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Full Length Research Article

Variability Pattern for Resistance to Purple Blotch (*Alternaria porri*) Disease of Onions (*Allium cepa* L.) in North Western Nigeria

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ABSTRACT: Five onion cultivars Red Creole, Kaharda, Koumassa, Sokoto local and ori were selected on the basis of diverse genetic backgrounds with respect to resistance to *Alternaria porri* (Ellis.) Cif. The cultivars were crossed in a complete diallel, the 25 F_1s generated and their parents were evaluated in replicated yield trials at Sokoto in Sokoto State and Talata Mafara in Zamfara State, Nigeria, during the 2004/2005 and 2005/2006 dry seasons. The experiments were laid out in a randomised complete block design (RCBD) with three replications. Analysis of the variance component for the combined seasons and locations indicate that genotypic variance was greater than the environmental variance for all characters under consideration with exception of bulb weight. Disease incidence recorded 31.20%, 30.58% and 5.42% as phenotypic, genotypic and environmental coefficients of variability. Disease severity recorded 34.96%, 32.84% and 11.00% as phenotypic, genotypic and environmental coefficients of variability. With respect to fresh bulb yield 94.90%, 93.53% and 15.78% were observed as phenotypic, genotypic and environmental coefficients of variability for the genotypes. Cured bulb yield recorded 103.47%, 102.27% and 14.96% respectively as phenotypic, genotypic and environmental coefficients of variability. Similarly 29.43%, 24.79% and 17.91% were observed for days to maturity, as phenotypic, genotypic and environmental coefficients of variability. Variability was found to exist among the genotypes for the various characters they were evaluated for.
Keywords: Variability, Resistance, Purple Blotch, Disease, Onions

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the genus *Allium*, of the family *Alliaceae* (Messiaen, 1994). It is a large genus containing five hundred or more species and despite the similarities, which bring the species together, the genus is a strikingly diverse one (Jones and Mann, 1963). There are five important species of the cultivated *Allium* of which the onion crop is the most important (Messiaen, 1994).

In Nigeria the crop is second only to tomatoes in importance among the vegetables and is mainly grown for its bulbs (Hussaini *et al.*, 2000). The demand for onion is world wide, with a production of 56.80, 4.26 and 1.06 million metric tonnes of dry bulb for the world, Africa and West Africa respectively, and 615, 000 metric tonnes for Nigeria in 2004 (FAOSTAT, 2004). Similarly, in 2004, 3.09 million hectares were cultivated with onion the world over. In Africa, West Africa and Nigeria 280,059 ha, 61,160 ha and 41,000 ha were cultivated with onions in 2004 (FAOSTAT, 2004). However, global average yield of onion in 2004 has been estimated at 18.3 tonnes/ha, with 15.21 tonnnes/ha for Africa, 15.187 tonnes/ha for West Africa and 15 tonnes/ha for Nigerian (FAOSTAT, 2004).

Onions are used both as food and seasoning, the immature and mature bulbs are eaten raw or they may be cooked and eaten as a vegetable (Messiaen, 1994). They also contain a phytochemical called quercetin, which is effective in reducing the risk of cardiovascular disease, an anticancer, and has promise to be an antioxidant (Smith, 2003).

Onion varieties were reported to differ widely in composition, from those with firm bulbs of high dry matter content to those with soft bulbs of low dry matter content, and from high to low pungency (Mc Callum *et al*., 2001). Varietal differences and high coefficients of variation in quercetin levels between onion varieties have been reported (Smith, 2003), with red and yellow onions having higher concentration and white onions having lower concentration. Onions like other vegetables are susceptible to numerous foliar, bulb and root pathogens that reduce yield and quality (Cramer, 2000). Purple blotch of onion caused by *Alternaria porri* is an important disease of onions worldwide (Chaput, 1995, Cramer, 2000 and Schwartz *et al*., 2005) especially in warm and humid environments (Suheri and Price, 2000). Green (1972) reported that wet season trials at IAR Samaru, Nigeria were associated

with decline in production, which was attributed to attack by leaf pathogens especially *A. porri.* The fungus attacks both leaves and flower stalks (Bock, 1964), reducing foliar production by 62-92% (Suheri and Price, 2001). The disease can cause a yield loss of 30% (Everts and Lacy, 1990) and 100% of the seed crop when the weather is favourable (Daljeet *et al*., 1992 and Schwartz, 2004).

This study was undertaken with a view to determining the existence of genetic variability for resistance to purple blotch disease of onion, which could serve as a basis for future breeding for resistance against the disease.

