yield (kg/ha): Fruit from four plants were randomly selected, weighed with a sensitive scale and the average value recorded.

2.6. Analysis of data

All data collected were analyzed using analysis of variance (ANOVA) at 5 % level of probability.

Genetic analysis

The genetic analysis was based on growth and yield related to genotypic and phenotypic expressions. The mean squares at treatment level were taken as the phenotypic variance (which is the portion of phenotypic variance caused by variation in genes). The mean square at the error level was subtracted from their corresponding phenotypic variance to give the genotypic variance and calculated as described as follows.

Heritability (Ho): heritability in the broad sense was calculated using this formula:

$Ho = \partial^2 g / \partial^2 ph \times 100$,

where $\partial^2 g$ = Genotypic variance,

$\partial^2 ph$ = Phenotypic variance, a

Genetic advance: this was calculated using this formula

$GA = \partial^2 g / \partial^2 ph \times K$,

where GA = Genetic Advance,

$\partial^2 ph$ = Square root of phenotypic variance,

K = 2.06 (selective index), and

$\partial^2 g$ = Genotypic variance

Genetic gain: The Genetic Gain (GG) was calculated in terms of the Genetic Advance (GA) expressed as a percentage of the population mean;

$GG = GA / \bar{x} \times 100$,

$\bar{x}$ = population mean.

3. RESULTS

The plant height of pepper varieties (Table 1) showed significant difference at 3, 6 and 9 WAP. However, plant height was at 3 and 6 WAP in Tatashe (16.97cm) and (29.24cm) and the least in 3 and 6 WAP in Atawewe (6.11cm) and Shombo (11.19cm) respectively. At 9 WAP, plant height was highest in Atarodo (34.14cm) and least in Shombo (14.75 cm).

Table 1. Plant height at 3, 6 and 9 weeks after planting

Variety	Weeks after Planting		
	3	6	9
Shombo	6.94^{c}	11.19^{c}	14.75^{b}
Atarodo	12.18^{b}	21.53^{b}	34.14^{a}
Tatashe	16.97^{a}	29.24^{a}	32.52^{a}
Atawewe	6.11^{c}	14.46^{c}	26.34^{a}
LSD ($p<0.05$)	2.50	7.06	9.35

Values with same alphabet in the same column are insignificantly different ($P<0.05$).

The number of leaves of pepper varieties is presented in Table 2. The number of leaves of pepper showed significant difference at 3 and 9 WAP. However, there was no significant difference at 6 WAP in the number of leaves of pepper varieties. At 3 and 6 WAP number of leaves was highest in Tatashe (17.69 leaves) and (53.88 leaves) least in Atawewe (9.50 leaves) and Shombo (40.19 leaves). At 9 WAP number of leaves was highest in Atawewe (121.00 leaves) and was least in Shombo (50.12 leaves).

Table 2. Number of leaves at 3, 6 and 9 weeks after planting

Variety	Weeks after planting		
	3	6	9
Shombo	11.19[b]	40.19	50.12[c]
Atarodo	12.88[b]	48.50	109.64[ab]
Tatashe	17.69[a]	53.88	62.50[bc]
Atawewe	9.50[b]	51.00	121.00[a]
LSD (P<0.05)	4.447	NS	50.78

Values with same alphabet in the same column are insignificantly different (P<0.05).

The number of branches of pepper varieties (Table 3) showed no significant difference in all the varieties treated. At 3 WAP, number of branches was highest in Tatashe (1.83) and the least in Shombo (1.00). At 6 WAP, the braches was highest with Atarodo (3.63) while the least number of branches in Shombo (2.69) while at 9 WAP, the highest number of branches in Atawewe (8.06) and the least in Shombo (4.75).

