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GENERATION AND EVALUATION OF MAIZE HYBRIDS (*Zea maize* L.) IN MAKURDI, BENUE STATE NIGERIA

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Abstract
High yielding and early maturing maize hybrids are crucial to improved production and food security in the face of climate change. The objective of this study was to generate and evaluate maize hybrids in Makurdi. Two early maturing and two medium maturing (SAMMAZ 27, SAMMAZ 50 and SAMMAZ 51 and SC 645) varieties were crossed to generate hybrids. Crossing was done in the Screen house of the molecular biology laboratory located at the Teaching and Research farm Joseph Sarwuan Tarka University of Makurdi, Benue state. The following Hybrids (SAMMAZ 27 (V3) X SC 645 (V1) = V3V1, SAMMAZ 51(V4) X SC 645 (V1) = V4V1, SAMMAZ 27(V3) X SAMMAZ 50 (V2)= V3V2, SAMMAZ 51 (V4) X SAMMAZ 50 (V2) = V4V2, SC 645 (V1) X SAMMAZ 27 (V3) = V1V3, SC 645 (V1) X SAMMAZ51 (V4) = V1V4.) lines obtained were evaluated at the Songhai Integrated Modern Pilot Farm located at Lower Benue River Basins development Authority. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Highly significant differences among hybrids evaluated was observed for days to 95 percent maturity and 50 percent tasseling. Also, significant differences were observed for plant height at tasseling, leaf length at tasseling, number of kernel rows per cob, number of kernels per row, cob length, weight of 100 kernels, days to 50% silking and unshelled cob weight (kg/ha). On the contrary, there were no significant differences among the hybrids for leaf width at tasseling, number of cobs per plant and cob circumference. Furthermore, the results showed that significant genetic variation for useful traits of maize can be generated from making single cross hybrids. The cross combinations that showed high grain yielding potential were SC 645 X SAMMAZ 51 and SC 645 X SAMMAZ 27. These cross combinations also exhibited remarkable earliness of 65 days to 95% maturity. Thus, SC 645, SAMMAZ 51, SAMMAZ 27 can be used for hybrid production to improve yield and earliness in Maize.

Introduction
Maize (*Zea mays L.*) is a member of the grass family (*graminecea*) (USDA-ARS, 2018). It is the most important cereal crop in sub- Saharan Africa (SSA) (FAO, 2002) Along with rice and wheat, maize is one of the three most important cereal crops in the world (Jaliya *et al,* 2008). Over 50 species

of maize exist and consist of different colors, textures, grains, shapes and sizes (Felice and Zegege, 2008). Yellow, white and red species are the most common types, but most people prefer the yellow and white species (Ojo, 2000).

Maize was introduced into Africa in more than 150 decades ago and has since become one of the dominant food crops in Africa. It originated from South and central America and was introduced to West Africa by the Portuguese in the 10th century (FAO, 2014).

Maize has become one of the most stable crops, especially in the developing countries of the world (Halweit, 2005). In some places it accounts for up to 80-90% total calories intake of rural population (Ayola, 2001). Every part of the maize plant has economic value. The grain, leaves, stalk, tassel, and cob all can be used to produce a large variety of food and non-food (IITA, 2009). Maize can be boiled or roasted on the Cob (Ibitoye and Shaibu, 2014). The grain can also be grounded into flour and be made into pap and corn meal. Industrially maize can be produced in flour, starch, alcohol and spirit. Maize is a major raw material for livestock feed.

Over the years the years, maize has become an important crops, taking over acreage from traditional crops such as millet and sorghum. In 2021, about 1.2 billion tonnes of maize was produced worldwide with America having 384 million metric tonnes which make them the largest producers on earth with Nigeria as the largest maize producer in Africa accounting for 775989.62 tonnes (FAOSTAT 2021).

