Asian Journal of Advances in Agricultural Research

4(1): 1-10, 2017; Article no.AJAAR.36784
ISSN: 2456-8864

Field Reactions of Pepper (*Capsicum* spp.) Lines and Accessions to Anthracnose Disease in Makurdi, Benue State, Nigeria

Chigoziri Ekhuemelo[1*], Ebenezer Jonathan Ekefan[1] and Alphonso Okechukwu Nwankiti[1]

[1]Department of Crop and Environmental Protection, Federal University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria.

Authors' contributions

This article is a collaborative work between all authors. Author CE designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EJE and AON managed the analysis of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2017/36784
Editor(s):
(1) Tancredo Souza, Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Portugal.
Reviewers:
(1) M. Ali Sevik, University of Ondokuz Mayis, Turkey.
(2) Oluyemi Idowu, Obafemi Awolowo University, Nigeria.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/22166

Original Research Article

Received 15th September 2017
Accepted 17th November 2017
Published 6th December 2017

ABSTRACT

Nursery and field experiments were conducted in 2012 and 2013 at the experimental site of the Federal University of Agriculture, Makurdi in the Southern Guinea Savannah of Nigeria (7° 45'N, 8° 35' E) to evaluate the field reactions of twenty eight pepper lines and accessions to anthracnose disease of pepper. Fifteen exotic pepper lines developed at the Asian Vegetable Research and Development Center (AVRDC) Taiwan (AVPP- 0013, 0802, 9809, 9905(Susceptible Check), 0401, 9814, 9807, 0403, 0706, 0513, 0412, 0114, 9801, 9813, 9612) and thirteen accessions sourced locally (Ex-kunkunu, Cayenne, GHA, Prof fintashi, N-M-Iddi, Tugantashi, Bor kono tsifidi, M'daku, African Birdeye pepper, Atarodo, Tatashe, Sombo, Nsukka yellow) were checked for the incidence of *Colletotrichum capsici* causal agent of pepper anthracnose on the seeds and then screened for field resistance to the disease. The field experiment was laid out in a Randomized Complete Block Design with three replications. Fifteen pepper lines/accessions which had better establishment were subjected to further screening for resistance to pepper fruit anthracnose under natural conditions. Results showed that African Bird's eye pepper and Nsukka yellow had the lowest

**Corresponding author: Email: chiekhuemelo@gmail.com;*

anthracnose severity of 1.0 while Borkono tsifidi and Sombo had the highest disease severity of 3.0 consistently for the two years. Ex-kunkunu was tolerant to pepper anthracnose. Correlation results showed moderate negative and significant relationship (P>0.01) between disease incidence in 2012 and disease severity in 2013(- 0.458**) while there was a strong positive and significant relationship (P>0.01) between disease incidence and disease severity in 2013 (0.822**).

Keywords: Screening; field resistance; anthracnose; pepper; accessions.

1. INTRODUCTION

Pepper (*Capsicum spp*) is considered to be one of the most important crops in the tropics. In Nigeria, pepper is regarded as the third most important vegetable after onions and tomatoes [1,2]. It is known as one of the commodities with great potential for commercialization in Nigeria [3]. It is cultivated mainly in the Northern Guinea Savanna with about 60% of the total national output [4]. Pepper was ranked seventh in North Central Nigeria and listed among the commodities with returns greater than US$1 billion over a period of 17years [3].

Anthracnose disease of pepper caused by *Colletotrichum capsici* is characterized by fruit lesions evident by concentric rings produced by the acervuli and is one of the most economic disease of pepper in the tropics [5]. *Colletotrichum* spp. is capable of causing disease on many of the chilli plant parts during any stages of growth. However, fruit lesions are the most economically important aspect of this disease [5]. Anthracnose causes yield loss and reduces the quantity and marketability of fruits by reducing the dry weight and lowering quantities of capsaicin and oleoresin. Infected seeds usually turn rusty while infected fruits often lose their pungency and taste [6]. Infected fruits showing blemishes are generally considered unfit for human consumption and may be toxic to humans and animals [6]. Small anthracnose lesions on pepper fruits have been reported to reduce their market value [7]. Incidence of the disease in the nursery and in the field is a problem in most pepper growing regions of Nigeria, where conditions are conducive for disease development especially in years recording high rainfall and humidity.

Crop protection achieved through host plant resistance is a preferred option, especially for the resource-poor farmers. The introduction of better adaptable, well performing varieties with tolerance/resistance to nursery and field diseases could be used to boost pepper production and quality of pepper in Nigeria. Identifying pepper accessions and lines with resistance to anthracnose diseases is important for effective and long term control of the diseases.

Some sweet pepper varieties were earlier screened for tolerance/resistance to pepper anthracnose by [8] but all the varieties tested were susceptible. There is the need to screen more exotic breeding lines and local pepper accessions of the sweet and hot pepper types for resistance to pepper anthracnose. The Identification and introduction of pepper accessions with high yield and resistance/tolerance to anthracnose is important for effective and long term management of the disease.

This study therefore seeks to evaluate some hot pepper and some sweet exotic and local accessions of pepper for resistance/tolerance to pepper anthracnose in the seedling and mature stages in order to select varieties of economic importance that can adapt well to the environment in Makurdi, North Central Nigeria.

