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Screening and Characterization of Onion Ecotypes for Resistance to Purple Blotch Disease in Sudan Savannah

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Abstract

Field experiment was conducted during 2023/2024 dry season at Teaching and Research Orchard of Kebbi State University of Science and Technology, Aliero and Teaching and Research Farm of Usmanu Danfodio University, Sokoto at Kwalkwalawa using twelve (12) local onion ecotypes (Ex-Dikwa, Ex-Kaffe, Ex-Bama, Ex-Aliero, Ex-Gothege, Ex-Gada, Ex-Wurno, Ex-GHM, Ex-Gaya, Ex-Borno, Ex, Lahodu and Ex-Goronyo). Factorial combination of inoculation were allocated on the main plot while ecotypes on the sub-plot and replicated three times in Randomized Complete Block Design (RCBD). The size of each plot was 1x2m (2m^2) with aim of screening and characterization of these ecotypes for their resistance to purple blotch disease caused by fungus *Altenaria porii*, where none of the ecotypes were found immune. However, based on the PDI result, the ecotypes Ex-Dikwa (19.53, 18.65), Ex-Kaffe (17.83, 19.21) and Ex-Borno (18.59, 18.32) were found to be moderately resistant to purple blotch disease. Ex-Bama (32.27, 34.27), Ex-Gothege (41.89, 40.78), Ex-Wurno (37.92, 36.82) and Ex-Goronyo (32.60, 34.50) were found to be moderately susceptible, while Ex-GHM (52.51, 51.43), Ex-Gaya (54.39, 56.39) and Ex-Lahodu (43.77, 41.57) were susceptible to purple blotch in Aliero and Sokoto respectively. Similarly, growth and yield parameters measured during this research work, such as plant height, leaf number, total biomass, above ground biomass, fresh bulb yield, cured bulb yield, bulb diameter characterized Ex-Dikwa, Ex-Kaffe and Ex-Borno as superior compare to other ecotypes, with Ex-Lahodu, Ex-GHM and Ex-Goronyo recording lower in growth and yield performance. The identified moderately resistant ecotypes can further be used for commercial cultivation or may be used as parent for future onion improvement program against purple blotch disease.

Keywords: *Altenaria porii*, Purple Blotch Disease, Onion, Screening, Resistance

INTRODUCTION

Onion (*Allium cepa* L.) is vegetable crop which belongs to the genus *Allium*, of the family *Alliaceae*. It is a biennial plant but usually grown as annual, and under good management practice can yield up to 5kg per meters-square in 90 days from planting date (Mike and Martin, 2009). It is also one of the most commonly consumed vegetable crops in the world, with China being the number one producer, while Japan and India are the second highest producers of green onions and dry onions respectively. FAO, (2015). The crop is used to improve the taste and flavor of the food, a source of income for many small -scale farmers, and helps them for improving their livelihood. Onion is also used for a medicinal purpose in the control of human and plant diseases (Ebrahimi-Mamaghani et al., 2014; Law et al., 2016; Marrelli et al., 2019).

Onion varieties were reported to differ significantly 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).

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). According to FAO, (2019) statistics and data research, Nigeria produces 997,900, 1,031,014, and 996,519 of onion in dry season in 2015, 2016 and 2017 respectively. In Nigeria onion is grown mostly in Kano, Kaduna, Jigawa, Sokoto, Plateau, Bauchi and Kebbi state (Inuwa, 2011) They also contain a phytochemical called quercetin, which is effective in reducing the risk of cardiovascular disease, an anticancer, and it is an excellent source of antioxidant (Smith, 2003). Despite being an important crop for household consumptions, medicinal uses, source of income, and contribution to the national economy through export products, the crop is constrained by several abiotic, biotic and socio-economic factors (Getachew et al., 2014).

Purple blotch disease, which is caused by *Altenaria porri* is one of the most destructive disease restricted to the genus *Allium* and widespread in many regions of the world (Crammer, 2000).

