African Crop Science Journal, Vol. 21, No. 4, pp. 323 - 335 ISSN 1021-9730/2013 $4.00


# PRODUCTIVITY OF MAIZE HYBRID MATURITY CLASSES IN SAVANNA AGRO-ECOLOGIES IN NIGERIA

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*(Received 17 July, 2013; accepted 3 September, 2013)*

## ABSTRACT

The recurrent droughts of the late 1960s and early 1970s in Nigeria necessitated research efforts to develop hybrid maize (*Zea mays* L.) of different maturity periods. These hybrids have proved to be suited to the full range of environments in predominantly lowland West African Savanna. With the continued development and release of such hybrids, there is need to continue to screen them in order to ascertain their potential productivity in different agro-ecologies. A study was, therefore, carried out between June and October 2011, to screen nine hybrid varieties of maize for growth and yield potentials in two savanna agro-ecologies of Saminaka (lowland) and Vom (mountainous). The varieties, which were distributed in three maturity classes include Sammaz -11, Sammaz -14 and Sammaz -17 (late-maturing), Sammaz -12, Sammaz -24 and Molt-cob (early-maturing) as well as Sammaz -13, Sammaz-18 and Sammaz -20 (extra early-maturing). Germination rate was significantly ($P<0.05$) higher in late-maturing variety Sammaz -11 than in the extra-early variety Sammaz -13 at both Saminaka and Vom. At both locations, plants flowered earlier in the extra-early varieties than in the late-maturing. Mean number of days to mid-tasselling and mid-silking was attained earlier in the extra-early varieties than in the late-maturing. Plant height, ear length, ear width and 1,000 kernel weight were higher in the late than early or extra-early maturing varieties. Grain yield was significantly higher in the extra-early variety Sammaz -18, than in the late-maturing Sammaz -17 and Sammaz -11. Generally, the germination rate, plant height and the total grain yield were higher at Saminaka. Ear length and width, as well as 1,000 kernel weight were higher at Vom than at Saminaka.

*Key Words:* Flowering, silking, tasselling, *Zea mays*

## RÉSUMÉ

La sécheresse répétée des années 1960 à 1970 au Nigeria avait nécessité des efforts de recherche pour développer des variétés des hybrides de ma¿s (*Zea mays* L.) de differentes périodes de maturité. Ces hybrides ont manifesté l'aptitude de s'adapter à des milieux divers, spécialement aux basses terres des savannes ouest africaines. Avec le developpement continue et la production de telles hybrides, leur étude s'avère nécessaire afin de déterminer leur productivité potentielle dans différents milieux agroécologiques. Pour ce faire, une étude était conduite entre Juin et Octobre 2011, pour tester la croissance et le rendement potentiel de neuf variétés d'hybrides de ma¿s dans deux savanes agroécologiques de Saminaka (basse terre) et de Vom (montagneuse). Les variétés qui étaient distribuées en trois classes de maturité Sammaz -11, Sammaz -14 et Sammaz -17 (maturité retardée), Sammaz -12, Sammaz -24 et Molt-cob (maturité précoce) ainsi que Sammaz -13, Sammaz-18 et Sammaz -20 (extra maturité précoce ). Le taux de germination était significativement ($P<0.05$) plus le élevé pour la variété à maturité retardée Sammaz -11 par rapport à la variété extra-précoce Sammaz -13 dans Saminaka et Vom. Dans les deux milieux, les plants des variétés extra précoces ont tôt fleuri par rapport aux variétés à maturité retardée. Le nombre moyen des jours à la mi-floraison mâle et mi-floraison femelle était attaint plus tôt dans les variétés extra précoces que dans les variétés à maturité retardée. La hauteur des plants, la longueur des épis, la largeur des épis et le poids de 1000 graines étaient plus élevés dans les variétés à maturité retardée que dans celles précoces ou extra précoces. Le rendement en grain était significativement plus élevé dans la variété extra précoce Sammaz -18 que dans celles à maturité retardée Sammaz -17 et Sammaz -11. Généralement, le taux de germination, la hauteur de plants et le rendement total en grain étaient plus élevés à Saminaka. La longueur et la largeur des épis ainsi que le poids de 1000 grains étaient plus élevés à Vom qu'à Saminaka.

*Mots Clés*: Floraison, floraison mâle, floraison femelle, *Zea mays*

## INTRODUCTION

Maize (*Zea mays* L.) is a food security crop which can grow in a wide variety of climates and on diverse kinds of soils. For optimum production, it requires fertile, well-drained loam soil, well-distributed rainfall, and moderate high temperature (Kochhar, 2005).

The Semi-Arid Food Grains Research and Development Agency (SAFGRAD) has developed hybrids of intermediate, extra-early and late-maturing maize. These hybrids have proved to be not only high-yielding but disease-resistant and are suited to a range of environments in predominantly lowland West African Savanna (Ado and Usman, 2009). Studies carried out by Ado *et al.* (1999) showed that the extra-early maize is useful to "catch up" with the season in situations where rainfall start late. It matures within 78-85 days.

