Original Research Paper

HETEROSIS FOR ENHANCED SHELF LIFE AND EARLINESS IN ONIONS (*Allium cepa* L.) GENOTYPES

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Abstract

Thirty-seven Onion (*Allium cepa* L.) genotypes comprising of twelve parents (12) and twenty-five hybrids were evaluated for enhanced storage shelf life and early maturity 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 research was to determine superior hybrids that can store as well as those that matures early. 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, yield and percentage loss after five months of storage. Cross B × K had the tallest plants (57.73 cm), B × E had the highest number of leaves/plant of 17, B × K had the broadest leaf area of 166.5 cm^2, B × E recorded the highest leaf area index of 4.704, H × L recorded highest bolting percentage of 69.45%, E × F recorded lowest number of days to maturity of 91 days, E × F recorded broadest bulb diameter of 8.75cm, D × H recorded tallest bulb height of 7.2 cm, B × E had the highest average bulb weight, fresh bulb yield and cured bulb yield of 0.282kg, 47t/ha, and 46.11t/ha respectively. Cross C × E had the least percentage loss of 23.60%, while E × F had the highest loss of 68.15%. Based on the results obtained. The cross C × E was recommended for storage while B × E was recommended for early maturity.

Keywords: Hybrid, heterosis, Shelflife, genotype.

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.) (Griffiths *et al.,* 2002). It originated from tropical central or western Asia and has been cultivated for a long period of time (Lonzotti, 2006). 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 behaviuor. It has diploid chromosome number 16 ($2n = 16$) (Khokhar, 2014). 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, fertilization, 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 (Seyede*et al.,* 2013).The total world production of onions in 2013 was

4,281,501 tons, out of which 648,247 tons were obtained from Africa, 267,164 tons from West Africa and 235,000 tons from Nigeria. These tonnages were obtained from 230,180 ha, 46,469 ha. 16,221 ha and 14,000 ha with average yield of 18,600.8 kg/ha globally, 13,950.1 kg/ha in West Africa, 16,470.3 kg/ha and 16,785.7 kg/ha for Nigeria (FAOSTAT, 2013). Onion is valued for its distinct pungent flavour and its essential ingredients cuisine. So it shows economical importance also, due to this perspective genomic technologies are also implemented to develop best quality products with developing its respective molecular markers, which can be also utilized for germ-plasm analysis and onion mapping (Jiffinvir s. Khosa , 2016). It is consumed round the year by all the sections of people through-out the world due to its healing properties in case of cardiac diseases, rheumatism, cancer, digestive disorders, blood sugar and prolong cough (Singh *et al.,* 2013). Onions are used both as foods and as seasoning; the immature bulbs are eaten raw or cooked and eaten as vegetable (Abubakar and Ado, 2013). Onion contains a phytochemical called Quercetin, which is effective in reducing cardiovascular diseases (Smith, 2003).According to Abubakar and Ado (2013), bulb Onion resembles maize with predominant out crossing, historical maintenance by open pollination, severe inbreeding depression and significant heterosisafter crossing among inbred lines. The objective of the study is to identify Onion hybrids that can be stored for at least five months without much loses as well as hybrids that mature early by determining their heterotic potentials

MATERIALS AND METHODS

The experiment was conducted at *Fadama*Teaching and Research farm of UsmanuDanfodiyo 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 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℃ (Arnborg, 1988).

The experiments consist 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 farm yard manure at the rate of 5.5 t/ha. A sunken bed of 3.5m × 3m 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 was also determined before planting (Table 3)

Table 1: List of parents and their designations

S/N	Parent	Designation	S/N	Designation	Parent
1	Koriya Tounfafi Niger	A	7	YarWurno	G
2	Yar Aka Aliero	B	8	Jar AlbasaIllela	H
3	Yaska	C	9	YarTungarTudu	I
4	Tasa	D	10	Jar AlbasaGwaranyo	J
5	Marsa	E	11	KibaGwaranyo	K
6	YarGigane	F	12	YarDawakin Kudu	L

