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Cowpea (*Vigna unguiculata* (L.) Walp) Accessions Evaluation for Cercospora Leaf Spot Resistance Under Changing Weather

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ABSTRACT

Background and Objective: Cowpea (*Vigna unguiculata* L. Walp) is considered to be an important food crop in Nigeria. However, its production in commercial quantity is constrained majorly by 64% fungal diseases especially Cercospora Leaf Spot Disease (CLSD). The objective of this research was to evaluate sixty-two cowpea accessions for resistance to Cercospora Leaf Spot Disease (CLSD) and determine their agronomic parameters to identify resistant accessions that could be used as breeding materials for improved cowpea germplasm. The study also aimed to assess the impact of weather conditions on disease incidence and severity. **Materials and Methods:** In line with this, a study was conducted to evaluate sixty-two cowpea accessions for resistance to CLSD at the Research Farm, Institute of Agricultural Research and Training, Obafemi Awolowo University, Ibadan, the site is located at (Latitude 07°23'N, Longitude 03°51'E). The trial took place during the dry season (August to November) 2017 and the wet season (May to August) 2018. The cowpea accessions were laid-out in Randomized Complete Block Design with three replications. Data were collected on disease incidence and severity as well as agronomic parameters. Data collected were subjected to Analysis of Variance and means of significant treatments were separated using Duncan's Multiple Range Test at $p<0.05$. **Results:** The results indicated that due to emerging weather conditions, the disease incidence and severity were significantly ($p<0.05$) different for the two seasons and also for the accessions, the disease reaction in the dry season showed that 2 accessions (TVu-9202 and TVU-9276) were highly resistant, 31 were resistant, 23 were moderately resistant and 6 were moderately susceptible. However, in the wet season, 29 accessions were moderately resistant, 32 moderately susceptible and one (IFE BPC) was susceptible based on 0-5 adopted severity scale. **Conclusion:** Cercospora Leaf Spot (CLS) disease has serious implications on cowpea production and yield based on the prevalent weather condition and the inherent genetic trait. Hence, the observed resistant cowpea accessions found in this study can be further evaluated in different agroecological zones.

KEYWORDS

Screening for resistance, cowpea accessions, susceptible, cercospora leaf spot, genetic, weather

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INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important food and forage legumes grown in the semi-arid tropics and some temperate regions of the world[1-3]. It has much importance, which ranges from being a source of protein for animals and man, a cover crop for the fixation of nitrogen to stressed soil[3,4]. However, cowpea is attacked by a wide range of constraints which include several biotic factors such as insect pest, parasitic nematodes, virus, bacterial and fungi attack and also abiotic factors such as nutrient stress, poor soil nutrient, drought, planting dates and poor planting seeds[4,5].

Fungi disease mainly Cercospora Leaf Spot (CLS) caused by *Cercospora canescens* (Ellis and Martins) is one of the principal infections that causes more destructive damage on cowpea crops with symptoms of severe defoliation at the reproductive stages of growth[4,5]. This disease is of great importance to farmers and breeders as it poses a serious threat to cowpea production[6-8]. It spreads rapidly in susceptible varieties causing premature defoliation and reduction in the size of pods and grains. The damage caused to the photosynthetic area of the cowpea leaf could be considerable at the point of flowering and thus, a principal contributive factor in the reduction of cowpea yields. The disease starts to appear 30-40 days after planting at the peak of the reproductive stage[9]. Hence, the management of Cercospora leaf spot is highly recommended which involves the use of clean seeds, this is either obtained from a reliable seed supplier or the seed is cleaned to remove plant debris before planting[9,10]. The land to be used for cultivation must be free of volunteer plants of cowpea and other legumes before field planting. The spread of the disease can also be removed by alternating rows of cowpea (or other legumes) with maize or sorghum[11,12]. The new cowpea seed should not be planted from older infected CLSD cowpea crop to ensure high viability. After harvesting the cowpea, the trash should be collected and burnt or buried. Chemical fungicides can also be used in the treatment of fungal diseases of cowpea through the treatment of seeds with fungicides such as mancozeb (80 kg^{-2} of seeds) followed by 2-3 foliar sprays of mancozeb at 250 kg L^{-1} or a teaspoon of mancozeb in 2 L of water applied at 10-14 days' intervals[12]. Though this method has been implicated by the misuse of chemical fungicides and thus, had posed a harmful effect on the environment and the cosumers. This has been the major factor that necessitated the research for other methods of disease management that are free, economical and health to consumers health. Presently, there is a dearth of information on the control of Cercospora leaf spot disease on cowpea plants without the use of fungicides[13] due to changes in the weather condition and unstable climatic changes. Hence the objective of this study was to isolate the causal pathogen of Cercospora leaf spot disease and to screen sixty-two cowpea accessions for inherent resistance to Cercospora leaf spot disease under a natural field condition constrained by the changing weather condition imposed by Climate change globally experienced, especially in Nigeria agricultural belts.

MATERIALS AND METHODS

The experiment was carried out at the Institute of Agricultural Research and Training (I.A.R. and T.), Moor Plantation, Ibadan which is located on Latitude 07°23'N, Longitude 03°51'E and altitude 650 m in the humid zone of the rainforest belt of Southwestern Nigeria with a mean annual rainfall of 1220 mm and mean temperature of 26°C. The rainfall is usually heavy during the wet season (April to September) and scanty in the dry season (November to March). High temperatures and plenty of sunshine generally prevail during the dry season.

Sixty-two cowpea accessions were sourced (Table 1) from the genetic bank of IITA and IAR&T. They were selected from those commonly grown in the Guinea Savanah agricultural belt of Nigeria. The experiment was arranged in a Randomized Complete Block Design (RCBD) made of 186 plots (62 by 1 m) on a single-row plot with three replications. Five plants were randomly selected in each plot and tagged, each plot size was 5×1 m with an average of 10 plants per row. Harvesting was done at physiological maturity manually and each plot was harvested separately.

The experimental site was plowed and harrowed and the field was laid out in experimental plots. No fertilizer or pesticides was applied. Two seeds were planted per hole at a depth of approximately 2-3 cm. At the first leaf stage, seedlings were thinned to 1 plant per stand in other to ensure a uniform plant population and to avoid competition for nutrients and water among the plants, the same field was cultivated for the experiment in the 2017 dry season and 2018 wet season, respectively. The experimental plots were located on well-drained sandy loam soil. The soil was classified as Ibadan series (local name) Alfisol[14].

Isolation and identification of the pathogens associated with Cercospora leaf spot disease of Cowpea plants: The fungi pathogens were recovered from the sections of the infected leaf of the 62 cowpea accessions found in the experimental field of the Institute of Agricultural Research and Training, Ibadan. The diseased cowpea leaves were severed from diseased plants collected from the research farm to the laboratory where disease sample leave were surface rinsed using tap water and the leaf tissue was cut into pieces about 2-3 mm long, the leaves surface was sterilized by immersion in 10% Sodium Hypochlorite (NaOCl) for two minutes, rinsed in three changes of sterile distilled water (SDW) and blotted dry with sterile filter paper. With the aid of a mounting needle. The causal fungal organisms were isolated following the standard procedure of fungal isolation, the disinfected leaves were plated onto freshly prepared Potato Dextrose Agar (PDA) amended with 0.6 mg L^{-1} streptomycin in a petri dish and incubated at room temperature (27±2°C) and observed daily for fungal growth for 3 to 4 days. After incubation, colonies of fungi were observed on the plates. The fungal growth was subcultured into freshly prepared PDA to obtain pure cultures. Pure cultures of each fungal colony type were obtained and maintained. This was achieved by sub-culturing each of the different fungal colonies onto PDA plates and incubating again at room temperature until pure cultures were obtained and also for the production of spores. The pure cultures were stained with cotton blue lacto phenol, examined and photographed using an Olympus camera-mounted microscope (DP71 Shinjuku Monolith, 3-1, Nishi Shinjuku 2-chome, Shinjuku-ku, Tokyo, Japan) at ×100 and ×400, magnifications. Fungi were identified using cultural and morphological characteristics based on the manual[15], identities of the isolates were confirmed by the use of fungi compendium[16]. Pure cultures of the isolated fungi were subcultured on the PDA slants in McCartney bottles and preserved until needed for further studies, the percentage frequency of the isolated fungal pathogens was calculated:

$$\text{Percentage frequency of isolation (PFI)} = \frac{\text{Number of times a fungus is encountered}}{\text{Total number of times all fungus was encountered}} \times 100$$

Disease incidence was recorded at 6-10 weeks after planting (WAP) which was a percentage of total plants that exhibited symptoms of Cercospora leaf spot infection while the disease severity assessment was based on the percentage of leaf surface covered with spots and halo appearance of the cowpea plant at 6-10 weeks after planting (WAP). Adopted disease severity scale 0-5 was used, where 0 = visible symptoms, 1 = less than 10% infection, 2 = 11-20% infection, 3 = 21-30% infection, 4 = 41-50% infection and 5 = more than 50% infection[17]:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of healthy and infected plants}} \times 100$$

Data on agronomic parameters (cowpea canopy height, number of branches, number of leaves), yield and yield components including pod weight per plot (grams) and seed weight per plot (grams) were also recorded.

Agrometeorological data: Mean monthly weather parameters of the experimental site were obtained from the Institute of Agricultural Research Institute Weather Station Ibadan, Oyo State. The Agrometeorological data recorded included the monthly mean value of rainfall, maximum temperature, minimum temperature and relative humidity.

Statistical analysis: The data collected were subjected to the Analysis of Variance (ANOVA) procedure of SAS 9.0[18] to affirm if there was a significant difference among the sixty-two accessions. Means were separated using the Duncan's Multiple Range Test (DMRT) at a 5% probability level.

RESULTS

The cowpea accessions used for this study were selected based on their ease of tolerance and physiological characteristic Table 1 and Fig. 1.

Fig. 1: Sixty two cowpea accessions planted

Table 1: Sources of planting materials and their characteristic appearance

Serial number	Cowpea accession	Source	Characteristics
1	TVu-9099	IITA	The seed coat is the smooth red, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
2	TVu-9100	IITA	The seed coat is the smooth brown, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
3	TVu-9101	IITA	The seed coat is the smooth white, the white eye with a round irregular-shaped dark pigmented area encircling the hilum, early maturing
4	TVu-9105	IITA	The seed coat is the smooth red, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
5	TVu-9106	IITA	The seed coat is the smooth white, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
6	TVu-9107	IITA	The seed coat is speckled with white and red, the white eye with a dark round irregular-shaped pigmented area encircling the hilum, early maturing
7	TVu-9109	IITA	The seed coat is smooth brown, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
8	TVu-9117	IITA	The seed coat is the white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
9	TVu-9118	IITA	The seed coat is the speckled brown, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
10	TVu-9171	IITA	The seed coat is the white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
11	TVu-9172	IITA	The seed coat is whitish-brown, with white eyes with a round irregular-shaped pigmented area encircling the hilum, early maturing
12	TVu-9174	IITA	The seed coat is the white, the white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
13	TVu-9175	IITA	The seed coat is speckled with the white and red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
14	TVu-9176	IITA	The seed coat is smooth and red speckled with the white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
15	Tvu-9179	IITA	The seed coat is the smooth red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
16	TVu-9180	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing
17	TVu-9181	IITA	The seed coat is white speckled with brown red, white eyes with a round irregular-shaped pigmented area encircling the hilum, early maturing
18	TVu-9182	IITA	The seed coat is white speckled with red, white eyes with a brown round irregular-shaped pigmented area encircling the hilum, early maturing
19	TVu-9183	IITA	The seed coat is the white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing accession
20	TVu-9184	IITA	The seed coat is smooth brown speckled with red and white eyes with a round irregular-shaped pigmented area encircling the hilum, early maturing accession
21	TVu-9185	IITA	The seed coat is smooth red, white eye with a round irregular-shaped pigmented area encircling the hilum, small seed sized(3cm) and early maturing
22	TVu-9186	IITA	The seed coat is smooth red speckled with white, white eye with a round irregular-shaped pigmented area encircling the hilum and are early maturing
23	TVu-9187	IITA	The seed coat is smooth red, white eye with a dark round irregular-shaped pigmented area encircling the hilum, early maturing seeds
24	TVu-9189	IITA	The seed coat is smooth brown, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
25	TVu-9190	IITA	The seed coat is white spotted with red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
26	TVu-9191	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
27	TVu-9192	IITA	The seed coat is white speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
28	TVu-9194	IITA	The seed coat is smooth brown, white eyed with a dark round irregular-shaped pigmented area encircling the hilum, early maturing seeds
29	Tvu-9195	IITA	The seed coat is smooth brown speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
30	TVu-9197	IITA	The seed coat is white speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
31	TVu-9198	IITA	The seed coat is brown red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds

Table 1: Continue

Serial number	Cowpea accession	Source	Characteristics
32	TVu-9199	IITA	The seed coat is white, white eyed with a brown irregular-shaped pigmented area encircling the hilum, early maturing seeds
33	TVu-9200	IITA	The seed coat is white, white eyed with a dark irregular-shaped pigmented area encircling the hilum, early maturing seeds
34	TVu-9201	IITA	The seed coat is smooth brown, white eye with a brown round irregular-shaped pigmented area encircling the hilum, early maturing seeds
35	TVu-9202	IITA	The seed coat is brown speckled with red and white pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
36	TVu-9204	IITA	The seed coat is white, white eyed with a dark irregular-shaped pigmented area encircling the hilum, early maturing seeds
37	TVu-9205	IITA	The seed coat is white speckled with red, white eye with brown round irregular-haped pigmented area encircling the hilum, early maturing seeds
38	TVu-9206	IITA	The seed coat is brown speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
39	TVu-9207	IITA	The seed coat is brown speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
40	TVu-9272	IITA	The seed coat is white, white eye with a dark irregular-shaped pigmented area encircling the hilum, early maturing seeds
41	TVu-9273	IITA	The seed coat is white, white eye with a white round irregular-shaped pigmented area encircling the hilum, early maturing seeds
42	TVu-9276	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
43	TVu-9277	IITA	The seed coat is white, white eye with a round prominent dark irregular-shaped pigmented area encircling the hilum, early maturing seeds
44	TVu-9281	IITA	The seed coat is speckled with white and red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
45	TVu-9283	IITA	The seed coat is speckled with white and brown, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
46	TVu-9284	IITA	The seed coat is speckled with white and red, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
47	TVu-9285	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
48	TVu-9287	IITA	The seed coat is brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds
49	TVu-9288	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
50	TVu-9289	IITA	The seed coat is white smeared with speckled brown, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
51	TVu-9292	IITA	The seed coat is stained white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
52	TVu-9294	IITA	The seed coat is brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds
53	TVu-9295	IITA	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
54	TVu-10860	IITA	The seed coat is light brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds
55	TVu-10862	IITA	The seed coat is brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds
56	TVu-13401	IITA	The seed coat is stained white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
57	TVu-13402	IITA	The seed coat is stained white, white eye with a prominent round irregular-shaped pigmented area encircling the hilum, early maturing seeds
58	TVu-13664	IITA	The seed coat is white speckled with red pigment, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
59	MODUPE	IAR&T	The seed coat is white, white eye with a round irregular-shaped pigmented area encircling the hilum, early maturing seeds
60	ART 98-12-W	IAR&T	The seed is large curved with white seed coat, white eyed with a brown round irregular-shaped pigmented area encircling the hilum, early maturing seeds
61	IFE BROWN	IAR&T	The seed coat is light brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds
62	IFE BPC	IAR&T	The seed coat is light brown red, white eye with an irregular-shaped pigmented area encircling the hilum, early maturing seeds

Percentage of fungi pathogens isolated from the diseased leaves of the 62 accessions of cowpea at 10 WAP during the wet season of 2017 and dry season of 2018: Fungi isolates were obtained from the infected cowpea plant leaves of the sixty-two cowpea accessions (Fig. 1) in both 2017 dry and 2018 wet seasons, seven fungal genera were identified belonging to *Cercospora* species (61.8 and 67.0%), *Colletotrichum* spp. (18.4 and 24.6%), *Rhizotonia* spp. (5.2 and 3.8%), *Fusarium* spp. (1.4 and 3.2%) and a few common saprophytes were also isolated such as *Trichoderma* (2.4, 0%) isolates, *Aspergillus niger* (5.0, 0%) and other isolates with name likely *Pseudocercospora* (5.8 and 1.4%) isolates (Fig. 2). The wet season had more fungi inoculum than the dry season except that opportunistic fungi like trichoderma and Aspergillus were not isolated on the cowpea leaves during the wet season. Cercospora pathogen was the most isolated fungal species causing the foliar leaf spot on cowpea (Fig. 2) as observed in the field and confirmed by the koch postulate in the screening house.

Pathogenicity test: Pathogenicity test revealed that of all the pathogens isolated from diseased leaves of the sixty-two cowpea plants only *Cercospora* spp., was capable of inducing leafspot disease in healthy cowpea plant leaves. At 14 days' post inoculation, red spots were observed on the inoculated plant leaves while no leaf spot infection was seen on the other pathogen inoculated and the un-inoculated controls.

Identification of the pathogen that caused the leaf spot observed: The fungal pathogen formed a uniformly dense colony on Potato Dextrose Agar (PDA). The colony generally appeared as whitish-brown mat. The medium beneath the colony gradually changes its colour from white to dark red. Hypha of the fungus was brownish to black, septated and branched when observed under the microscope. The fungus grew slowly on PDA medium maximum growth was achieved after 6 days with convex, fluffy whitish mycelial was observed there was no growth recorded after 12-13 days, but beneath the fungal culture which was initially dark brown changed to purple colour due to the production of metabolite identified as cercosporin metabolite (Fig. 3a-b and 4). Table 2 shows a comparison of the morphological characteristics of *Cercospora canescens* from cowpea leaves with the earlier reports on it[19]. The table demonstrates that the leaf spot pathogen of cowpea had dark to brown narrow multiseptated amphigenous conidiophore that produces conidia that are straight or slightly bent with dense fascicle straight to variously curved, with a size range of 2.5-5.0 (rarely 6) ×30-300 µ. On the other hand, the fruiting structure of the pathogen had conidia while the conidiophore was dark multiseptated and measured 2.0-6.9×10-100 µm, with terminal unbranched, darkened and refractive color (Table 2). Hence, the fungus was identified as *Cercospora canescens*[20].

Disease incidence of Cercospora leaf spot infection on the accessions of cowpea: Disease symptoms were first observed at 8 weeks after planting (WAP) during flowering. The disease began with intermingled spots of normal light green to brown lesions. The disease incidence of Cercospora Leaf Spot Disease was significantly different ($p<0.05$) for both 2017 dry and 2018 wet seasons in the the experimental farm. There was no significant difference ($p>0.05$) for the interaction between the seasons and accessions. However, the wet season of 2018 disease incidence was significantly higher ($p<0.05$) than that of the dry season of 2017. The disease incidence ranged from 2.0-68.3% in both seasons, (Table 3). IFE BPC cowpea accession had the highest percentage of disease incidence and severity in both seasons than other accessions at 10 WAP and during the 2017 dry season, however, TVU-9202 and TVU-9276 were not affected by the leaf spot disease at 10 WAP, but in the wet season 2018, there was significant difference in the disease incidence among the accessions studied (Table 3). The 62 cowpea accessions had higher disease incidence along with the accessions Tvu-9202 and Tvu-9276 that escaped the disease in the dry season of 2017.

Disease severity of Cercospora leaf spot on the cowpea accessions during the dry season of 2017 and wet season 2018: The disease severity for the 62 accessions of cowpea was significant ($p<0.05$) for all the accessions at 8 WAP and 10 WAP (Table 4). There was no significant difference in the interaction between the seasons and accessions for disease severity. There was a progressive increase in severity from

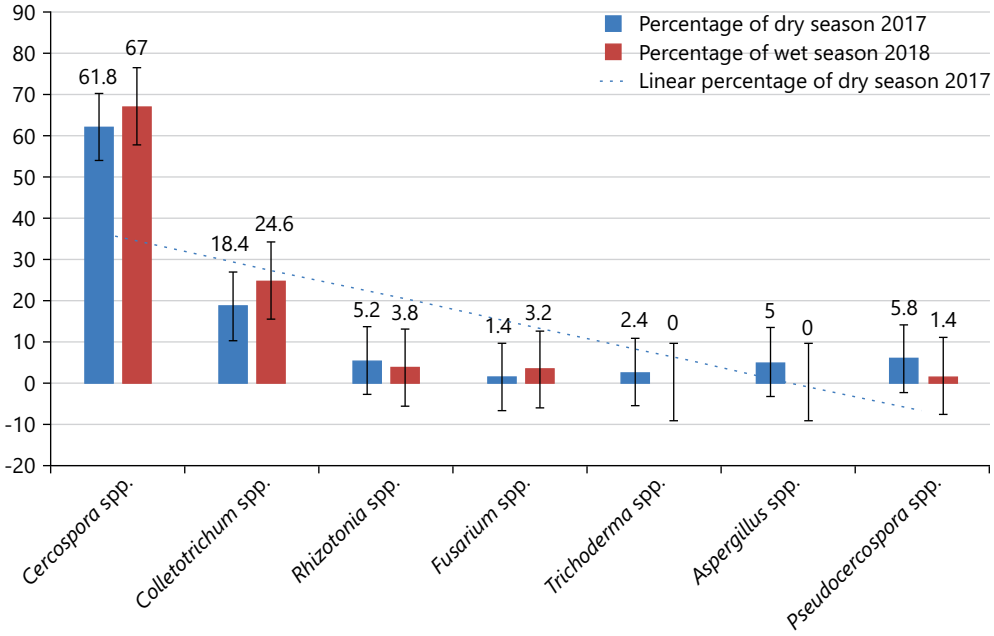

Fig. 2: Percentage of disease incidence of fungi infection isolated from the diseased leaves of the 62 accessions of cowpea at 10 WAP during the wet season of 2017 and dry season of 2018

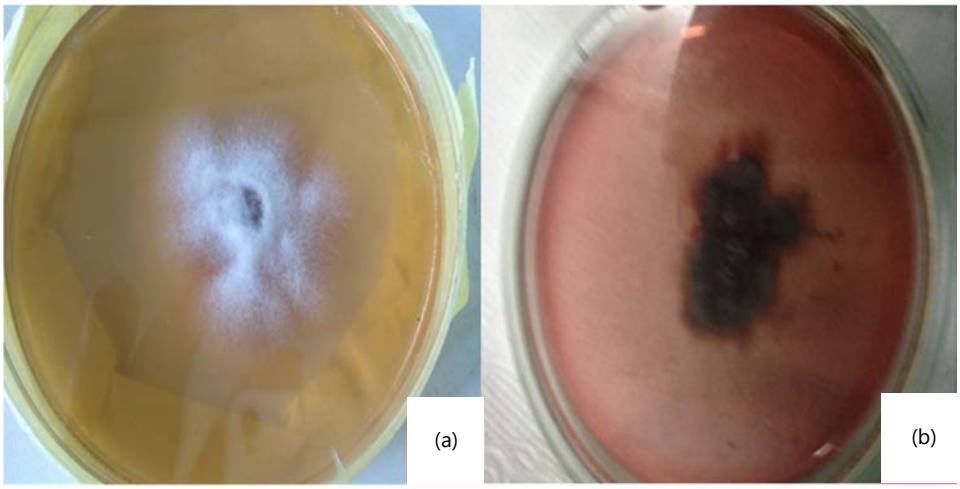

Fig. 3(a-b): (a) Front view of Culture plate of *Cercospora canscens* showing growth and (b) Back view of culture plate of *Cercospora canescens* showing cercosporin metabolite production