Early-maturing hybrids could be used to produce two or more crops in relay, especially where irrigation facilities are available. Because of their early maturity, fewer pesticide applications are carried out.

In spite of these advantages, maize hybrids, in general have gained low acceptability by farmers due to high seed cost, time and effort involved in growing them. Their successful cultivation depends largely on the right choice of varieties, the length of the growing season and the purpose for which the crop is grown. The early-maturing hybrids are often expensive and are not readily available to farmers in West Africa.

Grain yield is the major objective of any breeding programme. It is quantitatively inherited and its expression is influenced by genotypic and environmental factors. Although the early-maturing varieties of maize are generally recommended under rainfall conditions, a negative correlation between grain yield and maturity may occur (Chopra, 2001). This could be due to grain yield long duration process.

With the continued development and release of hybrid maize of different maturity periods, it is necessary to ascertain their potential productivity in different agro-ecologies. The objective of this study, therefore, was to screen hybrid maize varieties for productivity in two savanna agro-ecologies of Saminaka (lowland savanna) and Vom (mountainuous or highland savanna) in Nigeria.

## MATERIALS AND METHODS

A field experiment was conducted at two locations, namely Saminaka in Kaduna State (North-Western Nigeria) and Vom in Plateau State (North-Central Nigeria). Saminaka is located in Lere Local Government Area at latitude 10$^o$ 27'N, longitude 08$^o$ 35'E; and at an altitude of 1,000 metres above mean sea level. Vom is located in Jos-South Local Government Area at latitude 09$^o$ 44'N, longitude 09$^o$ 47'E; and at an altitude of 1,239.4 m above mean sea level. The experiment was concurrently carried out at the two locations between June and October, 2011.

The nine hybrid varieties of maize used in the experiment were obtained from the Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU), Zaria in Kaduna State of Nigeria. The hybrids, which were distributed in three maturity classes, included Sammaz -11, Sammaz -14 and Sammaz -17 (late-maturing), Sammaz -12, Sammaz -24 and Molt-cob (early-maturing); as well as Sammaz -13, Sammaz-18 and Sammaz -20 (extra early-maturing). The agronomic characteristics of these varieties are shown in Table 1.

The varieties were laid out in a randomised complete block design, with five replications. Gross plot size was 36 m x 17 m; while the net plot size was 3 m x 4 m. Each plot consisted of four rows of 3 metres long and 1 metre wide. Sowing was done on the same day at 30 cm within rows and 90 cm between rows. Two seeds were sown per hole.

TABLE 1. Agronomic characteristics of hybrid varieties of maize used in the field experiment in 2011

| Variety | Agronomic characteristics |
|---|---|
| Sammaz - 11 | White grain colour, large seed and semi-dented. Large cob and good husk cover. Matures within 110-120 days and attains a plant height of 180-185 cm. Tolerant to *Striga*. |
| Sammaz - 14 | White grain colour, large seed and cob , good husk cover. Matures between 110-120 days; attains a plant height of 180-200 cm. Quality Protein Maize (QPM). |
| Sammaz - 17 | White grain colour, large seed. Attains a height of 220 cm; is tolerant to *Striga hermonthica.* QPM with a potential yield of 5.0 t ha$^{-1}$. |
| Sammaz - 12 | White grain colour with small seeds and cobs. The husk is good. Matures between 90-110 days with a plant height of 170-180 cm. |
| Sammaz - 29 | Grain colour is white. It takes 57 days to silk with a plant height of 170 cm. It is tolerant to *Striga hermonthica.* |
| Molt cob | Grain colour is white, seed is large and dented. Cob is large with good husk cover. It matures between 90-110 days. It is still being researched into. |
| Sammaz - 13 | Grain colour is yellow, cobs and seeds are medium in size. It matures between 70-80 days. Husk cover is good and plant height is 170-180 cm. |
| Sammaz - 18 | Grain colour is white with a plant height of 225 cm and a potential yield of 4.5 t ha$^{-1}$. It takes 53 days to mid-silk and 85-90 days to mature. It is tolerant to *Striga hermonthica.* |
| Sammaz - 20 | Grain colour is white, attains a height of 185-195 cm and potential yield of 3-4 t ha$^{-1}$. It takes 52 days to mid-silk and 90-100 days to mature. It is highly tolerant to drought. |

Source: Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria

A blanket application of Vestrazine and Parae force (170 g ha$^{-1}$) was applied using a knapsack sprayer at both locations to control weeds.

Fertiliser NPK (15:15:15) was applied to all the plots at the rate of 120 kg ha$^{-1}$, at 21 days after sowing (DAS). This was equivalent to 320 g per plot. Seedlings were thinned to one plant per stand at 21 DAS. The plots were earthed up (roots and lower parts of the stems were covered with heaped-up earth to prevent lodging) at 50 DAS at which time nitrogen was supplied in the form of urea at the rate of 60 kg ha$^{-1}$. This was equivalent to 156.5 g per plot.