Table 3. Number of branches/plant at 3, 6 and 9 WAP

Variety	Weeks after planting		
	3	6	9
Shombo	1.00	2.69	4.75
Atarodo	1.33	3.63	7.81
Tatashe	1.83	3.13	3.56
Atawewe	1.50	3.06	8.06
LSD (p<0.05>	NS	NS	NS

NS: not significant

The leave area of pepper varieties (Table 4) shows a significant difference among the varieties at 3, 6 and 9 WAP. At 3WAP, leaf area was highest in Atarodo (1077.90cm^2) and the least (213.60cm^2). The same trend was maintained at 6 with Atarodo (7228.00) having the highest number of leaves and Shombo (999.00) being the least. A similar trend was found at 9 WAP with Atarodo (18012.00) being the highest while Shombo (1539.00) had the least.

Table 4. Leaf area/plant (cm^2) at 3, 6 and 9 weeks after plantin

Variety	Weeks after planting		
	3	6	9
Shombo	213.60[b]	999.00[c]	1539.00[b]
Atarodo	1077.90[a]	7228.00[a]	18012.00[a]
Tatashe	977.00a	4637.00[b]	5034.00[b]
Atawewe	223.40[b]	2501.00[c]	6340.00[b]
LSD (p<0.05)	552.30	2060.00	6013.80

Values with same alphabet in the same column are insignificantly different (P<0.05).

The length of petiole of pepper varieties is presented in Table 5. The length of petiole of pepper showed significant difference among all the varieties at 3, 6 and 9 WAP. At 3 WAP length of petiole was highest in Tatashe (3.15) and the least in Shombo (1.23). The same trend was maintained at 6 WAP with Tatashe (3.27) having the highest number of length of petiole and Shombo (1.34) being the least with significant differences across the varieties. However, at 9 WAP, length of petiole was Atarodo (3.17) and the least in Shombo (1.74) with significant differences among the varieties.

Table 5. Length of petiole/plant at 3, 6 and 9 WAP

Variety	Weeks after planting		
	3	6	9
Shombo	1.23[c]	1.34[c]	1.74[b]
Atarodo	2.24[b]	3.11[a]	3.17[a]
Tatashe	3.15[a]	3.27[a]	2.82[a]
Atawewe	1.43[c]	2.14[b]	2.40[ab]
LSD (p<0.05)	0.23	0.79	0.82

Values with same alphabet in the same column are insignificantly different (P<0.05).

The stem girth of pepper varieties (Table 3) showed significant difference at 3, 6 and 9 WAP. At 3 WAP, the stem girth was highest in Tatashe (3.10cm) and least in Atawewe (1.69). A similar trend maintained at 6 WAP, stem girth was highest in Tatashe (6.52cm) and least in Shombo (2.46). At 9 WAP, stem girth was highest in Atarodo (7.02cm) with significant differences across the varieties.

Table 6. Stem girth (cm) at 3, 6 and 9 WAP

Variety	Weeks after planting		
	3	6	9
Shombo	1.75[b]	2.46[c]	3.77[c]
Atarodo	2.98[a]	5.14[ab]	7.02[a]
Tatashe	3.10[a]	6.52[a]	6.13[ab]
Atawewe	1.69[b]	3.05[bc]	4.98[bc]
LSD (p<0.05)	0.51	2.42	1.72

Values with same alphabet in the same column are insignificantly different (P<0.05).

The % to days of flowering and maturity of pepper varieties is presented in Table 7 showed significant difference among the varieties. Variety Atarodo had the highest % of flowering and maturity at a value of 57.25 % and 74.75 % while Tatashe had a value of 42.00 % and 56.25 % being the least respectively. The length of fruits (cm) of pepper was significantly

different among the varieties. Atawewe had the highest length of fruit (cm) with a value of 27.91 while Shombo being the least in 7.37. Fruit width (mm) varies among the varieties. Variety Tatashe had the highest fruit width (mm) with a value of 60.23 mm. This was followed by Atarodo (27.22mm), Atawewe (23.80 mm) and the least being Shombo (9.55) in that order.

The fruit weights (kg/ha) of the varieties were significantly different. Variety Atawewe gave the highest fruit weight of 1997.50 and the least being Shombo with 183.30. The fruit yield of pepper varieties differed significantly. Variety Atawewe was the best yielding variety followed by Atarodo, while the least was Tatashe.