S/N= Serial Number

Table 2: List of the 25 genotypes comprising of the parents and their 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 – 15cm	15 – 30cm
Particle size distribution		
Sand (g/kg)	704	351
Silt (g/kg)	292	398
Clay (g/kg)	4	251
Ph	4.5	5.4
Organic carbon (g/kg)	10.6	10.2
Organic matter (g/kg)	18.3	17.6
Nitrogen (g/kg)	0.84	0.42
Phosphorous (g/kg)	1.04	0.94
Calcium (mol/kg)	0.50	0.35
Magnesium (mol/kg)	0.20	0.15
Potassium (mol/kg)	1.03	0.97
Sodium (mol/kg)	1.00	0.87
CEC (mol/kg)	6.36	5.06

The seedlings were laid out in a randomized complete block design with one raw per treatment replicated three time. 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 4th and 8th week after transplanting (WAT). After harvesting the cured bulbs were stored for five months. 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. Data collected ware analyzed using Genstat 17th edition.

RESULTS AND DISCUSSION

Result of the study indicated significant difference between the parents and the crosses with respect to plant height, leaf number, leaf area, leaf area index, bolting percentage and days to maturity (Table 4). Significant difference was also observed between the genotypes with respect to bulb diameter, bulb length, yield and cured bulb weight (Table 5).

Plant height: Cross B × K had the longest height of 57.76cm, followed by cross B × E with 57.73cm and KL with 57.40cm. Cross A × F on the other hand had the shortest plant height of 36.41cm followed by Parent H with 39.53cm and cross C × J with 41.19cm (Table 4). Since all the genotypes that recorded longest plants were hybrids, the vigorosity could be as a result of heterosis. According to Renato *et al.* (2014) high leaf-area index could be as a result of greater height of hybrid plants, which indicates a consequently high rate of photosynthesis, suggesting the production of more photoassimilates to be stored as reserves in the bulb. These crosses had high leaf area index with B × E recording the highest leaf area index. Similar results were obtained by Renato *et al.* (2014) while evaluating eight hybrids of onion.

Number of leaves per plant: In terms of number of leaves cross B × E had the highest leaves number of 17 leaves followed by parent L with 15 leaves and D and E and E × I with 13 leaves each (Table 4). Cross C × L, C × K and D × G however had the least leaves number of 8 leaves followed by cross H × L, G × L, H, E × H, C × G and A × F with 9 leaves each (Table 4). Cross B × E had the highest number of leaves per plant and leaf area index. The high leaf area could be as a result of high number of leaves which is one of the major contributors to high leaf area and leaf area index. In the same vain, cross B × E had the greatest average bulb weight, fresh bulb weight (Yield) and also cured bulb weight. This indicates that the high number of leaves gave the cross an upper hand for photosynthesis resulting producing high assimilates leading to large bulb size and consequently high yield.

Leaf area: Cross B × K had the broadest leaf area of 166.5cm^2 followed by cross K × L and B × E with 166.4 cm^2 and 164.8 cm^2 respectively (Table 4). Cross A × F on the other hand had the least leaf area of 66.0cm^2 followed by parent H and cross C × J with 80.70cm^2 and 88.50cm^{2}respectively (Table 4). The high leaf area obtained by B × K and B × E could be as a result of the height of the genotypes and also their high number of leaves. Leaf area is a function of plant height and number of leaves. The genotypes that had the broadest leaf area also had the highest average bulb weight, fresh bulb weight, and cured bulb yield. This indicates that genotypes with broad leaf area could yield better than genotypes with small leaf area.

Leaf area index: In terms of leaf area index cross B × E had the highest leaf area index of 4.704 followed by parent L and cross E × I with 3.794 and 3.433 respectively. Cross A × F had the least leaf area index of 0.935 followed by parent H and K with 1.180 and 1.260 respectively (Table 4). Leaf area index is a function of leaf area, the high leaf area index obtained by cross B × E is as a result of high leaf area observed in B × E.