2. MATERIALS AND METHODS

2.1 Source of Pepper Breeding Lines/Accessions and Viability Testing

Fifteen exotic breeding lines viz AVPP 0013(chilli pepper), AVPP 0401(sweet pepper), AVPP 9814(sweet pepper), AVPP 9809(sweet pepper) , AVPP 9807(sweet pepper), AVPP 0403(sweet pepper), AVPP 0706(chilli pepper), AVPP 0802(chilli pepper), AVPP 0513(chilli pepper), AVPP 0412(chilli pepper), AVPP 0114(sweet pepper), AVPP 9801(chilli pepper), AVPP 9813(chilli pepper), AVPP 9905(chilli pepper), AVPP 9612 were collected from the Genetics Resources and Seed Unit of The Asian Vegetable Research and Development Center (AVRDC) Taiwan in 2012. Additionally seven chilli pepper namely GHA, Tugantashi, Borkono tsifidi, M'daku, Prof fintashi, N-M-Iddi and Ex kunkunu were obtained from the Institute of

Agricultural Research (IAR) Zaria, Nigeria. The remaining six accessions namely African Bird's eye pepper, Atarodo (sweet pepper), Tatashe (sweet pepper), Sombo (chilli pepper), Nsukka yellow (sweet pepper) and Cayenne (chilli pepper) were sourced locally.

Assessment of the pepper seeds for viability and seed borne *C. capsici* was conducted in the laboratory. A total of 1400 seeds (at the rate of 50 seeds per pepper line and accession) were sterilized for one minute in 1% Sodium hypochlorite solution after which they were rinsed in three changes of Sterile Distilled Water (SDW) and blotted dry on sterile filter papers. The seeds were placed on double layer of moistened blotter papers placed in sterilized Petri dishes. The plates were incubated on the laboratory bench at ambient conditions of light and temperature (30 ± 2℃). The experiment was a Completely Randomized Design replicated three times. Seed germination counts were done and germination percentages computed. Incubated seeds were examined for the presence of *C. capsici*. Infected seeds were counted and recorded as percentages.

2.2 Nursery Screening

The nursery site was manually cleared and nursery beds measuring 1m x 2.5m wide made. Poultry dung was mixed with the top soil in a ratio of 3:2 at three weeks before planting. The seeds of fifteen pepper lines/accessions were treated with Seed Plus 30WS (a.i Imidactoprid 10% (Systemic insecticide) + Metalaxyl 10% (systemic fungicide) + Carbendazim 10% WS (systemic fungicide) at the recommended rate of 30ml/2kg seed and placed in drills. Fifty seeds of each line/accession were planted in drills 10cm apart and at 1 cm depth on nursery beds 1m x 2.5 m wide on the 10th of April, 2012 and 17th April, 2013. The experiment was a Completely Randomized Design replicated three times. The beds were watered and mulched with dry grass. Mulch was removed after seedling emergence and shade was removed at three Weeks after planting (WAP) to harden seedlings in preparation for transplanting at 4WAP.

After the initial nursery evaluation, five exotic pepper lines namely AVPP 0013, AVPP 0706, AVPP 0802, AVPP 9809, AVPP 9905 and six local accessions namely Borkono tsifidi, Ex-Kunkunu, Prof fintashi, GHA, M'daku, N-M-Iddi, Bird's eye, Nsukka yellow and Sombo which had high percentage germination were further evaluated for field resistance/tolerance to anthracnose in Makurdi.

2.3 Field Screening

Field trials were conducted in 2012 and 2013 cropping seasons at the experimental site of the University of Agriculture, Makurdi in the Southern Guinea Savannah of Nigeria (7^{o} 45'N, 8^{o} 35' E). The experimental site was manually cleared and ridged. The same site was used for the experiment in both years.

Seedlings of the different pepper lines/ accessions were transplanted to micro plots of 2.5 m x 1.5 m size. The experiment was laid out on a land measuring 12m x 21m (252m^2) with micro plots measuring 2.5 x 0.75m (1.88m^2). The experiment was set up in Randomized Complete Block Design with three replications for fifteen pepper lines/accessions that survived the nursery stage. The pepper seedlings were transplanted six weeks after planting on 26th of May 2012 and 1st June 2013. Fertilizer (NPK.15:15:15) was applied once at two weeks after transplanting at the rate of 20 g per plant.

2.4 Data Collection from Nursery and Field Experiments

Data were collected on environmental conditions (Agroclimatological Indices) from Nigerian Meteorological Agency, Makurdi and on some important growth parameters and yield characters**.** Data on seedling establishment was calculated as the percentage of seedlings established relative to number of seedlings transplanted at four weeks after transplanting (WAT). Seedling height at 30 days after planting (DAP) was measured from the ground level to shoot apex of the plant with a ruler. The incidence of anthracnose infection (percentage calculated on the basis of diseased plants over the total plants assessed) was recorded.

