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Estimates of Heritability for Enhanced Storage Shelf Life and Early Maturity in Onions (*Allium cepa* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author AAG performed the statistical analysis, contributed in writing the protocol and wrote the first draft of the manuscript. Author LA developed the protocol, supervised the work and reviewed the first draft. Authors BMS and AAA supervised the field work and contributed in reviewing the first draft of the work. All authors read and approved the final manuscript.

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ABSTRACT

Thirty-seven Onion (*Allium cepa* L.) genotypes comprising of twelve parents (12) and twenty-five hybrids were evaluated at the *Fadama* Teaching and Research farm of the Department of Crop Science, Usmanu Danfodiyo University, Sokoto during the 2015/2016 dry season. The objective of the study was to estimate heritability, phenotypic coefficient of variation, the genotypic coefficient of variation and environmental coefficient of variation. The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. After harvesting, the genotypes were stored for five months under farmers practice. The analysis of the results indicated significant ($P < 0.05$) difference between the genotypes with respect to plant height, number of leaves per plant, leaf area, leaf area index, percentage bolting, days to maturity, bulb diameter, bulb height, average bulb weight, fresh bulb yield, cured bulb yield, and percentage weight loss after five months of storage. High phenotypic and genotypic coefficients of variation were observed. However, cured bulb weight recorded the highest values for both phenotypic (176.57%) and genotypic coefficients of variation (167.67%) followed by percentage bolting with 65.51 and 56.58% respectively. Days to maturity and plant height, on the other hand, recorded the lowest phenotypic coefficient of variation of (11.64 and 12.79% respectively) as well as genotypic coefficient of variation of 11.43 and 9.18%

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respectively. Percentage loss had the highest heritability (98.01%) while leaf area index had the lowest heritability of 14.11%. At the end of the research, it was concluded that all the characters were highly heritable with the exception of leaf area index.

Keywords: Shelf life; onions; heritability; genetic variability; GCV.

1. INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae, other members include shallot *(A. cepa* L. var. *aggregation G.* Don.), common garlic *(A. sativum* L.), leek *(A. ampeloprasum* L. var. *porrum* L.) and chive *(A. schoenoprasum* L.) [1]. It originated from tropical central or western Asia and has been cultivated for a long period of time [2]. The cultivated onion is grown under a wide range of climates from temperate to tropical, it is the most important member of the family Alliaceae with monocotyledonous and cross pollinating behaviour. It has diploid chromosome number 16 (2*n* = 16) [3]. Onion is a biennial vegetable crop; its economic yield is bulb. Bulb formation is complicated and environmental factors such day length, temperature, moisture, soil type, fertilisation, pests and diseases affect its yield. Onion cultivars do not always perform in the same way year in year out and environmental factors strongly affect the development of onion cultivars [4]. The total world production of onions in 2016 was 5,725,132 tons, out of which 1,912,077 tons were obtained from Africa, 1,482,734 tons from West Africa and 2247,475 tons from Nigeria. This tonnage were obtained from 253,661 ha, 94,094 ha. 64,094 ha and 15,339 ha with an average yield of 231.3 kg/ha globally, 203.2 kg/ha in Africa, 225.7 kg/ha and 161.3 kg/ha for West Africa and Nigeria respectively [5]. Onion is valued for its distinct pungent flavour and its essential ingredients cuisine. It is consumed around the year by all the sections of people throughout the world due to its healing properties in case of cardiac diseases, rheumatism, cancer, digestive disorders, blood sugar and prolong cough [6]. Onions are used both as foods and as seasoning; the immature bulbs are eaten raw or cooked and eaten as a vegetable [7]. Onion contains a phytochemical called Quercetin, which is effective in reducing cardiovascular diseases [8]. Heritability is defined as the proportion of the observed total variability that is genetic, its estimates from variance component give more useful information of genetic variation from the total phenotypic differences on individuals or families [9]. The objective of the study was to estimate heritability for enhanced storage shelf life and earliness in Onions.

2. MATERIALS AND METHODS

The experiment was conducted at *Fadama* Teaching and Research farm of Usmanu Danfodiyo University, Sokoto (Lat 13º 06' 28" N and Long 05º 12' 46" E) during the 2015/2016 onion season (October 2015 – April 2016). The climate is semiarid with a zone of savannah-type vegetation as part of the sub-Saharan Sudan belt of West Africa. falls in Sudan Savanna agro-ecological zone. The rainfall starts mostly in June and ends in October with a mean annual rainfall of about 350 - 700 mm. The temperature of Sokoto ranges from 40 to 15°C [10].

