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# PRELIMINARY ASSESSMENT OF BAMBARA GROUDNUTNUT [*VIGNA SUBTERRANEA (L.) VERDC.*] LANDRACES FOR INCIDENCE OF PRE-EMERGENCE DAMPING-OFF DISEASE AND YIELD UNDER IRRIGATED AND RAIN-FED CONDITIONS

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## *ABSTRACT*

*Fusarium oxysporum* attacks Bambara groundnut at all stages of development. Attack prior to seed germination results in pre-emergence damping-off disease that can lead to losses in crop stands which eventually reduce crop yield. Dry and wet season field trials were conducted to evaluate the effect of incidence of the disease on yield of Bambara nut landraces in Maiduguri, northeastern Nigeria. Three Bambara nut landraces (Cream, Red and Black) were laid out in Randomized Complete Block Design replicated three times in each season. Significant (P≤0.05) differences were observed among the landraces in respect of percentage seed germination, seedling emergence, disease incidence and pod yield. Seed germination ranged from 68.9 - 80.0 %. Field emergence test taken from the average of the two seasons ranged from 40.4 – 72.3 %. Mean across the seasons showed that Black had the highest (72.3) percent emerged seedlings, lowest (26.7 %) disease incidence and highest pod yield of 207.2 kg/ha. While Cream had the highest (65) percent disease incidence, the lowest (40.4) percent emerged seedlings and lowest pod yield of 76.6 kg/ha. Cream is the most popular choice of the farmers and consumers, and coincidentally the most susceptible among the landraces. Low disease incidence in the wet season did not result in higher pod yield due to end of season drought. With uncertainty/variability of rainfall pattern in the region, dry season is the second best option for planting the crop.

**Contribution/Originality:** Although northeastern Nigeria is the center of Bambara nut production, it lacks in reports on diseases affecting the crop. This preliminary assessment sought to fill this gap. It is the first field report on Fusarium related disease and yield of Bambara nut in both wet and dry seasons.

## 1. INTRODUCTION

Bambara groundnut or Bambara nut (*Vigna subterranean* (L.) Verdc. has been variously described as an "orphan crop", which represents a neglected and under researched/ underutilized plant genetic resource (Halimi, Barkla, Mayes, & King, 2020; Majola, Gerrano, & Shimelis, 2021) or "poor man's crop" with little economic value (Damfami & Namo, 2020). Awareness about the potential of Bambara groundnut as a food crop in dry areas has increased in recent years (Mayes et al., 2019) due to the current research on its medicinal value and the high protein content which can compete with animal protein (Damfami & Namo, 2020). The cheap protein-rich source can improve the food and nutrition security status of rural households. Biochemical analysis of the carbohydrate, fat, protein and mineral content reveals that Bambara groundnut produces an almost balanced diet (Khan, Rafii, Ramlee, Jusoh, &

Al-Mamun, 2021; Mubaiwa, Fogliano, Chidewe, Bakker, & Linnemann, 2018). The nut was found to be richer in essential amino acids than groundnut (Enwere & Ngoddy, 1986), with a protein score of 80% as compared to 65% for groundnut, 74% for soya bean and 64% for cowpea (Schaafsma, 2012). As a "complete food", this crop has recently been treated as a new millennium crop (Khan et al., 2021).

FAOSTAT (2020) record showed that the annual production of Bambara groundnut is estimated to be 0.2 million tonnes from an area of 0.25 million hectares worldwide. A larger quantity of Bambara groundnut is produced by West African countries, with a total production of 0.14 million tonnes in 2018 from an estimated area of 0.18 million hectares. The top global Bambara groundnut producing countries are Burkina Faso, Niger, Nigeria and Cameroon, contributing to 74% of global production (FAOSTAT, 2020; Hillocks, Bennett, & Mponda, 2012).

