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Inheritance studies of some quantitative traits in onion (*Allium cepa* L.)

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Abstract

Inheritance studies for some onion quantitative traits namely plant height, number of leaves, bulb yield, bolting rate and soluble solid content were carried out to evaluate genetic parameters such as genotypic and phenotypic coefficient of variability, heritability, genotypic and phenotypic correlation coefficient, and genotypic and phenotypic variances in onion cultivar using half-sib family intra-class correlation and selection response. The result indicates the existence of high genetic variability within the families studied with high negative heritability in some yield traits such as soluble solid content which shows the preponderance of this trait when selecting this type of local cultivar for breeding.

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Introduction

Onion (*Allium cepa* L.) is a biennial plant often grown as annual and propagated mainly by seeds through transplants. It is one of the most important crops grown in Nigeria which serves as spice as well as vegetable. Commercial production is carried out in northern part of the country with average annual yield of over 1.2 million metric tonnes. Leading producers of onion in the world include China, India and the United States of America (Burden, 2007). The current world production of onion according to FAO, (2009) was 64.48 million tonnes from 3.45 million hectares area.

High yielding onion cultivars with high soluble solid content could provide good incentive to increase production for processing and storage such as dehydration so as to minimize onion lost due to poor storage by farmers and marketers. According to Wall and Corgan, (1999), soluble solids are known to comprise the bulk of onion dry mass and that dehydrator cultivars are developed from breeding populations that have high dry mass content.

The demand for onion has been on the increase probably due to its vital use to the body. It serves as a good medicinal compound for cataract, cardiovascular disease, and cancer due to its hypocholesterolemic, thrombolytic and antioxidant effects (Nuutila, *et al.*, 2003), In addition to lowering blood pressure and cholesterol level. Ly *et al.*, (2005) reported several antioxidant compounds, mainly polyphenols such as flavonoids in onion and garlic. It has also been shown to be one of the major sources of dietary flavonoids in many countries, specifically, onion has been characterised for its flavonol quercetin and quercetin derivates (Roldan, Sanchez, Ancos and Cano, 2008).

Considering the fact that onion is a perishable crop of low storability and therefore consumed directly as they do not store well, there is need to study the inheritance pattern of some of its quantitative trait with the aim of improving the locally grown cultivars through proper evaluation of genetic material to understand its genetic variability, heritability and character association so as to obtain information for the development of proper breeding program, which is the aim of this study. Similar studies by Haydar, *et al* (2007) on genetic variability and interrelationship in onion was undertaken to work out appropriate breeding strategies for bulb yield improvement. Therefore, development of onion cultivars with good storage ability and desirable traits by consumers is necessary.

Among the cultivars grown in north eastern Nigeria, Ex-Borno is most popular. It has a very low pungency and light brown in colour with moderate to large bulb size. It is the commonly grown cultivar in the region and most preferred by consumers, unfortunately, this cultivar has very poor storability leading to great loss by farmers, marketers and consumers. Amans and Kadams, (1990) studied the yield, bolting and storage loses of selected onion cultivars and found that they were subjected to spoilage either by bolting or rotten within a short period time, justifying poor storability of the local onion cultivars.

Materials and methods

Study area and experimental design

The field trials, both crossing nursery and field experiments was conducted at Lake Gerio Irrigation site of the Upper Benue River Basin Development Authority Jimeta,Yola, Nigeria during the 2009/2010 and 2010/2011 dry seasons. It is located within latitude 9^o, 10'N and longitude 12^o, 35' E in the Northern guinea savannah ecological zone of Nigeria. The soil type is sandy clay loam (Adebayo and Tukur, 1999). The site was previously cropped with maize (*Zea mays*) and sorrel (*Habiscus sabdariffa*). The materials used for this study is the local Ex-Borno onion (*Allium cepa* L.) cultivar because of its features mentioned earlier which makes it the choice for this experiment.

One hundred bulbs were collected from local farmers in and around Yola. These were weight and analysed for soluble solids in the laboratory using the hand type refractometer as outlined by Nieuwhof, De Bruyn and Frieda (1973). Twenty bulbs with highest amount of soluble solid were selected. The bulbs were then planted free from other onion fields for the production of maternal half-sib family seeds in the (2009/2010) dry season. Open pollination was allowed to occur thereby giving each plant equal opportunity to serve as a pollen parent to each of the families.

Evaluation of progenies

Twenty half-sib family seeds were raised from the mother bulbs during (2009/2010) season. The seeds were sown in the nursery beds (2010/2011) in rows 30cm apart with each row representing a family and nursed for a period of exactly six weeks. The seedlings were then transplanted unto sunken beds 2m long by 2m wide with 20cm spacing between rows and 15cm spacing within rows using onion marker constructed locally for equidistance spacing as recommended by (Kadams and Amans, 1991).