MATERIALS AND METHOD

Experimental Site

The experiment were conducted in two locations simultaneously; one location at Teaching and Research Orchard of Kebbi State University of Science and Technology, Aliero (KSUSTA) located within the campus, and one location at Teaching and Research Farm of Usmanu Danfodio University, Sokoto located at Kwalkwalawa. The experiment were conducted during 2023/2024 dry season. The two states (Kebbi and Sokoto States) are located in Sudan Savannah agro-ecological zone of Nigeria. The climate of the areas is characterized by annual rainfall range from 550 - 700mm, and temperature average between 30°C during dry season and 27°C and 41°C during the raining season and the relative's humidity range from 21 to 47% in the dry season and 51 to 79% during rainy season. The areas are characterized by long dry season with a cool air during harmattan (November to February), followed by short rainy season may/June to September/October (Anonymous 2021).

Materials

Sources of Onion Ecotypes

The onion ecotypes used for the research were sourced from 8 northern states namely; Kebbi, Sokoto, Zamfara, Jigawa, Kano, Yobe and Borno due to their prominence as onion producing areas.

Source of Inoculum

Infected onion leaves showing typical symptoms of onion purple blotch were collected from the farmers' fields of onion within Aliero town, $12^0$32´17 N, $04^0$51'09 E and 685m above sea level in the Sudan Savannah zone. Leaves were labelled, preserved and transported to the Mycology Laboratory Department of Microbiology, Usmanu Danfodio University, Sokoto for further processing. Collected leaf samples were washed with running water, cut into 5–10 mm size pieces, sterilized three (3) min in 0.5% sodium hypochlorite (NaOCl) solution, rinsed in three changes of sterile distilled water (SDW) and blot within folds of sterile filter paper (Whatman No.1). Three pieces of infected leaves were transferred onto PDAs media amended with streptomycin sulphate at 0.6 μg/L. The labelled Petri dishes were arranged in a Gallenhamp incubator set at 27 ± 2^0C and observed daily for development of fungal mycelia. Growing fungi will be sub-cultured onto fresh PDAs to obtain pure culture.

Microscopic features of growing fungi were identified using the Manual authored by Barnett and Hunter (2006). Pure culture of the isolated fungi were preserved in labelled McCartney bottles and store in culture herbarium of the Department before use.

METHODS

Treatment and Experimental Design

The treatment consists of twelve (12) onion landraces (Ecotypes). Namely: EX-GADA, EX-DIKWA, EX-GHM, EX-LAHODU, EX-GORONYO, EX-GAYA, EX-WURNO, EX-ALIERO, EX-KAFFE, EX-BAMA, GOTHEGE and EX-BORNO. The treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times.

Application of Inoculum

0.5ltr of inoculum was prepared into 2 liters of water and application was done using syringe on onion leaves to avoid drifting.

Data Collection

Agronomic Parameters

Agronomic parameters measured includes plant height, leaf number, total biomass weight, above ground biomass weight, fresh bulb yield weight, cure bulb yield weight and bulb diameter.

Disease Epidemiological Parameters

Days to symptoms appearance

Number of days taken for the first symptom appearance after inoculation was recorded.

Symptom type

The type of symptom produced by each onion ecotypes after inoculation were assessed and recorded.

Assessment of Disease Incidence

Disease observations were carried out randomly on 20 onion plants two weeks after inoculation. Diseased onion plants are those that produced symptoms such as sunken spots on the leaves, which later enlarged to become purple with yellow halo, and elongated destroying the leaf tissue and eventually causing the bulb to rot. Disease incidences were determined based on the appearance of the symptoms on plants sampled. Disease incidence of each plots were calculated as the percentage (%) of visually diseased plants from the twenty (20) plants assessed in a plot using the formula of Hidayat *et al.* (2020) to calculate the percentage of disease incidence of each ecotype.

Disease Incidence (DI %) = $\frac{n \times 100}{N}$

Where:

n = number of symptomatic plants

N = sum of all plants observed or assessed

Assessment of Disease Severity

Onion purple blotch disease severity was assessed using 0-5 scale of Sharma (1986) and percent disease index (PDI) was computed by the following formula given by Wheeler, (1969).