However, fungal diseases are a major constraint on Bambara groundnut production in Nigeria (Tanimu & Aliyu, 1997), Burkina Faso (Sérémé, Kiwallo, & Zida, 1991); Kenya (Wakhungu, Tabu, Otaye, & Wasike, 2017), and South Africa (Anonymous, 2016). Damping-off is one among other fungal diseases which affects all agricultural field crops. *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp. and *Phytophthora* spp. are the most frequently associated with damping-off and are considered the most important causal agents of the disease in literature (Lamichhane, Durr, Schwanck, Robin, & Sarthou, 2017). Laboratory examination of some Bambara nut landraces had revealed the presence of *Fusarium* sp in the seeds as well as diseased samples from the field. F. *oxysporum* is a common soil as well as seedborne pathogen and saprophyte that feeds on dead and decaying organic matter. It survives in crop debris as mycelia and is commonly recovered from cultivated soil as chlamydospores (Maina et al., 2015). *F. oxysporum* attacks Bambara nut at all stages of development. The propagules gain entry into the plant through cut seed surfaces, damaged roots and stem tissues of young and stressed plants, infected seeds and through wounds caused by insects (Leslie, Summerell, & Bullock, 2006). Affected seeds result in pre-emergence damping-off disease which prevent seeds from germination while affected seedlings collapse at post emergence and die. Effect at later stage of plant growth shows wilt symptom. The disease represents for farmers one of the most important yield constraints both in nurseries and fields (Lamichhane et al., 2017). It reduces yields by lowering plant populations in all or portions of fields (Hudge, 2015). *F. oxysporum* infestation on Bambara nut causes yield losses ranging from trace to total crop failure, especially when adverse environmental conditions persist after planting through flowering (Cook, 1978). In Nigeria, Bambara nut is widely grown presently in most parts of the country during the rainy season or wet season. It is the period of the year during which rainfall distribution characteristics are suitable for crop germination, establishment, and full development. But this period is also characterized by high temperatures and humidity which predispose the crop to fungal attacks. Bambara nut is not usually grown during the dry season in Nigeria. But its trial for adaptation outside the main growing season has proved its productivity during this period. This period is characterized by high temperature and low relative humidity which has the advantage of disease escape, especially foliar diseases due to reduced humidity (Makanda, Tongoona, Madamba, Icishahayo, & Derera, 2009). Investigations conducted on Bambara nut were so far limited to the crop nutritional value (Okonkwo & Opara, 2010), seed yield (Abejide, Falusi, Adebola, Daudu, & Salihu, 2018), processing and utilization (Aviara, Lawal, Atiku, & Haque, 2013), response to fertilizer (Effa, Nwagwu, Osai, & Shiyam, 2016), and seedborne *Aspergillus* spp. (Isadeha & Time, 2018; Iwuagwu et al., 2019) with little or no field pathological reports either in the wet or the dry season. The objective of this study was to assess the quality of seed through germination test and determine the incidence of pre-emergence damping-off and yield of three Bambara nut landraces during dry and wet planting seasons in Maiduguri, northeastern Nigeria.

## 2. MATERIALS AND METHODS

Sources of seeds: Three Bambara groundnut landraces Cream, Black, and Red were purchased from Gamboru and Monday markets Maiduguri, Borno State, Nigeria. These were transported to the Plant Pathology Laboratory,

Department of Crop Protection for seed germination test. Thereafter, they were taken to the Teaching and Research farm of the Faculty of Agriculture, University of Maiduguri for the dry and wet season trials.

Seed germination test: Ten seeds of each of the landraces were plated on two layers of moistened filter papers placed in 9.0 cm diameter Petri dishes. The Petri dishes were arranged on a laboratory bench in a completely randomized design (CRD) with three replications for 10 days. Germination counts were taken daily until the final counts on the tenth day and expressed as a percentage of the total number of seeds per plate.