Parameters measured included seedling emergence, days to flowering, days to 50% tasselling, days to 50% silking, plant height and ear length. Others included ear width, ear weight, kernals per cob, grain yield and heritability.

**Seedling emergence.** Ten days after sowing, the rate of seedling emergence was taken as the ratio of the number of seedlings that emerged to the total number of seeds planted and multiplied by 100.

**Days to onset of flowering.** This was recorded as the number of days from sowing to the onset of flowering in each plot.

**Days to 50% tasselling.** This was recorded as the number of days from sowing to when at least 50% of the total number of plants in each plot had tasselled.

**Days to 50% silking.** The number of days to 50% silking (mid-silking) was recorded as the number of days from sowing to when at least 50% of the total number of plant stands in each plot had silked.

**Height.** Five plants were sampled from each plot at random, the length of each of which was measured from the ground level to the flag-leaf, using a metre-rule.

**Ear length.** Five ears were randomly sampled at harvest from each plot, the length of each of which was measured from the base to the tip. This was divided by five to give the mean ear length.

**Ear width.** The width of each of the five sampled ears in each plot was measured at the widest part and recorded. This was divided by five to give the mean ear width.

**Ear weight.** The five sampled ears in each plot were weighed using the digital electronic balance (Model LP 502A). This was divided by five to give the mean ear weight.

**Kernels per cob**. The number of kernels in the five sampled plants in each plot was counted. This was divided by five to obtain the mean number of kernels per cob.

**One thousand kernel weight.** One thousand kernels were taken per plot after shelling. These were weighed using the digital electronic balance.

**Total grain yield.** All the grains in each plot were weighed and the weight was converted to tonnes per hectare. Grain yield was calculated at 13% moisture content, at which figure it is believed to store more satisfactorily (Koli, 1970; Namo, 1994).

**Heritability estimate.** The broad sense heritability was computed in order to ascertain the influence of the environment on the varieties. This was computed as the ratio of the genotypic variance ($\sigma^2$ g) to the phenotypic variance ($\sigma^2$p), using the formula by Fehr (1987).

$$H^2 = \frac{\sigma^2 g}{\sigma^2 g + \frac{ems\ (\acute{o}^2 p)}{r}} \quad \text{........... Equation 1}$$

Where $H^2$ = Broad sense heritability
$\sigma^2$ g = Genotypic variance
$\sigma^2$ p = Phenotypic variance
r = Number of replications

**Data analysis**. Data were analysed using the analysis of variance (ANOVA) to determine variability among the varieties. The Statistical Analysis Software (SAS) (Version 9.1) was used to analyse the data. Means were separated using the least significance difference (LSD) at 5% probability level.

## RESULTS

**Rate of seedling emergence.** At Saminaka, the rate of seedling emergence ranged from 85% in the late-maturing variety Sammaz -11, to 23.89% in the extra-early maturing variety Sammaz -13 (Table 2). Generally, the late-maturing varieties had the highest rate of seedling emergence followed by the early-maturing .

At Vom, the rate of seedling emergence was highest in the early-maturing variety Sammaz -12, and lowest in the extra-early maturing variety Sammaz -13. The highest rate of seedling emergence was observed in the late-maturing varieties, followed by the early-maturing.

Results of the pooled data showed that the early-maturing hybrid Sammaz -12 had the highest rate of seedling emergence; while the extra-early maturing variety Sammaz -13 had the lowest (Table 2). Generally, rate of seedling emergence was higher at Saminaka than at Vom location.

**Days to flowering.** At Saminaka, the number of days to onset of flowering was significantly higher in the late-maturing variety Sammaz -14 than in the extra-early maturing variety Sammaz -20 (Table 3). Generally, the extra-early maturing varieties flowered earlier than the late- or early-maturing ones.

At Vom, the late-maturing variety Sammaz -17 had the highest number of days to onset of flowering; while the extra-early maturing variety Sammaz -20 had the lowest (Table 3). Overall, the extra-early maturing varieties flowered earlier than the early or late-maturing ones. Pooled data show that the extra-early maturing varieties flowered earlier than the early or late-maturing ones. Generally, plants flowered earlier at Saminaka than at Vom location.

**Days to 50% tasselling (mid-tasselling).** At Saminaka, the late-maturing variety Sammaz-17 had a significantly higher number of days to mid-tasselling than the extra-early maturing variety Sammaz-20 (Table 5). Generally, the extra early-maturing varieties attained mid-tasselling earlier than the early or late-maturing ones.

At Vom, the number of days to mid-tasselling varied from 71.6 in the late-maturing varieties Sammaz-11 and Sammaz-17 to 60.6 in the extra-early maturing variety Sammaz-13. Generally, the extra-early varieties attained mid-tasselling earlier than the early or late-maturing ones.