Severity of fruit anthracnose was assessed using the following modified severity key adopted from [9]:

0= no infection (no spot/no infection) 1= 1- 20 % of fruits with small lesions

2 = 21- 40 % of fruits with lesions 3= 41- 60 % of fruits with lesions

4 = 61- 80 % of fruits with lesions 5 = 81- 100 % of fruits with lesion

2.5 Data Analysis

Arc sine transformation was applied to incidence data while square root transformation was done for germination percentages before analysis. Pearson correlation coefficients between disease and yield parameters were determined across the two seasons at 5% and 1% probability.

Data were subjected to Analysis of Variance (ANOVA) using Genstat 10 statistical software and SAS version 9.2 Edition [10]. Significant differences in treatment means were separated using DMRT at 5% level of significant [11]. T-test analysis was conducted and used for the comparism of the means of anthracnose incidences, severity and yield of pepper lines/accessions in 2012 and 2013.

3. RESULTS

3.1 Meteorological Data of Experimental Site

Data presented in Fig. 1 shows the trend of temperature (℃), relative humidity (%) and rainfall (mm) for the 2012 and 2013 cropping season. Temperature and relative humidity was favourable for anthracnose development during the time the experiment was carried out in both years. Temperature differed slightly during the two cropping seasons with temperature varying between 26 – 29℃, relative humidity ranged between 62% and 80% and monthly rainfall between 123-352 mm. Total annual rainfall for 2012 was 1392.30 mm while for 2013 was 1287.80 mm. Relative humidity of 80% was recorded in August (13 WAT) for both years corresponding to the fruiting stage when anthracnose was observed on pepper fruits.

In 2012, the peak rainfall (352 mm) was observed in July (9 WAT) at the flowering and fruiting stage coinciding with the flooding experienced at the location during the 2012 cropping season. In 2013 the rainfall had its peak in September (285 mm) which was the harvesting period (17 WAT) when fruit anthracnose occurred.

3.2 Incidence of *Colletotrichum capsici* on Pepper Seeds

The result presented in Table 1 shows the percentage incidence of *Colletotrichum capsici* on pepper seeds before planting in 2012. The incidence of *C. capsici* was significantly higher ($P<0.05$) on Prof fintashi seeds with an incidence of 35.0% followed by AVPP 9809 with 25.0% incidence, AVPP 9905, Ex kunkunu and Birdeye seeds recorded 15.0% incidence while N-M-Iddi had 5.0% incidence. All other lines/ accessions had no incidence of *C. capsici* on their seeds before planting.

3.3 Germination of Pepper Breeding Lines / Accessions

The germination of twenty eight breeding lines and accessions determined in the laboratory and in the nursery is presented in Table 2. The viability test showed high germination

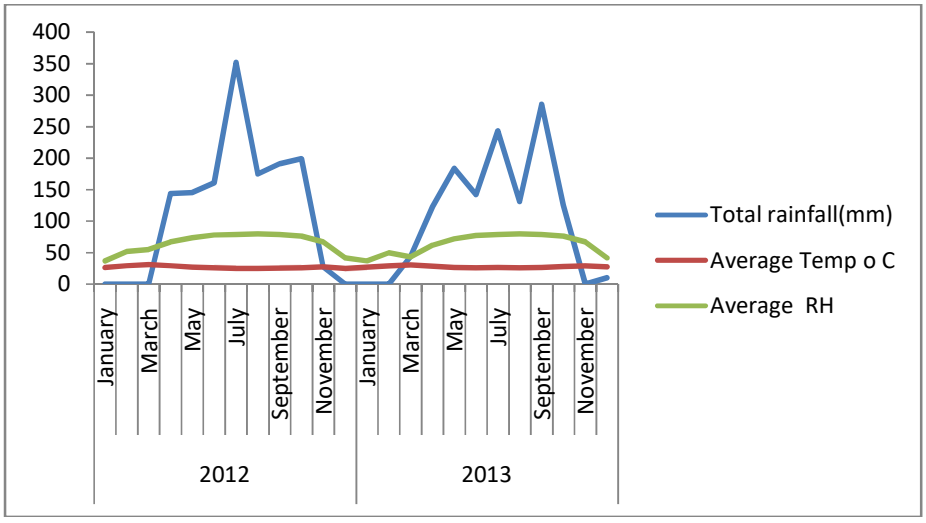

Fig. 1. Meteorological data of the 2012 and 2013 cropping season for Makurdi, Nigeria

percentages for exotic lines but they exhibited low establishment. In 2012, the exotic lines germinated better than the local varieties. Percentage germination ranged between 10 - 100% with Borkono tsifidi having the least germination (10%) while AVPP 0013, 9814, 0706, 0802, and 9905 had 100% germination. AVPP 0802 reached 100% germination eleven days after planting. Prof fintashi had the tallest seedling with a height of 11.4 cm in 2012 while Ex-kunkunu was the tallest with a height of 20.7cm in 2013. Sombo had the shortest seedling with a height of 3.1 cm in 2012 while AVPP 9814 and Atarodo with a height of 8.5cm respectively were the shortest seedlings in 2013 cropping season.