Table 2: Comparison of morphological characters of *Cercospora canescens* from cowpea leaves, with the earlier report on it

References	Morphological characters
Cercospora canescens[20]	The leaf spot pathogen had dark to brown narrow multiseptated amphigenous conidiophore that produces conuidia that are straight or slightly bent with dense fascicle straight to variously curved, with a size range of 2.5-5.0 (rarely 6) ×30-300 µ
Cercospora canescens of cowpea (under study)	The Fruiting structure the pathogen had conidia while the conidiophore are dark multiseptated and measured 2.0-6.9×10-100 µm, with terminal unbranched, darkened and refractive colour

8 WAP to 10 WAP at the reproductive stage, while the 62 accessions were mostly infected with the Cercospora leaf spot at a scale ranging from 0.00-3.20 at 8 WAP and at 10 WAP. The disease severity of the Cercospora leaf spot in the 2017 dry season varied significantly among the 62 cowpea accessions. The IFE BPC cowpea accession had the highest severity of (3.0 and 3.2) for both dry and wet seasons, respectively, while TVU-9292 (0.0) and TVU-9276 (0.0) had the lowest disease severity at 10 WAP. However,

Table 3: Disease incidence of Cercospora leaf on the accessions of cowpea during the dry season 2017 and wet season 2018

	Disease incidence (%)			
	Weeks after planting dry season 2017		Weeks after planting wet season 2018	
Accession	8	10	8	10
TVu-9099	17.9^{a}	52.2^{abc}	34.0^{a}	53.3^{abc}
TVu-9100	0.0^{d}	56.3^{ab}	30.0^{ab}	42.7^{abc}
TVu-9101	0.0^{d}	52.3^{abc}	20.0^{a-d}	57.0^{ab}
TVu-9105	6.7^{bcd}	50.7^{a-d}	13.3^{a-d}	45.3^{abc}
TVu-9106	0.0^{d}	35.3^{a-e}	20.0^{a-d}	43.0^{abc}
TVu-9107	0.0^{d}	41.3^{a-e}	20.0^{a-d}	44.3^{abc}
TVu-9109	0.0^{d}	33.3^{a-e}	20.0^{a-d}	37.3^{abc}
TVu-9117	0.0^{d}	39.3^{a-e}	20.0^{a-d}	43.7^{abc}
TVu-9118	0.0^{d}	31.3^{a-e}	20.0^{a-d}	44.7^{abc}
TVu-9171	0.0^{d}	26.7^{cde}	20.0^{a-d}	38.0^{abc}
TVu-9172	13.3^{ab}	36.7^{a-e}	20.0^{a-d}	46.0^{abc}
TVu-9174	0.0^{d}	39.3^{a-e}	20.0^{a-d}	48.7^{abc}
TVu-9175	0.0^{d}	24.7^{cde}	20.0^{a-d}	42.0^{abc}
TVu-9176	0.0^{d}	26.0^{cde}	20.0^{a-d}	44.7^{abc}
TVu-9179	0.0^{d}	21.3^{e}	20.0^{a-d}	35.3^{abc}
TVu-9180	0.0^{d}	32.0^{a-e}	20.0^{a-d}	43.3^{abc}
TVu-9181	0.0^{d}	25.3^{cde}	26.7^{abc}	44.7^{abc}
TVu-9182	0.0^{d}	28.3^{b-e}	20.0^{a-d}	43.3^{abc}
TVu-9183	0.0^{d}	36.0^{a-e}	13.3^{a-d}	31.3^{abc}
TVu-9184	0.0^{d}	26.7^{cde}	0.0^{d}	34.7^{abc}
TVu-9185	0.0^{d}	34.7^{a-e}	26.7^{abc}	45.3^{abc}
TVu-9186	0.0^{d}	26.7^{cde}	20.0^{a-d}	41.3^{abc}
TVu-9187	0.0^{d}	32.0^{a-e}	20.0^{a-d}	53.3^{abc}
TVu-9189	0.0^{d}	27.3^{b-e}	20.0^{a-d}	44.0^{abc}
TVu-9190	0.0^{d}	20.9^{e}	13.3^{a-d}	27.1^{abc}
TVu-9191	0.0^{d}	14.7^{e}	15.3^{a-d}	33.3^{abc}
TVu-9192	0.0^{d}	18.0^{e}	0.0^{d}	26.7^{abc}
TVu-9194	0.0^{d}	30.0^{a-e}	13.3^{a-d}	33.3^{abc}
TVu-9195	0.0^{d}	26.0^{cde}	3.3^{cd}	24.4^{bc}
TVu-9197	0.0^{d}	36.3^{a-e}	6.7^{bcd}	30.7^{abc}
TVu-9198	0.0^{d}	21.0^{e}	0.0^{d}	32.0^{abc}
TVu-9199	0.0^{d}	37.3^{a-e}	13.3^{a-d}	40.7^{abc}
TVu-9200	0.0^{d}	20.7^{e}	3.3^{cd}	30.7^{abc}
TVu-9201	0.0^{d}	28.0^{b-e}	6.7^{bcd}	31.5^{abc}
TVu-9202	0.0^{d}	2.0^{e}	13.3^{a-d}	40.0^{abc}
TVu-9204	0.0^{d}	25.3^{cde}	0.0^{d}	28.9^{abc}
TVu-9205	0.0^{d}	18.7^{e}	0.0^{d}	27.1^{abc}
TVu-9206	0.0^{d}	26.7^{cde}	6.7^{bcd}	31.7^{abc}
TVu-9207	0.0^{d}	33.3^{a-e}	0.0^{d}	45.0^{abc}
TVu-9272	5.0^{cd}	43.7^{a-e}	13.3^{a-d}	49.3^{abc}
TVu-9273	0.0^{d}	30.7^{a-e}	26.7^{abc}	44.0^{abc}
TVu-9276	0.0^{d}	2.0^{e}	13.3^{a-d}	33.3^{abc}
TVu-9277	0.0^{d}	20.0^{e}	0.0^{d}	34.7^{abc}
TVu-9281	0.0^{d}	20.0^{e}	6.7^{bcd}	38.9^{abc}
TVu-9283	0.0^{d}	19.5^{e}	0.0^{d}	46.7^{abc}
TVu-9284	0.0^{d}	24.0^{cde}	0.0^{d}	46.7^{abc}
TVu-9285	0.0^{d}	20.0^{e}	6.7^{bcd}	32.7^{abc}
TVu-9287	0.0^{d}	20.0^{e}	13.3^{a-d}	33.3^{abc}
TVu-9288	0.0^{d}	22.0^{de}	0.0^{d}	22.7^{c}
TVu-9289	9.3^{bc}	25.3^{cde}	13.3^{a-d}	33.3^{abc}
TVu-9292	0.0^{d}	31.7^{a-e}	20.0^{a-d}	40.0^{abc}
TVu-9294	0.0^{d}	26.7^{cde}	23.3^{a-d}	53.3^{abc}
TVu-9295	0.0^{d}	30.7^{a-e}	26.7^{abc}	45.3^{abc}

Table 3: Continue

	Disease incidence (%)			
	Weeks after planting dry season 2017		Weeks after planting wet season 2018	
Accession	8	10	8	10
TVu-10860	0.0^{d}	23.2^{cde}	13.3^{a-d}	37.7^{abc}
TVu-10862	0.0^{d}	25.3^{cde}	6.7^{bcd}	30.7^{abc}
TVu-13401	0.0^{d}	32.0^{a-e}	26.7^{abc}	44.0^{abc}
TVu-13402	0.0^{d}	31.7^{a-e}	20.0^{a-d}	34.7^{abc}
TVu-13664	0.0^{d}	29.3^{a-e}	20.0^{a-d}	43.3^{abc}
MODUPE	0.0^{d}	42.0^{a-e}	26.7^{abc}	43.7^{abc}
IFE BROWN	9.7^{bc}	30.7^{a-e}	33.3^{a}	55.3^{abc}
IFE 98-12	0.0^{d}	36.0^{a-e}	20.0^{a-d}	38.3^{abc}
IFE BPC	13.3^{ab}	57.3^{a}	20.0^{a-d}	68.3^{a}

Means with same letters, along same column, are not significantly different ($p<0.05$) using Duncan Multiple Range Test

Table 4: Disease severity of Cercospora leaf spot on the accessions of cowpea during the dry season 2017 and rainy season 2018

	Disease severity			
	Weeks after planting dry season 2017		Weeks after planting wet season 2018	
Accession	8	10	8	10
TVu-9099	1.7^{a}	2.7^{a-d}	1.7^{a}	2.7^{a-d}
TVu-9100	1.5^{ab}	2.8^{ab}	1.5^{ab}	2.6^{a-d}
TVu-9101	0.0^{c}	2.8^{ab}	1.0^{abc}	2.9^{ab}
TVu-9105	0.7^{ab}	2.0^{a-e}	0.7^{abc}	2.3^{a-d}
TVu-9106	0.0^{c}	1.8^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9107	0.0^{c}	2.1^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9109	0.0^{c}	1.3^{a-e}	1.0^{abc}	1.9^{a-d}
TVu-9117	0.0^{c}	1.7^{a-e}	1.0^{abc}	2.4^{a-d}
TVu-9118	0.0^{c}	1.4^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9171	0.0^{c}	1.0^{a-e}	1.0^{abc}	1.9^{a-d}
TVu-9172	1.0^{a}	1.6^{a-e}	1.0^{abc}	2.3^{a-d}
TVu-9174	0.0^{c}	1.8^{a-e}	1.0^{abc}	2.4^{a-d}
TVu-9175	0.0^{c}	0.9^{a-e}	1.0^{abc}	2.1^{a-d}
TVu-9176	0.0^{c}	1.0^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9179	0.0^{c}	0.5^{b-e}	1.0^{abc}	1.8^{a-d}
TVu-9180	0.0^{c}	1.2^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9181	0.0^{c}	0.6^{b-e}	1.3^{ab}	2.2^{a-d}
TVu-9182	0.0^{c}	1.6^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9183	0.0^{c}	1.6^{a-e}	0.7^{abc}	1.5^{a-d}
TVu-9184	0.0^{c}	1.3^{a-e}	1.0^{abc}	2.1^{a-d}
TVu-9185	0.0^{c}	1.5^{a-e}	1.3^{ab}	2.3^{a-d}
TVu-9186	0.0^{c}	1.4^{a-e}	1.0^{abc}	2.1^{a-d}
TVu-9187	0.0^{c}	0.9^{a-e}	1.0^{abc}	2.7^{a-d}
TVu-9189	0.0^{c}	1.2^{a-e}	1.0^{abc}	2.2^{a-d}
TVu-9190	0.0^{c}	0.7^{a-e}	0.7^{abc}	1.4^{a-d}
TVu-9191	0.0^{c}	0.3^{de}	0.8^{abc}	1.7^{a-d}
TVu-9192	0.0^{c}	0.3^{de}	0.0^{c}	1.3^{bcd}
TVu-9194	0.0^{c}	0.8^{a-e}	0.7^{abc}	1.7^{a-d}
TVu-9195	0.0^{c}	0.5^{b-e}	0.3^{bc}	1.2^{cd}
TVu-9197	0.0^{c}	1.5^{a-e}	0.3^{bc}	1.9^{a-d}
TVu-9198	0.0^{c}	0.7^{a-e}	0.0^{c}	1.6^{a-d}
TVu-9199	0.0^{c}	1.6^{a-e}	0.7^{abc}	2.0^{a-d}
TVu-9200	0.0^{c}	0.5^{b-e}	0.3^{bc}	1.5^{a-d}
TVu-9201	0.0^{c}	1.1^{a-e}	0.3^{bc}	1.6^{a-d}
TVu-9202	0.0^{c}	0.0^{e}	0.7^{abc}	2.0^{a-d}
TVu-9204	0.0^{c}	0.7^{b-e}	0.0^{c}	1.4^{a-d}