The pooled data indicate that the extra-early varieties mid-tasselled earlier than the early or or late-maturing ones (Table 5). Generally, the

TABLE 2. Rate of seedling emergence (%) of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 85.00 | 67.67 | 75.80 |
| Sammaz -14 | Late | 83.89 | 67.78 | 75.80 |
| Sammaz -17 | Late | 80.00 (82.96) | 75.00 (69.82) | 77.50 (76.37) |
| Sammaz -12 | Early | 80.56 | 82.22 | 82.00 |
| Sammaz -29 | Early | 65.00 | 67.78 | 66.40 |
| Molt Cob | Early | 72.22 (72.59) | 52.78 (67.59) | 62.50 (70.30) |
| Sammaz -13 | Extra-early | 23.89 | 18.89 | 21.40 |
| Sammaz -18 | Extra-early | 73.33 | 60.00 | 66.70 |
| Sammaz -20 | Extra-early | 73.89 (57.04) | 62.78 (47.22) | 68.40 (52.17) |
| LSD(0.05) | | 19.42 | 8.98 | 15.45 |
| CV (%) | | 5.37 | 2.86 | 22.60 |

Figures in parentheses are mean rate of seedling emergence of the three varieties in the same maturity class at the same location

TABLE 3. Number of days to onset of flowering of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 46.40 | 62.60 | 54.50 |
| Sammaz -14 | Late | 47.60 | 63.00 | 55.30 |
| Sammaz -17 | Late | 46.00 (46.87) | 63.20 (62.93) | 54.90 (54.90) |
| Sammaz -12 | Early | 43.80 | 52.40 | 48.10 |
| Sammaz -29 | Early | 43.40 | 52.40 | 47.90 |
| Molt Cob | Early | 45.20 (44.13) | 53.40 (52.73) | 49.30 (48.43) |
| Sammaz -13 | Extra-early | 40.80 | 48.40 | 44.60 |
| Sammaz -18 | Extra-early | 42.00 | 49.60 | 45.80 |
| Sammaz -20 | Extra-early | 39.60 (40.80) | 48.60 (48.87) | 44.10 (44.83) |
| LSD(0.05) | | 0-66 | 0.72 | 0.68 |
| CV (%) | | 0.30 | 0.22 | 1.34 |

Figures in parentheses are mean number of days to onset of flowering of the three varieties in the same maturity class at the same location

varieties attained mid-tasselling earlier at Saminaka than at the Vom location.

**Days to 50% silking (mid-silking).** At Saminaka, varieties Sammaz-13 and Sammaz-18 (extra early-maturing) attained mid-silking earlier than the variety Sammaz-14 (late-maturity) (Table 5). Generally, the extra-early varieties attained mid-silking earlier than the early or late-maturing ones.

At Vom, the extra-early variety Sammaz– 13 attained mid-silking earlier than the late-maturing variety Sammaz-11 (Table 5). Generally, the extra-early varieties attained mid-silking earlier than the early or late-maturing ones. Generally, the varieties attained mid-silking at Saminaka earlier than at the Vom location.

**Plant height at harvest.** There were no significant plant height differences among the hybrids; except that Sammaz-11 tended to be taller than the rest for both locations (Table 6).

**Ear length.** The late-maturing varieties (Sammaz-11, Sammaz-14 and Sammaz-17) produced the longest ears; while the extra-early variety (Sammaz-13) produced the shortest at the Saminaka location. On average, the longest ears were observed in the late-maturing varieties, followed by the early-maturing and the extra-early ones (Table 7).

At Vom, ears were significantly longer ($P<0.05$) in the early-maturing variety Molt cob than in the variety Sammaz-12 (also early-maturing) (Table 7). Generally, ears were longer in the extra-early than in the early or late-maturing varieties.

The ears were generally longer at Vom than at the Saminaka location in all but the varieties Sammaz -17 and Sammaz -12.

**Ear width.** At Saminaka, ear width was similar in the varieties (Table 8). The smallest ears were observed in the extra- early variety, Sammaz -20

TABLE 4. Number of days to 50% tasselling of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 51.00 | 71.60 | 61.30 |
| Sammaz -14 | Late | 50.00 | 71.40 | 61.50 |
| Sammaz -17 | Late | 51.20 (50.73) | 71.60 (71.53) | 61.40 (61.40) |
| Sammaz -12 | Early | 47.40 | 64.40 | 55.90 |
| Sammaz -29 | Early | 47.20 | 64.60 | 55.90 |
| Molt Cob | Early | 49.60 (48.07) | 63.60 (64.20) | 56.60 (56.13) |
| Sammaz -13 | Extra-early | 45.60 | 60.60 | 53.10 |
| Sammaz -18 | Extra-early | 46.40 | 61.00 | 53.70 |
| Sammaz -20 | Extra-early | 44.80 (45.60) | 61.40 (61.00) | 53.10 (53.30) |
| LSD(0.05) | | 1.85 | 0.54 | 0.85 |
| CV (%) | | 0.75 | 0.16 | 1.46 |

