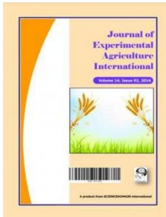

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# Screening Groundnut (*Arachis hypogeae*) Genotypes for Resistance to Early and Late Leaf Spot Diseases

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author MSA designed the study, managed the literature searches, wrote the protocol, author AS performed the statistical analysis wrote the first draft of the manuscript and author MA managed the analyses of the study. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background for the Study:** Groundnut (*Arachis hypogaea* L.) is an important crop both in subsistence and commercial agriculture in Ghana. Early leaf spot (*Cercospora arachidicola*) and late leaf spot (*Cercosporidium personata*) are major limiting factors to groundnut productivity in Ghana.
**Aim:** The objective of the study was to screen groundnut genotypes for resistance to Early and Late leaf spot diseases.
**Study Design:** The treatments were arranged in a randomized complete block design and replicated three (3) times.
**Place and Duration of Study:** The research was conducted from May to December 2013 at the Savanna Agricultural Research Institute experimental site at Nyankpala in the Northern Region. The site lies between latitude 9°25´141 North and longitude 0°58'142 West and an altitude of 183 m.
**Methodology:** The land was done using a tractor and field divided into plots of 2 m x 5 m with 1 m interval between plots. Sowing was done on 3rd June 2013. One seed was planted per hole at a

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depth of approximately 4 cm. Early and late leaf spot ratings were recorded at 30, 60 and 90 days after planting, using a ten-point scale. At pod maturity, plants from the middle two rows of each plot were hand-harvested and weights of the above ground foliage and underground pods were oven-dried to obtain dry haulm weight and pod yield respectively. Data collected were subjected to analysis of variance using Genstat statistical package (12th edition). Means were separated using the least significant difference at 5%.

**Results:** The were significant differences (P < .001) among the groundnut genotypes in terms of severity for both early and late leaf spot diseases. F-Mix, NC 7, PC 79-79, F-Mix × SINK 24 and NKATIE-SARI had lowest score for both early and late leaf spot diseases. Among the 21 groundnut genotypes, F-Mix recorded the highest pods yield of 1100kg/ha and haulm weight of 5867 kg/ha followed by NC 7 with total pods yield of 900 kg/ha and haulm weight of 5373 kg/ha. PC 79-79 had a total pods yield of 666.7 kg/ha and haulm weight of 4867kg/ha. The pods yield of F-Mix × SINK 24 was 533.3 kg/ha and haulm weight of 4600 kg/ha. NKATIE-SARI recorded pods yield of 500 kg/ha and haulm weight of 4633 kg/ha.

**Conclusions:** From the study, the genotypes F-Mix, NC 7, PC 79-79, F-Mix × SINK 24 and NKATIE-SARI were found to be resistance to both early and late leaf spot disease whereas Chinese, Doumbala, GM 120, GM 324 and ICGV 86015 were susceptible to both diseases.

*Keywords: Groundnut; disease severity; leaf spot; genotypes; leaf defoliation; crop rotation.*

## 1. INTRODUCTION

Groundnut *(Arachis hypogeae L.)* is an important economic food and cash crop grown globally. The crop contributes to the world diet and is used for food for people from both developed and developing countries.

Groundnut also has other uses such as; source of cooking oil, solvents and medicine. It can also be eaten raw, slightly cooked or when it is still fresh.

Groundnut vines (hay) can also serve as fodder for livestock especially during the dry season when there is scarcity of green forage for livestock [1,2].

According to Asiedu [3], groundnut is a herbaceous plant of which there are two types, bunch and runner types. Apart from the runner and bunch types, many intermediate forms or hybrids exist [4].

According to FAO estimate, the average world production of groundnut pods in 1990 – 2003 was between 34.4 million tons/year from 24.4 million hectares of land [5,6,7]. The largest producers of groundnuts are China and India followed by Sub- Saharan African countries, central and South America [8]. Approximately 85% of the land area under groundnut production is in the Sudan and Guinea Savanna zones. The total production in Sub-Saharan Africa was 8.2 million tons/year from 9.5 million hectares of land [5]. Groundnut is cultivated in all agro ecological zones of Ghana. However, a large proportion (92%) of the production is in Northern-Ghana [9,10].

