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Yield Evaluation of Three Early Maturing Bambara Groundnut (*Vigna subterranea* L. Verdc) Landraces at the CSIR-Crops Research Institute, Fumesua-Kumasi, Ghana

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Abstract: The aim of this study was to determine the field performance of three early maturing bambara groundnut landraces which were identified in a controlled environment study by the lead author at the University of Guelph, Guelph-Ontario, Canada between October 2008 and March, 2009. Bambara groundnut is an indigenous African grain legume which is cultivated for food especially in the dry areas with short and erratic rainfall. Three bambara groundnut landraces; Burkina, Zebra coloured and Mottled Cream were evaluated for yield at the CSIR-Crops Research Institute, Kumasi-Ghana. The trial was sown on the 1st of April, 2009. The experiment was arranged in a Randomized Complete Block Design with three replications. Plants were sown at a spacing of 50 by 20 cm at two seeds per hill and thinned to one seedling per hill at 20 DAS. Zebra coloured took the least number of days to mature (89.5 days) followed by Mottled Cream (98.2 days) and Burkina (112.5 days). Zebra coloured produced the greatest pod yield per plant (23.6 g) followed by Burkina (17.7 g) and Mottled Cream (12.5 g). The base colour of the three landraces which is cream has been identified to be the preference of bambara groundnut growers and consumers. In areas with erratic rainfall and the lower latitudes where long daylength can negatively affect bambara groundnut yields, these early maturing landraces have the potential to reduce variation in bambara groundnut yields.

Key words: Bambara groundnut, early maturing, yield, evaluation, pod yield

INTRODUCTION

Bambara groundnut (*Vigna subterranea* L. Verdc) is an indigenous African grain legume which is one of the most important food crops especially in the dry areas with short erratic rainfall. The immature seeds are boiled and eaten as snack while the mature seeds are boiled and eaten as pulse. The development of early maturing bambara groundnut landraces is of great importance to producers and consumers. This is in the light of the fact that in most areas where the crop is cultivated low and erratic rainfall affects the productivity of the crop. Short duration legumes can fit well into the existing cropping systems as they are drought tolerant and adapted to low input situations (Haggam *et al.*, 2000). Mefti *et al.* (2008) observed that in semi-arid areas such as the eastern high plateau of Algeria, early-cool season perennial grasses must be more persistent and sustainable than late ones. Dry matter performance, high water use efficiency and plant stature were all associated with earliness (Mefti *et al.*, 2008). Despite the ability of bambara groundnut to tolerate drought, the productivity of the crop can be adversely affected by soil moisture stress

(Babiker, 1989). Three early maturing bambara groundnut landraces were identified by the lead author during a study at the University of Guelph in Canada between September (2008) and March (2009). They include Burkina which was identified as an early maturing landrace in a two year field study in Wenchi in the Transition agroecology and Kumasi in the Forest agro-ecology in Ghana (2007, 2008). The additional two early maturing landraces identified are Mottled cream and Zebra coloured. The three landraces showed a relatively neutral response to daylength producing pods under both short day (12 h) and long day (14 h) at a controlled environment trial at the University of Guelph, Canada. Hall and Patel (1985) reported that early maturing cowpea varieties have proved more useful in some dry environments and years because of their ability to escape drought. Singh *et al.* (1997) observed that earliness in maturity of cowpea genotypes is a desirable trait so that cowpeas can be grown in the niches of cereal-based cropping system. Variation in bambara groundnut yields have been attributed by several workers to changes in photoperiod in areas where delayed sowing is affected by a shift in daylength Harris and Azam-Ali (1993) Linnemann (1991).

Khan *et al.* (2001) in a study to evaluate 12 high yielding groundnut varieties under diverse climatic conditions observed that genotypes PG 931 and P1-338337 matured earliest, taking 156.3 and 157.2 days to mature with the check variety (Swat Phalli-96) and genotypes P1-429624 and P.G 759 taking 166, 168 and 168 days to mature, respectively.

