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# Cowpea Rust Disease Incidence and Severity on Growth and Yield of Selected Cowpea Genotypes Under Different Cropping Systems in Western Kenya

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[*]Corresponding author - **Abstract**

The effect of cropping systems on cowpea rust caused by *Uromyces phaseoli* var *vignae* (Baarel) Arth, was evaluated in five cowpea genotypes under two cropping systems; cowpea pure stand and cowpea maize intercrop in Busia and Kakamega in western Kenya in short rains 2018 and long rains 2019. The experiment was laid in a Randomized Complete Block Design (RCBD) in split plot arrangement where cowpea genotype was the main treatment and cropping system the sub treatment. Five cowpea genotypes; Katumani 80 (K80), KVU 27-1, Tumaini, Dakawa and one local check, "Lwanda black eye" (Local) were evaluated. Data was subjected to mixed model ANOVA using SAS and means separated using LSD ($p \leq 0.05$). Cowpea genotypes in pure stand showed 35% lower disease incidence and 56% lower disease severity with higher leaf weights and grain yields than those in the maize intercrop in both Busia and Kakamega. Cowpea genotypes in intercrop were significantly taller than pure stand. Leaf Area Index (LAI) was higher in pure stand than intercrop. Dakawa and Tumaini had the highest LAI while K80 and local variety had the lowest in both Busia and Kakamega. Based on this result therefore, it may be suggested that farmers adopt pure stand for more leaves and grain weight. However, for intercropping purposes, they can use Dakawa and Tumaini cowpea genotypes as they have potential resistance to cowpea rust in both pure and intercrop.

**Key words:** Cropping system; Disease Incidence; Disease Severity; Cowpea rust; Intercrop

## Introduction

Cowpea (*Vigna unguiculata* var. *Vigna* (L.) Walp.), a legume of economic importance, is said to have been originated from Africa

(Langyintuo *et al*., 2003). It is an important food source and is estimated to be the major protein source for more than 200 million people in sub-Saharan Africa (OECD, 2015). It is a less utilized legume crop with a high potential for food and nutritional security in Africa, with grain, immature green pods and fresh leaves produced due to its nutritional composition (Gerrano *et al*., 2017). The cowpea can be used to produce a variety of dishes and snacks (Asif *et al*., 2013). On average, cowpea grains contain 23-25% protein and 50-67% starch in dry bases (Quin, 1997). Cowpea has many ecological beneficial characteristics usually non-food associated. It is an efficient nitrogen fixing, heat and drought-tolerant legume (Saidi *et al*., 2010).

Intercropping is a multiple cropping system where two or more crop species are planted simultaneously in a farm during a growing season (Mazaheri *et al*., 2006). It is practiced in developing tropical countries of Africa, India and Latin America. Whereas many crops are intercropped, legume intercropping is common because legumes have the potential of biological nitrogen fixation, which may be an important factor in improving soil nitrogen fertility, (Jensen *et al*., 2012; Voisin *et al*. 2014). The merits of intercropping include: increase in yield per land area and increase in economical returns as compared to sole crops or component crops. Despite these benefits intercropping has been shown in some environments to reduce nodulation and biological nitrogen fixation (Katayama *et al*, 1995). In addition, legume yields tend to reduce under intercropping due to the competition for light (Ofori & Stern, 1987). Intercropping legumes with cereal also create micro-climate which may favour disease manifestation and development (Margarida, 2013).

While the influence of intercropping on pest populations has received some attention, Allen (1982) states that relatively few studies have been made on the effects of cropping systems on diseases. The most commonly reported effect of associated cropping on disease is that, incidence or severity is decreased in the intercrop relative to pure stand (Musuku & Edje, 1982). In contrast, other research findings suggested that disease incidences and severity may be greater in an intercrop than in pure stand. For instance, white mould S*clerotina sclerotiorum* in beans was not influenced by maize association in variety trials in Arusha during 1988 though, there were varietal differences in susceptibility. The current study seeks to evaluate the influence of intercropping cowpea and maize on cowpea rust (*Uromyces phaseoli* var. *vignae* (Baarel) [Arth] on selected improved cowpea genotypes in Western Kenya.