The experiment consists of 12 parents (Table 1) and 25 hybrids (Table 2) making 37 Onion genotypes. Seeds of the genotypes were raised in the nursery where the soil was thoroughly mixed with farmyard manure at the rate of 5.5 t/ha. A sunken bed of 3.5 m × 3 m was constructed, divided into 37 segments and irrigated for two days. Seeds of the genotypes were broadcasted in each segment and covered with millet stalk. The bed was irrigated daily and the stalks removed gradually after one week. The seedlings were then watered in the evening daily for ten days, then at three days' interval. The seedlings were allowed to grow for seven weeks and then transplanted. The land of the study experimental area was cleared off vegetation, ploughed and harrowed. The physical and chemical properties of the site were also determined before planting (Table 3).

The seedlings were laid out in a randomised complete block design with one row per treatment replicated three times. N.P.K; 15:15:15 was applied at 30kg N/ha, 30kg P_2O_5/ha and 30 kg K_2O/ha as a basal application and subsequently top dressed with 30 kg N/ha using urea at 3 WAT. Seedlings were planted at a spacing of 15cm × 20cm. Irrigation was at two days after planting and thereafter at five days' interval. The first and second weeding were done at 4^{th} and 8^{th} week after transplanting

Table 1. List of parents and their designations

S/N	Parent	Designation	S/N	Parent	Designation
1	Koriya Tounfafi Niger Republic	A	7	Yar Wurno	G
2	Yar Aka Aliero	B	8	Jar Albasa Illela	H
3	Yaska	C	9	Yar Tungar Tudu	I
4	Tasa	D	10	Jar Albasa Gwaranyo	J
5	Marsa	E	11	Kiba Gwaranyo	K
6	Yar Gigane	F	12	Yar Dawakin Kudu	L

S/N= Serial Number

(WAT). Data was collected on plant height (cm), number of leaves/plant, leaf area (cm_2), leaf area index, bolting percentage (%), days to maturity, bulb diameter (cm), bulb height (cm), fresh bulb weight (t/ha), cured bulb weight (t/ha) and percentage loss. After harvesting the cured bulbs were stored for five months, between the months of April and August. The climate is semiarid with a zone of savannah-type vegetation as part of the sub-Saharan Sudan belt of West Africa. falls in Sudan Savanna agro-ecological zone. Data collected ware analysed using Genstat 17th edition.

Broad sense heritability was estimated using the formulae described by Fehr (1987).

$h^2 = \frac{\delta_g^2}{\delta_{ph}^2}$ x 100

$GCV = \frac{\delta_g^2}{x} \times 100$

$PCV = \frac{\delta_{ph}^2}{x} \times 100$

$ECV = \mathrm{PCV} - \mathrm{GCV} \times 100$

Where:

GCV = Genotypic coefficient of variation
PCV = Phenotypic coefficient of variation
ECV= Environmental coefficient of variation
δ_g^2 = Genotypic coefficient of variation
δ_{ph}^2 = Phenotypic variance
x = Grand mean

Table 2. List of 25 hybrids

S/N	Gen	S/N	Gen
1	A× C	14	D × H
2	A × F	15	D × J
3	A× L	16	E × F
4	B × E	17	E × H
5	B × K	18	E × I
6	C × E	19	E × K
7	C × F	20	F × J
8	C × G	21	F × L
9	C × H	22	G × K
10	C × I	23	G × L
11	C × J	24	H × L
12	C × K	25	K × L
13	D × G		

S/N= Serial Number and Gen= Genotype

Table 3. Physical and chemical properties of soil of the experimental site at Kwalkwalawa village Sokoto

Parameters	0 – 15 cm	15 – 30 cm
Soil physical properties:		
Particle size distribution		
Sand (g/kg)	704	351
Silt (g/kg)	292	398
Clay (g/kg)	4	251
Ph	4.5	5.4
Soil chemical properties:		
Organic carbon (g kg^{-1})	10.6	10.2
Organic matter (g/kg)	18.3	17.6
N (g/kg)	0.84	0.42
P (g/kg)	1.04	0.94
Ca (mol/kg)	0.50	0.35
Mg (mol/kg)	0.20	0.15
K (mol/kg)	1.03	0.97
Na (mol/kg)	1.00	0.87
CEC (mol/kg)	6.36	5.06