Table 1. Percentage incidence of *Colletotrichum capsici* isolated from pepper seeds incubated in the laboratory before the study in 2012

Breeding line/accessions	Percentage incidence (%)
AVPP 0013	0.0[e]
AVPP 0706	0.0[e]
AVPP 0802	0.0[e]
AVPP 9809	25.0[b]
AVPP 9905	15.0[c]
Birdeye	15.0[c]
Bor kono tsifidi	0.0[e]
Cayenne	0.0[e]
Ex Kunkunu	15.0[c]
GHA	0.0[e]
M'daku	0.0[e]
N-M- Iddi	5.0[d]
Nsukka yellow	0.0[e]
Prof fintashi	35.0[a]
Sombo	0.0[e]

3.4 Seedling Establishment

The percentage seedling establishment for fifteen varieties of pepper screened for resistance to anthracnose for 2012 and 2013 cropping season is presented in Table 3. Thirteen pepper lines and accessions died off in all the replications in the nursery indicating that they did not adapt to the Southern Guinea Savannah agro- ecology of Nigeria.

Percentage establishment was not significantly different among the remaining fifteen pepper lines and accessions screened in 2012. However, highest seedling establishment of 93.33% was recorded by Cayenne and Ex-kunkunu while the least seedling establishment of 60% was recorded by Nsukka yellow, Bird's eye and AVPP 0706 in 2012. There was significant difference in seedling establishment among pepper lines and accessions in 2013. AVPP 0013, Borkono tsifidi, Cayenne, Ex-kunkunu, Prof fintashi and Sombo had 100% seedling establishment and this was significantly ($P \leq 0.05$) higher compared with AVPP 0802, AVPP 9905 and M'daku with 93.3% establishment. The lowest seedling establishment of 40% was recorded by AVPP 0706, AVPP 9809 and Bird's eye in 2013.

3.5 Fruit Anthracnose

Data on the incidence of fruit anthracnose for 2012 and 2013 is presented in Table 4. The incidence of pepper fruit anthracnose was significantly ($P \leq 0.05$) higher in 2013 compared with 2012. In 2012, anthracnose incidence was significantly higher in AVPP 9809 (31.14%) compared with GHA (1.44%) and Bird's eye (2.43%). In 2013, anthracnose incidence increased significantly in Borkono tsifidi and Sombo (38.44%) and decreased significantly in AVPP 0706 (1.00%) and Nsukka yellow (1.90%) compared with Bird's eye and GHA in which anthracnose incidence increased slightly in 2013. GHA had the least percentage incidence for anthracnose (2.13%) and this was not significantly different ($P \geq 0.05$) from the anthracnose recorded in Bird's eye accession (2.89%). The t-test indicated significant difference ($P \leq 0.01$) between anthracnose incidence in 2012 and 2013 (T- value = 3.87, P = 0.0004).

The data on the severity of pepper fruit anthracnose for 2012 and 2013 cropping season is presented in Table 5. Disease severity ranged between 1.0 (1-20% of fruits with lesions) and 3.0 (41-60% of fruits with lesions) with AVPP 9905, Borkono tsifidi and Sombo having the highest severity value of 3.0 in 2012 and 2013. Bird's eye and Nsukka yellow had low severity score of 1.00 for both years. Although the mean anthracnose severity appeared to be higher in 2013, it was not significant (T value = 1.14, P = 0.26).

The yield of fifteen lines/accessions of pepper screened for anthracnose disease response for two consecutive years in Makurdi is presented in Table 6. In 2012, yield was significantly ($P \leq 0.05$) higher in Ex kunkunu (2.84 t/ha) compared with AVPP 9905(0.64 t/ha), Sombo (0.68 t/ha), GHA (0.72 t/ha), Cayenne (0.73 t/ha) and Bird's eye

Table 2. Seed viability, germination percentages and average seedling height of twenty eight pepper lines and accessions for 2012 and 2013 cropping season in Makurdi