$PDI = 100\ [\Sigma SNR]\ [(N)\ (MDR)]^{-1}$

Where,

ΣSNR = is the sum of numerical ratings

N = is the number of observations

MDR = is the maximum disease rating based on 0-5 scale

Assessment of ecotype resistant to onion purple blotch

Onion ecotypes screened were assess for their resistance to onion purple blotch using the method as previously described by Pathak *et al.* (1986) and the ecotypes were categorized as Immune: I (PDI = <5%), Resistant: R (PDI = 5-10%), Moderately Resistant: MR (PDI = 11 – 20%), Moderately Susceptible: MS (PDI = 21-40%), Susceptible: S (PDI = 41-60%) and Highly Susceptible: HS (PDI = > 61%).

Data Analysis

Data collected was subjected to the Analysis of Variance (ANOVA) to test the significance of the treatment effects and means will be separated using Duncan Multiple Range Test (DMRT).

RESULTS

Table 1: Plant height (cm) of Onion Ecotypes as inoculated with *A. porii* at Aliero and Sokoto locations during 2023/2024 dry season

Treatments	Aliero			Sokoto		
	4WAT	8WAT	12WAT	4WAT	8WAT	12WAT
Ecotypes (E)						
Ex-Dikwa	9.37[a]	15.88[ab]	17.00[a]	10.07[a]	13.89[ab]	15.12[ab]
Ex-Kaffe	9.16[a]	16.13[a]	16.92[a]	10.12[a]	14.54[a]	15.29[a]
Ex-Bama	8.75[a]	14.51[cd]	15.33[bcd]	9.72[ab]	12.76[c]	13.11[cd]
Ex-Alieru	8.66[ab]	14.46[cd]	15.50[bc]	9.22[bc]	11.58[e]	13.19[cd]
Ex-Gothege	7.82[b]	14.22[cd]	14.82[cde]	8.86[cd]	11.81[de]	13.23[cd]
Ex-Gada	8.77[a]	14.20[cd]	13.92[e]	8.69[cde]	12.37[cd]	13.07[cd]
Ex-Wurno	9.28[a]	14.65[cd]	14.35[de]	9.46[b]	12.12[cde]	13.44[c]
Ex-GHM	8.64[ab]	14.47[cd]	13.93[e]	8.38[ef]	12.08[cde]	12.93[cd]
Ex-Gaya	8.82[a]	13.77[d]	14.21[e]	8.13[f]	12.10[cde]	12.87[d]
Ex-Borno	9.04[a]	14.95[bc]	16.19[ab]	9.68[ab]	13.65[b]	14.65[b]
Ex-Lahodu	8.68[ab]	13.58[d]	14.65[cd]	8.18[ef]	11.93[de]	12.80[d]
Ex-Goronyo	8.86[ab]	13.96[cd]	14.25[e]	8.91[cd]	12.22[cde]	12.94[cd]
SE±	**0.192**	**0.291**	**0.277**	**0.078**	**0.127**	**0.073**
***A. Porii* Inoculation (P)**						
Inoculated	8.53[b]	12.58[b]	13.47[b]	8.98[b]	11.99[b]	12.75[b]
Non-inoculated	9.08[a]	16.55[a]	16.71[a]	9.26[a]	13.18[a]	14.36[a]
SE±	**0.078**	**0.714**	**0.113**	**0.032**	**0.051**	**0.030**
Interaction						
E x P	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DNMRT

Table 2: Leaf Number of Onion Ecotypes as treated with *A. porii* inoculum at Aliero and Sokoto locations during 2023/2024 dry season