MATERIALS AND METHODS

Seeds of five onion varieties Red Creole (H), Kaharda (I), Koumassa (A), Sokoto Local (G) and Ori (E) were crossed in a complete diallel mating to generate diversity for resistance to purple blotch disease (Table 1) during the 2003/2004 onion growing season (October 2003 – May 2004). Sokoto local was also chosen because it is the local standard cultivar. Seeds of the varieties were raised in a nursery where the soil was thoroughly mixed with farmyard manure at the rate of 5.5 tonnes/ha (NAERLS, 1993). The seedlings were allowed to grow for a period of forty- nine days and later transplanted into plastic pots of 1458cm^3. The seedlings were allowed to grow to form bulbs. Bulbs generated were then cut across to encourage flowering and planted into plastic pots of the same dimension for growth up to flowering. At flowering diallel cross was made among the five varieties in all possible combinations giving rise to twenty-five progenies, including the crosses, selfs and the reciprocals.

Table 1: Description of the five onion varieties used in the study

Variety	Source	Description	Purple blotch resistance rating
Red Creole	Seminis Vegetable Seeds. Los Angeles, California, U.S.A.	Red, long storage, flattened, globe shape. Long season to maturity and low yields, short day 'Asgrow' brand. Selected for growing in the hot and humid environment of Louisiana, U.S.A.	Highly resistant
Kaharda	Office National des Am'enagements Hydro-agricoles (ONAHA), Konni, Niger Republic.	Light red, late maturing.	Resistant
Koumassa	Institut National de Recherches Agronomiques du Niger (INRAN), Maradi, Niger Republic	Red, late maturing.	Moderately Resistant
Sokoto local	Farmers collections from Kwalkwalawa village, Wamakko Local Government Area, Sokoto State	Brown, flat globe and late maturing	Susceptible
Ori	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Sadore, Niamey, Niger Republic. Bred by Hazera, Israel.	Texas Grano type, early maturing, matures very uniformly, light brown skin, short storage.	Highly susceptible

The twenty five progenies and their parents were evaluated over two onion growing seasons (2004/2005 and 2005/2006) at two locations: Sokoto (Kwalkwalawa village; latitude 13^0 06' 28" N and longitude 05^0 12' 46" E) in Sokoto State and T/Mafara (latitude 12^0 13' 18"N and longitude 06^0 05' 05" E and altitude 1150m) in Zamfara State of Nigeria. In each field trial the genotypes were laid out in a Randomised Complete Block Design (RCBD) and replicated three times at each location and growing season. The total farm area was 333m^2 per season, with a plot size of 1.8m x 1.5m of sunken beds. The genotypes were:

1 = A ,	2 = E,	3 = G,	4 = I,
5 = H,	6 = A x E,	7 = A x G,	8 = A X I,
9 = A X H,	10 = A X A,	11 = E X A,	12 = E X G,
13 = E X I,	14 = E X H,	15 = E X E,	16 = G X A,
17 = G x E,	18 = G x I,	19 = G x H,	20 = G x G,
21 = I x A,	22 = I x E,	23 = I x G,	24 = I x H,
25 = I x I,	26 = H x A,	27 = H x E,	28 = H x G,
29 = H x I	30 = H x H		

Seeds for all the experiments were broadcasted on 15th of October of each year in a nursery. In the nursery farmyard manure at the rate of 5.5 tonnes/ha (NAERLS, 1993) was thoroughly incorporated into the soil of the nursery beds, thereafter sunken beds of 2m x 1m dimensions were made. The soil was made into fine tilth after removing large stones and stumps and watered then left for two days. Seeds of the genotypes for evaluation were separately broadcast into the sunken beds and mulched with millet stalks and irrigated. One week after germination the mulch materials were removed from the beds. The seedlings were thereafter watered (irrigated) in the evenings at two days interval initially and later at five days interval until the time of transplanting.

Transplanting of the seedlings was carried out forty nine days after sowing (7 WAS). The seedlings were removed from the seedbeds after watering to moisten the soil. At the field sites, the seedlings were transplanted at a spacing of 30cm between rows and 15cm within rows. Each plot consisted of six rows of ten plants/ row, the genotypes being evaluated were planted in the two middle rows of each plot and the other four rows were planted with a guard row onion variety (Aleiro variety). No fertilizer was applied to the fields because according to Awad *et al*. (1978) application of nitrogen to onion plants increases susceptibility to purple blotch disease due to the production of succulent leaves, while addition of potassium and calcium super phosphate improves resistance to purple blotch.