Wallis *et al.* (1981) reported that appreciable reduction in the life cycle duration of Extra-Short-Duration (ESD) pigeon pea cultivars has made it not only possible to grow the crop as an intensively managed commercial crop but also to grow it over a wider range of latitudes. Drought, temperature and photoperiod are three major environmental factors that influence global adaptation of crops. Wallace and Yan (1998) observed that cultivars that are developed for higher latitudes should not only mature before the winter sets in but the partitioning of dry matter into grains should also be less sensitive to long photoperiod and thus produce high seed yield. The objective of this study was to determine the field performance of three early maturing bambara groundnut landraces identified at the controlled environment study at the University of Guelph, Canada.

MATERIALS AND METHODS

The three landraces Burkina, Mottled Cream and Zebra Coloured were sowed at the CSIR-Crops Research Institute, Fumesua-Kumasi in the Ashanti Region of Ghana at a spacing of 50 by 20 cm. The experiment was arranged in a Randomized Complete Block design with three replications. The plot has been cultivated to cowpea in the previous year. The plot was ploughed and harrowed. Plot size was 6×6 m (13 and 31 hills). Sowing was done on 1st April 2009, at two seeds per hill and seedlings were thinned to one seedling per hill at 20 DAS. Weeds were controlled using hand-hoeing. No spraying was done against pests and diseases because the crop is relatively tolerant to pests and diseases and generally the crop is free from pests and diseases in Ghana. Ten plants within the final harvest area were not removed. They were used for the final harvest data.

Data taken: Days to 50% emergence was recorded as the number of days 50% of seedlings on a plot emerged. Seedlings were considered to have emerged when the first true leaf had broken from the soil and is visible. Days to 50% flowering was recorded as the number of days 50% of the plants on a plot showed fully opened flower with visible corolla colouration.

Plant stand at emergence and final harvest was recorded as the number of plants counted on a plot at

harvest. Days to maturity was recorded as the number of days at least 50% of sampled plants on a plot mature. Plants were considered mature when the leaves became yellow and majority of the pods had hard shells and ripe seeds. Number of pods per plant was recorded as the number of pods counted from a harvested plant. Number of seeds in 100 pods was determined as the number of seeds counted from 100 pods. Total pod yield was determined as the total weight of oven-dried pods harvested from sampled plants in grams. Hundred pod and seed yield was determined as the weight of 100 randomly selected oven-dried pods and seeds. Pod yield per plant was determined as the total pod weight divided by the number of plants harvested.

Data analysis: Data analysis was conducted using the Genstat statistical package. Means separation was undertaken using the LSD at 5% level of probability.

RESULTS

Days to 50% emergence: Significant difference was observed in the days to 50% emergence of the three landraces ($p = 0.003$). Mottled cream used the least number of days to emerge (6.0 days). This however, was not significantly different from Zebra coloured (6.3 days) with Burkina taking a mean of 7.5 days to emerge (Table 1).

Days to 50% flowering: Significant difference was also observed in the number of days to 50% flowering. Mottled Cream took the least number of days to 50% flowering (39.3) with Zebra coloured and Burkina taking 40.0 and 40.5 days to 50% flowering respectively (Table 1).

Days to maturity: Significant difference was observed among the landraces with respect to days to maturity. Mottled Cream was the earliest maturing landrace (89.5 days) with Burkina maturing latest among the three landrace (112.5 days) (Table 1).

Plant stand at emergence and harvest: Significant difference was observed with respect to the plant stand at

Table 1: Mean number of days to 50% emergence, 50% flowering and maturity

Landrace	Days to 50% emergence	Days to 50% flowering	Days to maturity
Mottled cream	6.0	39.3	89.2
Zebra coloured	6.3	40.0	89.5
Burkina	7.5	40.5	112.5
Mean	6.58	39.92	100.1
Cv (%)	5.7	0.9	2.2
LSD 0.05	0.6	0.6	3.8
p-value	0.003	0.009	0.001

Table 2: Number of pods/plant, seeds/100 pods, 100 pod seed weight and pod yield per plant as affected by landraces

Landrace	No. of pods per plant	No. of seeds per 100 pods	100 pod dry weight (g)	100 pod seed weight (g)	Pod yield per plant (g)
Burkina	36.0	121.2	65.3	53.5	17.70
Zebra Col	43.3	124.5	67.3	49.0	23.70
Mot. Cream	25.0	132.5	71.8	48.5	12.50
Mean	34.8	126.1	67.9	50.3	17.90
LSD (0.05)	13.8	NS	NS	NS	10.23
p-value	0.05				0.05

emergence among the three landraces with Burkina recording the least plant stand at emergence (46.3) and Zebra coloured the highest (49.0). Plant stand at harvest however, was not significantly different among the three landraces with Burkina (31.0), Zebra coloured (30.0) and Mottled cream (34.0) plants at harvest.