It is produced both as a commercial and a subsistence crop [1]. Groundnut yields are however very low in Ghana averaging less than 1000 kg/hectare in comparison with an average of 2500 kg/hectare obtained in developed countries [11,10]. In Ghana, the common limiting factor to groundnut production is the prevalence of diseases, most importantly early leaf spot caused by *Cercospora arachidicola* and late leaf spot caused by *Cercosporidium personata* [12]. Both diseases are distributed widely and occur in epidemic proportion in northern Ghana [13]. The incidence of early and late leaf spot on susceptible groundnut genotypes can lead to total defoliation which can drastically reduce yield [14]. High defoliation can also affect hay quality of vines fed to livestock [1,7].

Leaf spot disease appear as reddish brown to black necrotic spot on leaves. The necrotic spot in early leaf spot are bounded by a yellow halo which separates it from late leaf spots which have no halo. Both diseases reduce the leave area available for photosynthesis and cause premature defoliation and yield loss as much as 70% in West Africa [8].

Annual yield losses of up to 50% attributable to the disease can occur in northern Ghana. The most common method of control is by the use of fungicides. However, in Ghana, a large number of farmers do not practice any control for these diseases in their groundnut farms largely due to inadequate resources to use the appropriate chemical control and/or difficulty in obtaining fungicides [13,15]. Moreover, these chemicals leave toxic residues in the environment [16,17].

Gibbons [18], discovered that application of chemicals against leaf spot as well as against other diseases should be reduced to a minimum on health and environmental grounds. Tuormaa [19] reported that, world health organization (WHO) report estimated that there were between 800,000 and 1,500,000 cases of unintentional pesticides poisoning in the world, resulting to about 3,000 and 28,000 deaths.

A case study finding showed highly disturbing levels of pesticides misuse and abuse leading to poisoning of families and livestock [20,21].

Due to the above mentioned reasons, the use of disease – resistant cultivars is the best and economically way to control diseases of food crops [22,23]. It is the most cost efficient of all the control measures [24].

Resistant cultivars save time, effort and money which would have been spent in controlling plant diseases. The environment also gains because there will be no application of pesticides [16]. Subrahmanyam [25] reported that some genotypes of groundnut are resistant to cercospora leaf spot (early and late leaf spot).

The objective of this study was to screen groundnut genotypes for resistance to early and late leaf spot diseases.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The research was conducted from May to December 2013 at the Savanna Agricultural Research Institute experimental site at Nyankpala in the Northern Region. The site lies between latitude 9°25´141 North and longitude 0°58’142 West and an altitude of 183 m.

### 2.2 Field Experiment and Design

The land was ploughed and harrowed using a tractor and divided into plots of 2 m x 5 m with 1 m interval between plots. The treatment were arranged in a randomized complete block design and replicated three (3) times. Sowing was done manually on 3rd June 2013. One seed was planted per hole at a depth of approximately 4 cm. A plot consisted of six rows with spacing of 0.5 m between rows and 0.2 m between plants in a row. Weed control was done using hoe to remove weeds and hand pulling of weeds where necessary.

**Table 1. Groundnut genotypes and their sources**

| Number | Genotype | Sources |
|---|---|---|
| 1 | NC 7 | Tamale-Ghana |
| 2 | NKATIE-SARI | Tamale-Ghana |
| 3 | ICGV 86015 | Tamale-Ghana |
| 4 | FDRS × F-MIX | Tamale-Ghana |
| 5 | ICGV 92096 | Tamale-Ghana |
| 6 | F-MIX × SINK 24 | Tamale-Ghana |
| 7 | CHINESE | Tamale-Ghana |
| 8 | F-MIX | Tamale-Ghana |
| 9 | DOUMBALA | Burkina Faso |
| 10 | TS-32-1 | Burkina Faso |
| 11 | PC 79-79 | Burkina Faso |
| 12 | GM 204 (123) | Burkina Faso |
| 13 | ICGV 86124 | Tamale-Ghana |
| 14 | ICGV 97188 | Tamale-Ghana |
| 15 | ICGV 96814 | Tamale-Ghana |
| 16 | ICGV 86015 | Tamale-Ghana |
| 17 | GM 656 | Burkina Faso |
| 18 | GM 155 | Burkina Faso |
| 19 | GM120 | Burkina Faso |
| 20 | GM 663 | Burkina Faso |
| 21 | GM 324 | Burkina Faso |

#### 2.2.1 Source of groundnut genotypes

Twenty-one (21) groundnut genotypes obtained from CSIR-Savanna Agricultural Research Institute and its collaborators from Burkina Faso were used for the study. The groundnut genotypes used and their source are listed in Table 1.