Treatments	Aliero			Sokoto		
	4WAT	8WAT	12WAT	4WAT	8WAT	12WAT
Ecotypes (E)						
Ex-Dikwa	6.97^{ab}	12.59^{a}	13.82^{a}	5.68^{abc}	10.69^{ab}	13.89^{a}
Ex-Kaffe	7.18^{a}	12.78^{a}	13.19^{ab}	6.39^{a}	11.18^{a}	14.19^{a}
Ex-Bama	6.40^{bc}	10.29^{c}	12.08^{cde}	6.17^{ab}	9.37^{c}	11.69^{de}
Ex-Aliero	6.10^{cde}	10.00^{cd}	11.71^{de}	5.75^{abc}	8.84^{cde}	11.40^{e}
Ex-Gothege	5.50^{e}	9.51^{de}	11.87^{cde}	4.98^{c}	8.92^{cd}	12.36^{bc}
Ex-Gada	6.28^{cd}	9.44^{de}	11.38^{de}	6.44^{a}	9.10^{c}	11.89^{cde}
Ex-Wurno	6.06^{cde}	9.90^{cde}	12.27^{bcd}	5.65^{abc}	8.82^{cde}	12.79^{b}
Ex-GHM	5.52^{e}	9.23^{e}	10.97^{e}	5.57^{abc}	8.77^{cde}	12.17^{cd}
Ex-Gaya	6.10^{cde}	9.38^{de}	11.40^{de}	5.90^{abc}	8.97^{cd}	12.08^{cd}
Ex-Borno	6.54^{bc}	11.51^{b}	12.90^{abc}	5.83^{abc}	10.11^{b}	13.84^{a}
Ex-Lahodu	5.70^{de}	9.43^{de}	11.32^{de}	5.33^{bc}	8.30^{de}	12.06^{cd}
Ex-Goronyo	5.63^{de}	9.15^{e}	11.53^{de}	5.22^{bc}	8.17^{e}	11.76^{de}
SE±	**0.106**	**0.135**	**0.283**	**0.211**	**0.130**	**0.076**
***A. Porii* Inoculation (P)**						
Inoculated	6.09^{a}	9.60^{b}	10.71^{b}	5.49^{b}	8.30^{b}	11.90^{b}
Non-inoculated	6.24^{a}	10.93^{a}	13.37^{a}	6.00^{a}	10.23^{a}	13.12^{a}
SE±	**0.260**	**0.055**	**0.115**	**0.086**	**0.053**	**0.031**
Interaction						
E x P	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DNMRT

Table 3: TBMS,AGBMS, FBYD of Onion Ecotypes as treated with *A. porii* inoculum at Aliero and Sokoto locations during 2023/2024 dry season

Treatments	Aliero			Sokoto		
	TBMS	AGBMS	FBYD	TBMS	AGBMS	FBYD
Ecotypes (E)						
Ex-Dikwa	24.92^{a}	5.54^{ab}	19.46^{a}	28.30^{a}	5.58^{ab}	15.63^{b}
Ex-Kaffe	24.99^{a}	5.85^{a}	19.02^{a}	27.98^{ab}	5.67^{a}	22.03^{a}
Ex-Bama	22.36^{bc}	5.02^{abcd}	17.21^{bc}	26.13^{cd}	5.15^{c}	20.72^{a}
Ex-Aliero	21.23^{cd}	4.67^{bcd}	16.53^{bc}	24.74^{e}	4.68^{d}	20.88^{a}
Ex-Gothege	22.23^{bc}	5.27^{abcd}	16.82^{bc}	26.80^{bc}	5.26^{bc}	21.34^{a}
Ex-Gada	21.45^{cd}	4.56^{cd}	17.09^{bc}	25.16^{de}	4.12^{e}	20.88^{a}
Ex-Wurno	23.30^{b}	5.47^{abc}	17.67^{b}	27.99^{ab}	5.37^{abc}	22.16^{a}
Ex-GHM	18.32^{e}	4.72^{bcd}	13.55^{d}	25.36^{de}	4.26^{e}	20.97^{a}
Ex-Gaya	21.30^{cd}	4.49^{d}	16.64^{bc}	24.91^{de}	4.17^{e}	20.56^{a}
Ex-Borno	25.00^{a}	5.71^{a}	19.17^{a}	27.04^{abc}	5.25^{bc}	21.65^{a}
Ex-Lahodu	17.61^{e}	4.33^{d}	13.16^{d}	25.07^{de}	4.32^{e}	20.41^{a}
Ex-Goronyo	20.58^{d}	4.93^{abcd}	16.17^{c}	24.66^{e}	4.17^{e}	20.25^{a}
SE±	**0.478**	**0.215**	**0.390**	**0.437**	**0.029**	**4.60**
***A. Porii* Inoculation (P)**						
Inoculated	21.08^{b}	4.56^{b}	16.48^{b}	24.49^{b}	4.05^{b}	19.82^{b}
Non-inoculated	22.80^{a}	5.53^{a}	17.27^{a}	27.86^{a}	5.62^{a}	21.43^{a}
SE±	**0.195**	**0.088**	**0.159**	**0.178**	**0.012**	**1.880**
Interaction						
E x P	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DNMRT

