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Incidence and Severity of Cowpea Rust Disease among selected Cowpea Genotypes

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ABSTRACT

Rust infections interfere with root development and nutrient uptake as well as photosynthetic processes in cowpea plants and can cause up to about 40 % yield losses in susceptible genotypes. This study evaluated the incidence and severity of cowpea rust disease on six cowpea genotypes and also determine the impact of the disease on yield under natural field conditions. The experiment was laid out in Randomized Complete Block Design with three replications at Nyankpala, Tolon District of northern Ghana during the 2021 cropping season. Rust disease intensities and yield data were measured. Results revealed that four genotypes; IT07K-303-1, IT10K-1070-2, IT10K-837-1, and IT14K-1424-12 were highly resistant to the disease. SARI-2-50-80 was susceptible to the disease, whilst SARI-3-11-100 was observed to be highly susceptible. Disease incidence and severity had a significant negative association with pod yield and grain yield. Variations in the resistance among cowpea genotypes as identified in this study will serve as important information for future breeding interventions against the disease.

Key Words: *Cowpea, Genotype, Rust disease, Resistance*

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) cultivation is frequent among subsistent farmers across most countries of the Sub-Saharan region (Abate *et al*., 2012; Ndalira *et al*., 2020). Kirse & Karklina (2015) and Khalid & Elhardallou (2016) in their respective reports revealed that cowpea contains protein (20-30 %), carbohydrate (50-67 %), and other essential nutrients. This makes it a very important crop in achieving food security among the resource poor in rural and urban areas. It also plays a major role in managing both gender equity issues as well as natural resources. In addition, its nitrogen fixing ability, heat and drought tolerance, and as a cover crop plays a major role in soil amendment schemes. According to Rusike *et al*. (2013) about 97 % of the global cowpea production is in the Sub-Saharan region, with over 87 % obtained from West Africa. In Ghana, the Northern, Upper east, and Upper west regions are reported to be the highest producers of cowpea (MOFA, 2016).

In as much as Ghana has been reported as the 5th largest producer of cowpea in Africa, it is among the countries with lowest cowpea yields in both Africa and the world at large (MOFA, 2016; FAOSTAT, 2017).

This could perhaps be due to production constraints such as disease and pest outbreaks, leading to an unabated level of imports into the country. At every growing stage of cowpea, it is usually attacked by antagonistic organisms such as weeds, insect pests, bacterial, viral and fungal pathogens, causing various disease in the plant (Fatokun, 2002; Akpalu *et al*., 2014; Gomes *et al*., 2019). The rust disease (*Uromyces phaseoli* var. *vignae*) is one of the most detrimental diseases that has a negative impact on both foliar health and yield in cowpea (Ndalira *et al*., 2020). According to Weraduwage *et al*. (2016), growth and development in green plants is greatly dependent on the photosynthetic ability of the plant. The rust disease, is known to affect all above ground parts of the plant, including the leaves, stem, branches, and pods (PAN, 2014).This causes an interference in photosynthetic processes, leading to reduced rate of root development and general yield of the crop.

Even though farmers rely mostly on chemical application to manage the disease, Souza *et al.* (2013) reported that there is currently no single, reliable and cost-effective way of managing it. Also, application of these chemicals could pose a threat on farm workers, traders, and non-targeted microorganisms, not forgetting its possible residues in crop produce that could cause food poisoning in both humans and animals (Mensah *et al*., 2019; Ndalira *et al*., 2020). As effective as many studies has reported the use of resistance varieties as a sure-way in reducing the menace caused by the rust disease, it is also reported that disease resistance abilities in most crops breaks with time (Mensah *et al*., 2019). This means more cowpea genotypes should constantly be evaluated to identify more resistant cultivars. Also, the use of resistant cowpea cultivars could be one of the cheapest and most effective and environmentally friendly ways of managing the disease. Subsequently, this will lead to an increased yield and general productivity in cowpea farms. This study therefore seeks to evaluate the incidence and severity of the cowpea rust disease among the selected cowpea genotypes and to identify resistant or susceptible genotypes. Findings from this study will serve as relevant information to both cowpea breeders and farmers in their choices of varieties.

METHODOLOGY

Location of the study

The study was conducted at the CSIR-Savanna Agricultural Research Institute, Nyankpala, Ghana in the 2021 cropping season under field conditions. Nyankpala can be found in the Northern region of Ghana and coordinates 9.3965° N, 0.9892° W.

Genotypes used in the study

Six (6) advanced breeding lines, obtained from the Cowpea improvement programme of the CSIR-SARI were used for the experiment. The cowpea lines were laid in a Randomized Complete Block Design (RCBD) and replicated three times. A planting distance of 0.60 m x 0.2 m was used whilst two cowpea seeds were planted per stand. A pre-emergence herbicide (Pendimethalin) was applied at a rate of 1 kg/ha to control weeds. To improve vegetative growth at the initial stages, NPK fertilizer 15-15-15 at 100 kg/ha was applied two weeks after planting. Manual weed control was done when necessary. Insect pests were controlled at vegetative, flowering, and podding stages, using K-Optimal (Cyhalothrine 15 g + Acetamippride 20 g) and (Cypermethrine + Dimethoate) at a rate of 500 ml/ha.