Breeding line/Accession	Seed Viability (% laboratory germination in 2012)	% Nursery germination 2012	% Nursery germination 2013	Average seedling height (cm) 2012	Average seedling height (cm) 2013
AVPP 0013	100.0^{a}	59.0^{de}	36.0^{f}	9.0^{d}	14.5^{e}
AVPP 0706	100.0^{a}	74.0^{b}	20.0^{h}	10.7^{b}	15.0^{e}
AVPP 0802	100.0^{a}	70.0^{b}	50.0^{d}	5.8^{gh}	16.8^{d}
AVPP 9809	70.0^{dc}	56.0^{e}	12.0^{i}	6.2^{g}	18.0^{c}
AVPP 9905	100.0^{a}	22.0^{j}	50.0^{d}	4.6^{k}	12.8^{f}
AVPP 9814	100.0^{a}	62.0^{dc}	6.0^{j}	9.0^{d}	8.5^{h}
AVPP 0513	90.0^{ab}	8.0^{lm}	0.0^{k}	5.0^{ijk}	0.0^{i}
AVPP 9813	90.0^{ab}	0.0^{n}	0.0^{k}	0.0^{n}	0.0^{i}
AVPP 0403	90.0^{ab}	40.0^{g}	0.0^{k}	5.4^{hi}	0.0^{i}
AVPP 9807	90.0^{ab}	0.0^{n}	0.0^{k}	0.0^{n}	0.0^{i}
AVPP 0114	80.0^{bc}	64.0^{c}	0.0^{k}	6.2^{g}	0.0^{i}
AVPP 9612	70.0^{dc}	24.0$^{i.j}$	0.0^{k}	3.4^{lm}	0.0^{i}
AVPP 0401	70.0^{dc}	62.0^{dc}	0.0^{k}	9.0^{cd}	0.0^{i}
AVPP 9801	60.0^{de}	22.0^{j}	0.0^{k}	3.7^{l}	0.0^{i}
AVPP 0412	60.0^{de}	12.0^{kl}	0.0^{k}	5.8^{gh}	0.0^{i}
Tugantashi	30.0^{gh}	4.0^{nm}	0.0^{k}	4.9^{jk}	0.0^{i}
Atarodo	40.0^{fg}	50.0^{f}	44.0^{e}	5.1^{ij}	8.5^{h}
Tatashe	35.0^{gh}	50.0^{f}	36.0^{f}	7.0^{f}	14.5^{e}
Birdeye	30.0^{gh}	92.0^{a}	24.0^{g}	7.5^{e}	15.2^{e}
Bor kono tsifidi	10.0^{i}	14.0^{k}	50.0^{d}	9.1^{cd}	20.0^{ab}
Cayenne	25.0^{h}	40.0^{g}	60.0^{c}	7.9^{e}	17.7^{cd}
Ex Kunkunu	40.0^{fg}	28.0^{i}	40.0^{f}	9.5^{c}	20.7^{a}
GHA	40.0^{fg}	28.0^{i}	42.0^{e}	3.6^{l}	18.2^{c}
M'daku	50.0^{ef}	22.0^{j}	44.0^{e}	7.8^{e}	19.5^{b}
N-M- Iddi	70.0^{dc}	26.0^{ij}	70.0^{a}	8.9^{d}	18.2^{c}
Nsukka yellow	80.0^{bc}	42.0^{g}	38.0^{f}	5.3^{ij}	10.8^{g}
Prof fintashi	40.0^{fg}	34.0^{h}	44.0^{e}	11.4^{a}	20.0^{ab}
Sombo	35.0^{gh}	88.0^{a}	66.0^{a}	3.1^{m}	18.8^{d}

Means followed by the same alphabet along the column are not significantly different from one another according to Duncan Multiple Range test at 5% probability level.

(0.85 t/ha). Yield in 2013 was significantly (P≤0.05) higher in Sombo (2.18t/ha), M'daku (1.87 t/ha) and AVPP 0802 (1.73 t/ha) compared with AVPP 9809 (0.53t/ha), Borkono tsifidi (0.59 t/ha), GHA (0.64) and AVPP 0013 (0.71 t/ha). Ex- kunkunu had the highest average yield of 2.24t/ha while GHA had the lowest average yield of 0.68t/ha. The t-test showed non-significant difference (P≥0.01) between the yields of the lines/accessions for the two years of the trial (T-value = 1.27, P = 0.21).

Correlation coefficient between disease and yield parameters of fifteen varieties of pepper screened for pepper fruit anthracnose in 2012 and 2013 cropping is presented in Table 7. There was moderate negative and significant relationship (P>0.01) between disease incidence in 2012 and disease severity in 2013(- 0.458**) while there was a strong positive and significant relationship (P>0.01) between disease incidence and disease severity in 2013 (0.822**).

4. DISCUSSION

Pepper lines and accessions evaluated in this study had good seed germination percentages of 75% to 100% during the laboratory germination test but had reduced seedling emergence in the nursery. The differences in the seed germination and seedling emergence could be attributed to variability in environmental conditions. This is in line with the report of [12] which observed that germination tests done in the laboratory do not represent field germination due to differences in environmental conditions. According to [12] laboratory germination tests using filter paper had a higher germination percentage of grass

seeds than grass seeds planted in the field. The incidence of *C. capsici* on the pepper seeds suggests the possibility of nursery-to-field infection due to the seed borne nature of *C. capsici*. This agrees with the report of [13] in which a carry-over of nursery-initiated infections was reported on the field for some pathogens including *Colletotrichum gloeosporioides*. According to [14], seed contamination contributed to initial infections on tomato transplants. Furthermore [15] observed that disease estimation under controlled condition such as in the laboratory may be unreliable and may not be applicable to field conditions due to environmental fluctuations in the field. [16] reported that laboratory germination was not significantly correlated with field emergence of wheat lines, [17] however reported that good laboratory performance produced good field emergence in rice genotypes. [18] reported differences among kenaf genotypes for twenty one traits studied and recommended the selection of the traits for improvement based on variability of the genotypes.