Table 4: Continue

	Disease severity			
	Weeks after planting dry season 2017		Weeks after planting wet season 2018	
Accession	8	10	8	10
TVu-9205	0.0^{c}	0.7^{b-e}	0.0^{c}	1.4^{a-d}
TVu-9206	0.0^{c}	0.9^{a-e}	0.3^{bc}	1.6^{a-d}
TVu-9207	0.0^{c}	1.3^{a-e}	0.0^{c}	2.3^{a-d}
TVu-9272	0.0^{c}	1.1^{a-e}	0.7^{abc}	2.5^{a-d}
TVu-9273	0.0^{c}	0.9^{a-e}	1.3^{ab}	2.2^{a-d}
TVu-9276	0.0^{c}	0.0^{e}	0.7^{abc}	1.7^{a-d}
TVu-9277	0.0^{c}	0.3^{de}	0.0^{c}	1.7^{a-d}
TVu-9281	0.0^{c}	0.8^{a-e}	0.3^{bc}	1.9^{a-d}
TVu-9283	0.0^{c}	0.7^{a-e}	0.0^{c}	2.3^{a-d}
TVu-9284	0.0^{c}	0.5^{b-e}	0.0^{c}	2.3^{a-d}
TVu-9285	0.0^{c}	0.8^{a-e}	0.3^{bc}	1.6^{a-d}
TVu-9287	0.0^{c}	0.3^{de}	0.7^{abc}	1.7^{a-d}
TVu-9288	0.0^{c}	0.8^{a-e}	0.0^{c}	1.1^{d}
TVu-9289	0.0^{c}	0.3^{de}	0.7^{abc}	1.7^{a-d}
TVu-9292	0.0^{c}	1.0^{a-e}	0.0^{b}	2.0^{a-d}
TVu-9294	0.0^{c}	0.3^{de}	1.2^{abc}	2.7^{a-d}
TVu-9295	0.0^{c}	1.2^{a-e}	1.3^{ab}	2.3^{a-d}
TVu-10860	0.0^{c}	0.5^{b-e}	0.7^{abc}	1.9^{a-d}
TVu-10862	0.0^{c}	0.9^{a-e}	0.3^{bc}	1.5^{a-d}
TVu-13401	0.0^{c}	0.9^{a-e}	1.3^{ab}	2.2^{a-d}
TVu-13402	0.0^{c}	1.3^{a-e}	1.0^{abc}	1.7^{a-d}
TVu-13664	0.0^{c}	0.8^{a-e}	1.0^{abc}	2.2^{a-d}
MODUPE	0.0^{c}	2.3^{a-e}	1.3^{ab}	2.2^{a-d}
IFE BROWN	1.7^{a}	1.9^{a-e}	1.7^{a}	2.8^{abc}
IFE 98-12	0.0^{c}	1.8^{a-e}	1.0^{abc}	2.1^{a-d}
IFE BPC	1.7^{a}	3.0^{a}	1.7^{a}	3.2^{a}

Means with same letters, along same column, are not significantly different ($p<0.05$) using Duncan Multiple Range Test

for the 2018 wet season, there was a significant difference of disease severity on all the 62 cowpea accessions as all were infected at 10 WAP. The disease severity was significantly higher ($p<0.05$) during the 2018 wet season than the 2017 dry season (Table 4).

Disease reactions of cowpea accessions to Cercospora leaf spot: It was revealed that among the 62 accessions evaluated, there were significant ($p<0.05$) differences among the accessions on CLS disease incidence and severity in both seasons and the disease reaction were also significantly ($p<0.05$) different in both seasons and there was no significant difference for the interaction between the season and accessions for both disease incidence and severity, varying symptoms of Cercospora leaf spot were observed on the foliage of the accessions as rated by the severity score on the experimental field. it was observed that the 62 cowpea accessions were infected with Cercospora leaf spot at the varying incidence and severity rates ranging from 60.2-68.0% in the wet season and 0.0-3.20 in both seasons 2017 dry and 2018 wet seasons. The disease reaction in the dry season shows that 2 accessions (TVu-9202 and TVU-9276) were highly resistant, 31 were moderately resistant, 23 were moderately susceptible and 6 were susceptible based on the 0-5 adopted severity scale (Table 5a). However, in the wet season the disease reaction result showed that non-were resistant, 29 accessions were moderately resistant, 32 were moderately susceptible and IFE BPC showed susceptible symptoms to *Cercospora canescens* (Table 5b). No accession was completely free of spots during the wet season and none of the accessions were found to be resistant to the disease in the wet season while none of the accessions show very severe symptoms at 10 WAP in both the dry and wet seasons.

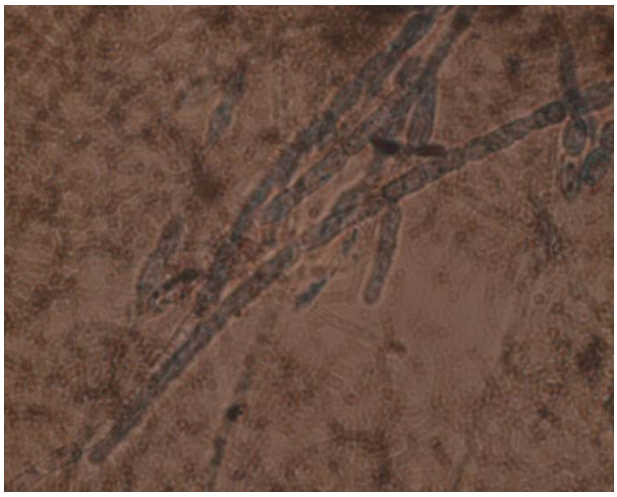

Fig. 4: Photomicrographed slide viewed under the microscope at (×400)

Table 5a: Scale of disease severity accessions of cowpea against Cercospora leaf spot in the experimental field during the dry seasons of 2017

Scale	Disease severity of *C. canescens*	Cowpea accessions at 10 weeks after planting
0	No visible symptoms (Immune) 2	TVu-9202 and TVu-9276
1	Visible symptoms (Resistant) 31	TVu-9171, TVu-9175, TVu-9176, TVu-9179, TVu-9181, TVu-9187, TVu-9190, Tvu-9191, TVu-9192, TVu-9194, TVu-9195, TVu-9198, TVu-9200, TVu-9204, TVu-9205, Tvu-9206, TVu-9273, TVu-9277 TVu-9281, TVu-9283, TVu-9284, TVu-9285, TVu-9287, Tvu-9288, TVu-9289, TVu-9292, TVu-9294 TVu-10860, TVu-10862, TVu-13401 and TVU-13664
2	Mild symptoms (Moderately resistant) 23	TVu-9105, TVu-9106, TVu-9109, TVu-9117, TVu-9118, TVu-9172, TVu-9174, Tvu-9180, TVu-9182, TVu-9183, TVu-9184, TVu-9185, TVu-9186, TVu-9189, TVu-9197, Tvu-9199, TVu-9201, TVu-9207, TVu-9272, TVu-9295, TVu-13402, IFE-BROWN and IFE 98-12-W
3	Moderate symptoms (Moderately susceptible) 6	TVu-9099, TVu-9100, TVu-9101, TVu-9107, MODUPE and IFE BPC
4	Severe symptoms (Susceptible) 0	-
5	Very severe symptoms (Highly susceptible) 0	-

Table 5b: Scale of disease severity accessions of cowpea against Cercospora leaf spot in the experimental field during the wet season of 2018

Scale	Disease severity of *C. canescens*	Cowpea accessions at 10 weeks after planting
0	No visible symptoms (Immune)	-
1	Visible symptoms (Resistant)	-
2	Mild symptoms (Moderately resistant) 29	TVu-9109, TVu-9171, TVu-9179, TVu-9183, TVu-9190, TVu-9191, TVu-9192, Tvu-9194, TVu-9195, TVu-9197, TVu-9198, TVu-9199, TVu-9200, TVu-9201, TVu-9202, Tvu-9204, TVu-9205, TVu-9206, TVu-9276, TVu-9277, TVu-9281, TVu-9285, TVu-9287, Tvu-9288, TVu-9289, TVu-9292, TVu-10860, TVu-10862 and TVu-13402
3	Moderate symptoms (Moderately susceptible) 32	TVu-9099, TVu-9100, TVu-9101, TVu-9105, TVu-9106, TVu-9107, TVu-9117, Tvu-9118, TVu-9172, TVu-9174, TVu-9175, TVu-9176, TVu-9180, TVu-9181, TVu-9182, Tvu-9184, TVu-9185, TVu-9186, TVu-9187, TVu-9189, TVu-9207, TVu-9272, TVu-9273, Tvu-9283, TVu-9284, TVu-9294, TVu-9295, TVu-13401, TVu-13664, IFE-MODUPE, IFE brown and IFE ART 98-12
4	Severe symptoms (Susceptible) 1	IFE BPC
5	Very severe symptoms (Highly susceptible) 0	_

Effect of Cercospora leaf spot on growth parameters during the dry season (2017) and wet season (2018)

Canopy height of cowpea accessions

Canopy height: Canopy height evaluated showed varied effects on the sixty-two accessions evaluated. This study revealed a high significant ($p<0.05$) difference among the accessions at 6-10WAP, the variation as presented in Table 6. The IFE 98-12 W had the tallest canopy height (24.1 cm) while Tvu-9276 had the

Table 6: Agronomic performance for canopy height (cm) of cowpea accessions during the dry season 2017 and wet season 2018