Bolting percentage: Cross H × L had the highest bolting percentage of 69.45% followed by E × I with 53.33. Cross B × E and parent D had no bolters (0%) while parent F and cross D × H had the list bolting percentage of 6.67% (Table 4). Bolting in onions is not preferred. This is because bolting is an attempt to reproduce; therefore, bolting will reduce bulb size since vegetative growth and consequently bulb size will be reduced at maturity and reproductive stage. Bolting is also negative for storage, during bolting a seed stem is produced which gives room for microorganisms that causes spoilage (bacteria and fungus) to have access to inner part of the bulbs thereby making the bulbs unfit for storage.

Days to maturity: With regard to days to 50% maturity, cross C × E had the highest number of days of 138days followed by C × I with 135 days, cross E × F on the other had the least number of days to 50% maturity of 91 days followed by E × K with 94 days followed by E × I and G × L with 95 days (Table 4). In this location (Sokoto) storage of fresh onions is a problem, therefore genotypes that matures early might be desirable for farmers that will like to harvest early and sale at the beginning of the season when the Onion

Bulb diameter: With respect to bulb diameter, cross E × F had the widest bulb with diameter of 8.75 cm followed by GL and B × E with 8.09 and 7.93 cm respectively (Table 5). Cross G

× K on the other hand had the least bulb diameter of 4.5 cm followed by C × J and D × I with 5.18 cm and 5.44 cm respectively (Table 5).

Bulb height: In terms of bulb height, cross D × H had the tallest bulb with height of 7.20 cm followed by parent C and L with 7.06 and 6.91 cm respectively (Table 5). Cross G × K, C × J and parent J on the other hand had the least bulb height of 3.30, 3.49, and 4.15 cm respectively (Table 5).

Average bulb weight: with respect to average bulb weight cross B × E weighed highest with weight of 0.2820 kg, followed by parent E with 0.2562 kg. Parent I on the other hand recorded the least weight of 0.0516 kg (Table 5).

Fresh bulb yield: The highest yield of 47 t/ha was obtained in Cross B × E followed by parent E and cross D × J with 42.70 and 41.45 t/ha respectively. Parent I on the other hand had the list yield of 8.60 t/ha followed by D × G and C × K with 9.10 t/ha and 12.25 t/ha respectively Cross B × E had highest bulb weight of 0.2820 kg followed by cross E × F with 0.2562 kg (Table 5).

Cured bulb weight: In terms of cured bulb weight cross B × E had the highest weight of 46.11 t/ha followed by parent E and cross J with 38.15 and 37.62 t/ha respectively. The least cured bulb weight was however recorded by parent I as 7.93 t/ha followed by D × G and K × L with 8.42 t/ha and 11.01 t/ha respectively (Table 5).

Percentage weight loss: With regards to percentage weight loss over five months, cross E × F had the highest loss of 68.15 % followed G × L and D × J with 67.35 % and 66.95 % respectively. Cross C × E on the other hand had the lowest percentage loss of 23.60 % followed by D × G and C × I with 26.10 % and 27.45 % respectively (Table 5).

Mid-parent heterosis: The result of mid-parent heterosis with respect to percentage weight loss over five months showed heterosis ranging from -65.37 % to 113.30 %. Cross B × E had the highest heterosis (MPH) of 113.30 % followed by E × I with 67.44 % . Cross C × J on the other hand had the least heterosis (MPH) of-65.37 % followed by C × K with -64.37 % (Table 6).

High parent heterosis: The result of high parent heterosis with respect to weight loss over five months showed high-parent heterosis ranging from -57.32 % to 106.36 %. Cross B × E however had the highest heterotic value of 106.36 % followed by F × J and K × L with 65.69 and 45.78 % respectively. Cross C × E on the other hand had the least heterosis of -57.32 % followed by D × H and C × I with -51.62 and -50.36 % respectively (Table 6).

Table 4:Effect of genotype on quantitative characters Onion evaluated during 2015/2016 dry season at UsmanuDanfodiyo University Teaching and Research Fadama Farm, Sokoto.