Table 3. Percentage field establishment of fifteen varieties of pepper screened for pepper fruit anthracnose for 2012 and 2013 cropping season in Makurdi

Pepper line/ Accession	Percent establishment 2012	2013
AVPP 0013	80.0^{a}	100.0^{a}
AVPP 0706	60.0^{a}	40.0^{e}
AVPP 0802	73.3^{a}	93.3^{b}
AVPP 9809	86.7^{a}	40.0^{e}
AVPP 9905	73.3^{a}	93.3^{b}
Bird's eye	60.0^{a}	40.0^{e}
Borkono tsifidi	86.7^{a}	100.0^{a}
Cayenne	93.3^{a}	100.0^{a}
Ex Kunkunu	93.3^{a}	100.0^{a}
GHA	73.3^{a}	86.7^{c}
M'daku	66.7^{a}	93.3^{b}
N-M- Iddi	66.7^{a}	86.7^{c}
Nsukka yellow	60.0^{a}	53.3^{d}
Prof fintashi	86.7^{a}	100.0^{a}
Sombo	80.0^{a}	100.0^{a}

Means followed by the same alphabet along the column are not significantly different from one another according to Duncan Multiple Range test at 5% probability level.

The varying viability and germination percentages of pepper varieties screened for resistance to anthracnose may also be attributed to the presence of fungi in the seeds before planting. The presence of C*. capsici* on pepper seeds in this study may be responsible for the low germination of seeds. [19] attributed poor germination to fungal infection and noted that seed borne fungal infection results in seedling diseases under the right environmental conditions and may lead to poor yield. Similarly, seed borne fungi could retard seed germination and seedling viability resulting in poor stand establishment [20]. Also, [21] observed that poor quality seeds will result in low field emergence producing seedlings that are more sensitive to plant diseases with reduced quality and yield.

Table 4. Response of Pepper lines and Accessions to Fruit Anthracnose infection in 2012 and 2013 in Makurdi

Lines/ accessions	Percentage incidence (%) 2012	2013
AVPP 0013	4.93^{e}	14.59^{d}
AVPP 0706	9.49^{c}	1.00^{g}
AVPP 0802	2.69^{fg}	22.85^{b}
AVPP 9809	31.14^{a}	11.56^{e}
AVPP 9905	19.71^{b}	6.86^{f}
Bird's eye	2.43^{fg}	3.35^{g}
Borkono tsifidi	5.66^{e}	38.44^{a}
Cayenne	3.80^{ef}	18.15^{c}
Ex Kunkunu	2.43^{fg}	17.22^{c}
GHA	1.44^{g}	2.82^{g}
M'daku	7.67^{d}	22.94^{b}
N-M- Iddi	3.76^{ef}	26.83^{b}
Nsukka yellow	10.96^{c}	1.90^{g}
Prof fintashi	9.00^{cd}	34.22^{b}
Sombo	5.15^{e}	38.44^{a}

Means followed by the same alphabet along the column are not significantly different from one another according to Duncan Multiple Range test at 5% probability level.

The number of plants established in the field relative to number sown is the final analysis of success of the planting operation. Planting of pepper seeds was more successful in 2013 than in 2012 because of the higher seedling establishment. This may have been due to non acclimatization of the breeding lines/accessions to the environment in the first year of the trial. Successful crop establishment involves the germination and emergence of plants with strong seedling vigour. The report of [22] attributed poor performance of pepper to poor early growth while [20] noted that healthy plant varieties that germinate fast are considered the strongest and are better able to tolerate pathogens.

The significant effect of seedling height in this study shows the vigorous nature of seedling

growth in this study. This is in line with the report of [23] which reported plant height as the strongest morphological trait used to identify vigorous seedlings of *Acacia senegal*.

Table 5. Severity of pepper anthracnose on pepper lines and accessions in 2012 and 2013 cropping season in Makurdi

Line/ accession	Disease severity	
	2012	2013
AVPP 0013	2.0[b]	3.0[a]
AVPP 0706	2.0[b]	2.0[b]
AVPP 0802	2.0[b]	3.0[a]
AVPP 9809	2.0[b]	2.0[b]
AVPP 9905	3.0[a]	3.0[a]
Birdeye	1.0[c]	1.0[c]
Borkono tsifidi	3.0[a]	3.0[a]
Cayenne	1.0[c]	2.0[b]
Ex Kunkunu	2.0[b]	2.0[b]
GHA	2.0[b]	2.0[b]
M'daku	2.0[b]	3.0[a]
N-M- Iddi	1.0[c]	3.0[a]
Nsukka yellow	1.0[c]	1.0[c]
Prof fintashi	1.0[c]	3.0[a]
Sombo	3.0[a]	3.0[a]

Means followed by the same alphabet along the column are not significantly different from one another according to Duncan Multiple Range test at 5% probability level.

The higher severity of anthracnose on pepper fruits in 2012 may be attributed to high rainfall (285 mm) and high humidity (85%) during the harvesting stage which provided favourable environment for disease development. This agrees with the findings of [24] in which high rainfall was attributed to increased fruit rot among pepper accessions of South West Nigeria. This also agrees with the report of [25, 26] in which severe sorghum anthracnose disease was recorded in areas with high rainfall and intermediate temperature. The report of [25, 26] observed a strong influence of rainfall on anthracnose development. [27] also attributed variations in the incidence and severity of plant diseases to host genotypes and planting environment. The lower incidence of pepper anthracnose on Bird's eye and Nsukka yellow fruits suggests that the two accessions probably have genes for resistance to pepper anthracnose.

Table 6. Mean yield of fifteen varieties of pepper screened for pepper fruit anthracnose 2012 and 2013 cropping season in Makurdi.