Table 4: CBW, BDM, DI of Onion Ecotypes as treated with *A. porii* inoculum at Aliero and Sokoto locations during 2023/2024 dry season

Treatments	Aliero			Sokoto		
	CBW	BDM	DI	CBW	BDM	DI
Ecotypes (E)						
Ex-Dikwa	18.63a	4.61a	26.40f	21.13a	5.20a	22.66a
Ex-Kaffe	1.8.09a	4.54a	26.62f	20.34ab	5.02ab	23.15b
Ex-Bama	16.52b	3.89cde	32.26cd	19.84ab	4.36cde	32.29a
Ex-Aliero	15.81bc	3.93cd	35.89ab	20.05ab	3.98de	32.77a
Ex-Gothege	15.83bc	4.05c	32.30cd	20.04ab	4.26cde	31.41a
Ex-Gada	16.09bc	4.15bc	34.65abc	19.58b	4.57bcd	30.78a
Ex-Wurno	16.77b	4.24abc	30.42de	21.04a	4.12de	25.43b
Ex-GHM	12.32d	3.52e	36.37a	20.18ab	4.06de	32.65a
Ex-Gaya	15.33c	3.91cde	36.68a	19.72ab	3.83e	32.79a
Ex-Borno	18.23a	4.44ab	27.94ef	20.65ab	4.81abc	25.04b
Ex-Lahodu	12.37d	3.60de	34.06abc	19.53b	3.83e	29.49a
Ex-Goronyo	15.26c	3.62de	33.06bcd	19.47b	4.09de	32.21a
SE±	**0.345**	**0.038**	**2.515**	**0.444**	**0.093**	**2.599**
***A. Porii* Inoculation (P)**						
Inoculated	15.65b	3.93b	64.45a	19.26b	4.14b	58.45a
Non-inoculated	16.22a	4.15a	0.00b	21.00a	4.55a	0.00b
SE±	**0.141**	**0.015**	**1.026**	**0.181**	**0.038**	**1.061**
Interaction						
E x P	Ns	Ns	Ns	Ns	Ns	Ns

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of significance using DNMRT

Table 5: Disease severity as treated with A. porii at Aliero and Sokoto locations during 2023/24 dry season

Ecotypes	Aliero			Sokoto			Disease Incidence	
	PDI	Disease Grade	Category of Resistance	PDI	Disease Grade	Category of Resistance	Aliero	Sokoto
Ex-Dikwa	19.53	2	MR	18.65	2	MR	26.40[f]	22.66[a]
Ex-Kaffe	17.83	2	MR	19.21	2	MR	26.62[f]	23.15[b]
Ex-Bama	32.27	3	MS	34.27	3	MS	32.26[cd]	32.29[a]
Ex-Aliero	49.35	4	S	50.11	4	S	35.89[ab]	32.77[a]
Ex-Gothege	41.89	3	MS	40.78	3	MS	32.30[cd]	31.41[a]
Ex-Gada	52.71	4	S	50.34	4	S	34.65[abc]	30.78[a]
Ex-Wurno	37.92	3	MS	36.82	3	MS	30.42[de]	25.43[b]
Ex-GHM	52.51	4	S	51.43	4	S	36.37[a]	32.65[a]
Ex-Gaya	54.39	4	S	56.39	4	S	36.68[a]	32.79[a]
Ex-Borno	18.59	2	MR	18.32	2	MR	27.94[ef]	25.04[b]
Ex-Lahodu	43.77	4	S	41.57	4	S	34.06[abc]	29.49[a]
Ex-Goronyo	32.60	3	MS	34.50	3	MS	33.06[bcd]	32.21[a]
SE±							**2.515**	**2.599**
***A. Porii* Inoculation (P)**								
Inoculated							64.45[a]	58.45[a]
Non-inoculated							0.00[b]	0.00[b]
SE±							**1.026**	**1.061**
Interaction								
E x P							Ns	Ns