	Canopy height cm/plant					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-9099	15.3^{abc}	17.5^{a-e}	20.0^{a-d}	22.4^{a}	25.2^{a}	26.8^{a}
TVu-9100	11.4^{a-f}	13.1^{a-i}	16.5^{a-d}	23.0^{a}	20.8^{a}	24.4^{a}
TVu-9101	14.7^{a-d}	18.3^{a-e}	20.3^{a-d}	24.4^{a}	22.9^{a}	27.2^{a}
TVu-9105	14.9^{a-d}	15.7^{a-e}	18.4^{a-d}	22.7^{a}	28.5^{a}	29.0^{a}
TVu-9106	14.2^{a-d}	16.3^{a-e}	18.2^{a-d}	16.8^{a}	19.8^{a}	20.8^{a}
TVu-9107	16.9^{ab}	17.5^{a-e}	22.0^{abc}	22.8^{a}	21.2^{a}	24.2^{a}
TVu-9109	11.5^{a-f}	13.0^{a-i}	17.3^{a-d}	17.0^{a}	20.4^{a}	23.6^{a}
TVu-9117	13.7^{a-d}	16.7^{a-e}	18.9^{a-d}	23.0^{a}	21.5^{a}	23.3^{a}
TVu-9118	13.6^{a-d}	15.4^{a-e}	17.5^{a-d}	23.5^{a}	24.0^{a}	26.3^{a}
TVu-9171	13.4^{a-d}	14.1^{a-h}	18.9^{a-d}	24.8^{a}	22.3^{a}	29.5^{a}
TVu-9172	11.4^{a-f}	12.7^{a-i}	15.9^{a-d}	21.0^{a}	24.2^{a}	26.5^{a}
TVu-9174	10.9^{a-g}	12.0^{a-i}	16.6^{a-d}	22.3^{a}	27.4^{a}	31.3^{a}
TVu-9175	10.1^{a-h}	11.6^{a-i}	14.7^{a-f}	16.0^{a}	20.7^{a}	27.0^{a}
TVu-9176	10.9^{a-g}	13.3^{a-i}	16.6^{a-d}	19.7^{a}	26.7^{a}	30.5^{a}
TVu-9179	10.2^{a-h}	11.6^{a-i}	17.6^{a-d}	23.0^{a}	23.8^{a}	26.8^{a}
TVu-9180	13.8^{a-d}	15.8^{a-e}	19.6^{a-d}	24.8^{a}	25.5^{a}	28.3^{a}
TVu-9181	9.3^{b-h}	9.8^{c-i}	15.4^{a-e}	21.2^{a}	22.8^{a}	25.8^{a}
TVu-9182	8.1^{c-h}	9.9^{c-i}	11.7^{c-g}	22.3^{a}	26.8^{a}	27.8^{a}
TVu-9183	14.0^{a-d}	15.5^{a-e}	21.3^{abc}	19.5^{a}	24.6^{a}	25.7^{a}
TVu-9184	14.7^{a-d}	17.9^{a-e}	20.5^{a-d}	22.1^{a}	24.5^{a}	30.1^{a}
TVu-9185	12.4^{a-e}	14.1^{a-h}	19.2^{a-d}	25.0^{a}	21.2^{a}	27.0^{a}
TVu-9186	12.6^{a-e}	15.4^{a-e}	18.7^{a-d}	19.5^{a}	22.6^{a}	26.3^{a}
TVu-9187	13.2^{a-d}	15.7^{a-e}	20.0^{a-d}	25.3^{a}	26.7^{a}	28.3^{a}
TVu-9189	17.8^{a}	21.4^{a}	23.0^{ab}	23.7^{a}	23.3^{a}	26.6^{a}
TVu-9190	15.4^{abc}	17.8^{a-e}	21.1^{a-d}	17.0^{a}	20.2^{a}	22.5^{a}
TVu-9191	12.3^{a-e}	16.1^{a-e}	22.0^{abc}	23.6^{a}	26.9^{a}	27.2^{a}
TVu-9192	14.2^{a-d}	16.1^{a-e}	21.0^{a-d}	20.3^{a}	22.8^{a}	28.7^{a}
TVu-9194	13.8^{a-d}	17.5^{a-e}	21.2^{abc}	17.6^{a}	19.3^{a}	23.9^{a}
TVu-9195	14.1^{a-d}	17.0^{a-e}	21.1^{abc}	24.9^{a}	23.1^{a}	28.2^{a}
TVu-9197	8.7^{b-f}	10.3^{b-i}	20.7^{a-d}	20.8^{a}	26.4^{a}	27.8^{a}
TVu-9198	10.5^{a-h}	14.3^{a-g}	20.8^{a-d}	22.9^{a}	23.1^{a}	25.0^{a}
TVu-9199	12.1^{a-e}	14.7^{a-g}	18.3^{a-d}	25.8^{a}	26.1^{a}	25.8^{a}
TVu-9200	3.7^{fgh}	8.6^{e-i}	6.0^{efg}	15.2^{a}	22.5^{a}	18.5^{a}
TVu-9201	14.9^{a-d}	18.2^{a-e}	23.1^{ab}	20.1^{a}	22.6^{a}	25.4^{a}
TVu-9202	13.3^{a-d}	16.6^{a-e}	19.6^{a-d}	23.1^{a}	24.5^{a}	27.5^{a}
TVu-9204	12.2^{a-e}	14.8^{a-f}	20.0^{a-d}	16.4^{a}	22.2^{a}	26.3^{a}
TVu-9205	16.9^{ab}	19.2^{abc}	22.4^{abc}	23.8^{a}	24.7^{a}	26.1^{a}
TVu-9206	16.9^{ab}	18.1^{a-e}	22.0^{abc}	16.9^{a}	24.3^{a}	23.7^{a}
TVu-9207	13.4^{a-d}	16.1^{a-e}	19.4^{a-d}	20.5^{a}	23.0^{a}	24.7^{a}
TVu-9272	8.6^{b-f}	9.2^{abc}	10.5^{d-g}	15.4^{a}	21.5^{a}	22.8^{a}
TVu-9273	14.4^{a-d}	19.8^{ab}	22.7^{abc}	18.1^{a}	22.9^{a}	26.4^{a}
TVu-9276	3.2^{gh}	3.8^{i}	4.3^{g}	14.3^{a}	26.2^{a}	19.9^{a}
TVu-9277	2.8^{h}	5.3^{f-i}	6.0^{efg}	13.4^{a}	21.0^{a}	15.4^{a}
TVu-9281	12.5^{a-e}	17.7^{a-e}	19.2^{a-d}	19.7^{a}	23.7^{a}	26.0^{a}
TVu-9283	12.1^{a-e}	16.6^{a-e}	20.6^{a-d}	22.9^{a}	24.2^{a}	25.6^{a}
TVu-9284	13.3^{a-d}	14.9^{a-f}	18.3^{a-d}	18.8^{a}	20.9^{a}	22.5^{a}
TVu-9285	11.7^{a-e}	14.0^{a-h}	18.8^{a-d}	16.8^{a}	18.6^{a}	23.6^{a}
TVu-9287	6.7^{d-h}	9.0^{e-i}	13.1^{b-f}	16.1^{a}	19.7^{a}	17.5^{a}
TVu-9288	13.0^{a-d}	16.6^{a-e}	19.2^{a-d}	19.5^{a}	20.1^{a}	23.8^{a}
TVu-9289	12.3^{a-e}	16.3^{a-e}	18.8^{a-d}	17.5^{a}	21.9^{a}	26.6^{a}
TVu-9292	10.2^{a-h}	11.8^{a-i}	18.3^{a-d}	23.6^{a}	22.1^{a}	24.3^{a}
TVu-9294	12.7^{a-d}	14.0^{a-h}	18.8^{a-d}	23.8^{a}	25.6^{a}	26.9^{a}
TVu-9295	14.9^{a-d}	15.5^{a-e}	5.2^{fg}	14.4^{a}	20.8^{a}	15.9^{a}

Table 6: Continue

	Canopy height cm/plant					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-10860	14.8^{a-d}	14.6^{a-g}	22.2^{abc}	20.1^{a}	21.5^{a}	23.2^{a}
TVu-10862	14.1^{abcd}	17.3^{abcde}	20.4^{a-d}	22.8^{a}	24.7^{a}	25.9^{a}
TVu-13401	4.5^{e-h}	4.6^{hi}	5.5^{fg}	18.0^{a}	22.4^{a}	25.5^{a}
TVu-13402	7.7^{c-h}	16.2^{a-e}	18.1^{a-f}	17.7^{a}	18.8^{a}	24.7^{a}
TVu-13664	11.2^{a-f}	12.4^{a-i}	14.6^{a-f}	16.1^{a}	22.1^{a}	26.7^{a}
MODUPE	14.7^{a-d}	17.4^{a-e}	19.4^{a-d}	17.3^{a}	21.3^{a}	23.9^{a}
IFE BROWN	15.4^{abc}	19.2^{abc}	21.2^{abc}	19.8^{a}	22.2^{a}	23.5^{a}
IFE 98-12	13.7^{a-d}	17.0^{a-e}	24.1^{a}	19.2^{a}	21.7^{a}	25.9^{a}
IFE BPC	15.0^{a-d}	19.0^{a-d}	21.5^{abc}	24.2^{a}	18.2^{a}	29.0^{a}

Means with same letters, along same column, are not significantly different ($p<0.05$) using Duncan's Multiple Range Test

shortest canopy height (4.3 cm) at 10 WAP. However, for wet season 2018, there were no statistically significant differences in the mean height of the sixty-two accessions ($p<0.05$) of cowpea evaluated at 6, 8 and 10 WAP.

Number of branches (peduncles) of cowpea accessions: The sixty-two Cowpea accessions exhibited strong variations in the number of branches (peduncles). The cowpea accession evaluated showed substantial significant ($p<0.05$) differences at 6-10 WAP found within them, In Table 7, dry season 2017, TVu-9100 (19.3) had the highest number of branches and TVu-9276 (2.7) had the lowest branches at 10 WAP, while the wet season 2018, there was no significant difference in the number of the branches at 8 and 10 WAP.

Number of leaves of the cowpea accessions: The number of leaves evaluated showed a high significant ($p<0.05$) difference at 8-10 WAP, (Table 8), except at 6 WAP which recorded no significant difference in plant leaves at 10 WAP TVu-9181 (34.2), TVU-9180 (31.8), Tvu-9206 (33.1), Tvu-9183 and Tvu-9185 had 33.5 plant leaves, respectively had the highest plant leaves and TVu-9276 (6.1) had the lowest leaves at 10 WAP. For the wet season 2018, the leaves of the sixty-two accessions were statistically comparable and there was no significant difference ($p>0.05$) in the number of leaves at 10 WAP, respectively.

Effect of Cercospora leaf spot on yield and yield components (pod and seed weights): The harvested yield parameters for the sixty-two cowpea accessions evaluated revealed that the pod weight and seed weight were significantly different ($p<0.05$) for seasons and accessions, but the interaction between season and accessions for both pod weight and seed weight had no significant difference ($p>0.05$), (Table 9). The TVu-9206 had the highest yield in terms of total pod weight and seed weight (74.9 and 64.8 g) in the dry season of 2017. The TVu-9187 had the lowest in dry season with pod weight (4.3 g) and seed weight (2.4 g), while for 2018 wet season, TVu-9206, Tvu-9099, TVu-9118, TVu-9176, TVu-9197, TVu-9201 and TVu-9281 accessions had the highest pod weight and seed weight, respectively.

Agrometeorological data for 2017 dry season and 2018 wet season: In the 2017 dry season, the mean monthly temperature was generally similar throughout the experiment ranging between 25.5°C in September, 2017 and 27.5°C in November, 2017 and July, 2018. Relative humidity in the same period ranged from 88% in September to 92% in August 2017. The highest rainfall was recorded in September (174 mm) and the least rainfall was in November (19 mm) (Fig. 5). Mean temperature was generally similar during the experimental period except in August (28°C) where higher temperature occurred (Fig. 5) for 2018 wet season, the mean monthly temperature was lower during the wet season than the dry season it ranged between 25.5°C in June, 2018 and 27.5°C July. Relative humidity in the same period ranged from 87% in May to 92% in July 2018. The highest rainfall was recorded in June (184 mm) and reduced rainfall was observed in August (144 mm) in 2018.