Cowpea worldwide production is estimated to be 5.72 million tons of which Africa producing 5.42 million tons; East Africa with 0.52 million tons and Kenya produces about 122,682 tons (FAO, 2013). In Kenya, production potential is estimated at 1.6tonha$^{-1}$, indicating there is a huge yield gap in cowpea grain production. The situation is worse for Western Kenya where yields are much lower than the average 0.53tonha$^{-1}$. There are a number of constraints to sustainably produce cowpea. For instance, susceptibility to a number of insect pests and diseases is an important factor hindering a sustainable cowpea production. Cowpea rust appearance in the late 1990s has been identified as a big threat to cowpea production in East Africa, particularly in Kenya and other regions worldwide (Allen *et al*., 1998). Diseases reduce the quality and quantity of the leaves and seeds considerably. More than ten diseases have been recorded on cowpeas in Kenya (Mukunya & Keya, 1978). Cowpea rust caused by *Uromyces phaseoli* var *vignae* (Baarel) Arth, is among the top five major diseases which are responsible for reducing crop grain yield appreciably. If the disease appears early, it completely defoliates the crop. Unfortunately, very little work has been done on the cowpea rust in Kenya and therefore, no indication of the losses caused by the disease can be ascertained (Opio, 1979). Although the disease is of economic importance it has attracted little attention in East Africa and many other parts of the world. Therefore, since cowpea rust is one of the major diseases of cowpea in Kenya, work of the basic nature has to be undertaken to help provide the knowledge needed to control it by use of resistant varieties in the breeding program. Opio (1979), from the findings of her study, suggested that breeding for disease resistance to cowpea rust in Kenya needs further investigation.

## Materials and Methods

### Experimental sites

The experiment was conducted in Kakamega and Busia Counties of western Kenya in short rains 2018 and long rains

2019. In Kakamega, the experiment was conducted at Kenya Agricultural, Livestock Research Organization (KALRO) Kakamega station (00°16.9' N, 034° 46.07'E). In Busia County, the experiment was conducted at KALRO Alupe station (00° 28.0'N, 34° 07.00'E). The soil in Kakamega is classified as Ferralic-orthic acrisol (Jaetzold & Schmidt, 2007), deep, well drained highly weathered soil with inherently moderate fertility whereas the soil in Busia is well drained, very deep, dark red Orthic ferralisols (Jaetzold & Schmidt, 2007). Both soils are poor in nutrients, thus require regular fertilization. Kakamega and Busia sites represent the Upper Midlands 2 (UM 2) and Low Midlands 2 (LM 2) respectively with an altitude of approximately 1585 m and 1010 m a.s.l respectively (Jaetzold & Schmidt, 2007). The two counties have generally cool wet climate receiving bimodal annual rainfall ranging between 1250 mm-1750 mm in Kakamega and 760mm -2000mm in Busia and temperature range of between 14°C -27°C in Kakamega and 19°C -31°C in Busia (Jaetzold & Schmidt, 2007). In both Counties, rainfall is often unreliable and mid-season drought spells are frequent, although less in Kakamega than Busia.

**Experimental design**

The experimental design was Randomized Complete Block Design (RCBD) in split plot arrangement. The main plot factor was cowpea genotype (K80, KVU27-1, Dakawa, Tumaini and Local landrace) while sub-plot factor was cropping system (pure stand and cowpea maize intercrop) resulting in a total of ten treatment combinations with three replications. The sub-plots measured 3 m wide and 5m long and 1 m in between the subplots. The experiment was conducted in short rains 2018 and long rains 2019.

Tillage was done manually using a hand hoe two weeks before planting. Prior to planting composite soil samples were taken from each plot, analyzed using methods described in Anderson and Ingram (1993). Two cowpea seeds were planted manually at recommended standard spacing of 0.6 m x 0.1 m in pure stand and 0.75 m x 0.3 m in intercrop respectively KARI (2000), resulting in 6 rows of cowpea plants in pure stand and 4 rows in intercrop. The plants were thinned to one plant per hole after emergence. Seeds were planted 2 cm deep resulting in a plant population of 166,667 and 44,444 plants $ha^{-1}$ for pure stand and intercrop respectively. Prior to planting, Sympal (a fertilizer blend for legumes: NPK: 0:23:15 + 10 CaO + 4 S + 1 MgO, MEA Ltd Kenya) 30 kg P and 30 kg K $ha^{-1}$ was applied to offset possible P, K, Ca, S and Mg deficiencies. Fertilizer was applied in site band dug 5 cm deep and 10 cm away from cowpea planting lines at planting time and the experiment was kept weed free by manual weeding.