Figures in parentheses are mean number of days to 50% tasselling of the three varieties in the same maturity class at the same location

TABLE 5. Number of days to 50% silking of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 60.40 | 75.80 | 68.10 |
| Sammaz -14 | Late | 60.80 | 76.40 | 68.60 |
| Sammaz -17 | Late | 60.60 (60.60) | 76.00 (76.07) | 68.30 (68.33) |
| Sammaz -12 | Early | 57.20 | 68.40 | 62.80 |
| Sammaz -29 | Early | 57.40 | 68.60 | 63.00 |
| Molt Cob | Early | 59.40 (58.00) | 68.40 (68.47) | 63.90 (63.23) |
| Sammaz -13 | Extra-early | 51.60 | 64.60 | 58.10 |
| Sammaz -18 | Extra-early | 51.60 | 65.00 | 58.30 |
| Sammaz -20 | Extra-early | 52.00 (51.73) | 65.40 (65.00) | 58.70 (58.37) |
| LSD (0.05) | | 0.87 | 0.61 | 0.75 |
| CV (%) | | 0.30 | 0.17 | 1.16 |

Figures in parentheses are mean number of days to 50% silking of the three varieties in the same maturity class at the same location

(17 cm). Ears were generally larger in the late than in the early or extra-early varieties.

At Vom, the variety Sammaz-17 (late-maturing) had the largest ears; while the variety Sammaz-12 (early-maturing) had the smallest. The ears were generally larger at Vom than at the Saminaka location in all but the variety Sammaz-14.

**Ear weight.** Table 9 shows result of the ear weight of maize varieties in different maturity classes at Saminaka and Vom.

At Saminaka, mean ear weight ranged from 160.4 g in the variety Sammaz-14 (late-maturing) to 81.6 g in the variety Sammaz - 13 (extra-early). At Vom, the variety Sammaz - 17 (late-maturing) produced ears, which were significantly heavier (133.9 g) than those produced by the extra-early variety Sammaz-13 (Table 9); ears were heavier in the late- than in the early or extra-early varieties. But for variety Sammaz-12 (early-maturing), the ears were generally heavier at Saminaka than at Vom in all the varieties.

TABLE 6. Plant height at harvest (m) of maize varieties in different maturity classes at Saminaka and Vom in in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 2.01 | 1.80 | 1.90 |
| Sammaz -14 | Late | 1.70 | 1.70 | 1.70 |
| Sammaz -17 | Late | 2.00 (1.90) | 1.90 (1.80) | 1.90 (1.83) |
| Sammaz -12 | Early | 1.84 | 1.40 | 1.60 |
| Sammaz -29 | Early | 1.80 | 1.83 | 1.80 |
| Molt Cob | Early | 1.75 (1.80) | 1.67 (1.63) | 1.70 (1.70) |
| Sammaz -13 | Extra-early | 1.74 | 1.64 | 1.70 |
| Sammaz -18 | Extra-early | 1.90 | 1.66 | 1.80 |
| Sammaz -20 | Extra-early | 1.83 (1.82) | 1.58 (1.63) | 1.70 (1.73) |
| LSD(0.05) | | 0.12 | 0.17 | 0.12 |
| CV (%) | | 1.19 | 1.89 | 7.77 |

Figures in parentheses are mean height of the three varieties in the same maturity class at the same location

TABLE 7. Ear length (cm) of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 27.00 | 27.00 | 27.00 |
| Sammaz -14 | Late | 27.00 | 27.00 | 27.00 |
| Sammaz -17 | Late | 27.00 (27.00) | 24.00 (26.00) | 26.00 (26.67) |
| Sammaz -12 | Early | 24.00 | 21.00 | 23.00 |
| Sammaz -29 | Early | 24.00 | 27.00 | 26.00 |
| Molt Cob | Early | 23.00 (23.67) | 29.00 (25.67) | 26.00 (25.00) |
| Sammaz -13 | Extra-Early | 21.00 | 28.00 | 25.00 |
| Sammaz -18 | Extra-Early | 25.00 | 28.00 | 27.00 |
| Sammaz -20 | Extra-Early | 24.00 (23.33) | 27.00 (27.67) | 25.00 (25.67) |
| LSD (0.05) | | 0.02 | 0.02 | 0.02 |
| CV (%) | | 1.40 | 1.40 | 7.58 |

Figures in parentheses are mean ear length of the three varieties in the same maturity class at the same location

**Number of kernels per cob.** At the Saminaka location, variety Molt Cob (early-maturing) had the highest mean number of kernels per cob; while the lowest was recorded in the extra-early variety Sammaz - 20 (Table 10). Generally, the early varieties produced a higher mean number of kernels per cob than the extra-early or late-maturing ones (Table 10).