Treatment	Plant Height (cm)	Number Leave/plant	Leaf Area (cm)	Leaf Area Index	Bolting Percentage (%)	Days to Maturity
A	47.75^{a-h}	11^{c-f}	119.4^{a-h}	2.048^{d-j}	20.00^{g-l}	100^{cde}
A × C	44.31^{d-i}	10^{c-f}	103.2^{d-i}	1.640^{e-j}	26.67^{d-i}	112^{gh}
A × F	36.41^{i}	9^{def}	66.0^{i}	0.935^{j}	33.33^{c-g}	126^{l}
A × L	49.49^{a-h}	12^{cde}	127.6^{a-h}	2.446^{c-i}	46.67^{bc}	112^{gh}
B	56.7^{3ab}	12^{cde}	161.7^{ab}	3.146^{bcd}	20.00^{g-l}	126^{l}
B × E	57.73^{a}	17^{a}	166.4^{a}	4.704^{a}	0.00^{m}	98^{bcd}
B × K	57.76^{a}	10^{c-f}	166.5^{a}	2.643^{b-g}	39.45^{b-e}	99^{bcd}
C	52.54^{a-f}	11^{c-f}	141.9^{a-f}	2.602^{b-h}	20.00^{e-l}	112^{gh}
C × E	51.17^{a-g}	10^{c-f}	135.5^{a-g}	2.260^{c-j}	39.45^{b-f}	138^{n}
C × F	44.69^{d-i}	10^{c-f}	105.0d^{e-i}	1.808^{e-j}	26.67^{d-j}	129^{lm}
C × G	45.82^{c-i}	9^{def}	110.3^{c-i}	1.668^{e-j}	20.00^{e-l}	133^{mn}
C × H	52.48^{a-f}	10^{c-f}	141.7^{a-f}	2.302^{c-i}	20.00e^{f-l}	111^{gh}
C × I	46.29^{b-i}	10^{c-f}	112.5^{b-i}	2.012^{d-j}	46.67^{bc}	135^{n}
C × J	41.19^{ghi}	10^{c-f}	88.5^{ghi}	1.477^{f-j}	19.45^{g-l}	114^{hi}
C × K	47.33^{a-h}	8^{f}	117.4^{a-h}	1.504^{f-j}	13.33^{i-m}	118^{ij}
D	48.31^{a-h}	13^{bc}	122.0^{a-h}	2.679^{b-f}	0.00^{m}	107^{fg}
D × G	42.28^{f-i}	8^{ef}	93.6^{f-i}	1.302^{g-j}	20.00^{e-l}	133^{mn}
D × H	49.53^{a-h}	10^{c-f}	127.8^{a-h}	2.335^{c-i}	6.67^{ilm}	113^{hi}
D × J	55.04^{a-d}	12^{bcd}	153.8^{a-d}	3.214^{bcd}	13.33^{i-m}	105^{ef}

E	42.26^{f-i}	13^{bcd}	93.5^{f-i}	1.947^{d-j}	0.00^{m}	124^{jl}
E × F	55.87^{abc}	11^{c-f}	157.6^{abc}	2.881^{b-e}	13.33^{g-m}	91^{a}
E × H	45.29^{c-i}	9^{def}	107.8^{c-i}	1.556^{e-j}	26.67^{d-k}	111^{gh}
E × I	54.66^{a-e}	13^{bcd}	151.9^{a-e}	3.433^{bc}	53.33^{ab}	95^{abc}
E × K	49.81^{a-h}	10^{c-f}	129.1^{a-h}	2.077^{d-j}	19.45^{g-l}	94^{ab}
F	50.62^{a-g}	11^{c-f}	132.9^{a-g}	2.358^{c-i}	6.67^{i-m}	115^{hi}
F × J	46.39^{b-i}	10^{c-f}	113.0^{b-i}	1.883^{d-j}	13.33^{g-m}	109^{fgh}
F × L	46.29^{b-i}	10^{c-f}	112.5^{b-i}	1.892^{d-j}	26.67^{d-k}	125^{l}
G	52.32^{a-f}	10^{c-f}	140.9^{a-f}	2.283^{c-i}	20.00^{e-l}	118^{ijk}
G × K	55.83^{abc}	10^{c-f}	157.5^{abc}	2.625^{b-g}	20.00^{e-l}	112^{gh}
G × L	54.12^{a-e}	9^{def}	149.4^{a-e}	2.243^{c-j}	13.33^{g-m}	95^{a-d}
H	39.53^{hi}	9^{def}	80.7^{hi}	1.180^{ij}	26.67^{d-i}	118^{gh}
H × L	48.61^{a-h}	9^{def}	123.5^{a-h}	1.772^{e-j}	69.45^{a}	129^{lm}
I	45.70^{c-i}	11^{c-f}	109.7^{c-i}	1.941^{d-j}	40.00^{bcd}	101^{de}
J	53.12^{a-e}	10^{c-f}	144.7^{a-e}	2.408^{c-i}	41.12^{bcd}	115^{hi}
K	43.89^{e-i}	8^{f}	101.2^{e-i}	1.267^{hij}	26.67^{d-k}	96^{a-d}
K × L	57.40^{a}	12^{cde}	164.8^{a}	3.176^{bcd}	19.43^{g-l}	125^{l}
L	53.90^{a-e}	15^{ab}	148.4^{a-e}	3.794^{ab}	33.33^{c-h}	98^{bcd}
Significance	**	**	**	**	**	**
C.V (%)	10.9	17.7	20.0	29.4	36.9	2.7
S.E	3.100	1.513	14.600	0.383	5.748	1.768
F Pr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: Treatment Means assigned with the same letters are not statistically different at 5% level of significance Duncan's New Multiple Range Test (DNMRT). **= Highly significant.