**Data collection procedure**

Ten plants were randomly selected from a $1m^2$ quadrat within the net plot consisting of two middle rows in both intercrop and pure. On these plants, disease incidence, severity, plant height, number of leaves, Leaf Area Index was assessed at three weeks interval up to physiological maturity. Destructive sampling was done at physiological maturity for both green leaf biomass and grain yield.

**Cowpea rust disease incidence**

Quadrat measuring 1 m by 1 m was casted ten times randomly in the net area to get the data on disease incidence in each site. The incidence was described as the proportion of rust infected plants to the total number of plants in the quadrat and was scored on a scale of 0-9 (Mayee and Datar, 1986), where:

0 = No symptoms (No pustules): very resistant.

1 = 1-10%, leaflet area covered with rust pustules: Resistant.

3 = 11-25%, leaflet area covered with rust pustules: Moderately resistant

5 = 26-50%; leaflet area covered with rust pustules: Moderately susceptible.

7 = 51-75%; leaflet area covered with rust pustules: Susceptible.

9 = > 75% leaflet area covered with rust pustules: Highly susceptible.

**Cowpea rust disease severity**

Disease severity was rated as a percentage of leaf area affected in the lower, mid and upper canopy of each of the plants under quadrat using 0-8 visual scale score method in which a rating of 0 = no disease, 1 = disease severity up to 2.5%, 2 = disease severity 2.5-5%), 3 = disease severity 5-10%, 4 = disease severity 10-15%, 5 = disease severity 15-25%, 6 = disease severity 25-35%, 7 = disease severity 35-

67.5% and 8 = disease severity 67.5-100%. The midpoint value of each rating range was used to convert the rating to percent.

**Growth Parameters**

**Plant height**

Plant height was measured on the ten randomly selected plants within the quadrat using measuring tape from soil surface to terminal/apical bud at three weeks' interval after plant emergence up to physiological maturity.

**Number of leaves**

Number of leaves was determined by visual counting of all fully opened leaves on each randomly selected plant at an interval of three weeks after plant emergence (Agbogidi and Ofuoku, 2005).

**Leaf Area Index**

Leaf area measurements were taken at the same time with leaf count on the same plants. Leaf area (LA) was calculated as the product of the length and breadth at the broadest point of the longest leaf multiplied by 0.75 (Abukutsa, 2007). Leaf area index (LAI) was then calculated by dividing the LA by spacing after every three weeks after emergence (Abukutsa, 2007).

**Yield and yield component parameters**

**Number of pods per plant**

Number of pods was assessed in the field by visual counting on a scale of 1–9 following the procedure of Egho (2009) at physiological maturity. The number of pods was then divided by the number of cowpea plants to get the number of pods per plant.

**Green leaf biomass**

Green leaf biomass was determined at physiological maturity when 95% of the pods had changed colour to brown. Leaf biomass samples were taken from all plots by plucking the mature leaves from each plant in the net area. Plants for biomass accumulation were randomly selected in an area of 0.6 $m^2$ within the net area. Fresh leaves were weight using an electronic balance and the weight recorded (Woomer *et al.*, 2011).

**Cowpea grain yield**

Pods were harvested at physiological maturity, 65–70 days after planting when pods turned yellow. Harvesting was done in the net plot that excluded the boarder rows and end plants in each sub-plot. The net area was 4 m × 1.8 m, i.e. 7.2 $m^2$. Pods were harvested with hand and fresh weights of pods recorded. The pods were air dried to a constant weight and then shelled. The weight of the grains and empty pods were recorded separately. Grain yield in kg $ha^{-1}$ were standardized to 13 % storage moisture content.

## Results

### Influence of cropping system on plant height, number of leaves, disease incidences, disease severity and Leaf Area Index

Cropping system significantly influenced plant height, number of leaves, disease incidence, disease severity and leaf Area index at both locations. In Busia, cowpea plants under pure stand were 2.5 times shorter with 2.5 times more leaves compared to those under intercrop. Leaf area index was also significantly higher under pure stand. However, disease incidence and severity was significantly higher in intercrop when compared to pure (Table 1).

A similar trend was observed in Kakamega where cowpea plants under pure stand were 2.7 times shorter with 2.5 times more leaves compared to those under intercrop. On the same note, LAI was significantly higher on cowpea plants under pure stand than those under intercrop. Subsequently, disease incidence and severity was significantly higher in cowpea under intercrop than those in pure stand (Table 2).