3. RESULTS

The highest phenotypic variance and genotypic variances were observed in leaf area (880.16 and 453.70 respectively) followed by Bolting percentage (258.46 and 192.77). High phenotypic and genotypic coefficients of variation were observed. However, cured bulb weight had the highest values for both phenotypic (176.57%) and genotypic (167.67%) coefficients of variation followed by percentage bolting having 65.51 and 56.58% respectively. Days to maturity and plant height, on the other hand, recorded the lowest phenotypic coefficient of variation of 11.64 and 12.79%; respectively as well as genotypic coefficient of variation of 11.43 and 9.18%; respectively (Table 4). The highest broad sense heritability was observed in percentage loss (98.01%) followed by days to maturity with 96.39%. Leaf area index, on the other hand, had the lowest heritability of 14.11% (Table 4).

4. DISCUSSION

The values for phenotypic coefficient of variation (PCV) were higher than the genotypic coefficient of variation (GCV) values for all the traits (i.e positive environmental coefficient of variation (ECV)) which indicates the environmental role in trait expression. Higher PCV values than the GCV values have been reported by Khosa and Dhatt [11]. Deshmukh et al. [12] suggested that PCV and GCV values greater than 20% are regarded as high, values between 10% to 20% as medium, whereas values less than 10% are considered to be low. Bolting percentage, cured bulb weight, average bulb weight, fresh bulb weight, and percentage weight loss after five months recorded high PCV and GCV. A number of leaves per plant, leaf area and leaf area index on recorded high PCV and moderate GCV. Plant height recorded moderate PCV and low GCV. None of the characters had low PCV and low GCV. The genotypic coefficient of variance provides information about the genetic variability in the quantitative traits but it does not give any estimation of what amount of variation was heritable from the genotypic coefficient of variation [13].

High heritability (Broad sense) estimates for traits such as percentage loss, fresh bulb weight, average bulb weight, cured bulb weight, days to maturity and bulb length indicated that they can easily be selected for, which enhances the possibility of their breeding.

According to Puri et al. [14], if the estimate of broad-sense heritability of a particular trait is high, it indicates that environmental conditions have little impact on the phenotypic differences observed in the population. Those traits that had low heritability would not respond to selection easily, Obilana and Fakorede [15] reported that, if a character is influenced by environment, its heritability would be low in a population. Therefore, the low heritability observed in leaf area index indicates that the characters is highly influenced by the environment.

Table 4. Phenotypic variance (PVR), Genotypic variance (GV), Broad sense heritability (BSH), Phenotypic coefficient of variation (PCV), Genotypic coefficient of variation (GCV) and Environmental coefficient of variation (ECV) estimates for growth and yield characters

Traits	PVR	GVR	PCV (%)	GCV (%)	ECV (%)	BSH (%)
Plant height (cm)	39.68	20.45	12.79	9.18	3.61	51.54
Number of leaves per plant	4.90	2.64	21.19	15.58	5.62	54.02
Leaf area (cm^2)	880.17	453.70	23.45	16.84	6.61	51.55
Leaf area index	0.88	0.12	48.89	18.37	30.52	14.11
Bolting percentage (%)	258.46	192.77	65.51	56.58	8.93	74.59
Days to maturity	173.39	167.14	11.64	11.43	0.21	96.39
Bulb diameter (cm)	1.21	0.68	16.39	12.29	4.10	56.21
Bulb length	1.21	0.72	19.48	15.02	4.47	59.40
Cured bulb weight (cm)	99.18	89.43	176.57	167.67	8.90	90.17
Average bulb weight (kg)	0.004	0.004	40.85	38.57	2.29	89.12
Fresh bulb yield (kg/ha)	108.53	96.72	40.85	38.57	2.29	89.12
Percentage weight loss (%)	181.30	177.70	30.12	29.82	0.30	98.01

5. CONCLUSION

All the characters can easily be selected for cultivar development program with the exception of leaf area index. Therefore, the results of this experiment indicated that the parents used in this experiment can be used in Onion breeding programs, that involves improvement of any of the characters considered, more especially, storability (percentage loss) and earliness (days to maturity).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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