### 2.3 Data Collection and Analysis

Data was collected on leaf spot disease severity, number of pods per 5 plants, haulm weight, pod yield and maturity rating. Data on leaf spot severity were taken at 30, 60 and 90 days after planting using the Florida scale of (1-10) based on visual observations where 1 = no disease, 2 = very few lesions on leaves in lower canopy, 3 = few lesions on leaves in lower and upper canopy, 4 = some lesions on leaves in lower and upper canopy with ≤10% defoliation, 5 = lesions noticeable in upper canopy and ≤ 25% defoliation, 6 = lesion numerous with ≤50% defoliation, 7 = lesions very numerous with ≤75% defoliation, 8 = numerous lesions on few remaining leaves with ≤90 defoliation, 9 = remaining leaves covered with lesions with ≤95% defoliation, and 10 = plants defoliated or dead (Maninder *et al.,2011*). Ten plants were sampled per plot. Data also was taken on incidence of rossete as additional data.

At pod maturity, plants from the middle two rows of each plot were hand-harvested and weights of the above ground foliage and underground pods were oven-dried to obtain dry haulm weight and pod yield respectively. Data collected were subjected to analysis of variance and the mean difference separated using the least significant difference test at LSD of p≤ 0.05 using Genstat statistical package (4$^{th}$ edition).

## 3. RESULTS

### 3.1 Disease Score of Early and Late Leaf Spot

The results indicated that there was significant difference (P < .001) among the groundnut genotypes in the severity of both early and late leaf spot diseases. The genotypes NC7, F-MIX, ICGV 96814, PC 79-79, NKATIE-SARI, F-MIX × SINK-24 and FDRS-F-MIX-39, had lower disease severity scores for early leaf spot and so have some level of resistance to early leaf spot while

**Table 2. Effect of groundnut genotype on severity score for early and late leaf spot diseases**

| Treatments | Disease score | |
|---|---|---|
| | **Early leaf spot** | **Late leaf spot** |
| Chinese | 5.133 a-d | 6.933 a |
| Doumbala | 4.533 d-f | 6.200 bc |
| F-MIX | 4.200 f | 5.200 de |
| F-MIX × SINK 24 | 4.600 c-f | 5.333 de |
| FDRS × F-MIX-39 | 4.867 a-e | 5.933 bc |
| GM 120 | 5.267 ab | 6.467 ab |
| GM 155 | 5.200 abc | 6.200 bc |
| GM 204 (123) | 5.267 ab | 6.267 bc |
| GM324 | 5.333 a | 6.333 b |
| ICGV 86015 | 5.000 a-e | 6.267 bc |
| ICGV 86024 | 5.267 ab | 6.267 bc |
| ICGV 92096 | 4.867 a-e | 6.133 bc |
| ICGV 96814 | 4.400 ef | 6.067 bc |
| ICGV 97188 | 5.133 a-d | 6.133 bc |
| ICGV 86124 | 5.133 a-d | 6.133 bc |
| TS-32-1 | 5.133 a-d | 6.133 bc |
| NC 7 | 4.133 f | 5.333 de |
| NKATIE-SARI | 4.667 b-f | 5.067 e |
| PC 79-79 | 4.600 c-f | 5.733 cd |
| GM 656 | 5.067 a-d | 6.067 bc |
| GM 663 | 5.000 a-e | 6.000 bc |
| P value | <.001 | <.001 |
| CV% | 2.6 | 0.5 |
| SED | 0.3039 | 0.2786 |

*Genotypes with different letters in a coloumn are significantly different (protected LSD test, P<0.05)*