Forty seedlings were transplanted in each plot representing each family. Thus each of the 20 half-sibs families were evaluated in a replicate trial using Randomised Complete Block Design (RCBD) with three replications. All agronomic practices for onion cultivation were carried out uniformly as the need arose. Crops were harvested when about 80% of the tops have fallen over as a sign of full maturity.

Data collection

Ten plants were chosen at random from the forty plants (Alternate plants within each central row to minimize border effect). For the purpose of this work, the following quantitative characters were reported: number of bolters, numbers of leaves plant-1, plant height (cm), bulb yield and soluble solids.

Data analysis

Analysis of variance was performed for all the traits using the model for half-sib family analysis described by Wall, Mohammad and Corgan, (1996). The components of variance were estimated from the expected mean square in the analysis of half-sib family. These are δ^2B, δ^2P and δ^2W.

Where δ^2B = Variance among half-sib families, δ^2P =Variance due to interaction of half-sib families within replication, δ^2W = Variance within half-sib family line and δ^2T = Total genetic variance.

The estimate of narrow sense heritability in this case, requires the variance components of half-sib family analysis, also described by Wall, *et al.*, (1996).

Heritability $h^2 = \delta^2A / \delta^2A + \delta^2P + \delta^2W$

$\delta^2A = 4\ \delta^2B$ = Additive Genetic Variance

Hence, $h^2 = 4\ \delta^2B / 4\ \delta^2B + \delta^2P + \delta^2W$.

The estimates of correlation, which is the degree of relationship between two characters or the influence of one variable on another which could either be positive or negative for any two characters 1 and 2 in the half-sib families were calculated using the method described by Dowker *et al.*,(1976). This was done for all pair of traits as follows:

$r_{1.2} = cov(1.2) / \sqrt{MS(1)\ X\ MS(2)}$

Where $r_{1.2}$ = correlation coefficient between characters 1 and 2, MS = Mean Square

cov = Mean Product

The mean squares and products for these correlations were obtained from the analysis of variance and covariance. The analysis of covariance for a pair of traits was obtained by combination of the analysis of variance for both traits in a pair. The genotypic correlations were derived using the among half-sib family and within half-sib family items. The replicate x genotypes mean squares gave the environmental correlation and that of the totals gave the phenotypic correlations. The statistical SAS software was used in the analysis.

Results and discussion

Genetic parameters

Genetic parameters which include genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2), genotypic variance (δ^2g), and phenotypic variance (δ^2p) were estimated for five quantitative traits in half-sib families of onion and presented in table 1. The traits varied significantly in their genotypes. High GCV was recorded for soluble solid content (276.11) and bulb yield (250.10) which is an indication that greater genetic variability exist in these traits. The heritability estimate for soluble solid content (SSC) and bulb yield (BY) were also high and suggested that these traits could be controlled by additive genetic effect and can therefore be used for improvement through phenotypic selection. When heritability of a trait is medium to high, selection based on individual level of performance allows a relatively rapid rate of improvement (Obilana and Fakorede, 1980). Higher heritability is known to be important in selection of superior genotypes based on phenotypic performance. The estimate of genotypic coefficient of variation GCV and genotypic variance are lower than there corresponding phenotypic coefficient of variation and genotypic variance in all the traits which indicates environmental influence in the traits expression.

Table 1. Estimate of genetic parameters for five characters in onion.

Traits	Mean	Range	δ^2g	δ^2p	GCV	PCV	H^2
B	5.13	0-10	3.56	5.15	16.10	19.23	0.1301
NL	12.61	8-19	120.50	120.70	80.41	80.50	0.6310
PH	65.13	28-110	563.71	684.20	38.51	40.01	0.4201
BY	180.0	80–280	150136.1	1509233.0	250.10	250.41	0.7131
SSC	9.0	6.0–9.5	25.4310	25.8121	276.11	279.50	0.8995

B=bolting, NL=number of leaves, PH= plant height, BY=bulb yield, SSC=soluble solid content, GCV=genotypic coefficient of variation, PCV=phenotypic coefficient of variation, δ^2p=genotypic variance, δ^2p=phenotypic variance H^2=heritability

Table 2. Mean squares and components of variance estimate from half-sib family analysis.

SOV	D.F	B	NL	PH	BY	SSC
		Mean		**Squares**		
B.HSF	19	12.711^{**}	9.7152^{*}	455.35^{**}	4170.11^{**}	6.413^{**}
RF	2	95.01^{*}	441.42^{**}	22160.0^{**}	610362^{*}	90.131^{**}
WRF	112	5.5101	0.7731	90.311	180.33	0.2775
		Components	**of**	**Variance**		
δ^2B	-	-0.0931	0.1976	0.31015	834.16	0.5216
δ^2P	-	250.24	15.152	70.856	18612.60	3.1801
δ^2W	-	0.1541	0.0614	14.214	181.33	0.3153
δ^2T	-	250.30	15.411	85.380	19628.09	4.017

B.HSF=between half-sib families, RF=replication in families, WRF= within replication in families, δ^2B =variance among half-sib families, δ^2P =variance due to interaction of half-sib families within replication, δ^2W =variance within half-sib family line δ^2T =total genetic variance, SOV=source of variation, D.F=degree of freedom

Mean squares and components of variance estimate

The analysis of variance showing mean squares and components of variance is presented in table 2. The analysis of variance indicated by the mean squares showed significant differences among genotypes for all the traits which indicate notable genetic variability among the parents and the crosses derived from them, suggesting that these traits will respond to selection. According to Falcona, (1989), the amount of improvement obtained by selection among crosses is dependent on the amount of genetic variability and the selection intensity.