Table 7: Agronomic performance for number of branches (peduncles) of cowpea accessions during the dry season 2017 and wet season 2018

	Number of branches plant					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-9099	12.6^{a}	13.6^{ab}	16.0^{abc}	7.8^{ab}	10.9^{a}	17.3^{a}
TVu-9100	12.0^{abc}	17.2^{a}	19.3^{a}	7.3^{ab}	12.3^{a}	15.7^{a}
TVu-9101	4.9^{f-j}	6.6^{c-h}	9.9^{bc}	6.2^{ab}	13.1^{a}	17.4^{a}
TVu-9105	7.4^{d-h}	9.3^{b-f}	10.9^{a-k}	7.3^{ab}	10.7^{a}	13.8^{a}
TVu-9106	9.9^{b-f}	12.2^{abc}	15.4^{abc}	6.3^{ab}	11.0^{a}	15.9^{a}
TVu-9107	8.0^{c-g}	12.4^{abc}	17.4^{ab}	8.9^{a}	11.5^{a}	13.9^{a}
TVu-9109	5.2^{f-j}	10.3^{bcd}	14.6^{a-d}	7.8^{ab}	12.4^{a}	15.5^{a}
TVu-9117	3.7^{g-j}	7.4^{b-h}	11.2^{a-k}	5.2^{ab}	9.3^{a}	15.2^{a}
TVu-9118	5.2^{f-j}	7.9^{b-h}	12.2^{a-i}	5.4^{ab}	10.7^{a}	15.4^{a}
TVu-9171	4.5^{g-j}	6.8^{c-h}	9.2^{b-k}	5.3^{ab}	9.4^{a}	14.0^{a}
TVu-9172	3.7^{g-j}	6.9^{c-h}	10.4^{b-k}	6.5^{ab}	12.7^{a}	16.6^{a}
TVu-9174	7.0^{d-i}	9.3^{b-f}	14.7^{a-d}	6.5^{ab}	11.7^{a}	15.0^{a}
TVu-9175	4.6^{fg-j}	8.3^{b-g}	10.7^{b-k}	3.8^{ab}	8.9^{a}	13.6^{a}
TVu-9176	3.7^{g-j}	4.2^{d-h}	5.9^{e-k}	6.2^{ab}	9.5^{a}	13.6^{a}
TVu-9179	3.8^{g-j}	5.1^{d-h}	7.7^{c-k}	5.9^{ab}	12.7^{a}	15.5^{a}
TVu-9180	3.9^{g-j}	5.3^{d-h}	7.6^{c-k}	6.8^{ab}	9.6^{a}	13.0^{a}
TVu-9181	4.0^{g-j}	6.3^{c-h}	9.8^{b-k}	5.3^{ab}	10.8^{a}	14.2^{a}
TVu-9182	4.9^{f-j}	7.2^{b-h}	10.3^{b-k}	5.4^{ab}	9.6^{a}	13.4^{a}
TVu-9183	5.0^{f-j}	7.4^{b-h}	9.7^{b-k}	5.3^{ab}	10.4^{a}	13.7^{a}
TVu-9184	4.8^{f-j}	6.5^{c-h}	11.4^{a-k}	4.5^{ab}	8.1^{a}	13.0^{a}
TVu-9185	4.9^{f-j}	8.5^{b-g}	14.7^{a-d}	5.7^{ab}	10.7^{a}	14.8^{a}
TVu-9186	5.2^{f-j}	9.2^{b-f}	14.3^{a-e}	4.5^{ab}	8.9^{a}	11.3^{a}
TVu-9187	5.9^{e-j}	9.7^{b-e}	14.7^{a-d}	7.1^{ab}	9.4^{a}	11.3^{a}
TVu-9189	5.4^{e-j}	6.6^{c-h}	10.2^{b-k}	5.8^{ab}	8.5^{a}	11.0^{a}
TVu-9190	4.5^{g-j}	8.4^{b-g}	13.7^{a-f}	5.0^{ab}	9.3^{a}	13.5^{a}
TVu-9191	4.7^{f-j}	6.8^{c-h}	11.4^{a-i}	5.3^{ab}	9.0^{a}	12.1^{a}
TVu-9192	3.7^{g-j}	6.6^{c-h}	13.4^{a-f}	5.1^{ab}	8.7^{a}	9.8^{a}
TVu-9194	1.8^{h-j}	5.9^{c-h}	9.8^{b-k}	5.1^{ab}	8.6^{a}	9.4^{a}
TVu-9195	3.9^{g-j}	7.5^{b-h}	11.1^{a-k}	6.1^{ab}	9.8^{a}	11.3^{a}
TVu-9197	2.6^{g-j}	4.2^{d-h}	10.3^{b-k}	5.7^{ab}	8.6^{a}	10.4^{a}
TVu-9198	1.6^{ij}	3.9^{d-h}	8.5^{c-k}	5.4^{ab}	10.4^{a}	12.7^{a}
TVu-9199	3.2^{g-j}	5.3^{d-h}	15.0^{a-d}	4.1^{ab}	9.5^{a}	14.2^{a}
TVu-9200	1.3^{j}	2.8^{fgh}	4.7^{g-k}	4.3^{ab}	8.7^{a}	12.2^{a}
TVu-9201	4.5^{g-j}	7.8^{b-h}	14.7^{a-d}	5.5^{ab}	9.2^{a}	11.1^{a}
TVu-9202	3.6^{g-j}	8.2^{b-g}	16.1^{abc}	5.5^{ab}	7.9^{a}	10.9^{a}
TVu-9204	3.4^{g-j}	7.3^{b-h}	10.9^{a-k}	4.2^{ab}	7.6^{a}	9.0^{a}
TVu-9205	3.8^{g-j}	9.0^{b-f}	15.7^{abc}	4.1^{ab}	8.2^{a}	10.5^{a}
TVu-9206	3.7^{g-j}	9.4^{b-f}	14.1^{a-f}	3.5^{b}	8.3^{a}	9.4^{a}
TVu-9207	3.7^{g-j}	6.9^{c-h}	13.4^{a-f}	3.4^{b}	8.3^{a}	10.4^{a}
TVu-9272	1.5^{ij}	5.1^{d-h}	11.3^{a-i}	4.0^{ab}	7.1^{a}	11.0^{a}
TVu-9273	2.7^{g-j}	7.0^{c-h}	8.3^{c-k}	3.8^{ab}	7.0^{a}	10.6^{a}
TVu-9276	0.8^{j}	2.3^{gh}	2.7^{k}	4.4^{ab}	8.3^{a}	11.0^{a}
TVu-9277	1.7^{ij}	2.0^{h}	4.3^{h-k}	3.5^{b}	7.9^{a}	9.6^{a}
TVu-9281	5.0^{f-j}	12.0^{abc}	17.4^{ab}	3.3^{b}	7.1^{a}	9.2^{a}
TVu-9283	3.6^{g-j}	6.2^{c-h}	9.8^{b-k}	4.7^{ab}	8.6^{a}	9.5^{a}
TVu-9284	2.2^{hij}	3.6^{e-h}	8.0^{c-k}	4.5^{ab}	7.7^{a}	11.3^{a}
TVu-9285	2.3^{hij}	5.1^{d-h}	10.5^{b-k}	5.3^{ab}	7.4^{a}	8.5^{a}
TVu-9287	1.3^{j}	3.0^{fgh}	3.8^{ijk}	7.4^{ab}	9.9^{a}	8.1^{a}
TVu-9288	3.3^{g-j}	8.0^{b-h}	15.0^{a-d}	5.0^{ab}	9.1^{a}	11.3^{a}
TVu-9289	2.8^{g-j}	4.3^{d-h}	10.8^{a-k}	5.6^{ab}	8.2^{a}	11.0^{a}
TVu-9292	3.4^{g-j}	7.1^{c-h}	12.1^{a-i}	5.2^{ab}	8.8^{a}	9.6^{a}
TVu-9294	4.0^{g-j}	6.0^{c-h}	12.9^{a-h}	5.0^{ab}	8.8^{a}	12.2^{a}

Table 7: Continue

	Number of branches plant					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-9295	2.7^{g-j}	7.0^{c-h}	11.0^{a-k}	6.0^{ab}	7.8^{a}	11.7^{a}
TVu-10860	2.5^{g-j}	3.9^{d-h}	9.2^{b-k}	3.8^{ab}	8.0^{a}	10.2^{a}
TVu-10862	10.4^{b-e}	4.1^{d-h}	8.1^{c-k}	5.3^{ab}	7.9^{a}	8.3^{a}
TVu-13401	4.9^{f-j}	5.5^{c-h}	5.5^{f-k}	4.3^{ab}	6.7^{a}	9.8^{a}
TVu-13402	14.6^{ab}	14.7^{ab}	14.7^{a-d}	5.0^{ab}	8.3^{a}	11.8^{a}
TVu-13664	3.3^{g-j}	4.4^{d-h}	5.6^{f-k}	5.1^{ab}	9.7^{a}	10.3^{a}
MODUPE	4.7^{f-j}	9.4^{b-f}	13.1^{a-g}	4.5^{ab}	7.2^{a}	9.4^{a}
IFE BROWN	3.5^{g-j}	6.4^{c-h}	11.1^{a-k}	3.7^{b}	7.3^{a}	10.0^{a}
IFE 98-12	3.4^{g-j}	6.8^{c-h}	9.5^{b-k}	4.3^{ab}	7.7^{a}	8.5^{a}
IFE BPC	2.9^{g-j}	5.3^{d-h}	9.0^{b-k}	4.7^{ab}	7.0^{a}	8.5^{a}

Means with same letters, along same column, are not significantly different ($p<0.05$) using Duncan Multiple Range Test

Table 8: Agronomic performance for number of leaves/plants of the cowpea accessions during the dry season 2017 and wet season 2018

	Number of leaves/plants					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-9099	12.6^{a-f}	17.7^{a-h}	24.6^{a-e}	17.0^{a}	34.9^{a}	60.0^{a}
TVu-9100	15.5^{a-f}	17.5^{a-h}	18.5^{a-h}	15.7^{a}	28.7^{a}	53.2^{a}
TVu-9101	14.9^{a-f}	17.0^{a-h}	21.2^{a-g}	17.4^{a}	28.2^{a}	54.5^{a}
TVu-9105	12.1^{a-f}	13.5^{c-h}	21.1^{a-g}	14.4^{a}	21.8^{a}	48.9^{a}
TVu-9106	9.6^{b-f}	11.8^{c-h}	20.1^{a-g}	15.8^{a}	24.7^{a}	55.2^{a}
TVu-9107	18.4^{a-e}	20.9^{a-g}	25.6^{a-d}	14.2^{a}	26.4^{a}	51.5^{a}
TVu-9109	18.3^{a-e}	22.1^{a-g}	27.6^{abc}	15.8^{a}	25.0^{a}	58.9^{a}
TVu-9117	16.2^{a-f}	19.2^{a-h}	24.7^{a-e}	18.3^{a}	25.9^{a}	53.1^{a}
TVu-9118	15.8^{a-f}	19.3^{a-h}	28.0^{abc}	15.3^{a}	24.1^{a}	49.4^{a}
TVu-9171	14.0^{a-f}	18.1^{a-h}	25.2^{a-d}	17.2^{a}	31.3^{a}	55.0^{a}
TVu-9172	15.1^{a-f}	21.1^{a-f}	27.1^{abc}	18.3^{a}	33.0^{a}	61.6^{a}
TVu-9174	16.0^{a-f}	19.1^{a-h}	22.7^{a-e}	17.1^{a}	28.0^{a}	44.5^{a}
TVu-9175	16.6^{a-f}	21.8^{a-f}	26.2^{a-d}	19.0^{a}	32.8^{a}	50.6^{a}
TVu-9176	13.7^{a-f}	17.8^{a-h}	24.4^{a-e}	20.6^{a}	30.7^{a}	53.7^{a}
TVu-9179	14.8^{a-f}	21.2^{a-f}	28.5^{abc}	15.4^{a}	27.9^{a}	52.4^{a}
TVu-9180	22.9^{ab}	25.1^{a-d}	31.8^{a}	14.7^{a}	29.3^{a}	50.1^{a}
TVu-9181	19.6^{abc}	24.0^{a-e}	34.2^{a}	16.7^{a}	30.1^{a}	51.7^{a}
TVu-9182	12.1^{a-f}	27.7^{abc}	28.7^{a-e}	17.3^{a}	39.1^{a}	50.5^{a}
TVu-9183	17.3^{a-e}	24.9^{a-e}	33.5^{a}	18.6^{a}	36.9^{a}	52.0^{a}
TVu-9184	21.7^{ab}	26.4^{a-d}	29.9^{abc}	14.2^{a}	34.9^{a}	45.9^{a}
TVu-9185	17.0^{a-e}	23.2^{a-e}	33.5^{a}	19.3^{a}	32.2^{a}	45.9^{a}
TVu-9186	15.3^{a-f}	21.5^{a-f}	27.4^{a-g}	14.3^{a}	37.7^{a}	49.3^{a}
TVu-9187	17.5^{a-e}	22.8^{a-e}	26.4^{a-g}	19.5^{a}	34.2^{a}	51.4^{a}
TVu-9189	18.8^{a-d}	24.4^{a-e}	27.6^{a-f}	16.1^{a}	28.6^{a}	57.8^{a}
TVu-9190	17.2^{a-e}	19.6^{a-h}	29.3^{a-d}	15.0^{a}	22.1^{a}	36.5^{a}
TVu-9191	17.6^{a-e}	21.1^{a-f}	25.1^{a-g}	19.1^{a}	32.3^{a}	55.2^{a}
TVu-9192	18.5^{a-e}	19.9^{a-h}	27.3^{a-g}	15.2^{a}	30.3^{a}	48.1^{a}
TVu-9194	17.0^{a-e}	22.4^{a-f}	24.6^{a-g}	18.5^{a}	31.2^{a}	48.1^{a}
TVu-9195	22.0^{ab}	25.7^{a-d}	29.6^{a-d}	19.0^{a}	30.3^{a}	56.9^{a}
TVu-9197	12.2^{a-f}	14.0^{b-h}	28.8^{a-e}	18.0^{a}	32.6^{a}	51.3^{a}
TVu-9198	10.1^{b-f}	16.5^{b-h}	28.4^{a-e}	22.3^{a}	30.0^{a}	59.2^{a}
TVu-9199	15.9^{a-f}	22.1^{a-f}	26.6^{a-g}	23.3^{a}	34.0^{a}	53.2^{a}
TVu-9200	5.3^{c-f}	6.4^{fgh}	13.5^{d-h}	20.1^{a}	27.1^{a}	35.5^{a}
TVu-9201	14.6^{a-f}	20.6^{a-g}	26.3^{a-g}	25.2^{a}	33.3^{a}	57.0^{a}