Field experiment: Field experiment was conducted at the Teaching and Research Farm of University of Maiduguri from January to April, 2017 during the dry season, and from July to October, 2018 during the wet season. At the beginning of each experiment, previous crop residues were cleared and the land ploughed by hoe and leveled. The three Bambara nut landraces (Cream, Red and Black) were laid out in Randomized Complete Block Design replicated three times in each season. One seed was taken from each seed lot and sown directly into sowing holes. The plants were spaced 20 cm apart within a row and 50 cm apart between rows. Permethrin insecticide was spot applied to control soldier ants and other insects feeding on Bambara leaves. The field was irrigated throughout the experiment during the dry season trial. While sowing during the wet season was done only when the rains have established. Weeding was carried out as at when necessary using hoe.

Data collection: Parameters assessed were percentage seed germination, seedling emergence and incidence of pre-emergence damping off, plant height (cm), canopy width (cm), number of pods per plant, pod weight per plant (g) and pod weight per plot converted to kg/ha.

Data analysis: Data collected on disease incidence, growth, yield and yield components were subjected to analysis of variance and means were separated using Least Significant Difference (LSD) at 5 %.

## 3. RESULTS

Seed germination on filter paper was higher than seeds planted in the field Figure 1. Germination on filter paper using blotter method ranged from 68.9 – 80 %, compared with average of seed germination from the two seasons which ranged from 40.4 - 72.3 %. Only 40.4 % of Cream germinated when planted in the field compared to 68.9 % on filter paper, and 60.2 % of Red germinated in the field compared to 80 % on filter paper. Black remained the highest with over 70 % germination in both field and laboratory tests.

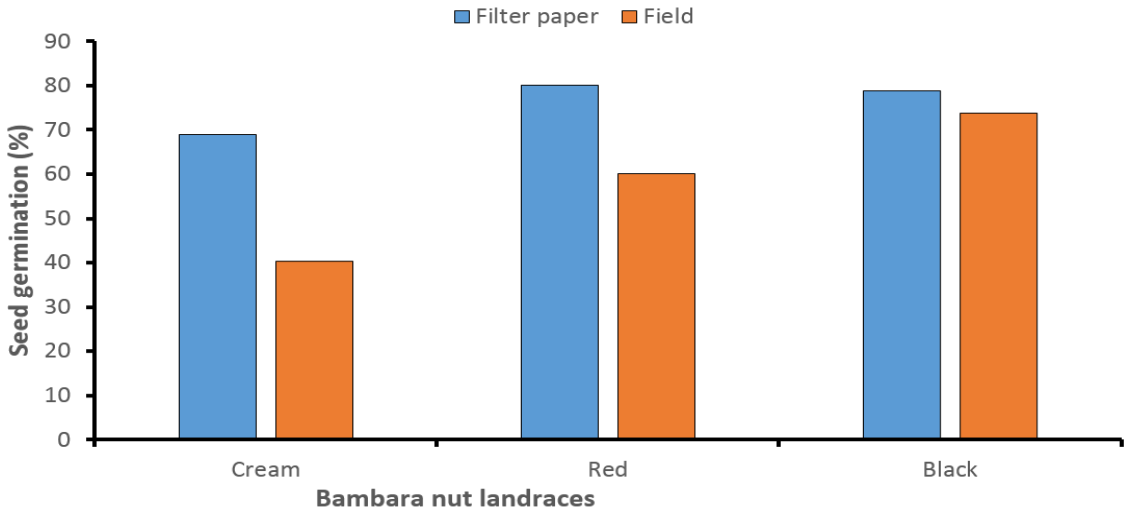


**Figure 1.** Seed germination (%) test in the laboratory (filter paper) and field.

Percentage seedling emergence and pre-emergence damping-off incidence were significantly (P≤0.05) different among the landraces in both the dry and the wet seasons trials Table 1. Black had the highest emergence and the lowest disease incidence during the dry season trial while Red had the highest emergence and the lowest incidence

during the wet season trial. Across the seasons Black had the lowest (26.6 %) damping- off incidence and the highest (72.3 %) seedling emergence. Across the landraces, damping-off incidence was lower and seedling emergence was higher during wet season than in the dry season trial.