**Table 1: Influence of cropping system on mean plant height, number of leaves, cowpea rust incidences, severity and Leaf Area Index at Busia**

| Cropping System | Plant Height | Number of Leaves | Disease Incidence | Disease Severity | Leaf Area Index |
|---|---|---|---|---|---|
| **Pure Stand** | 42.4b* | 24.9a | 1.4b | 3.2b | 2.8a |
| **Intercrop** | 105.0a | 9.9b | 2.7a | 4.5a | 2.6b |
| **LSD** | 3.5 | 1.60 | 0.29 | 0.52 | 0.17 |
| **CV %** | 14.7 | 28.3 | 24.5 | 22.6 | 20.7 |

Means followed by the same lower-case letter (s) within the column are not significantly different ($P \leq 0.05$)

**Table 2: Influence of cropping system on mean plant height, number of leaves, cowpea rust incidences, severity and Leaf Area Index Kakamega**

| Cropping System | Plant Height | Number of Leaves | Disease Incidence | Disease Severity | Leaf Area Index |
|---|---|---|---|---|---|
| **Pure Stand** | 39.7b* | 26.9a | 4.5b | 1.9b | 2.8a |
| **Intercrop** | 105.7a | 10.7b | 5.2a | 2.8a | 2.5b |
| **LSD** | 5.1 | 1.8 | 0.59 | 1.97 | 0.1 |
| **CV %** | 25.6 | 25.2 | 24.4 | 28.7 | 27.5 |

*Means followed by the same lower case letter (s) within the column are not significantly different ($P \leq 0.05$).

## Influence of cropping system on yield and yield components

Cropping system significantly influenced yield and yield components at both locations. In Busia, there were 48%, 32% and 40% more pods per plant, leaf yield and grain yield respectively in cowpea under pure stand compared to those under intercrop (Table3). Similar trend was observed in Kakamega (Table 4).

**Table 3: Influence of cropping system on the mean number of pods per plant, leaf yield and grain yield in Busia**

| Cropping System | Number of Pods per Plant. | Leaf yield (kg $ha^{-1}$) | Grain yield (kg$ha^{-1}$) |
|---|---|---|---|
| **Pure Stand** | 14.2a* | 4113.5a | 503.1a |
| **Intercrop** | 9.6b | 3121.9b | 358.1b |
| **LSD** | 1.5 | 961.2 | 120.9 |
| **CV%** | 19.6 | 24.8 | 26.8 |

*Means followed by the same lower case letter (s) within the column are not significantly different ($P \leq 0.05$)

**Table 4: Influence of cropping system on the mean number of pods per plant, leaf yield and grain yield in Kakamega**

| Cropping System | Number of Pods per Plant. | Leaf yield (kg $ha^{-1}$) | Grain yield (kg$ha^{-1}$) |
|---|---|---|---|
| **Pure Stand** | 10.0a* | 2664.1a | 440.7a |
| **Intercrop** | 8.3a | 1881.3b | 322.9b |
| **LSD** | 1.62 | 666.9 | 100.5 |
| **CV%** | 23.5 | 28.5 | 34.5 |

*Means followed by the same lower case letter (s) within the column are not significantly different ($P \leq 0.05$)

**Interaction effects of cowpea genotype and cropping system on disease incidence and severity**

In Busia, both disease incidence and severity were significantly lowest in Dakawa cowpea variety planted as either pure stand or intercrop compared to other treatment combinations (Figure 1). Similar trend was observed in Kakamega (Figure 2).