Table 5: Effect of genotype on quantitative characters Onion evaluated during 2015/2016 dry season at UsmanuDanfodiyo University Teaching and Research Fadama Farm, Sokoto.

Treatment	Bulb Diameter (cm)	Bulb Height (cm)	Average Bulb Weight (kg)	Fresh bulb weight (t/ha)	Cured Bulb Weight (t/ha)	Weight loss (%)
A	7.82^{a-d}	6.18^{a-g}	0.2292^{b}	38.20^{b}	37.57^{b}	54.90^{opq}
A × C	6.61^{b-i}	6.17^{a-g}	0.1497^{e-j}	24.95^{e-j}	24.68^{d-h}	41.35^{jk}
A × F	$6.00e^{f-j}$	5.31^{c-i}	0.0978^{k-o}	16.30^{k-o}	14.91^{k-o}	32.75^{def}
A × L	6.95^{b-i}	5.87^{a-g}	0.1497^{e-j}	24.95^{e-j}	24.65^{d-h}	46.90^{lm}
B	6.03^{e-j}	5.71^{a-i}	0.2403^{ab}	40.05^{ab}	39.39^{b}	32.25^{def}
B × E	7.93^{abc}	4.55^{g-k}	0.2820^{a}	47.00^{a}	46.11^{a}	66.55^{rs}
B × K	7.66^{a-e}	5.77^{a-h}	0.2253^{bc}	37.55^{bc}	36.95^{b}	57.15^{pq}
C	7.43^{a-f}	7.06^{ab}	0.1014^{j-n}	16.90^{j-n}	16.13^{j-n}	55.30^{opq}
C × E	5.57^{g-j}	5.41^{b-i}	0.1422^{e-k}	23.70^{e-k}	21.93^{e-k}	23.60^{a}
C × F	6.05^{d-j}	6.12^{a-g}	0.1266^{g-l}	21.10^{g-l}	19.47^{g-l}	30.60^{cde}
C × G	6.53^{b-i}	6.29^{a-f}	0.1407^{e-k}	23.45^{e-k}	21.00^{f-k}	27.90^{bc}
C × H	7.14^{a-h}	6.80^{a-d}	0.1209^{h-m}	20.15^{h-m}	19.04^{h-m}	49.40^{mn}
C × I	5.98^{e-j}	6.80^{a-d}	0.1356^{e-l}	22.60^{e-l}	20.88^{f-l}	27.45^{abc}
C × J	5.18^{ij}	5.38^{b-i}	0.1731^{d-g}	28.85^{d-g}	26.69^{c-g}	39.30^{hij}
C × K	5.66^{f-j}	4.76^{f-k}	0.0735^{mno}	12.25^{mno}	11.21^{no}	37.00^{ghi}
D	7.27^{a-g}	4.92^{e-k}	0.1818^{cde}	30.30^{cde}	29.53^{cd}	53.95^{op}
D × G	6.25^{c-j}	6.39^{a-f}	0.0546^{no}	9.10^{no}	8.48^{o}	26.10^{ab}