Data collection and analysis

Disease incidence and severity were assessed biweekly for four times from the first incidence of the disease on the field. Disease assessment was done using a 6-point Godoy *et al*. (1997) and Arafa *et al.* (2016) rating scale in terms of abundance of the of the rust disease on the plants. Where

0 = no visible symptom (0%), 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4 = 51- 75% and 5 = more than 75% of the leaf lamina covered by pustules with possible defoliation. According to the scale, genotypes were ranked as < 1 = highly resistant (HR), 1.1 – 2 = resistant (R), 2.1 – 3 = moderately resistant (MR), 3.1 - 4 = susceptible (S), 4.1 - 5 = highly susceptible (HS). Disease incidence, severity and area under the disease progress curve were calculated as follows:

$$\text{Disease incidence (DI\%)} = \frac{No.of\ plants\ infected}{Total\ number\ of\ plants\ assessed}\ x\ 100$$

$$\text{Disease severity (DS)} = \frac{Sum\ of\ individual\ ratings}{Number\ of\ plants\ assessed\ x\ highest\ rating\ in\ the\ scale}$$

Area under the disease progress curve(AUDPC) = $\sum_{i=1}^{n-1} \frac{(y_i + y_{i+1})}{2}) t_{i+1} - t_i)$ Where y_i is the disease severity cores or percentage incidence observed at $_i$th observation, whiles t_i is the time (days) at the different evaluation dates ($_i$th observation), n is the total number of observations (Shaner & Finney, 1977). Pod yield and grain yield were also measured. Genotype means were tested for variations using One-way Analysis of variance (ANOVA) in GensStat (edition 12). Genotype means that exhibited significant variations ($P < 0.05$) were separated using (LSD) at 5% significant level.

RESULTS

Rust disease incidence and severity

Incidence of rust disease in this study varied among cowpea genotypes ($P < 0.001$). The highest percentage disease incidence was 99.88 % and was observed for SARI-3-11-100. Four genotypes; IT07K-303-1, IT10K-1070-2, IT10K-837-1, and IT14K-1424-12 had a 0 % disease incidence whilst SARI-3-11-100 had a percentage disease incidence of 97.56%. Similarly, disease severity scores were highest for SARI-2-50-80 and SARI-3-11-100 (3.75 and 5.00, respectively) whilst the remaining four genotypes, IT07K-303-1, IT10K-1070-2, IT10K-837-1, and IT14K-1424-12, with no incidence of the disease remained unaffected (Table 1).

Figure 1: Rust disease in cowpea. A) Resistant genotype, B) Susceptible genotype

The results of this study also revealed that the disease was present on only two genotypes. This brings to light a significant variation ($P < 0.001$) in the response of the six genotypes to the rust disease. Based on the disease severity scores, IT07K-303-1, IT10K-1070-2, IT10K-837-1, and IT14K-1424-12 were classified as highly resistant genotypes (< 1). SARI-2-50-80 was classified as susceptible (3-4), whilst SARI-

3-11-100 was classified as highly susceptible (4-5) (Table 1).

Cowpea genotypes in this study exhibited significant variations ($P < 0.001$) with reference to rust disease epidemics, measured as AUDPC based on incidence (DI-AUPDC) and severity (DS-AUDPC). DI-AUDPC values were significantly higher for SARI-2-50-80 and SARI-3-11-100 (2097.4 and 2048.4, respectively). DS-AUDPC followed the same trend as DI-AUDPC. SARI-2-50-80 and SARI-3-11-100 had DS-AUDPC values of 78.75 and 105.00, respectively. Because the disease was not present on IT07K-303-1, IT10K-1070-2, IT10K-837-1, and IT14K-1424-12, both DI-AUDPC and DS-AUDPC values for these genotypes were 0 (Table 1).

Table 1: Disease incidence, severity and rating of cowpea genotypes

Genotypes	DI_score	R_score	DI_AUDPC	DS-AUDPC	Response rating
IT07K-303-1	0.00 a	0.0 00a	0.00 a	0.00 a	HR
IT10K-1070-2	0.00 a	0.00 a	0.00 a	0.00 a	HR
IT10K-837-1	0.00 a	0.00 a	0.00 a	0.00 a	HR
IT14K-1424-12	0.00 a	0.00 a	0.00 a	0.00 a	HR
SARI-3-11-100	97.56 b	5.00 b	2048.40 b	105.00 b	HS
SARI-2-50-80	99.88 c	3.75 b	2097.40 c	78.75 b	S
Mean	32.85	1.41	691.00	30.61	
CV	1.70	70.00	1.90	70.00	

Yield

There was a significant difference ($P < 0.001$) among genotypes with reference to pod and grain yields. IT14K-1424-12 recorded the highest pod yield (2937 kg/ha) and was significantly different from the yield obtained for SARI-3-11-100 (1526 kg/ha). Pod yields for IT10K-837-1 and IT07K-303-1 were above the average of 2216.5 kg/ha. Grain yield followed the same trend as pod yield. IT14K-1424-12 gave the highest grain yield (2335 kg/ha) whilst the lowest grain yield was observed for SARI-3-11-100 (1028 kg/ha). The remaining genotypes, IT10K-837-1, IT07K-303-1, and IT14K-1424-12 had grain yields above the average of 1609.17 kg/ha (Table 2).