DISCUSSION

For the development of any disease, favorable environment, pathogen load, stage of crop growth and duration of infection play vital role (Pat *et'al*, 2017). Under field and epiphytotic condition during 2023/24 dry season in Aliero and Sokoto trial location. Twelve (12) local onion ecotypes Viz: (Ex-Dikwa, Ex-Kaffe, Ex-Bama, Ex-Aliero, Ex-Gothege, Ex-Gada, Ex-Wurno, Ex-GHM, Ex-Gaya, Ex-Borno, Ex, Lahodu and Ex-Goronyo) were grown to Screened for their resistance to purple blotch disease. The disease occurred on all the tested ecotypes (Table 5). However, analysis of data showed a different response among the ecotypes with regards to disease intensity. Percentage disease index (PDI) indicated that Ex-Dikwa, Ex-Kaffe and Ex-Borno as the best ecotypes among the twelve ecotypes tested. Ex-Aliero, Ex-Gada, Ex-GHM, Ex-Gaya and Ex-Lahodu are the most affected by purple blotch disease.

Inoculated and non-inoculated onion ecotypes show considerable difference in the result and indicating negative difference on all the parameters tested (Table 1 and 2). Also there was significance variation among the effect of disease on the ecotypes. The variation may be attributed to genetic make-up of the ecotypes which could not be influence by the environment. Similar findings by Lancaster *et'al* (1996) show purple blotch affected the crop from the above soil surface leading to its total destruction and considerable yield loss, thus the effect on all ecotypes alike.

Effect on Growth Parameters

Plant height of inoculated ecotypes at 4, 8 and 12 WAT (8.53cm, 12.58cm and 13.47cm) respectively, shows significance decrease than non-inoculated (9.08cm, 16.55cm and 16.71cm) at Aliero, and (8.98cm, 11.99cm and 12.76cm) for inoculated, and (9.26cm, 13.18cm and 14.36cm) for non-inoculated in sokoto location. This result is in accordance with Yemane *et'al* (2014) that showed significance difference in plant height among onion cultivars. Similarly, in terms of leaf number, there is significant disease effect on the inoculated ecotypes than the non-inoculated ecotypes on both trial locations at 4, 8 and 12 WAT. As shown in table 2. This is in accordance with Molah *et'al* (2015) and Rao *et'al* (2013) indicated variation in leaf numbers among onion varieties.

Effect on Yield Parameters

The yield parameters such as total biomass, above ground biomass, fresh bulb yield, cure bulb weight and bulb diameter in table 3 and 4 also shows significance difference from inoculated to non-inoculated from both locations. With inoculated ecotypes showing (21.08t/ha^{-1}, 4.56t/ha^{-1}and 16.8t/ha^{-1}) for TBMS, AGBMS and FBYLD respectively in Aliero and (24.49t/ha^{-1}, 4.05t/ha^{-1}, 19.80t/ha^{-1}) for Sokoto compare to non-inoculated with (22.80t/ha^{-1}, 5.55t/ha^{-1}, 17.27t/ha^{-1}) in Aliero, and (27.86t/ha^{-1}, 5.62t/ha^{-1}, 21.43t/ha^{-1}) in Sokoto.

Inoculated ecotypes bulb diameter (3,9cm, and 4.14cm) in Aliero and Sokoto respectively is significantly lower than non-inoculated (4.15cm and 4.55cm) in Aliero and Sokoto. The result is in accordance with Yemane *et'al* (2014) that showed significance difference in bulb diameter among onion cultivars.

Also disease incidence (DI) recorded higher (64.45%) in Aliero than (58.45%) in Sokoto.

CONCLUSION

All the onion ecotypes grown are affected by purple blotch disease. However, Ex-Dikwa, Ex-Kaffe and Ex-Borno perform better in terms of resistance than the other ecotypes. All the growth and yield parameters are significantly affected by the purple blotch at various stages of growth and development.

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