D × H	6.92^{b-i}	7.20^{a}	0.1317^{f-l}	21.95^{f-l}	20.74^{f-l}	42.05^{jk}
D × J	8.00^{abc}	4.15^{h-k}	0.2487^{ab}	41.45^{ab}	37.45^{b}	66.95^{rs}
E	6.36^{b-i}	4.80^{e-k}	0.2562^{ab}	42.70^{ab}	38.15^{b}	30.15^{b-e}
E × F	8.75^{a}	6.84^{abc}	0.1554^{e-i}	25.90^{e-i}	23.13^{d-j}	68.15^{s}
E × H	5.50^{g-j}	4.88^{e-k}	0.181^{5cde}	30.25^{cde}	27.11^{c-f}	38.05^{g-j}
E × I	7.87^{abc}	6.50^{a-e}	0.2259^{bc}	37.65^{bc}	33.65^{bc}	64.95^{rs}
E × K	7.19^{a-h}	5.11^{d-j}	0.1293^{f-l}	21.55^{f-l}	19.94^{f-l}	51.65^{no}
F	7.16^{a-h}	5.95^{a-g}	$0.1350e^{f-l}$	22.50^{e-l}	20.12^{f-l}	51.25^{no}
F × J	7.02^{a-h}	5.90^{a-g}	0.0897^{l-o}	14.95^{l-o}	13.41^{l-o}	48.80^{mn}
F × L	5.87^{fg-j}	4.03^{ijk}	0.1602^{e-h}	26.70^{e-h}	24.07^{d-i}	33.95^{efg}
G	6.96^{b-i}	5.70^{a-i}	0.2169^{bcd}	36.15^{bcd}	32.52^{bc}	46.20^{lm}
G × K	4.50^{j}	3.30^{k}	0.1116^{h-m}	18.60^{h-m}	16.79^{i-n}	40.15^{ijk}
G × L	8.09^{ab}	6.84^{abc}	0.1077^{i-m}	17.95^{i-m}	16.07^{j-n}	67.35^{s}
H	5.69^{f-j}	5.46^{b-i}	0.0738^{mno}	12.30^{mno}	11.80^{mno}	35.05^{fgh}
H × L	6.72^{b-i}	6.11^{a-g}	0.1134^{h-m}	18.90^{h-m}	16.87^{i-n}	29.40^{bcd}
I	6.48^{b-i}	5.91^{a-g}	0.0516^{o}	8.60^{o}	7.93^{o}	39.20^{hij}
J	5.44^{hij}	3.49^{jk}	0.2439^{ab}	40.65^{ab}	37.62^{b}	43.85^{kl}
K	7.72^{a-e}	5.41^{b-i}	0.1767^{def}	29.45^{def}	28.93^{cde}	59.05^{q}
K × L	6.00^{e-j}	4.80^{e-k}	0.0736^{mno}	12.27^{mno}	11.01^{no}	32.25^{def}
L	7.85^{abc}	6.91^{abc}	$0.1527e^{f-i}$	25.45^{e-i}	$22.93d^{e-j}$	63.05^{r}
Significance	**	**	**	**	**	**
C.V (%)	13.3	15.2	16.5	16.5	16.1	5.2
S.E	0.515	0.4951	0.01458	2.430	2.208	1.343
F Pr	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Note: Treatment Means assigned with the same letters are not statistically different at 5% level of significance Duncan's New Multiple Range Test (DNMRT). **= Highly significant

Table 6: Mid parent and High Parent heterosis for weight loss and early maturity for 19 cross evaluated during 2015/2016 dry season at UsmanuDanfodiyo University Teaching and Research Fadama Farm, Sokoto.