**Table 3. Effect of groundnut genotypes on total number of pods/plant; number of matured pods/plant and dry pod weight**

| Treatments | Total number of pods/plant | Number of matured pods/plant | Dry pod weight (kg/Ha) |
|---|---|---|---|
| Chinese | 5.67 j | 3.67 i | 500.0 b-f |
| Doumbala | 10.67 gh | 7.667 fgh | 866.7 a-d |
| F-MIX | 19.67 a | 17.00 a | 1100.0 a |
| F-MIX × SINK 24 | 17.00 ab | 14.33 abc | 533.3 b-f |
| FDRS-F-MIX-39 | 15.33 bcd | 12.67 bcd | 566.7 b-f |
| GM 120 | 7.67 ij | 4.00 i | 300.0 efg |
| GM 155 | 14.33 b-e | 10.33 def | 533.3 b-f |
| GM 204 (123) | 11.67 e-h | 9.00 efg | 400.00 efg |
| ICGV 86024 | 11.67 e-h | 7.67 fgh | 600.0 b-f |
| GM 656 | 11.33 fgh | 8.00 efg | 233.3 fg |
| GM 663 | 10.33 hi | 7.67 fgh | 366.7 efg |
| GM 324 | 7.6 ij | 4.33 hi | 366.7 efg |
| ICGV 86015 | 13.67 c-f | 10.33 def | 700.0 a-e |
| ICGV 86124 | 13.33 d-g | 11.33 bcd | 933.3 ab |
| ICGV 97188 | 13.33 d-g | 10.00 d-g | 500.0 b-f |
| ICGV IS 96814 | 10.33 hi | 6.67 ghi | 566.7 b-f |
| ICGV IS 92096 | 12.00 e-h | 9.00 efg | 466.7 c-f |
| TS-32-1 | 16.33 bc | 10.67 def | 433.3 d-g |
| NC 7 | 17.00 ab | 14.67 abc | 900.0 abc |
| NKATIE-SARI | 17.00 ab | 15.00 ab | 500.0 b-f |
| PC 79-79 | 16.33 bc | 13.33 a-d | 666.7 a-f |
| P value | <.001 | <.001 | 0.004 |
| CV% | 5 | 4.4 | 12.6 |
| SED | 1.462 | 1.745 | 217.9 |

*Genotypes with different letters in a row are significantly different (Protected LSD test, P< 0.005)*

the genotypes CHINESE, ICGV 86015, ICGV 86124, ICGV 97188, TS-32-1, GM 656, GM 155, GM 120, GM 204 (123) and GM 324 had higher disease severity score for early leaf spot and so were susceptible to early leaf spot disease. Chinese and Doumbala were used as susceptible checks while Nkatie-SARI was the resistant check.

For late leaf spot, the genotypes NKATIE-SARI, F-MIX, F-MIX × SINK 24, NC7 and PC 79-79 recorded the lowest disease severity scores while the genotypes GM 656, ICGV 96814, TS-32-1, ICGV 92096, ICGV 97188, ICGV 86124, ICGV 86015, GM 663, GM 155, ICGV 86024, GM 204 (123), GM 120, GM 324, DOUMBALA and CHINESE had the highest disease severity score and so exhibit some level of susceptibility to late leaf spots.

## 3.2 Total Number of Pod/Plant, Number of Matured Pod/Plant and Dry Pod Weight

Table 3 shows the effect of groundnut genotypes on total number of pods/plant; number of matured pods/plant and dry pod weight.

The genotypes F-MIX, NC 7, NKATIE-SARI, F-MIX × SINK 24, PC 79-79, TS-32-1, FDRS-F-MIX-39 and GM 155 recorded the highest total number of pods/ plant whereas CHINESE, GM 120, GM 324, GM 663, DOUMBALA, GM 656 and GM 204 (123) had the lowest total number of pods/plant.

Also, F- MIX, NKATIE-SARI, NC 7, F-MIX × SINK 24, PC 79-79 and FDRS-F-MIX-39 had the highest number of matured pods while Chinese, GM 120, GM 324, ICGV 96814, Doumbala and GM 663 recorded the lowest number of matured pods.

The genotypes F-Mix, NC 7, ICGV 86124, ICGV 86015, and PC 79-79 recorded the highest dry pod weight while Chinese, GM 656, GM 120, and GM 324 which recorded the lowest dry pod weight (kg/ha).

## 3.3 Dry Haulm Weight (kg/ha)

The results indicated that there were significant differences (P< 0.005) dry haulm weight among the groundnut genotypes (Fig. 1).