Table 7. Flowering and yield components

Variety	Days to 50 % Flowering	Days to 50 % Maturity	Length of Fruit (cm)	Fruit width (mm)	Fruit weight (kg/ha)	Fruit yield (kg/ha)
Shombo	51.50^{b}	69.00^{b}	7.37^{ab}	9.55^{b}	183.30^{b}	27.50^{b}
Atarodo	57.25^{a}	74.75^{a}	7.41^{b}	27.22^{ab}	362.50^{b}	55.25^{ab}
Tatashe	42.00^{d}	56.25^{d}	10.61^{ab}	60.23^{a}	690.00^{b}	9.50^{b}
Atawewe	46.50^{c}	61.00^{c}	27.91^{a}	23.80^{b}	1997.50^{a}	150.25^{a}
LSD ($p<0.05$)	4.15	4.11	19.46	34.06	677.50	107.10

Values with same alphabet in the same column are insignificantly different ($P<0.05$).

4. DISCUSSIONS

It was discovered that height of plant did not affect the yield of pepper. However, the ability for the pepper to resist lodging depended on the plant height. The significant variation in the height of pepper varieties may be attributed to their genetic potentials as well as environmental factors and ability to absorb nutrients (Nkansah, *et al.,* 2011). The number of leaves affect the plant yield as the increased number of leaves increase the area available for photosynthetic activities. Abdulai *et al.* (2012) reported that yield stability depend on the photoperiod sensitivity of the various cultivars. The study showed number of branches had no any effect on the yield and growth of pepper plant. Atarodo at 9 WAP for leaf area varied significantly from other varieties.

Days to 50 % flowering deferred significantly for all four varieties. Some mature earlier and this can be attributed to the differences in their genome. Geleta *et al.* (2005) reported that this type of variability may be due to genetic makeup and environmental interactions. The wide variation in fruit length must be due to variation in genetic constitution of the varieties. According to Lee *et al.* (2008) the orientation of fruit and the fruit shape are linked to gene. Atawewe had the highest yield among all variety due to high fruit production.

High heritability (Ho) and Genetic Gain (GG) values were observed at 3, 6 and 9 WAP for plant height, leaf area and petiole length; days to 50 % lowering and maturity and fruit weight. High Heritability leads to high Genetic Gain. High value for Heritability may be ascribed to additive gene effect (Sadeghi, 2011). Hence, this can be used as basis for selection. Low Heritability and Genetic Gain is as result of non-additive gene. The higher the broad sense heritability value, the lower the influence of the environment on the expression of the trait. Knowledge on the nature of genetic origin and environmental variations is essential for breeding activities, as improving certain agronomic traits depends on basic knowledge about the inheritance of traits, the genetic variability available for improvement and estimates of genetic parameters (Dias *et al*., 2013). Atawewe which had the highest fruit weight and fruit yield, and thus can be used to improved other varieties if the varieties are compatible.

5. CONCLUSION

Vegetative growth varied highly and slightly significant in some parameters among the varieties. Characters with high Heritability (Ho) and Genetic Gain (GG) were as a result of additive gene expression. Characters with high Heritability (Ho) and Genetic Gain (GG) can be used as a basis for selection. Characters with low Heritability (Ho%) and Genetic Gain (GG) were as a result of non-additive gene expression and cannot be used for selection as such characters cannot be easily improved on. The Atawewe variety which had the highest fruit weight and fruit yield.

Recommendation

Based on the result emanating from the study the following recommendation were made Farmers in the study area should be encouraged through agricultural

extension service providers to adopt Atawewe variety. This will enhance the production as the variety has proved to be a better one. There is need to test these varieties with different fertilizer treatment, this will help to know the effect of different rate of fertilizers on the varieties. There is also the need to replicate this experiment in dry season, this will help to prove the effect of season variation on the studied varieties.