**Table 1.** Percentage seedling emergence and incidence of pre-emergence damping-off for three Bambara groundnut landraces during 2017/2018 dry and wet season field trials.

| Landrace | Seedling emergence (%) | | Mean | Pre-emergence damping-off incidence (%) | | Mean |
|---|---|---|---|---|---|---|
| | Dry season | Wet season | | Dry season | Wet season | |
| Cream | 40.4b | 40.4b | 40.4 | 70.3a | 59.6a | 65.0 |
| Red | 43.0b | 77.3a | 60.2 | 53.3a | 22.7b | 38.0 |
| Black | 73.8a | 70.7a | 72.3 | 24.1b | 29.3b | 26.7 |
| Mean | 52.4 | 62.8 | 57.6 | 49.2 | 37.2 | 43.2 |
| SE± | 10.9 | 4.66 | | 14.4 | 4.7 | |

**Note:** Means followed by the same letter(s) within the same column are not significantly different using Duncan's Multiple Range Test (DMRT) at P≤0.05.

Landraces did not differ significantly in the number of pods produced per plant and dry pod yield produced in kg/ha Table 2. However, Black produced the highest (9.5) pods/plant in the dry season trial, and had the highest pod yield of 336.1 and 78.3 kg/ha in the dry and wet seasons trials, respectively. Mean across the seasons showed that Black had the highest (207.2 kg/ha) pod yield while cream had the lowest pod yield of 76.6 kg/ha. The average across the landraces showed dry season trial with higher number of pods/plant and pod yield than the wet season trial.

**Table 2.** Number of pods per plant, pod yield and days to 50 % flowering for three Bambara groundnut landraces during 2017/2018 dry and wet season field trials.

| Landrace | No. of pods/plant | | Mean | Pod yield (kg/ha) | | Mean |
|---|---|---|---|---|---|---|
| | Dry season | Wet season | | Dry season | Wet season | |
| Cream | 4.8 | 4.2 | 4.5 | 109.9 | 43.3 | 76.6 |
| Red | 7.1 | 3.5 | 5.3 | 128.8 | 72.8 | 100.8 |
| Black | 9.5 | 3.1 | 6.3 | 336.1 | 78.3 | 207.2 |
| Mean | 7.1 | 3.6 | 5.4 | 191.6 | 64.8 | 128.2 |
| SE± | 2.53 | 1.30 | | 287.2 | 26.95 | |

Figure 2 shows the height of the three Bambara groundnut landraces recorded during the dry and wet season field trials. Red recorded the highest height of 10.5 cm and 20.4 cm in the dry and wet season trials, respectively. Cream had the lowest height in both season. Mean across the landraces showed that wet season planted crops were taller than those planted during the dry season trial.