At the Vom location, the variety Sammaz-17 (late-maturing) produced the highest number of kernels per cob; while variety Sammaz-20 (extra-early) produced the lowest. Generally, the late-maturing varieties produced more kernels per cob than the early-maturing or the extra-early varieties.

The same trend was observed for pooled data (Table 10). Across the varieties, more kernels were produced at Saminaka than at Vom except in the varieties Sammaz-11, Sammaz-14 and Sammaz-17 (all late-maturing) and Sammaz-12 (early-maturing).

**One-thousand kernel weight.** There were no significant differences for kernel weight among

TABLE 8. Ear width (cm) of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 20.00 | 20.00 | 19.00 |
| Sammaz -14 | Late | 20.00 | 17.00 | 19.00 |
| Sammaz -17 | Late | 19.00 (19.67) | 23.00 (20.00) | 21.00 (19.67) |
| Sammaz -12 | Early | 18.00 | 18.00 | 18.00 |
| Sammaz -29 | Early | 19.00 | 22.00 | 21.00 |
| Molt Cob | Early | 20.00 (19.00) | 20.00 (20.00) | 20.00[b] (19.67) |
| Sammaz -13 | Extra-Early | 20.00 | 22.00 | 21.00 |
| Sammaz -18 | Extra-Early | 19.00 | 20.00 | 19.00 |
| Sammaz -20 | Extra-Early | 17.00 (18.67) | 20.00 (20.67) | 18.00 (19.33) |
| LSD (0.05) | | 0.01 | 0.03 | 0.02 |
| CV (%) | | 1.20 | 2.61 | 9.67 |

Figures in parentheses are mean ear width of the three varieties in the same maturity class at the same location

TABLE 9. Ear weight (g) of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 102.03 | 81.53 | 91.80 |
| Sammaz -14 | Late | 162.40 | 84.86 | 123.60 |
| Sammaz -17 | Late | 150.28(138.24) | 133.86(100.08) | 142.10(119.17) |
| Sammaz -12 | Early | 117.25 | 121.91 | 119.60 |
| Sammaz -29 | Early | 108.91 | 84.53 | 96.70 |
| Molt Cob | Early | 147.28(124.48) | 114.67(107.04) | 130.90 |
| Sammaz -13 | Extra-early | 81.63 | 65.18 | 73.50 |
| Sammaz -18 | Extra-early | 150.28 | 124.46 | 117.20 |
| Sammaz -20 | Extra-early | 110.01(114.64) | 79.62(89.75) | 77.40(89.37) |
| LSD (0.05) | | 28.30 | 19.26 | 25.73 |
| CV (%) | | 4.72 | 3.81 | 23.05 |

Figures in parentheses are mean ear weight of the three varieties in the same maturity class at the same location the hybrid classes. The highest kernel weight at Saminaka was observed in the variety Sammaz -14 (late-maturing), which was statistically similar to the varieties Sammaz -11, Sammaz -17 and Sammaz -29 (Table 11). Generally, kernels produced by the late-maturing varieties were heavier than the early-maturing varieties and the extra-early varieties.

At Vom, the kernel weight observed in Sammaz -17, a late-maturing variety, was significantly higher than that of the early-maturing variety Sammaz -12, with a mean one-thousand kernel weight of 137.0 g (Table 11). Generally, the kernels produced by the late-maturing varieties were heavier than those of the early-maturing and extra-early ones. The same trend was observed in the pooled data. Generally, the kernels produced at Vom were heavier than those produced at the Saminaka location, in all but the varieties Sammaz-11 and Sammaz 14, which are late-maturing and the variety Sammaz-20 (extra-early maturing).

**Grain yield.** Result of total grain yield of maize hybrids in different maturity classes at Saminaka

TABLE 10. Number of kernels per cob of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 372.80 | 483.20 | 428.00 |
| Sammaz -14 | Late | 413.60 | 431.80 | 418.20 |
| Sammaz -17 | Late | 500.20(428.97) | 502.00(472.33) | 501.10(449.10) |
| Sammaz -12 | Early | 471.00 | 479.20 | 475.10 |
| Sammaz -29 | Early | 462.00 | 378.60 | 420.40 |
| Molt Cob | Early | 591.20(508.07) | 457.60(438.47) | 524.40(473.30) |
| Sammaz -13 | Extra-Early | 490.00 | 466.80 | 478.40 |
| Sammaz -18 | Extra-Early | 481.60 | 439.20 | 460.40 |
| Sammaz -20 | Extra-Early | 372.00(447.87) | 325.20(410.40) | 348.60 |
| LSD (0.05) | | 68.40 | 77.73 | 75.55 |
| CV (%) | | 2.90 | 3.32 | 16.26 |

Figures in parentheses are mean number of kernels per cob of the three varieties in the same maturity class at the same location