Soil tests were conducted at both locations and for both seasons. The results of the soil analysis indicate that the soil at Sokoto is sandy loam while at Talata Mafara the soil is loamy sand.

The inoculation of the field was carried out at two weeks after transplanting allowing the seedlings to overcome the transplanting shock, and also close enough to 10 WAS when the varieties used in the study were at the 5-7 leaf stage. This is in accordance with Arboleya *et al.* (2003) who reported that plants should be inoculated at 5-7 leaf stage. Thirty mls of 10^{-1} *cfu* of the spore suspension of *Alternaria porri* was poured in the centre of each plot immediately after irrigation.

The first three irrigations of the fields after transplanting were carried out every four days. Thereafter, irrigations were maintained at five day interval up to harvest. At Sokoto irrigation was by flooding method using water pump, while at Talata Mafara irrigation was by flooding using the gravity method, using water from canals constructed by the Bakolori irrigation project. No sprays of any kind were carried out. Three weedings were carried out during each season at each location.

Harvesting was carried out when more than 50 % of the tops were down for all the materials. The crops were carefully harvested using hoes to bring the bulbs to the surface of the soil, while the upper parts of the plants were cut with knives and sickles to separate the bulbs from the tops level with the neck. The harvested bulbs were cured by spreading them on the floor of a ventilated room and allowed to dry for ten days.

Data on fresh bulb yield (kg/ha), cured bulb yield (kg/ha), average bulb weight (g) were determined by weighing ten bulbs. Bulb diameter was determined using a vernier calliper for ten bulbs, and days to maturity was recorded when 50 % tops were down for each plot. Number of leaves/plant were counted at maturity. Disease incidence (%) and disease severity were assessed fortnightly. Disease incidence was determined according to Tarr (1981):

$$\text{DiseaseIncidence}(\%) = \frac{\text{Numberof diseased plants}}{\text{Totalnumber of plants}} \text{x} 100$$

Diseased plants were plants that had sunken spots on leaves, which later enlarged to become purple with a yellow halo, and elongated destroying the leaf tissue and eventually causing the bulb to rot. Disease severity was determined for each plot on the basis of standard procedures recommended by the International Plant Genetic Resource Institute, Rome, Italy. The rating was in the following order: 1= Highly resistant, 2 = Resistant, 3 = Moderately resistant, 4 = Susceptible and 5 = Highly susceptible (IPGRI *et al.,* 2001).

Data collected were statistically analysed using the Statistical Analysis Systems (SAS)(1996) computer package. Means were subsequently separated using the Duncan's New Multiple Range Test. The statistical model used for the combined analysis over seasons and locations was a mixed model given by Obi (1986) as:

$$Y_{ijkl} = \mu + G_i + L_j + S_k + RL + (GL)_{ij} + (GS)_{ik} + (LS)_{jk} + (GLS)_{ijk} + e_{ijkl}$$

Where,
Y_{ijkl} = the observation on i^{th} genotype in j^{th} environment in k^{th} replication
μ = the general mean
G_i = the effect of genotypes
L_j = the effect of location
S_k = the effect of season
RL = the effect of replication within season and location
$(GL)_{ij}$ = the effect of genotype x location interaction
$(GS)_{ik}$ = the effect of genotype x season interaction
$(LS)_{jk}$ = the effect of location x season interaction
$(GLS)_{ijk}$ = the effect of genotype x location x season interaction
e_{ijkl} = is the error effect associated with $ijkl^{th}$ observation

MS subscript: The observed mean squares of the subscript effect. The components of variance were estimated from the mean squares for each character by using the observed mean squares.

$\delta_e^2 = MS_1$ and

$$\delta_g^2 = \frac{MS_2 - MS_1}{r}$$

$$\delta_{ph}^2 = \frac{MS_2 - MS_1}{r} + MS_1$$

Genotypic, Phenotypic and environmental coefficients of variation were determined using methods of Burton (1951)

$$GCV(\%) = \frac{\sqrt{\delta_g^2}}{\bar{\chi}} \times 100$$

$$PCV(\%) = \frac{\sqrt{\delta_{ph}^2}}{\bar{\chi}} \times 100$$

$$ECV(\%) = \frac{\sqrt{\delta_e^2}}{\bar{\chi}} \times 100$$

where,
GCV = Genotypic coefficient of variation
PCV = Phenotypic coefficient of variation
ECV = Environmental coefficient of variation,
$\bar{\chi}$ = mean

RESULTS

During the 2004/2005 season at Sokoto, estimates of components of variation indicate that disease incidence, disease severity, fresh and cured bulb yields and number of leaves per plant recorded higher genotypic variance (519.24, 1.41, 7502197.80, 4822689.7, and 2.47) than the environmental (18.07, 0.61, 205888.30, 103184.10, and 2.37) component of variation (Table 2). While bulb diameter (1.23), average bulb weight (304.55) and days to maturity (2.37) recorded higher environmental variance component (Table 4). Similarly the genotypic coefficient of variability was higher than the environmental coefficient for all the characters with the exception of bulb diameter, average bulb weight and days to maturity, where the environmental was higher (Table 2). Components of variation estimates for Sokoto during the 2005/2006 season followed a similar pattern as that observed during the previous season in the same location (Table 3).