Table 8: Continue

	Number of leaves/plants					
	Weeks after planting dry season			Weeks after planting wet season		
Accession	6	8	10	6	8	10
TVu-9202	21.8^{ab}	23.3^{a-e}	27.7^{a-f}	19.1^{a}	30.5^{a}	55.9^{a}
TVu-9204	13.9^{a-f}	19.6^{a-h}	26.5^{a-g}	20.5^{a}	32.0^{a}	51.9^{a}
TVu-9205	17.3^{a-e}	23.6^{a-e}	30.7^{ab}	20.8^{a}	29.9^{a}	53.6^{a}
TVu-9206	26.1^{a}	33.0^{a}	33.1^{a}	21.5^{a}	26.9^{a}	54.1^{a}
TVu-9207	21.0^{ab}	26.6^{abc}	29.6^{a-d}	18.6^{a}	29.7^{a}	55.0^{a}
TVu-9272	9.8^{b-f}	14.1^{b-h}	18.5^{a-h}	18.6^{a}	25.1^{a}	52.2^{a}
TVu-9273	12.7^{a-f}	23.8^{a-e}	31.4^{ab}	19.3^{a}	29.1^{a}	44.5^{a}
TVu-9276	2.7^{f}	5.4^{gh}	6.1^{h}	14.4^{a}	31.4^{a}	34.7^{a}
TVu-9277	4.3^{ef}	10.3^{d-h}	11.2^{gh}	12.3^{a}	28.3^{a}	31.7^{a}
TVu-9281	20.3^{ab}	25.9^{a-d}	29.2^{a-d}	20.6^{a}	34.3^{a}	53.1^{a}
TVu-9283	20.8^{ab}	29.7^{ab}	30.4^{ab}	17.1^{a}	27.9^{a}	50.9^{a}
TVu-9284	15.1^{a-f}	19.8^{a-h}	24.3^{a-g}	22.3^{a}	31.0^{a}	47.8^{a}
TVu-9285	12.0^{a-f}	18.0^{a-h}	31.0^{ab}	18.1^{a}	29.1^{a}	49.6^{a}
TVu-9287	5.8^{c-f}	8.8^{e-h}	11.5^{fgh}	13.7^{a}	31.6^{a}	35.1^{a}
TVu-9288	17.7^{a-e}	23.2^{a-e}	28.4^{a-e}	17.0^{a}	33.7^{a}	50.4^{a}
TVu-9289	17.1^{a-e}	22.0^{a-f}	27.7^{a-f}	13.2^{a}	25.7^{a}	39.4^{a}
TVu-9292	19.6^{abc}	27.1^{abc}	26.5^{a-g}	19.0^{a}	30.1^{a}	47.9^{a}
TVu-9294	12.9^{a-f}	21.7^{a-f}	27.4^{a-g}	19.1^{a}	27.9^{a}	49.1^{a}
TVu-9295	15.4^{a-f}	14.3^{b-h}	12.7^{e-h}	11.5^{a}	27.0^{a}	29.3^{a}
TVu-10860	15.5^{a-f}	22.8^{a-e}	30.0^{a-c}	15.4^{a}	28.6^{a}	43.8^{a}
TVu-10862	10.4^{b-f}	15.0^{b-h}	26.5^{a-g}	13.5^{a}	30.3^{a}	46.6^{a}
TVu-13401	4.9^{def}	4.2^{h}	15.0^{b-h}	14.9^{a}	32.0^{a}	43.6^{a}
TVu-13402	14.6^{a-f}	18.2^{a-h}	23.4^{a-g}	18.0^{a}	30.6^{a}	50.2^{a}
TVu-13664	10.2^{b-f}	11.8^{c-h}	13.9^{c-h}	19.9^{a}	30.8^{a}	45.9^{a}
MODUPE	13.2^{a-f}	15.7^{b-h}	20.4^{a-h}	18.0^{a}	23.9^{a}	39.9^{a}
IFE BROWN	11.1^{b-f}	14.9^{b-h}	23.9^{a-g}	15.2^{a}	24.0^{a}	43.9^{a}
IFE 98-12	10.3^{b-f}	15.4^{b-h}	24.5^{a-g}	17.1^{a}	26.2^{a}	30.2^{a}
IFE BPC	10.2^{b-f}	14.7^{b-h}	22.8^{a-g}	10.8^{a}	16.9^{a}	32.8^{a}

Means with same letters, along the same column, are not significantly different ($p<0.05$) using Duncan's Multiple Range Test

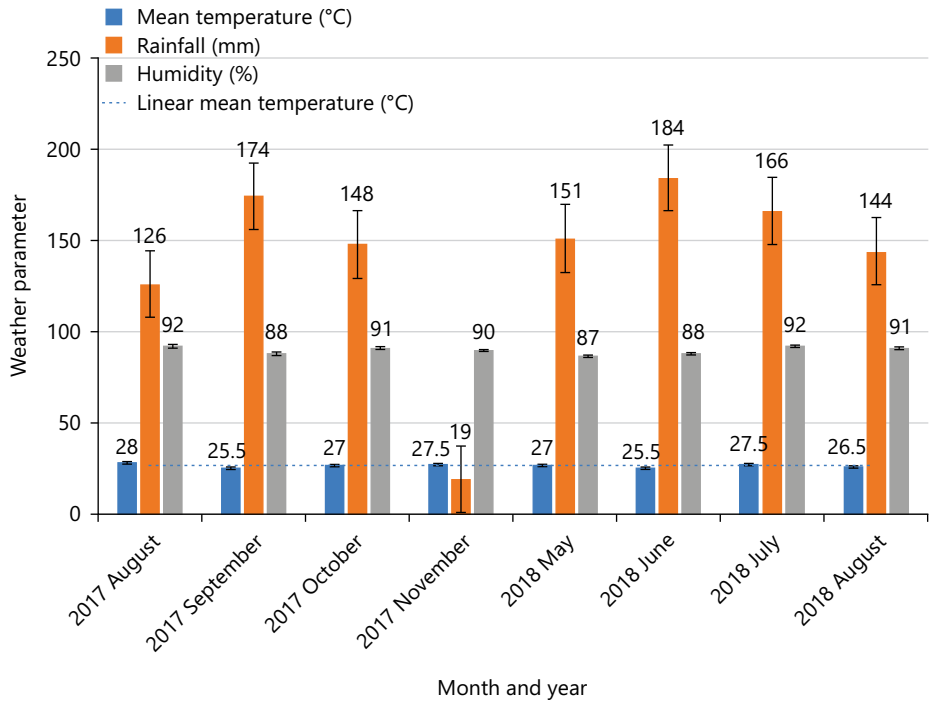

Fig. 5: Weather data for 2017 dry season and 2018 wet season

Table 9: Pod and seed weights (g) of cowpea accessions harvested for the 2017 and 2018 seasons

	Dry season (2017)		Wet season (2018)	
Accession	Pod weight (g)	Seed weight (g)	Pod weight (g)	Seed weight (g)
TVu-9099	45.2^{b-e}	30.4^{b-f}	24.1^{a}	15.2^{a}
TVu-9100	26.0^{d-i}	19.3^{c-i}	13.3^{b}	13.3^{a}
TVu-9101	5.0^{i}	3.7^{ij}	10.7^{b-e}	7.1^{bcd}
TVu-9105	8.0^{i}	5.3^{hij}	6.0^{c-h}	4.7^{c-k}
TVu-9106	15.9^{f-i}	11.7^{f-j}	7.4^{c-h}	5.4^{c-j}
TVu-9107	7.7^{i}	4.4^{ij}	3.8^{fgh}	2.2^{ijk}
TVu-9109	7.5^{i}	5.5^{hij}	5.9^{c-h}	5.3^{c-j}
TVu-9117	7.1^{i}	5.1^{hij}	5.5^{e-h}	3.9^{d-k}
TVu-9118	49.3^{bcd}	43.1^{b}	10.9^{bcd}	10.1^{b}
TVu-9171	11.1^{ghi}	7.9^{g-j}	5.9^{c-h}	3.6^{d-k}
TVu-9172	14.3^{g-i}	9.9^{f-j}	8.9^{b-f}	7.8^{bc}
TVu-9174	17.0^{f-i}	13.1^{e-j}	5.7^{d-h}	3.7^{d-k}
TVu-9175	24.1^{d-i}	16.2^{c-j}	6.1^{c-h}	4.8^{c-k}
TVu-9176	46.1^{b-e}	35.5^{bcd}	14.7^{ab}	3.4^{d-k}
TVu-9179	13.0^{ghi}	8.8^{f-j}	4.2^{fgh}	2.9^{e-k}
TVu-9180	11.5^{g-i}	8.7^{f-j}	4.6^{fgh}	3.3^{d-k}
TVu-9181	13.0^{ghi}	10.8^{f-j}	3.4^{fgh}	2.4^{h-k}
TVu-9182	16.3^{f-i}	12.6^{e-j}	5.5^{e-h}	4.1^{c-k}
TVu-9183	16.2^{f-i}	12.2^{e-j}	6.9^{c-h}	5.6^{c-i}
TVu-9184	13.2^{ghi}	9.6^{f-j}	4.7^{fgh}	3.5^{d-k}
TVu-9185	9.1^{hi}	6.2^{hij}	6.3^{c-h}	5.0^{c-k}
TVu-9186	18.4^{f-i}	8.5^{f-j}	11.2^{bc}	6.5^{b-g}
TVu-9187	4.3^{i}	2.4^{j}	7.1^{c-h}	5.0^{c-k}
TVu-9189	11.3^{ghi}	4.9^{ij}	8.8^{b-f}	6.6^{b-f}
TVu-9190	13.2^{ghi}	15.9^{c-j}	4.6^{fgh}	3.7^{d-k}
TVu-9191	11.8^{ghi}	7.4^{g-j}	3.6^{fgh}	4.2^{c-k}
TVu-9192	20.6^{e-i}	13.4^{e-j}	7.9^{c-g}	6.8^{b-e}
TVu-9194	15.0^{f-i}	12.2^{e-j}	5.5^{e-h}	4.3^{c-k}
TVu-9195	59.0^{abc}	36.4^{bc}	5.1^{fgh}	4.0^{c-k}
TVu-9197	28.6^{d-i}	20.9^{c-i}	6.1^{c-h}	4.3^{c-k}
TVu-9198	12.3^{ghi}	6.0^{hij}	4.5^{fgh}	2.9^{e-k}
TVu-9199	10.6^{ghi}	7.6^{g-j}	10.2^{a-k}	3.7^{d-k}
TVu-9200	11.8^{ghi}	9.3^{f-j}	4.0^{fgh}	2.8^{e-k}
TVu-9201	36.2^{c-g}	28.3^{b-g}	4.1^{fgh}	4.1^{c-k}
TVu-9202	11.2^{ghi}	7.9^{g-j}	3.6^{fgh}	2.1^{ijk}
TVu-9204	29.3^{d-i}	23.7^{b-j}	4.1^{fgh}	2.4^{h-k}
TVu-9205	18.0^{f-i}	14.9^{d-j}	4.1^{fgh}	2.4^{h-k}
TVu-9206	74.9^{a}	64.8^{a}	2.9^{gh}	1.9^{ijk}
TVu-9207	60.4^{ab}	27.0^{b-h}	2.8^{gh}	1.9^{ijk}
TVu-9272	25.6^{d-i}	20.0^{c-j}	3.8^{fgh}	2.2^{ijk}
TVu-9273	24.6^{d-i}	24.6^{b-i}	3.1^{gh}	2.3^{ijk}
TVu-9276	17.0^{f-i}	12.6^{e-j}	2.0^{h}	1.2^{k}
TVu-9277	17.5^{f-i}	11.6^{f-j}	3.7^{fgh}	1.7^{ijk}
TVu-9281	41.2^{b-f}	33.5^{bcd}	2.8^{gh}	1.5^{jk}
TVu-9283	35.2^{c-h}	24.4^{b-j}	3.9^{fgh}	2.2^{ijk}
TVu-9284	14.0^{fg}	9.2^{f-j}	3.3^{gh}	1.8^{ijk}
TVu-9285	16.4^{f-i}	12.7^{e-j}	3.1^{gh}	2.0^{ijk}
TVu-9287	19.4^{f-i}	16.0^{c-j}	5.3^{fgh}	3.9^{d-k}
TVu-9288	19.4^{f-i}	16.8^{c-j}	3.9^{fgh}	2.5^{g-k}
TVu-9289	14.5^{g-i}	12.7^{e-j}	2.7^{gh}	1.8^{ijk}
TVu-9292	16.7^{f-i}	14.4^{d-j}	2.6^{gh}	1.9^{ijk}
TVu-9294	25.5^{d-i}	20.3^{c-i}	3.2^{gh}	1.9^{ijk}
TVu-9295	19.3^{f-i}	15.7^{c-j}	2.4^{gh}	1.6^{ijk}
TVu-10860	9.6^{ghi}	7.6^{g-j}	4.8^{fgh}	3.1^{d-k}
TVu-10862	28.2^{d-i}	20.5^{c-i}	3.7^{fgh}	2.2^{ijk}