Variety	Yield (tons/ha)		Average yield
	2012	2013	(tons/ha)
AVPP 0013	1.54[bcd]	0.71[cd]	1.13[bc]
AVPP 0706	1.31[bcd]	1.02[bcd]	1.17[abc]
AVPP 0802	1.99[abc]	1.73[ab]	1.86[ab]
AVPP 9809	2.24[ab]	0.53[d]	1.39[abc]
AVPP 9905	0.64[d]	1.15[bcd]	0.90[bc]
Birdeye	0.85[d]	1.04[bcd]	0.95[bc]
Borkono tsifidi	1.31[bcd]	0.59[d]	0.95[bc]
Cayenne	0.73[d]	0.94[bcd]	0.84[bc]
Ex Kunkunu	2.84[a]	1.64[abc]	2.24[a]
GHA	0.72[d]	0.64[ab]	0.68[c]
M'daku	1.07[bcd]	1.87[ab]	1.47[abc]
N-M- Iddi	1.46[bcd]	1.62[abc]	1.54[abc]
Nsukka yellow	1.01[bcd]	0.93[bcd]	0.97[bc]
Prof fintashi	1.92[abc]	1.22[abcd]	1.57[abc]
Sombo	0.68[d]	2.18[a]	1.43[abc]

Means followed by the same alphabet along the column are not significantly different from one another according to Duncan Multiple Range test at 5% probability level.

The variation in yield could be due to different dry matter partitioning ability of pepper plants [28]. The work of [24] indicated that different accessions of pepper performed differently in different seasons due to the varying environmental factors that either enhance or limit productivity. The high rainfall during the growth period may have resulted in high cloud cover which reduced the rate of photosynthesis and subsequently reduced yield. The differences in

Table 7. Correlation coefficient between disease and yield parameters of fifteen varieties of pepper screened for pepper fruit anthracnose in 2012 and 2013 cropping season in Makurdi

	Disease severity 2012	Disease severity 2013	Disease incidence 2012	Disease Incidence 2013	Yield 2012	Yield 2013
Severity 2012	L					
Severity 2013	0.106	L				
Incidence 2012	0.202	-0.458**	L			
Incidence 2013	0.251	0.822**	-0.215	L		
Yield 2012	-0.10	0.134	0.147	0.175	L	
Yield 2013	0.115	0.370**	-0.195	0.433**	0.127	L

*** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).*

fruit yield recorded in the two cropping seasons in this study agrees with the report of [24] which reported significant effect of season on the yield of different pepper accessions with a higher yield in the second season than in the first season.

The lower yield recorded in GHA and Bird's eye which had lower anthracnose incidence could be attributed to their small fruit sizes. [8] had earlier reported that varieties with smaller fruits produced less weighty fruits per hectare. Also, [29] reported low incidence of pepper anthracnose in the southern part of Benue State where Bird's eye pepper was predominantly cultivated. [30] associated resistance to anthracnose disease with high concentrations of capsaicin in some chili varieties.

Although Ex- kunkunu recorded moderate anthracnose incidence and severity, its yield was higher compared with other lines and accession indicating it is tolerant to anthracnose. This agrees with the report of [31].

5. CONCLUSION AND RECOMMENDATION

This study showed that two local pepper accessions Bird's eye and Nsukka yellow had the least incidence of pepper anthracnose under field conditions. These accessions identified in this study can be used in further research aimed at the improvement of *Capsicum* spp. varieties by crossing these identified accessions with exotic lines with desirable traits to improve pepper productivity in pepper anthracnose endemic areas.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Agbogidi OM, Okonmah UL. Performance of sweet pepper (C*apsicum annuum*) as influenced by weeding frequency. International Journal of Advanced Biological Research. 2011;1(1):119-122.
2. Asawalam EF, Emeanor KC, Okezie JC. Control of pests of some *Capsicum* species (Pepper) cultivars using soil amendments in Umudike- Nigeria. Electronic Journal of Environmental Agricultural and Food Chemistry. 2007; 6(4):1975-1979.
3. Manyong VM, Ikpi A, Olayemi, JK. Agriculture in Nigeria: Identifying opportunities for increased commercialization and Investment. A summary report by IITA, USAID and University of Ibadan. 2004: 28pages.
4. Alao SEL. Pepper based stem rot and wilt disease. The story so far and available control options. NOMA. 1998;12:1-7.
5. Roberts PD, Pernezny KL, Kucharek TA. Anthracnose caused by *Colletotrichum sp*. on pepper; 2001. Available:http://edis.ifas.ufl.edu.document. PP104
6. Nayaka SC, Shankar ACU, Niranjana SR, Prakash HS, Mortensen CN. Anthracnose disease of chili pepper. Technical Bulletin published by Asian Seed Health Centre Karnataka, India and Danish Seed Health Centre for Developing Countries, Denmark. 2009;14.
7. Lubna M, Ali A, Shahzad A, Sofi TA. Cultural, morphological and pathogenic variability in *Colletotrichum capsici* causing Die-back and Fruit Rot of Chilli. Asian Journal of Plant Pathology. 2013;7:29-41.
8. Ekefan EJ, Olukotun FG, Nwankiti AO. Incidence of anthracnose and its effect on yield of sweet pepper (*Capsicum annuum* L.) in Makurdi, Nigeria. Nigerian Journal of Botany. 2010;23(2):297-306.
9. Ekefan EJ. Epidemiology and control of Yam anthracnose in Nigeria. PhD Thesis, University of Reading, United Kingdom. 1996;220.
10. SAS Institute Inc. SAS/STAT Guide for personal computers, Version 9.2 edition. SAS Institute Cary, NC.USA; 2009.
11. Obi IU. Statistical methods of detecting differences between treatment means and research methodology issues in laboratory and field experiments 2nd edition AP Express Publishers, Nsukka. 2002;117.
12. Frasier GW. Characterization of seed germination and seedling survival during the initial wet-dry periods following planting. Journal of Range Management. 1989;42(4):299-303.
13. Barnard EL. Diseases of seedlings in forest tree nurseries in Florida: History and status. Paper presented at the third meeting of IUFRO Working Party 57.03-04 (Diseases and Insects in Forest Nurseries). Orlando-Gainesville, Florida, USA. May 19-24, 1996;1-15.
14. Makelo MN. Assessment of seed borne pathogens for some important crops in