During the 2004/2005 season at Talata mafara, higher genotypic variance was recorded for all the characters under consideration than the environmental variance (Table 4). The characters also recorded higher genotypic coefficient of variability than the environmental coefficient during the season. Similar results were also obtained during the 2005/2006 season at same location (Table 5).

In the combined analysis across seasons and locations disease incidence, disease severity and fresh and cured bulb yields recorded high estimates of genotypic components of variation (Table 6). Bulb diameter, bulb weight, days to maturity and number of leaves/plant, however, recorded relatively low genotypic components of variation. Similarly fresh and cured bulb yields recorded high genotypic coefficient of variability (Table 6). Bulb diameter, days to maturity and number of leaves/plant recorded low genotypic coefficient of variability. Bulb weight, however, recorded relatively high environmental coefficient of variability.

Table 2: Components of variation and coefficients of variability for eight characters of onions at Sokoto during 2004/2005 season

Characters	Components of Variation			Coefficient of Variability (%)		
	Phenotypic	Genotypic	Environmental	Phenotypic	Genotypic	Environmental
Disease incidence	553.47	536.71	16.76	37.45	31.83	5.62
Disease severity	3.62	1.62	2.00	46.10	34.18	11.92
Fresh bulb yield	7741351.90	7551813.30	189538.60	104.27	90.01	14.26
Cured bulb yield	4935273.20	4843549.60	91723.60	112.13	98.56	13.56
Bulb diameter	2.24	1.30	0.94	43.11	23.31	19.80
Bulb weight	330.24	146.65	183.59	53.84	25.41	28.43
Days to maturity	2338.95	1530.90	808.05	41.94	24.29	17.65
No. of leaves/plant	5.36	3.40	1.96	47.80	27.18	20.62

Table 3: Components of variation and coefficients of variability for eight characters of onions at Sokoto during 2005/2006 season

Characters	Components of Variation			Coefficient of Variability (%)		
	Phenotypic	Genotypic	Environmental	Phenotypic	Genotypic	Environmental
Disease incidence	537.31	519.24	18.07	37.31	31.44	5.87
Disease severity	1.57	1.41	0.61	42.49	31.71	10.78
Fresh bulb yield	7708086.10	7502197.80	205888.30	104.56	89.70	14.86
Cured bulb yield	4925873.80	4822689.70	103184.10	112.73	98.34	14.38
Bulb diameter	1.95	0.72	1.23	39.12	16.93	22.19
Bulb weight	338.70	34.15	304.55	49.13	12.32	36.81
Days to maturity	1992.53	731.73	1260.80	38.32	16.57	21.75
No. of leaves/plant	4.84	2.47	2.37	45.08	22.76	22.32

Table 4: Components of variation and coefficients of variability for eight characters of onions at Talata mafara during 2004/2005 season

Characters	Components of Variation			Coefficient of Variability (%)		
	Phenotypic	Genotypic	Environmental	Phenotypic	Genotypic	Environmental
Disease incidence	515.39	498.56	16.83	35.56	30.04	5.52
Disease severity	1.67	1.49	0.18	43.84	32.57	11.27
Fresh bulb yield	7689573.10	7459192.40	230380.70	115.96	98.62	17.33
Cured bulb yield	4874544.60	4762867.50	111677.10	124.07	107.59	16.47
Bulb diameter	2.57	1.63	0.94	46.99	26.74	20.25
Bulb weight	328.27	179.16	149.11	59.08	30.89	28.19
Days to maturity	2690.87	1852.20	838.67	45.56	27.24	18.32
No. of leaves/plant	5.91	4.37	1.54	51.66	32.41	19.25

Table 5: Components of variation and coefficients of variability for eight characters of onions at Talata mafara during 2005/2006 season