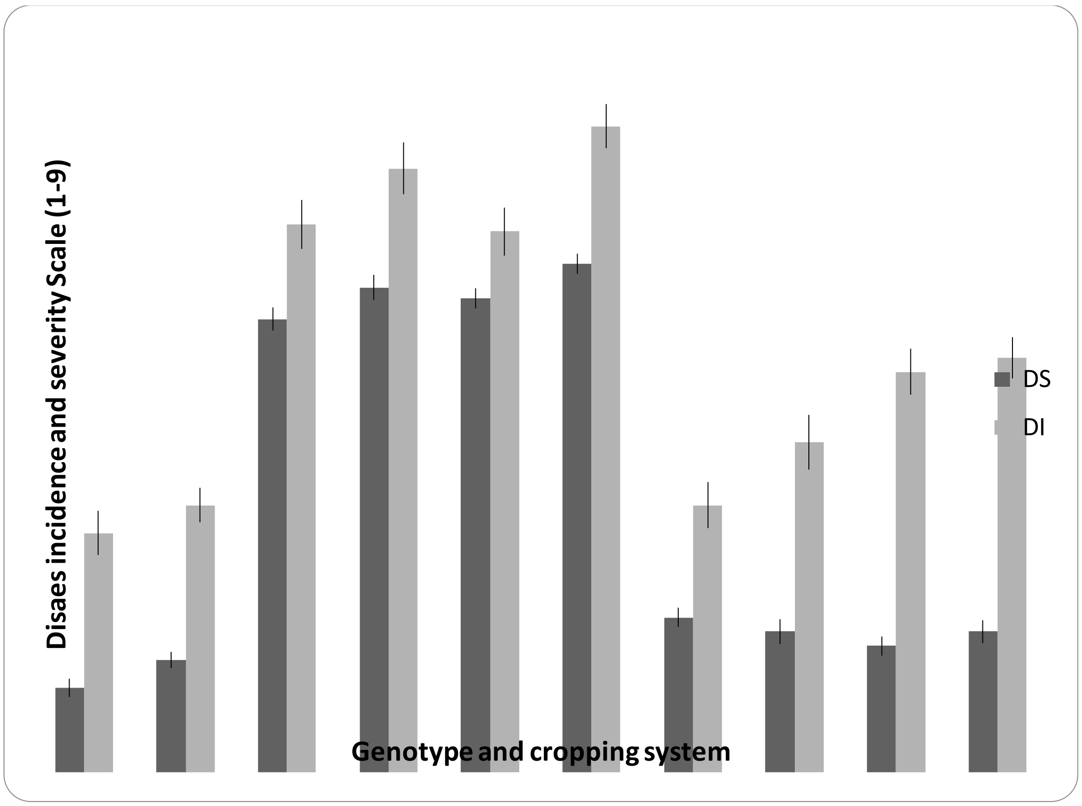


**Figure 1: Influence of Interaction of genotype and cropping system on Disease incidence and severity in Busia**

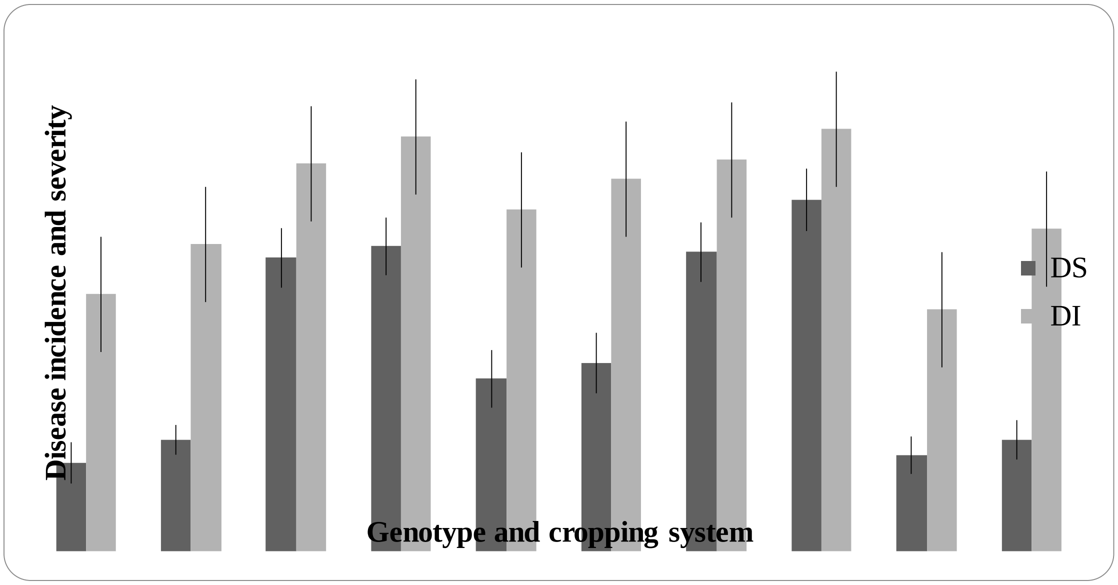


**Figure 2: Influence of Interaction of genotype and cropping system on Disease incidence and severity -Kakamega**

## Discussions

Cropping system had significant influence on plant height, number of leaves, disease incidence, severity, LAI, leaf weight, number of pods per plant and grain weight, among and between cowpea genotypes in Alupe and Kakamega. With pure stand recording higher number of leaves and leaf area index, lower disease incidence and severity than those under intercrop. These could be attributed to a number of factors including minimum exposure to light that is essential for photosynthesis a function of dry matter accumulation, logging on the ground due to etiolation because of weak stems, hence limited plant development and productivity. This finding is in agreement with Heitholt *et al*., (2005) who found out that abiotic and biotic stresses can reduce yield of crops for example moisture stress has been documented to reduce the yield benefit from narrow row spacing in Kansas by more than 20%.