Western Kenya, Machakos, Kenya. 2010; 1-7.

15. Idowu OTH, Popoola AR, Adeoti AYA, Salami AM. Reaction of *Sorghum bicolor* (L.) Moench cultivars to *Colletotrichum graminicola* (Cesati) Wilson in South – West Nigeria. Nigerian Journal of Plant Protection. 2011;25(1):43-54.
16. Anjorin ST, Mohammed M. Effect of seed borne fungi on germination and seedling vigour of watermelon (*Citrullus lanatus* humb). African Journal of Plant Science. 2014;8(5):232-236.
17. Adebisi MA, Okelola FS, Alake CO,Ayo-Vaughan MA, Ajala MO. Interrelationship between seed vigour traits and field performance in new rice for Africa (NERICA) Genotypes (*Oryza sativa* L.). Journal of Agricultural Science and Environment. 2010;10(2):15-26.
18. Kehinde TO, Adebisi MA, Esuruoso OA, Akinrinde GO, Famakinde O. Assessment of seedling vigour characteristics in Kenaf (*Hibiscus cannabinus* L.) Genotypes. Applied Tropical Agriculture. 2015;20(2): 24-31.
19. Mehrotra RS, Aggarwal A. Plant pathology. Teta Mc Graw-hill Publishing Company New Delhi second edition. 2003;254.
20. Ashilenje DS. Learn how to grow pepper. Phoenix publishers Limited Nairobi, Kenya. 2013;37.
21. Taye W, Laekemariam F, Gidago G. Seed germination, emergence and seedling vigor of maize as influenced by pre-sowing fungicides seed treatment. Journal of Agricultural Research and Development. 2013;3(3):35-41.
22. Ibrahim HM, Olasantan FO, Oyewale RO. Age of seedling at transplanting influenced growth and fruit yield of sweet pepper (C*apsicum annum* L. cv. Rodo). Net Journal of Agricultural Science. 2013; 1(4):107-110.
23. Zubairu SU. The influence of seed pre treatment on seed germination and seedling vigour in *Acacia senegal* in the nursery. Journal of Biology, Agriculture and Healthcare. 2014;4(12):57-62.
24. Idowu- Agida OO, Adetimirin VO, Nwanguma EI, Makinde AA. Effects of Seasonal variability on the Performance of Long Cayenne Pepper Collected from South- western Nigeria. Researcher. 2010; 2(10):85-92.
25. Chala A, Bruberg MB, Tronsmo AM. Incidence and severity of sorghum anthracnose in Ethiopia. Plant Pathology Journal. 2010;9:23-30.
26. Ngugi HK, King SB, Abayo GO, Reddy YVR. Prevalence, incidence and severity of sorghum diseases in Western Kenya. Plant Disease. 2002;86:65-70.
27. Neya A, Normand M. Responses of Sorghum genotypes to leaf anthracnose (*Colletotrichum graminicola*) under field conditions in Burkina Faso. Crop Protection. 1998;17:47-53.
28. Seleshi D. Evaluation of elite hot pepper varieties (*Capsicum* species) for growth, dry pod yield and quality under Jimma condition, South West Ethiopia. Master of Science Thesis submitted to Department of Horticulture, Jimma University, Ethiopia. 2011;58.
29. Ekhuemelo C, Ekefan EJ, Nwankiti AO. Morphological, pathological and molecular characterization of *Colletotrichum capsici* causal agent of pepper anthracnose in Benue State, Nigeria. Nigerian Journal of Plant Protection. 2016;30:1-12.
30. Wilawan K, Somsiri S, Sutevee S. Effect of Capsaicin on germination of *Colletotrichum capsici* conidia. Kasetsart Nature Science Journal. 2008;42(3):417-422.
31. Parey MA, Razdan VK, Sofi TA. Comparative study of different fungi associated with fruit rot of chilli and screening of chilli germplasm against *Colletotrichum capsici.* International Journal of Agricultural Crop Science. 2013; 5(7):723-730.

Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/22166