Characters	Components of Variation			Coefficient of Variability (%)		
	Phenotypic	Genotypic	Environmental	Phenotypic	Genotypic	Environmental
Disease incidence	481.30	469.76	11.54	33.88	29.29	4.59
Disease severity	1.76	1.62	0.14	44.32	34.38	9.93
Fresh bulb yield	7562541	7340342.10	222198.90	113.92	97.04	16.88
Cured bulb yield	4793221.20	4691474.40	101746.80	121.39	105.80	15.58
Bulb diameter	1.95	1.55	0.40	37.97	25.20	12.77
Bulb weight	297.48	196.96	100.52	54.20	31.61	22.58
Days to maturity	1980.97	1552.80	428.17	36.96	24.23	12.73
No. of leaves/plant	4.74	3.86	0.88	43.80	29.64	14.16

Table 6: Estimates of variance components and coefficients of variability of onion genotypes inoculated with *A. porri* at Sokoto and Talata Mafara during the 2004/2005 and 2005/2006 seasons

Variance Component	Disease incidence	Disease severity	Fresh bulb yield	Cured bulb yield	Bulb diameter	Bulb weight	Days to maturity	Number of leaves/plant
δ^2g	503.88	1.50	7443326.60	4769572.10	1.48	166.89	1598.20	3.77
δ^2gy	- 0.35	- 0.01	20.21	39568.20	- 0.14	- 26.96	- 135.52	- 0.04
δ^2gl	6.13	0.04	86989.30	298.06	- 0.14	- 10.40	- 142.22	- 0.19
δ^2gly	- 3.59	0.004	- 66949.30	- 29293.10	0.10	9.70	96.42	- 0.01
δ^2e	15.80	0.17	212001.60	102082.90	0.88	184.44	833.91	1.69
δ^2p	521.87	1.70	7675388.71	4882228.16	2.18	323.67	2250.79	5.22
Coefficient of variability (%)								
Phenotypic	31.20	34.96	94.90	103.47	30.13	39.38	29.43	34.15
Genotypic	30.58	32.84	93.53	102.27	24.79	28.27	24.79	29.01
Environmental	5.42	11.00	15.78	14.96	19.09	29.72	17.91	19.42

δ^2g = genotypic variance, δ^2gy = genotype x season variance, δ^2gl = genotype x location variance, δ^2gly = genotype x location x season variance, δ^2e = environmental variance and δ^2p = phenotypic variance

DISCUSSION

The estimates of components of variation and coefficients of variability from the combined analysis across seasons and locations (Table 6) indicate that substantial part of the phenotypic variability observed was a result of genotypic rather than environmental influences for disease severity, disease incidence, fresh bulb yield, cured bulb yield, bulb diameter, days to maturity and number of leaves/plant. The variability observed with respect to these characters is thus mainly genetic with little environmental influences, which shows that selection for these characters is possible. Messiaen (1994) reported that the genus *Allium* is a large and strikingly diverse one. McCallum *et al*. (2001) reported that onion varieties differ widely in composition, from those with firm bulbs of high dry matter content to those with soft bulbs of low dry matter content, and from high to low pungency, therefore existence of genotypic variability for resistance to purple blotch as observed in this study is normal.

Similarly, Rahman *et al*. (2002), in an evaluation of onion line 043 observed that, the variety showed variation in average performance for plant height, leaf number per plant, bulb diameter and bulb yield per plant. Hole *et al*. (2002) also reported existence of variability in onion cultivars in terms of skin characteristics and quality. According to Purseglove (1972) and Smith (2003) onions are out crossing species and are therefore heterozygous at many loci, exhibiting variations in the shape and colour of their bulbs, in their response to photoperiod, temperature, storage quality, pungency, stage of maturity, length of storage and in other characteristics. Esnault *et al*. (2005) reported that chilling requirement varies with cultivar and that the optimum temperature and duration of the cold treatment and or photoperiod must be determined for each variety. Varietal differences and high coefficients of variation in quercetin levels among onion varieties have been reported (Smith, 2003), with red and yellow onions having high concentration and white onions having low concentration.

Since phytochemicals are generally known to be the source of resistance to diseases in onions, variation in some of these compounds in onions can imply variability in resistance to diseases in onions, as was observed by this study. This has further strengthened the possibility of breeding for onion genotypes that are resistant to purple blotch disease of onions. This if achieved will go along way in improving the socio – economic characteristics of the farming communities in onion growing areas of Nigeria and West Africa as a whole.

CONCLUSION

Variability was observed among the genotypes evaluated for Disease Incidence, Disease Severity, Fresh bulb yield, Cured bulb yield, bulb diameter, bulb weight, days to Maturity and Number of leaves/Plant which suggests possibility exists for breeding of Onions for these characters.

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