	Weight Loss		Maturity	
Cross	MPH (%)	HPH (%)	MPH (%)	HPH (%)
A × C	-24.95*	-24.68*	5.8ns	0.0ns
A × F	-38.29**	-40.35**	17.2ns	9.6ns
A × L	-0.32*	-14.57*	13.3*	12.3*
B × E	113.30*	106.36**	-21.7*	-22.5*
B × K	25.19*	-3.22*	-40.0**	-47.2**
C × E	-44.76**	-57.32**	17.1ns	11.7ns
C × F	-42.56*	-44.67*	13.2*	14.6*
C × G	-45.02**	-49.55**	15.4*	12.4*
C × H	9.35ns	-10.67ns	-0.6ns	-0.9ns
C × I	-41.90*	-50.36*	26.9*	20.5*
C × J	-65.37**	-28.93**	-65.4**	-65.8**
C × K	-64.42**	-37.34**	-64.4**	-67.0**

D ×G	-0.21*	6.78*	-9.2*	-14.9*
D × H	-47.88**	-51.62**	18.1ns	12.4ns
D × J	-5.51*	-22.06*	3.3ns	1.2ns
E × F	-5.85*	-18.72*	10.3ns	7.2ns
E × H	36.91**	24.10**	-39.7**	-41.8**
E × I	67.44*	32.98*	-24.0*	-26.6*
E × K	-11.82*	-25.76*	-5.9ns	-10.4ns
F × J	43.62ns	65.69ns	-15.7*	-23.4*
F × L	-53.05*	-12.53*	-53.0**	-58.3**
G × K	-57.57**	-4.78**	-57.6**	-57.6**
G × L	-40.59**	-46.15**	16.9*	8.4*
H × L	-62.48**	-32.01**	-62.5*	-66.0*
K × L	23.30ns	45.78ns	-12.0*	-19.4*

Note: MPH = Mid-parent heterosis, HPH = High-parent heterosis, *= significant, ** = highly significant and ns = not significant.

DISCUSSION

The analysis of the results indicated that the genotypes differ with respect to plant height, this could be attributed to the effect of genotype. The three tallest genotypes i.e Cross B × K, B × E and K × L were hybrids indicating that heterosis for plant height in onions could be achieved.

The result observed variation in days to maturity, this may be due to the effect of the genotypes. There was also significant difference between the genotypes with respect to percentage weight loss over five months. With cross C × E, D × G, and C × I having the least weight loss. However the crosses and parents that matured early had wide bulb diameter and did not store well, this could be as a result of the short period they took on field which resulted in high moisture content, large bulb size and consequently low dry mater content. Yemane*et al.* (2013) concluded that the inability of Bombay Red to store well in their experiment could be as a result of its early maturity which resulted to large bulb size and low dry matter content. They however recommended the variety for immediate use after harvest. Martinez *et al.* (2005) reported storage quality to be negatively correlated with some bulb characteristics such as bulb diameter. Sorensen and Grevsen, (2001) also observed increased incident of neck rot disease in early harvested onion bulbs during storage. Big size Onion bulbs have been reported with highest juice and more weight loss in ambient storage (Sing and Sing, 2003). In terms cured bulb yield cross B × E had the highest mean followed by parent E and cross D × J, the significant difference observed could be as a result of the effect of genotype. The average yield obtained is by far greater than the FAOSTAT (2012) world average (18.68 t/ha), this indicates that famers might obtain yields higher than the world average with this cross.

The result of the study also revealed significant negative heterosis for the crosses evaluated for both storage loss and days to maturity. Excellent performance of hybrid onions ware reported by Holand (1960). Crosses D × G, C × G, C × E and C × I had the highest negative heterosis in terms of weight loss these could be excellent hybrid cultivars for the characters in this location. However, with regard to early maturity cross B× E, C× H, C × L, E × F, E × H, E × I, and G × L had negative heterosis, indicating that this crosses has the potentials of being used as commercial hybrids for early maturity. Earliness in onion hybrids also noticed by Veere Gowda (1988), and Netrapal and Singh (1999) in their studie

CONCLUSION

The results conclude that cross C × E is recommended for storage since it has appreciable cured bulb weight with the least storage loss, while B × E recommended for early maturity although it is not the earliest but it has the best yield.

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