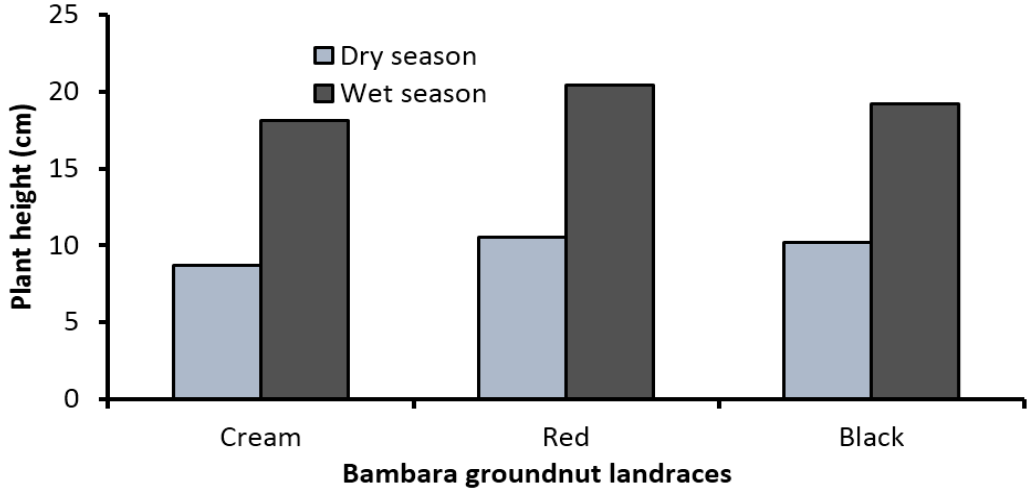


**Figure 2.** Height of three Bambara nut landraces during 2017/2018 dry and wet season field trails.

Canopy width of the three Bambara groundnut landraces is presented in Figure 3. Red had the widest (22.8 cm) width of the canopy in the dry season trial, and when averaged across the two seasons. Black had the lowest canopy width of 17.3 cm and 32.4 cm in the dry and wet season trials, respectively. The canopy width was wider in the wet season when averaged across the landraces than the dry season planted crops.

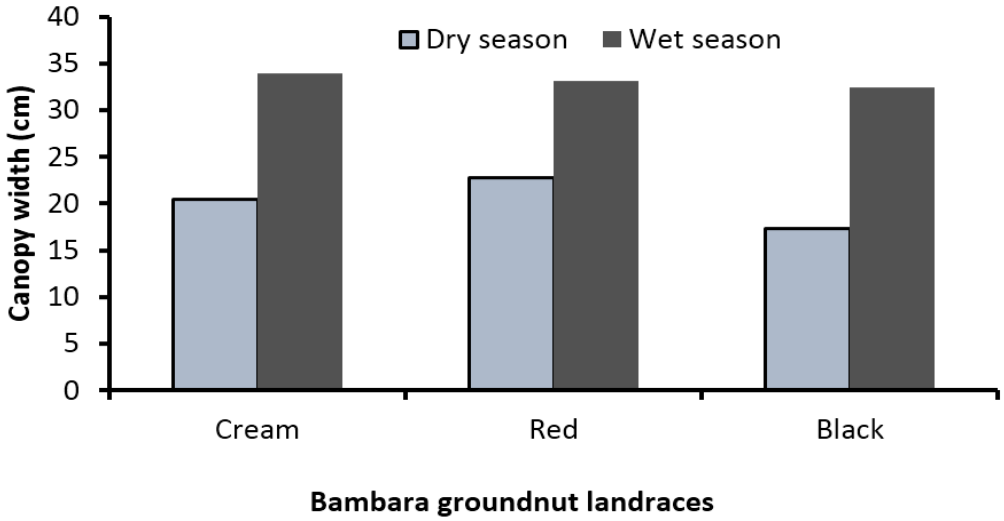


**Figure 3.** Canopy width of three Bambara groundnut landraces during 2017/2018 dry and wet season field trials.

## 4. DISCUSSION

Pre-emergence damping-off is an important disease worldwide, which can occur when seeds decay prior germination, or when the germinating seeds are killed by variety of seed- and soil- borne pathogens while shoot tissues are still below ground (Horst, 2013; Hudge, 2015). In the present study, about 27.7 – 59.6 % of the landraces planted in the field averaged across the seasons failed to emerge while 20 – 31.1 % failed to germinate when tested on blotter paper. Cream, the most susceptible lost 31.1 % seeds in germination test and 59. 6 % in the averaged field test. Salerno, Lori, and Morelli (2003) reported that seed contamination with *Fusarium* spp. affected the performance of most Ponderosa pine seed lots and reduced percentage seed germination. Similarly, Pandey, Kapkoti, and Kapkoti (1990) reported *Fusarium* spp. associated with *Pinus roxburgii.* seeds that failed to germinate. The reduced germination is often attributed to pre-emergence damping-off as *Fusarium*-contaminated seed produce weak germinant that die before the radicle emerges (Salerno et al., 2003).