Number of pods per plant: Significant differences were observed on number of pods per plant ($p = 0.05$) among the landraces. Mottled cream produced the least number of pods per plant (25.0) with Burkina and Zebra coloured producing 36.0 and 43.3 pods per plant respectively. Zebra coloured produced 72 and 20% more pods than Mottled cream and Burkina respectively (Table 2).

Number of seeds/100 pods: There was no significant difference among the three landraces with respect to number of seeds per 100 pods. Mottled cream however, had the greatest number of seeds per 100 pods (132.5) and Burkina the least (121.2) (Table 2).

Hundred pod dry weight (g): No significant difference was observed in the 100 pod dry weight for the three landraces. Mottled cream however, recorded the highest 100 pod dry weight of 71.8 g with Burkina recording the least 100 pod dry weight (65.5 g) (Table 2).

Hundred pod seed weight (g): The 100 pod seed weight is not equivalent to the 100 seed weight since some pods may contain more than two seeds. No significant difference was observed in the 100 pod seed weight. Burkina however, produced the highest 100 pod seed weight (53.5 g) with mottled cream producing the least (48.5 g) (Table 2).

Pod yield/plant (g): Significant difference was observed in pod dry weight per plant ($p = 0.05$). Zebra coloured recorded the greatest pod dry weight per plant (23.7 g) followed by Burkina (17.7 g) and Mottled cream (12.5 g) (Table 2).

DISCUSSION

Days to 50% emergence, 50% flowering and maturity: In a preliminary and second year field studies conducted

in Ghana, Burkina has been rated as the earliest maturing landrace among the landraces used. In a controlled environment study conducted to evaluate responses of 13 bambara groundnut landraces at the University of Guelph in Canada, Mottled cream and Zebra coloured were identified to have emerged and flowered earlier than Burkina. In the present study conducted under field environment at the CSIR-Crops Research Institute, Kumasi-Ghana, however, Mottled cream and Zebra coloured again took the least number of days to emerge (6.0 and 6.3 days) respectively. Mottled cream also took the least number of days to attain 50% flowering. Zebra coloured however, took the least number of days to maturity (89.50 days). From this study Zebra coloured and Mottled Cream can be regarded as early maturing landraces and Burkina a medium maturing landrace. Shumba-Mnyulwa (2002) reported that bambara groundnut cultivation in Zimbabwe occurs in agro-ecological zones where precipitation is sparse and erratic heightening moisture stress and depressing yield. The best way of resolving this problem is to breed for early maturing bambara groundnut varieties (Shumba-Mnyulwa, 2002). Ehlers and Hall (1997) reported that in addition to escaping drought, early maturing cultivars can escape insect infestation and early erect types could be important for mechanized production to enable the easy movement of farm equipment when cultivating, spraying pesticide and harvesting. Practically results from this study provides bambara groundnut growers with early maturing bambara groundnut materials. Mcpherson *et al.* (1985) observed that traditional pigeon pea cultivars are highly sensitive to photoperiod and take 175-280 days to mature, however, early maturing pigeon pea varieties developed by the International Crop Research Institute for the Semi Arid Tropics (ICRISAT) are relatively photoperiod insensitive and mature in 125-140 days.

Edamame (pronounced eh-dah-MAH-may) is a traditional Japanese vegetable also called vegetable soybean and sweet bean a nutritious and tasty vegetable or snack food with nutty flavour (Miles *et al.*, 2000). Miles *et al.* (2000) reported that all edamame except the earliest maturing varieties are photoperiod sensitive and for the cultivation in the high altitude under long summer days, early maturing varieties which are less sensitive to photoperiod must be cultivated. The findings of Miles *et al.* (2000) is in agreement with observations made with respect to the three early maturing landraces used in this study which also podded under 14 h photoperiod where most bambara groundnut landraces will not pod.