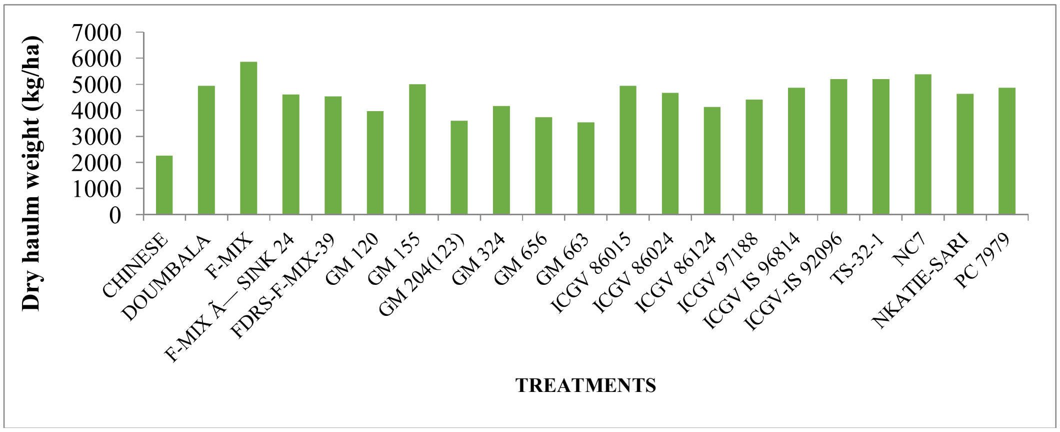


**Fig. 1. Effect of groundnut genotypes on dry haulm weight (kg/ha)**

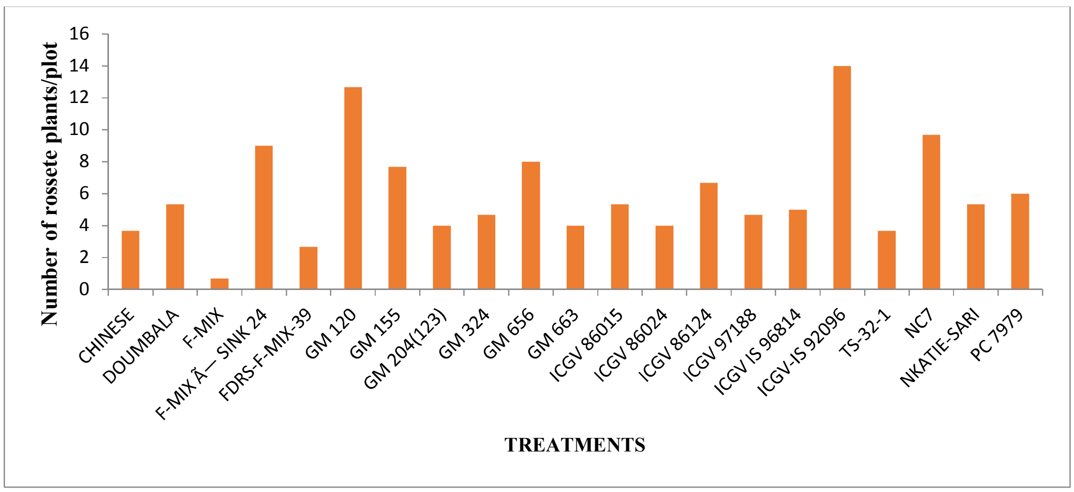


**Fig. 2. Incidence of Rossete on the groundnut genotypes**

For dry haulm weight (kg/ha) as expected, the genotypes F-mix, NC 7, TS-32-1, ICGV 86015 and ICGV IS 92096 recorded the highest dry haulm weight (kg/ha) while Chinese, GM 204 (123) and GM 663 recorded the lowest dry pod weight.

### 3.4 Number of Rossete Plants/10 m²

The results show no significant difference (P> 0.05) among the groundnut genotypes on the number of rossete plants/ 10 m² (Fig. 2).