Table 2: Impact of cowpea genotypes on grain yield and pod yield

Genotypes	Pod Yield (kg/ha)	Grain Yield (kg/ha)
IT07K-303-1	2544 c	1988 c
IT10K-1070-2	1852 d	1330 d
IT10K-837-1	2869 b	2307b
IT14K-1424-12	2937 a	2335 a
SARI-3-11-100	1526 f	1028 f
SARI-2-50-80	1572 e	1069 e
Mean	2216.5	1676.17
CV	0.2	0

Correlation analysis

The outcome of this study revealed that there were significant relationships among all the variables measured. DI-rating significantly and positively correlated with severity rating, Area under the disease progress curve for rust disease incidence (DI-AUDPC) and (Area under the disease progress curve for disease incidence for rust disease severity (DS-AUDPC), but correlated negatively with grain yield and pod yield. DS-rating significantly and positively correlated with both DI-AUDPC and DS-AUDPC, but correlated negatively with grain yield and pod yield. DI-AUDPC correlated significantly and positively with DS-AUDPC, but correlated negatively with grain yield and pod yield. DS-AUDPC correlated significantly and negatively with grain yield and pod yield, whilst grain yield also correlated significantly and positively with pod yield (Table 3).

Table 3: Correlation between DI-rating, R-rating, DI-AUDPC, DS-AUDPC, Grain yields and pod yield

Variables	DI_Rating	R_Rating	DI_AUDPC	DS_AUDPC	Grain_Yield	Pod_Yield
DI_Rating	-					
R_Rating	0.9048***	-				
DI_AUDPC	1.000***	0.9048***	-			
R_AUDPC	0.9048***	1.000***	0.9048***	-		
Grain_Yield	-0.8016***	-0.7313***	-0.8015***	-0.7313***	-	
Pod_Yield	-0.8019***	-0.7313***	-0.8019***	-0.7313***	0.9998***	-

** Significant at 0.05, ** = significant at 0.01, *** significant at 0.001.*

DISCUSSION

Rust disease is one of the most devastating diseases in cowpea production. In the current study, cowpea rust disease was present in the experimental field and was evident in the disease symptoms developed on cowpea lines evaluated. However, the response of the genotypes to the disease varied with…., recording the highest diseases incidence and severity. Two of the lines were however resistant with no observable disease symptoms. Disease epidemic measured as area under the disease progress curve showed that SARI-2-50-80 and SARI-3-11-100 recording higher DI-AUDPC values also recorded higher DS-AUDPC values. This result is in agreement with Lawrence (2005) who observed a significant positive correlation between disease incidence and disease severity. Variations in the response of cowpea genotypes in this study could be attributed to variations in their genetic makeup. According to Waller & Lenné (2001), plants possess cuticular cells on their leaves as a defensive mechanism against plant pathogens. In effect, this prevents or hinders the establishment of the pathogen and/or the development of the disease. However, cuticular wax prominence varies across different species or varieties. This finding corroborates Sanjeev *et al*. (2010) who reported a variation in rust disease resistance among some 225 cowpea germplasm collections.

To most cowpea farmers, productivity is measured through pod and grain yields. The result of the present study reveals that pod yield was between 1500 – 3000 kg/ha and between 1000 – 2400 kg/ha for grain yield. Both pod yield and grain yields in this study were higher for the resistant genotypes compared to the susceptible genotypes.

This could be as a result of an interference in the photosynthetic processes in susceptible genotypes. The finding of this study is in agreement with those of Mensah *et al*. (2019) and Ndalira *et al*. (2020) who also observed a reduction in yield and its components in susceptible cowpea genotype due to a reduction in their photosynthetic ability.

The influence of rust disease on yield in cowpea was evident in this study as DI-rating, R-rating, DI-AUDPC, and DS-AUDPC correlated negatively and significantly with pod yield and grain yield. This means that as DI-rating, R-rating, DI-AUDPC, and DS-AUDPC increases, pod yield and grain yield decreases. This finding is in line with Chandrashekar *et al*. (1989) who also reported a significant reduction in yield due to rust disease.

CONCLUSION

Four of the cowpea genotypes in this study were highly resistant to cowpea rust disease. Higher pod and grain yields were observed for resistant genotypes as compared to susceptible genotypes. The findings of this study will be useful in future cowpea breeding interventions.

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