TABLE 11. One-thousand kernel weight (g) of maize varieties in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 190.53 | 167.28 | 177.90 |
| Sammaz -14 | Late | 191.13 | 165.00 | 178.10 |
| Sammaz -17 | Late | 166.14 (182.60) | 226.68 (186.32) | 196.40 (184.13) |
| Sammaz -12 | Early | 145.76 | 137.04 | 141.40 |
| Sammaz -29 | Early | 173.68 | 177.04 | 175.40 |
| Molt Cob | Early | 161.83 (160.42) | 163.73 (159.27) | 162.80 (159.87) |
| Sammaz -13 | Extra-early | 160.80 | 164.95 | 163.70 |
| Sammaz -18 | Extra-early | 140.99 | 173.74 | 157.40 |
| Sammaz -20 | Extra-early | 160.78 (154.19) | 147.46 (162.05) | 159.10 (160.07) |
| LSD (0.05) | | 22.58 | 64.65 | 19.84 |
| CV (%) | | 2.67 | 1.58 | 10.25 |

Figures in parentheses are mean weight of kernels of the three varieties in the same maturity class at the same location and Vom is shown in Table 12. The highest total grain yield of 5.6 t $ha^{-1}$ at Saminaka was observed in the extra-early variety Sammaz -18; and this differed significantly from variety Sammaz -11 (late-maturing), with a total grain yield of 1.7 t $ha^{-1}$. At Vom, the highest total grain yield of 4.7 t $ha^{-1}$ was also observed in the variety Sammaz-18, while the lowest yield of 1.1 t $ha^{-1}$ was observed in the extra early-maturing variety Sammaz-13. Generally, the highest total grain yield was observed in the extra-early varieties, followed by the late maturing varieties. Across the varieties, the total grain yield was higher at Saminaka than at the Vom location.

**Heritability estimate.** Table 13 shows results of the broad sense heritability estimate of some growth and yield components of maize. The highest heritability estimate of 1.00 was observed in the number of days to onset of floweing, number of days to 50% tasselling and 50% silking, and the mean number of ears per plant. The lowest estimate of 0.72 was observed in the ear width and number of kernels per cob.

## DISCUSSION

**Seedling emergence.** Seed qualities, which affect the rate of seedling emergence and establishment are collectively expressed as seed vigour. Vigour is a highly significant factor in crop establishment, especially in legumes such as peas and beans; as well as in small-seeded vegetables (Forbes and Watson, 1992). Seeds with very low vigour hardly germinate as observed in the extra-early varieties, especially the variety Sammaz – 13, in this study (Table 2). Germinability and vigour are also affected by pre-harvest growing condition, harvest and drying as well as seed-size. Early harvesting and artificial drying of seeds can result in a dramatic loss in germinability. Physical damage such as cracks in the endosperm can also reduce vigour and germinability (Forbes and Watson, 1992). In this study, a higher germination rate was observed in the varieties with large seeds than in those with small seeds. The larger seeds

TABLE 13. Broad sense heritability estimate of some growth and yield components of maize in Nigeria

| Parameter | Heritability |
|---|---|
| Germination rate | 0.87 |
| Days to onset of flowering | 1.00 |
| Days to 50% tasselling | 1.00 |
| Days to 50% silking | 1.00 |
| Stand count at harvest | 0.95 |
| Plant height at harvest | 0.82 |
| Ear number per cob | 1.00 |
| Ear length | 0.85 |
| Ear width | 0.72 |
| Mea ear weight | 0.85 |
| Number of kernels per cob | 0.72 |
| 1,000 kernel weight | 0.86 |
| Grain yield | 0.90 |

TABLE 12. Total grain yield (t $ha^{-1}$) of maize varietieis in different maturity classes at Saminaka and Vom in Nigeria

| Variety | Maturity class | Location | | Pooled |
|---|---|---|---|---|
| | | Saminaka | Vom | |
| Sammaz -11 | Late | 1.73 | 1.13 | 1.43 |
| Sammaz -14 | Late | 3.88 | 3.49 | 3.69 |
| Sammaz -17 | Late | 1.75 (2.45) | 1.68 (2.10) | 1.72 (2.28) |
| Sammaz -12 | Early | 3.21 | 2.25 | 2.73 |
| Sammaz -29 | Early | 2.23 | 2.22 | 2.22 |
| Molt Cob | Early | 3.25 (2.89) | 1.61 (2.03) | 2.43 (2.46) |
| Sammaz -13 | Extra-early | 2.06 | 1.72 | 1.89 |
| Sammaz -18 | Extra-early | 5.58 | 4.66 | 5.12 |
| Sammaz -20 | Extra-early | 2.67 (3.43) | 2.05 (2.81) | 2.36 (3.08) |
| LSD (0.05) | | 1.51 | 1.15 | 0.34 |
| CV % | | 10.12 | 9.79 | 2.19 |

Figures in parentheses are mean grain yield of the three varieties in the same maturity class at the same location tend to give a faster or more even emergence than the smaller ones, partly, because they contain larger food reserves which are used to sustain the young seedlings before they are fully established.