## 4. DISCUSSION

### 4.1 Severity of Early and Late Leaf Spot Disease Score

Early and late leaf spot diseases are the most widespread foliar diseases of groundnut (*Arachis hypogaea* L.) [26], accounting for pod yield losses of up to 50% in severe epidemics [12]. Management strategies for leaf spot epidemics rely on reducing initial inocular via crop rotation or on reducing the rate of disease spread via resistant cultivars and fungicide applications [11]. Crop rotation for 2 to 3 years is recommended, because this may delay the development of a leaf spot epidemic by 2 to 3 weeks [11,12]. However, because of the rapid rate of increase of leaf spot diseases, crop rotation alone is insufficient for control, hence the need for the identification of groundnut genotypes resistant to leaf spot diseases.

NKATIE-SARI was released as a groundnut cultivar relatively resistant to both early and late leaf spots compared to the susceptible cultivar Chinese and Doumbala by CSIR- Savanna Agricultural Research Institute. The present study demonstrated that the groundnut genotypes FDRS-F-MIX-39 and GM 663 were as resistant to early and late leaf spots as NKATESARI. However, F-mix, ICGV-IS 92096, ICGV-IS 96814, F-mix × Sink 24, and PC 79-79 appeared to be more resistant to early and late leaf spot than NKATIE-SARI. They could possess genes that enable them to survive or they could be escapes. These genotypes could be further evaluated using molecular genetics to identify loci responsible for resistance to the leaf spot disease for crop improvement. The genotypes GM 120, GM 324 and TS 32-1 were highly susceptible to both early and late leaf spots diseases.

### 4.2 Total Number of Pods/Plant

As expected, the relatively resistant genotypes F-Mix, F-Mix × SINK 24, FDRS-F-Mix-39, NC 7, NKATIE-SARI and PC 79-79 had the highest total number of pods/plant. The genotypes Chinese, GM 120 and GM 324 recorded the lowest total number of pods/plant due to their susceptibility to *Cercospora* leaf spot disease. Bdliya [27] observed that *Cercospora* leaf spot is disastrous to groundnut especially towards pod formation stage of the crop causing low seed and haulm yield. The diseases cause premature leaves defoliation and a reduction in the photosynthetic area of the leaf surface which resulted in the low yield in the susceptible genotypes [8,10].

### 4.3 Number of Matured Pods/Plant

The genotypes F-Mix, NKATIE-SARI, NC 7 and F-Mix × SINK 24 that showed some level of resistance to leaf spots also had improved number of matured pods, apparently due to high production of photosynthate.

### 4.4 Dry Pod Weight

They improved sink source relationship due to leaf retention in the relatively resistant genotypes also resulted in increased dry pod weight.

### 4.5 Dry Haulm Weight (kg/ha)

The genotypes F-Mix, NC 7, TS-32-1, ICGV 86015 and ICGV 92096 recorded the highest dry haulm weight because they exhibited some level of resistance to both early and late leaf spot disease as compared to Chinese, GM 204 (123) and GM 663 which recorded the least dry haulm weight (kg/ha) probably because of loss of leaves to early and late leaf spot disease. This agrees with [27] who observed that *Cercospora* leaf spot is disastrous to groundnut especially towards pod formation stage of the crop causing low seed and haulm yield.

## 5. CONCLUSION AND RECOMMENDATION

From the study, the genotypes F-Mix, NC 7, PC 79-79, F-Mix × SINK 24 and NKATIE-SARI were found to be resistance to both early and late leaf spot disease whereas Chinese, Doumbala, GM 120, GM 324 and ICGV 86015 were very susceptible to both diseases.

The study also revealed that the genotypes F-Mix, NC 7, PC 79-79, F-Mix × SINK 24 and NKATIE-SARI recorded the highest total number of pods/plant as well as the highest number of matured pods/plant. For dry pod weight, the genotypes F-Mix, ICGV 86124 and ICGV 86015 had the highest dry pod weight. During the study there was high number of rossete plants observed, however there was no significant difference among the genotypes.

The recommendation was that, farmers should use F-Mix, NC 7, F-Mix × SINK 24 and Nkatie-SARI among others that exhibited some level of resistance to both early and late leaf spot diseases and were also high yielding. This will save them the cost of fungicide spray against the diseases and also improve their income from the increased yields. Also the susceptible genotypes especially Chinese that are widely cultivated should be improved upon through further crosses with the resistant genotypes to enhance their resistance to the leaf spot pathogen.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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