Table 9: Continue

	Dry season (2017)		Wet season (2018)	
Accession	Pod weight (g)	Seed weight (g)	Pod weight (g)	Seed weight (g)
TVu-13401	17.5^{f-i}	14.2^{d-j}	4.1^{fgh}	2.7^{f-k}
TVu-13402	23.8^{d-i}	19.5^{c-i}	4.5^{fgh}	2.0^{ijk}
TVu-13664	16.0^{f-i}	11.0^{f-j}	3.0^{gh}	2.1^{ijk}
MODUPE	18.1^{f-i}	14.0^{d-j}	4.9^{fgh}	3.1^{d-k}
IFE BROWN	14.4^{g-i}	9.6^{f-j}	3.2^{gh}	2.9^{e-k}
IFE 98-12	24.3^{d-i}	20.5^{c-i}	3.0^{gh}	1.7^{ijk}
IFE BPC	25.7^{d-i}	21.3^{c-j}	7.9^{c-g}	6.4^{c-g}

Means with same letters, along same column, are not significantly different ($p<0.05$) using Duncan's Multiple Range Test

DISCUSSION

This study investigated the incidence and identity of fungal pathogens causing foliar leaf spot disease on cowpea plants in Nigeria under emerging weather conditions. Fungal isolates were obtained from infected cowpea plant leaves of sixty-two accessions during both 2017 dry and 2018 wet seasons. *Cercospora* species was found to be the most isolated fungal species, causing foliar leaf spot disease on cowpea. Other fungi isolated were *Colletotrichum* spp., *Rhizotonia* spp., *Fusarium* spp., *Trichoderma*, *Aspergillus niger* and *Pseudocercospora* spp. Pathogenicity tests showed that only *Cercospora* spp., was capable of inducing leaf spot disease in healthy cowpea plants. The fungus was identified as *Cercospora canescens* based on its morphological characteristics. Disease symptoms were first observed at 8 weeks after planting during flowering. The disease incidence of Cercospora leaf spot disease was significantly different for both 2017 dry and 2018 wet seasons in the experimental farm.

From this study, cowpea accessions were infected with various field diseases for both seasons. These leaf spot wilt and anthracnose disease. These were similar to the findings reported by Groenewald *et al*.[20] that cowpea is infected by a number of diseases. The isolated pathogens from the observed field disease symptoms were *Cercospora* spp. and *Collectotricum* spp. The major disease that affected the cowpea accessions during the two seasons was Cercospora leaf spot. Symptoms of this disease were a circular red spot on the foliar of the cowpea plant. This disease was favoured by cool humid weather during which they destroyed a large portion of the cowpea plant foliage. The weather conditions experienced during these planting seasons were had significantly contributed to the greater leafspot disease observed for both seasons which conforms to the report of Craufurd *et al*.[21] that high weather condition favours the development of fungal disease Thus at the gross morphological level, photosynthesis is reduced by the presence of Cercospora fungal which disrupt the physiological state of the green leaves caused by increase respiration rate and reduced photosynthesis evidenced by reduced yields[21]. Hence, the quantity and quality of seed formed are affected. A high rate of Cercospora leaf spot incidence and severity was recorded in the wet season and no accessions were completely free of the disease as against the dry season this report helps to justify the effect of photoperiod on the disease performance of cowpea as reported by on cowpea[22,23]. There was a high rate of disease incidence and severity in the wet season than in the dry season, because the wet season favoured the spread of the Cercospora fungus which increased the disease ability to compete and establish disease infection on the host plant[24]. It was however, reported that the host plant resistance occupies a high value among integrated management techniques because it is easily adopted, requires few inputs and is economically advantageous[23,24], no accession was found to be immune or highly resistant when rated according to disease rating scale 0-5 with the findings in this study revealed that all the 62 cowpea accessions showed different levels of resistance against Cercospora leaf spot and no accession was completely free from the disease in the experimental field.

There was higher disease severity recorded in the wet season in 2018 than in the dry season 2017 because of the high rainfall. This observation corroborates earlier research findings[24-26] where it was reported that the occurrence and severity of a disease in an individual plant could be a result of deviation of each

environmental variable within the optimal range for disease development, thus weather condition affects all life stages of the pathogen and host[26,27]. The environmental condition might have affected the spread and growth of the plant pathogen, survival, vigor, rate of dispersal of the inoculum and penetration[27]. This could have been due to the effects of Cercospora leaf spot and favourable weather recorded for both seasons. These observations also agreed with the earlier report[27,28] on the Cercospora leaf spot of Green gram that the higher occurrence of CLS was due to high rainfall and favourable temperature.

Height impairment was higher in some accessions because the infection was more pronounced on them, unlike their moderately resistant counterparts. The difference in the heights could be attributed to their genetic ability to resist the infection and their ability to produce an immune responses to reduce the effect of the disease. Similarly, due to the genetic difference among the accessions investigated, the susceptible accessions were heavily affected leading to the production of few branches and a low number of leaves[28].

The sixty-two accessions of cowpea used in this research work were early maturing and the yield of Cowpeas was significantly different ($p<0.05$) among the cowpea accessions for both seasons. There was a better yield in the dry season than in the wet season which recorded a low yield. TVU-9099 had a relatively high yield, this result was rather absurd, but due to the fact that it was moderately susceptible to the CLS, the high yield observed could be attributed to the ability of the accessions to spread and maximize the rainfall and temperature for its yield, therefore, these accessions can be regarded as a high yielding accession[28]. This agreed with the report of Ahanger *et al*.[26], Timko and Singh[27] and Omoigui *et al*.[28] and Anembom *et al*.[29] that different reactions of cowpea genotypes to CLS were a result of genotypic differences. Generally, in this study the resistance to Cercospora leaf spot and yield of the accessions of cowpea were affected at a different rate on the accessions screened which attributes to the genetic makeup of the cowpea accessions. This result supports the hypothesis that Cercospora leaf spot has marked effects on cowpea yield and disease development in cowpea plants. As corroborated by the findings[29] which reported that *Cercospora canescens* have a serious effect on yield under severe infestation up to 42% loss in yield.

The screening of cowpea accessions for resistance to Cercospora leaf spot disease due to emerging weather conditions has become imperative due to the heavy loss incurred by a present change in weather conditions. The weather condition was implicated by the survival, multiplication sporulation and dispersal of the inoculum spores penetration and germination. The Cercospora leaf spot disease spread was favored by cool humid weather, high rainfall and moderate temperatures which must be favorable for combined initiation, development of plant disease during which it destroyed the foliage of the susceptible cowpea crops, the high rate of Cercospora leaf spot infection recorded in 2018 wet season was due to the high rainfall and high temperature recorded during the period of the experiment. The high temperature and moisture were favorable and combined for the initiation and development of plant disease which was consistent with the report[29,30] that high humid damp weather and high temperature favors the spread of Cercospora leaf spot disease. The high rate of Cercospora leaf spot incidence and severity was recorded in the wet season and no accessions were completely free of the disease. All 62 cowpea accessions showed different levels of resistance against the Cercospora leaf spot and no accession was completely free from the disease in the experimental field.

This study provided important information on the incidence, severity and prevalence of Cercospora leaf spot disease on cowpea accessions under emerging weather conditions. The findings suggested that the weather conditions, particularly rainfall and temperature, significantly influence the development of the disease, with higher incidence and severity recorded in the wet season. This study highlighted the need for the identification and selection of cowpea accessions that are resistant to the disease to reduce yield losses and ensure food security.

The findings of this study can be applied in the development of breeding programs aimed at improving the resistance of cowpea accessions to Cercospora leaf spot. The study can also inform the farmers and breeders the development of disease management strategies that are tailored to specific weather conditions. In addition, the study highlights the need for the adoption of integrated pest management practices to control the spread of the disease.

Based on the findings of the study, it is recommended that farmers should plant cowpea accessions that are resistant to Cercospora leaf spot to reduce yield losses. In addition, farmers should adopt integrated pest management practices, such as crop rotation and the use of disease-resistant varieties, to control the spread of the disease. The study also recommends the need for further research to identify the genes and molecular mechanisms that confer resistance to the Cercospora leaf spot disease in cowpea accessions under changing weather conditions. The study only focused on the incidence, severity and prevalence of Cercospora leaf spot disease on cowpea accessions under changing weather conditions. It did not explore other factors that could influence the development of the disease, such as the soil type and cultural practices. The study also did not investigate the economic implications of the disease on smallholder farmers who depend on cowpea as a source of food and income.

CONCLUSION

Overall, this study highlights the importance of identifying and selecting cowpea accessions that are resistant to Cercospora leaf spot disease, as well as the need for continued research on climate change and its impact on crop diseases. By breeding and cultivating resistant cowpea accessions, farmers and breeders can improve the productivity of cowpea crops and ensure food security in the face of changing weather patterns. Furthermore, it is recommended that further evaluations of the resistant accessions be conducted in various agroecological zones to determine their adaptability to different weather conditions.

SIGNIFICANCE STATEMENT

This study identifies cowpea accessions resistant to Cercospora leaf spot disease, valuable to breeders and farmers in developing improved germplasm critical for cowpea production. The selection of resistant accessions in different agro-ecological zones leads to sustainable and productive farming practices. The research has practical implications for improving cowpea production and the sustainability of agriculture in emerging weather conditions.

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