The higher heights and less number of leaves found in cowpea under intercropping could be as a result of shading conditions under intercropping resulting in removal of dry matter production centre from leaves to stems promoting the stem elongation at the expense of leaves to obtain high amounts of light (Kermah, *et al*., 2017; Gong *et al*., 2015; Ballare, 1999).

Dry matter accumulation under intercrop was low as compared to sole crop, due to negative effect of shading resulting in reduced amount of light required to stimulate growth and yield components (Carr *et al*., 1998; Carruthers *et al*., 2000). Similarly, previous studies reported that the negative effect of shading on soybean growth because of close planting of maize causes severe shading and absorbed most part of the light under maize-soybean relay-strip intercropping system (Wu *et al*., 2007; Yang *et al*., 2014; Gao *et al*., 2015). High grain dry matter accumulation and grain yield under sole crop compared to intercrop could also be attributed to competition for water and nutrients under intercropping (Chemada, 1997).

High disease incidence and severity in intercrop could be due to high relative humidity, long period of leaf wetness and low temperatures that favoured the pathogen infection. This is in agreement with Boudreau & Mundt (1992) who stated that intercropping generally reduce temperature and wind velocity but increase relative humidity which could alter disease development. Fininsa (2001) demonstrated that high humidity and leaf wetness favour many pathogens that infect more readily in moist condition for instance, angular leaf spot and white mould whose levels are higher in intercrop of beans and maize than in sole crops. Similarly, Raymundo and Alcazar (1982) observed an increased incidence of late blight in potato-sweet potato intercrop and attributed this to an increase in relative humidity. Previous research by Fujita *et al*. (1992) agreed that intercropping does not always reduce pest or pathogen, which is also the overwhelming finding of this study. Pests increase could be due to a second crop being a host for pests in intercropping, or increasing the shade effect by the canopy which provides favourable conditions for pests and pathogens activity to thrive. In another research finding, Adipala *et al*, (1997) confirmed that higher incidence and severity of viral diseases (caused by CAMV and CMV), anthracnose and scab were recorded during the wet season than during the dry season. It is worth noting that intercropping creates a microclimate that mimics wet season conditions. The difference in LAI in cowpea varieties as regards cropping system could have been because of disease incidences and severity among other factors. Pure stand had lower disease incidence and severity which prompted leaf growth and development unlike in intercrop that was confounded by light stress as well as limited nutrients besides cowpea rust disease incidence and severity. Disease incidences and severity affects cell division and elongation in the meristematic tissues. Intercropping reduced leaf weight and grain yield irrespective of cowpea genotype. This could be in correspondence to low LAI observed under intercropping resulting in less photosynthesis and hence low biomass accumulation under intercropping (Ondieki *et al.*, 2011; Balemi, 2009). Furthermore, legume yield has been found to reduce under intercropping due to competition for light (Ofori & Stern, 1987). Therefore, high yield recorded in the sole crop of cowpea than intercrop could be due to the better ability of cowpea to intercept light and soil resources (Baumann *et al.*, 2001).

Low disease incidence and severity recorded by Dakawa and Tumaini compared to K80 and Local variety, across the cropping system indicate that the genotypes had varied genetic compositions. Dakawa and Tumaini cowpea genotype recorded the least damage by cowpea rust disease in the two cropping system which could be associated with its superior inherent resistance to the disease attack over the other genotypes. Similar findings were also reported by Singh (1999), who confirmed similar superiority of IT90K-277-2 over the other improved varieties. Sharma and Franzmann (2000) also observed that variations in the susceptibilities and resistance among genotypes could be due to differences in their genetic makeup. Goenaga *et al*. (2008) also in his findings reported that the different yield potential of cowpea genotypes grown under virus pressure was due to the genetic diversity. Alsemaan *et al.* (2011), likewise reported the existence of genetic diversity within Rosa damascene accessions used to broaden the production of rose oil.

## Conclusion

From the current study, it can be concluded that planting pure stand has advantage over intercrop as there is reduced cowpea disease incidence and severity which directly translates to higher grain and biomass yield to resistant genotypes like Dakawa.

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