There was higher failure in emergence in the soil than germination test on paper suggesting more favorable conditions for development of the damping-off pathogens. In particular, contaminated seeds in soil, wet and cool soils, and cool to moderate air temperatures favor the development of *Fusarium* spp. (Lamichhane et al., 2017).

Landrace vs season show that Black was the least affected in both seasons with more than 70 % emerged seedlings. More than 59 and 70 % of Cream seeds failed to germinate when planted during the wet and dry seasons, respectively. The seasonal influence on the amount of seeds that failed to emerge was greater during the dry than in the wet season. Dry planting was conducted in February when the environmental and soil temperatures were cool and irrigation during this further cool the air and soil temperatures. These factors tend to predispose seed or seedlings to damping-off pathogens and increase the severity of infection. Predisposing factors such as contaminated seeds (in soil or growing media), wet (e.g., due to poor drainage or overwatering) and cool soils, cool to moderate air temperatures, higher soil pH and with increased N levels are particularly favorable for the development of *Fusarium* spp. (James, 2012).

Number of pods/plant and pod yield/ha were also influenced by pre-emergence damping-off. Cream was the most affected and had the lowest pod yields in both dry and rainy season trials. Seed quality/health of susceptible

varieties can be easily compromised by the seed or soil borne pathogens which weaken the ability of crops to become established and realize their full potential of yield and value (Salerno et al., 2003).

Black and Red landraces on the other hand, were the least affected and had the highest pod yields. These contain Phytochemicals such as Flavonoids and tannins in their seed coat (Khan et al., 2021). Tannins are complex chemical substances derived from phenolic acids (sometimes called tannic acid) that bind readily with proteins, cellulose, starches, and minerals to form substances that are insoluble and resistant to decomposition (Anonymous., 2021). The presence of these substances in the two landraces could have reduced their rot due to attack by the damping-off pathogens, hence the reduction in disease incidence.

The effect of the disease on plant height and canopy width was not significant in the present study. However, differences exist between heights and canopy sizes of landraces planted during dry season and those grown during the rainy season. Taller plants with larger canopies were observed in the rainy season trial than the dry season. Despite the luxuriant growth during the rainy season, pod yield was considerably reduced due to end of season drought. Abejide et al. (2018) similarly observed that water stress reduced the yield of the Bambara groundnut landraces by 47%. Without the stress factor, Kumaga, Ofori, and Coblavie (1988) observed higher yield in minor season sown Bambara groundnut than the major season. Where water can be provided, the dry season would be better for the cultivation of Bambara groundnut (Doku & Karikari, 1970). In contrast, Berchie et al. (2012). reported that in the Guinea savanna agro-ecology, the dry season cultivation of Bambara groundnut under irrigation produced low yields.

## 5. CONCLUSION

The presence of fungal pathogens on seed and in soil affects seed health which can reduce germination or seedling emergence. Soil environment favored activities of the pathogens where higher incidence of pre-emergence damping-off was observed in the field than on paper viability test. Among the three landraces, Black had the highest (72.3) percent emerged seedlings, lowest (26.7 %) disease incidence and highest pod yield of 207.2 kg/ha would have been the best for cultivation but is unpopular in the region. Cream is the most popular choice of the farmers and consumers, and coincidentally the most susceptible among the landraces. Introduction of high yielding disease resistant cream variety is necessary in the region. Awareness of uses of Bambara groundnut other than direct consumption may encourage farmers to increase cultivation of the Black variety. The influence of seasons on disease and crop yield depends on risk factors such as false start of rainy season, long dry spell in the middle of the rainy season and end of season drought which are accompanied by wide fluctuations in temperature and relative humidity. With these risk factors in the wet season, dry season is the second best option for planting the crop.

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