Low moisture content and temperature could also affect the rate of germination as observed in this study; the mean monthly maximum and minimum temperatures were higher at Saminaka than at the Vom location. Consequently, the germination rate was generally higher at Saminaka, a lowland savanna, than at Vom, a highland savanna.

**Days to flowering.** Variations in the number of days to flowering have been reported to be due to varietal differences and in response to temperature and photoperiod (Aitken, 1974; Purseglove, 1992), which trend was also observed in this study (Table 3). Plants started flowering and attained mid-tasselling and mid-silking earlier at Saminaka (where temperatures were higher) than at the Vom location with lower temperatures.

The expression of maturity traits such as days to flower, brown husk, kernel moisture at harvest and black layer formation, all of which affect the total grain yield of maize, is believed to differ with genotype, season and location (Dhillon, 2001). Contrary to the earlier report that grain yield of maize correlates negatively with maturity period (Dhillon, 2001), in this study, total grain yield was generally higher in the early than in the late-maturing varieties at both Saminaka and Vom locations (Table 12). This could be due to the fact that early-maturing varieties transited from vegetative to reproductive phase earlier and had a longer grain-filling period than the late-maturing ones.

Although higher stand counts were observed in the late-maturing varieties at harvest, the total grain yields in the early-maturing varieties were generally higher than in the former at both locations (Table 12). Grain yield of recently developed, early-maturing hybrids may be affected not only by high standability but also by early flowering, delayed senescence, rapid grain-filling, higher shelling and harvest indices, increased sink-size, reduced barrenness and shorter anthesis-silking interval. In other words, grain yield in maize like in other crops, is a quantitative trait that is influenced by genotypic and environmental factors (Russel, 1991; Dhillon, 2001).

Although Dilshad *et al.* (2001) reported that in maize taller plants produced higher numbers of cobs than the shorter ones, Dhillon (2001) noted that higher grain yields in recently developed hybrids were accompanied by, among others, early-maturity and shorter plants that make it easy for mechanical harvesting. In this study, shorter and early-maturing varieties produced higher grain yields than the taller and late-maturing ones. The high grain yield in the early-maturing varieties could be due to high harvest and shelling indices.

**Ear size.** The length and size of ears produced at the two locations could have been affected by the sodium, phosphorus and cation exchange capacity (CEC), which was higher at Vom than at the Saminaka location (Table 14). A high cation exchange capacity results in a high uptake of nutrients needed at the critical stage (grain-filling period) of the plant growth. Ear length and ear width are, however, not the only determinants of total grain yield in maize as shown in this study; even though the late-maturing varieties produced longer and larger ears than the early-maturing ones, the latter exceeded the former in the total grain yield. Grain yield is affected by both genotypic and environmental factors.

Two sequential steps are reportedly involved in the production of grain yield in maize: a sink of pollinated kernels capable of further development must be created and these must be supplied with photosynthate over the period of their development (Duncan, 1975). Thus, grain yield at harvest may be determined either by kernel or sink capacity established at pollination or by the quantity of photosynthate made available between pollination and maturity. Dhillon (2001) reported that grain yield in maize was related to the number of ears, kernel rows, kernels per row, test weight and shelling percentage. In this study, the early-maturing variety Sammaz-18, which produced heavy ears also produced high grain yield.

**Heritability.** The heritability estimates were for all traits studied (Table 13). Fakorede and Obilana

TABLE 14. Physico-chemical properties of topsoil collected from the two experimental sites

| Soil property | Location | |
|---|---|---|
| | Saminaka | Vom |
| Clay (g $kg^{-1}$) | 20 | 24 |
| Silt (g $kg^{-1}$) | 18 | 26 |
| Sand (g $kg^{-1}$) | 62 | 50 |
| Textural class | Sandy loam | Sandy clay loam |
| pH.$H_2O$ | 5.9 | 5.4 |
| Organic carbon (g $kg^{-1}$) | 0.63 | 0.82 |
| Total nitrogen (%) | 0.245 | 0.245 |
| Available phosphorus (mg $kg^{-1}$) | 12.3 | 23.63 |
| Exchangeable bases (Cmol $kg^{-1}$) | | |
| Calcium | 5.6 | 4.6 |
| Magnesium | 0.74 | 0.38 |
| Potassium | 0.23 | 0.93 |
| Sodium | 2.35 | 5.39 |
| Cation exchange capacity | 11.6 | 14.5 |

Source: Department of Crop Science, Ahmadu Bello University, Zaria, Nigeria

(1981) noted that if a trait is strongly influenced by environmental variations, its heritability in a population would be low. The high heritability estimates of the traits as observed in this study indicate that they might be quantitatively inherited, being influenced primarily by additive gene action. These traits could, therefore, be used as selection indices for the improvement of maize.

## ACKNOWLEDGMENT

The authors are thankful to the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, for providing the planting materials, and Kaduna State College of Education, Gidan-Waya, for funding the study.

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