Table 3. Estimate of yield parameters in different population types.

Traits	Pop.Type	Mean	Range	C.V
Bulb wt	100RSB	300	65-350	35.0
	20MB	160	55-285	38.0
	HSF	180	65-290	36.0
S.solid	100RSB	4.0	2.5-6.5	20.0
	20MB	6.5	5.0-8.0	8.0
	HSF	10.5	6.6-9.5	10.0

RSB=randomly selected bulbs, MB=mother bulbs, HSF=half-sib family, C.V=coefficient of variability, Pop. =population, S=soluble, wt=weight.

Table 4. Phenotypic (Upper) and Genotypic (Lower) correlation coefficient between five traits in onion.

Traits	B	NL	PH	BY	SSC
B		0.181360^{ns}	0.071932^{ns}	0.210101^{ns}	-0.17631^{ns}
NL	0.211420^{ns}		0.443101^{**}	0.613010^{**}	-0.49530^{*}
PH	0.173147^{ns}	0.411131^{**}		0.610015^{**}	-0.61325^{**}
BY	0.444631^{*}	0.653100^{**}	0.401090^{*}		-0.88753^{**}
SSC	-0.22730^{ns}	-0.46310^{*}	-0.66541^{**}	-0.95603^{**}	

^{ns}=not significant, *=significant p-0.05 **=highly significant p=0.01

Highly significant and positive component of variance among half-sib families (δ^2B) observed for bulb yield (834.16) with high error variance (δ^2W) of (181.33) is a good indication of high genetic variability among the genotypes for this trait implying that they will respond positively to selection when appropriate method is used. Similar trend was observed be Christopher, *et al.*, (2001) in which high values for yield was recorded with corresponding high error variance and suggested that, the high components of variance values are due to plant vigor which lead to variation in yield and could be a common phenomenon in onions.

Estimate of yield parameters

The mean, range and coefficient of variation for bulb weight and soluble solid content in the different onion population types which includes 100 randomly selected bulbs (RSB), 20 mother bulbs (MB) and the half-sib families (HSF) is presented in table 2.

It was observed that that the 100RSB had the least soluble solid content (4.0) followed by the MB with 6.5 and HSF having 10.5 the coefficient of variation was higher for RSB (20) but lower in the MB (8.0) with the HSF having (10.0). bulb weight ranges from (65-350) in the RSB, (55-285) in MB and (65-290) in the HSF with mean values of (300, 160 and 180) respectively. The mean bulb weight decreases as selection increases. The RSB had the highest mean weight followed by the HSF while the MB had the least. The soluble solid content for the HSF was the highest, being generated from the MB thereby showing slight improvement in the trait due to selection pressure of 20 percent exerted. Similar trend was followed for range and coefficient of variation for the trait, further showing positive effect of selection. Mohanty, (2001) reported that characters showing wide range of variation provide ample scope for efficient selection.

Genotypic and phenotypic correlation coefficient

The genotypic and phenotypic correlation coefficient for the five traits reported is presented in table 4 below. Both genotypic and phenotypic correlations were not significant between bolting rate and all the traits studied, indicating that selecting this trait for improvement in the other traits is inconsequential, but its significant genotypic correlation with bulb yield implies that increase in bolters affect total yield positively. All the other traits had significant positive correlation with each other. Angarawai, (2008), observed that the genotypic correlation provides a measure of genetic association between characters which helps to identify important traits for selection program.

There is highly significant negative genotypic correlation between soluble solid, bulb yield and plant height. This also implies that, for any increase in these traits, there is a decrease in the amount of soluble solid content. This is in agreement with the previous findings by Nieuwhof, (1973) that smaller onion bulbs tend to have higher dry matter content as compared to larger bulbs.

Conclusion

The result of this study showed that, there is sufficient variability among the half-sib families of this local onion cultivar and that selection for most of the important traits in onion like bulb yield, plant height, number of leaves and soluble solid content would likely improve this cultivar genetically, also crosses between families has the tendency to complement weaknesses within traits. The presence of high heritability for soluble solid and bulb yield together with high genetic correlation observed in these traits suggest that genetic factors affecting these traits within families is of great importance among other factors, therefore, the traits can be exploited for breeding program involving them.

To meet the need of the farmers and consumers, inheritance studies is necessary to focus on genetic variability of local breeds to increase production through genetic improvement for the purposes of storability, processing and consumer quality in horticultural onion.

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