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References

Adaigho D. & Tibi K., 2018. Assessment of pepper production and socio economics of Pepper farmers in Delta State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*.28 (2): pp. 1-7.DOI:10.9734/AJAEES/2018/44598

Abdulai A.L., Parzies H., Kouressy M., Vaksmann M., Asch F. & Brueck H., 2012. Yield stability of photoperiod sensitivity sorghum (*sorghum bicolor* L. Moench) accessions under diverse climatic environment. *International Journal of Agricultural Research*,.7, 17-32. DOI: 10.3923/ijar.2012.17.32

Adeol, R. G. Tijani-Eniola H. & Makinde E. A., 2011. Ameliorate the effect of poultry manure and NPK fertilizer on the performance of pepper relay cropped with two cassava varieties. *Global Journal of Science Frontier Research*., 11, 17-13. Online ISSN : 2249-4626 & Print ISSN: 0975-5896

Dagnoko S., Yaro-Diarisso N., Sango P. N., Adetula O., Dolo-Nantoume A., Gamby-Toure K., Traore-Thera A., Katile S. & Diallo-Ba D., 2013. Overview of pepper (Capsicum spp.) breeding in West Africa. *African Journal of Agricultural Research.*, 8, 1108-1114. https://doi.org/10.5897/AJAR2012.1758

Dias G. B., Vomes V. M., Moraes T. M. S., Zottich U. P., Rabelo G. R., Carvaiho A. O., Moulin M. L. S. A., Rodrigues R. & Cunha M., 2013. Characterization of Capsicum species using anatomical and molecular data. *Genetics and Molecular Research*, 4, 1-14. DOI: 10.4238/2013.

Edo, NG Climate Zone, Monthly Weather Averages and Historical Data". *tcktcktck.org*. Retrieved 2023-06-30

FAO, 2016. *FAOSTAT Database*. Roma,Italy. Available online at URL:www.fao.org

Gelata, L. F., Labuschangne, M. T & Vijoen C. D., 2005. Genetic variability in pepper (*Capsicum annuum L.*) estimated by morphological data and amplified fragment length polymorphism markers. *Biodiversity Conservation*, 14, 2361-2375. DOI: 10.1007/s10531-004-1669-9

Idowu-Agida, O.O., Ogunniyan, D.J. & Ajayi, E. O., 2012. Flowering and fruiting behavior of long cayenne pepper (*Capsicum frutescens L.*). *International Journal of plant breeding and genetics*, 6, 228-237. DOI: 10.3923/ijpbg.2012.228.237

Mohammed A.B., Ayanlere A.F., Ekenta C.M. & Mohammed S.A., 2013. Cost and return analysis of pepper production in Ethiopia West Local Government Area, Delta State. *Nigeria International Journal of Applied Research and Technology*, 2(2), 3-7. ISSN 2277-0585

Nkansah G. O., Ayarna A. & Gbokie T. J., 2011. Morphological and Yield Evaluation of Some Capsicum Pepper Lines in Two Agro-Ecological Zones of Ghana. *Journal of Agronomy*, 10(3), 84-91. DOI: 10.3923/ja.2011.84.91

Sadeghi S. M. 2011. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in landrace rice varieties. *World Applied Science Journal*, 13, 1229-1233. ISSN 1818-4952

Walsh B. M. & Hoot S. B., 2001. Phylogenetic relationships of Capsicum (Solanaceae) using DNA sequences from two noncoding regions: the chloroplast atpb-rbcl spacer region and nuclear waxy introns. *International Journal of Plant Science*, 162(6), 1409-1418. DOI: 10.1086/323273

Weeraoo S. R. & Somaratne S., 2010. Agro-morphological characterization and relationship among mustard germplasm (*Brassica juncea* L.) Czern and coss) Srilanka: A classification tree approach. *Journal of Agricultural Sciences*, 5, 89-97. DOI: 10.4038/jas.v5i2.2788

Weiss E. A., 2002. *World Production and Trade*. CABI Publishing, CAB International, Wallingford, UK. https://doi.org/10.1079/9780851996059.0000