The three early maturing varieties used in this study were able to produce some pods under 14 h photoperiod in a controlled environment photoperiod study at the University of Guelph in Canada. The three landraces used

in this study therefore would not only provide materials for cultivation in areas with short erratic rainfall, but can also produce some pods in the high latitudes with long summer days. These landraces therefore provide a wider adaptation to a range of environments which provides an advantage of extending the cultivation of the crop. Taffouo *et al.* (2010) reported that White Seed Colour (WSC) bambara groundnut landrace was observed to have relatively higher tolerance to soil sodium chloride ion concentration compared to the Black seed colour (BSC) and Red Seed Colour (RSC). They suggested that the WSC landrace could be grown in the coastal and semi-arid saline soils. These findings among the results of the current study provide the motivation for scientist in agricultural research to work hard to come out with bambara groundnut landraces that can be cultivated over a wide range of environment so as to enhance the status of this important but under researched and underutilized crop.

Number of pods/plant, seeds/pod and pod dry weight/plant:

Zebra coloured produced the highest number of pods per plant (43.3 g) and the highest pod dry weight per plant (23.7 g). Zebra coloured produced 89.2% more pod dry weight per plant than Mottled cream. The high pod yield for Zebra coloured could therefore be attributed to the high number of pods produced per plant. Similarly, Mottled Cream produced the least number of pods per plant (25.0) and this could have resulted in the least mean pod yield per plant (12.5 g). The range of pod dry weight per plant (12.5-23.7 g plant⁻¹) equivalent to (1.3-2.4 t ha⁻¹) for an early maturing under utilized and under researched drought tolerant legume gives a great degree of motivation to work towards improving the productivity of the crop. No significant difference was observed for plant stand at harvest therefore differences in pod yield among the three landraces at harvest could not be attributed to differences in number of plants harvested. The crop was grown at the beginning of the major season in Kumasi which is in the forest agro-ecology where rainfall is relatively high. It is possible if the crops were grown in the minor season or in the Transition agro-ecology where rainfall is relatively low, the yields could have been higher. Kumaga *et al.* (1998) observed that minor season sowing of bambara groundnut in Ghana, yields higher than the major season. Doku and Karikari (1970) observed that where water can be provided, the dry season would be better for the cultivation of bambara groundnut.

Cowpea genotypes that provided the highest seed yields under water-stressed conditions could serve as alternative crops because of their desirable attributes and resistance to major abiotic and biotic stresses (Singh *et al.*, 1997). Chauhan *et al.* (2002) observed a negative relationship between time of flowering and yield.

They noted that for better adaptation under long photoperiod regimes, selection for earliness may be desirable not only to ensure escape from frost but also reduce negative impact of photoperiod on grain yield. This result is in agreement with findings of the lead author where in an earlier study conducted from October 2008 to March 2009 at the Crop Science Department, University of Guelph, Canada under publication, the lead author observed that the three landraces evaluated in this study were among five which podded out of 13 landraces evaluated under 14 h photoperiod. Practically this results has an implication for bambara groundnut cultivation in most parts of Africa and Asia especially the higher latitudes where yield variations have been observed resulting from extended photoperiod when sowing is delayed. The grain colour of the three early maturing landraces were observed to be cream with a streak of black for Zebra coloured and red for mottled cream. Burkina however, has a cream colour. The cream colour was observed to be prioritized by both farmers and consumers as being more acceptable for cultivation and consumption (Berchie *et al.*, 2010; Brink and Belay, 2006). The identified landraces did not only meet ecological needs but also social acceptability by bambara groundnut growers not only in Ghana but in most bambara producing countries in Africa.

CONCLUSION

Three identified bambara groundnut landraces; Burkina, Zebra coloured and Mottled Cream were evaluated on the field to determine their performance. Zebra coloured was identified to be the earliest maturing landrace followed by Mottled Cream and Burkina. Pod yield was highest in Zebra coloured and least in Mottled Cream. Differences in mean pod yield per plant could be attributed to differences in number of pods per plant. Zebra coloured produced the greatest number of pods per plant and mottled cream the least number of pods per plant. The identified early maturing landraces will be an asset to bambara groundnut growers in areas with short and erratic rainfall. These materials were identified in controlled environment photoperiod trial to have podded under 14 h photoperiod. The landraces thus provide a good source of material for bambara groundnut growers in the higher latitudes where bambara groundnut yield is negatively affected by long daylength. The cream base colour of the three landraces were identified to be of preference by bambara growers and consumers.

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