Maize is one of the most important staple crops in the world, with over a billion people relying on it as a source of food and income. However, maize production in Nigeria is hampered by challenges such as pests and diseases, drought, inadequate and poor-quality seeds, and inadequate access to markets (Akinwale and Oluwale, 2020). These challenges have led to low productivity and yield, which, in turn, impact on the food security and income of farmers. One way to address these challenges is through the development and production of maize hybrids. However, there is currently limited research on the production and evaluation of maize hybrids in Nigeria. This study aims to fill this gap by developing and evaluating maize hybrids that have high yield potential.

The evaluation of maize hybrids is therefore crucial in maize breeding. It allows breeders to identify and select high-performing hybrids that can improve yields, resist pests and diseases, and enhance food security. Evaluation results also help farmers choose the most suitable hybrid for their specific needs, leading to increased profitability. Extensive hybrid evaluations are necessary to address the challenges and maximize the opportunities in maize agriculture.

According to Ragaspo *et al.* (2020), evaluation of maize hybrids is a critical process that enables breeders to identify high-performing hybrids that can increase yield potential, overcome biotic and abiotic stresses and improve food security. Therefore, maize hybrid varieties which are high yielding, and produce more than one or two cobs per plant at different inter-nodes and are early maturing are highly desirable by farmers to increase productivity and escape droughts. Hence, there is need to generate and introduce hybrid varieties which are high yielding and early maturing to farmers to increase productivity of maize for specific regions and locations. Therefore, this study was designed to generate and evaluate the performance of biparental hybrids of maize in Makurdi.

Materials and Methods

Experimental site

Crossing was done at the screen house of the Teaching and Research farm, Joseph Sarwuan Tarka University Makurdi, located between latitude 7.7322°N and longitude 8.5391°E. While the field evaluation of hybrids was done at the Songhai Modern Integrated Pilot farm, Lower Benue River

Basins Development Authority, located between latitude 7.72644°N and longitude 8.54107°.

Experimental Design and Treatment

Four maize varieties- two early maturing (SAMMAZ 27, and SAMMAZ 51) and two late maturing (SC 645 and SAMMAZ 50) varieties were crossed to generate hybrids. The parents were sown in 4 Litre plastic pots in the Screen house for crossing. Holes were drilled at the base of each pot to ensure drainage of excess water. The pots were filled with topsoil soil and two seeds from each parent were sown in six (6) different pots. 3 pots of the late maturing varieties were sown first. A week later, 3 pots of the early maturing and another 3 pots of the late maturing varieties were sown. A week later, the last 3 pots of the early maturing varieties were sown. Sowing at different dates was to ensure that the flowering of both early and late varieties was synchronize for successful crossing.

Tags were prepared before crossing began. On the crossing tag the following information were written. Date of sowing (DOS), Date of flowering (DOF), Date of pollination (DOP) and name of crossed parents, with the female parent written first. Other items prepared before crossing began included, clips, pollen bags, ear bags, maker, masking tape and clothe bags.

The following crosses were made:

(a) SAMMAZ 27 (V3) x SC 645 (V1) = V3V1.
(b) SAMMAZ 51 (V4) X SC 645 (V1) = V4V1.
(c) SAMMAZ 27 (V3) X SAMMAZ 50 (V2) = V3V2.
(d) SAMMAZ 51 (V4) X SAMMAZ 50 (V2) = V4V2.
(e) SC 645 (V1) X SAMMAZ 27 (V3) = V1V3.
(f) SC 645 (V1) X SAMMAZ 51 (V4) = V1V4.

Crossing was done by collecting pollen grains from the tassel of the desired male parent plant using a pollen bag and applying to the silk of the desired female plant. To apply the pollen grain to the female part (silk) the small bag covering the female flower (ear) was removed, and the pollen was applied by carefully dusting it over the silk. The envelope was again placed over the pollinated female flower and the bottom edge folded over. A clip was placed on the fold against the stem to keep the envelope secured. On the tag, number of pollen parent, date of pollination were recorded. Seeds were collected from the crosses as F_1 seeds. Both the F_1 seeds and the parents were taking to the field for evaluation.

Field Trials

The land for the field trial was first ploughed, manured (at the rate of 4 tonnes per hectare), limed and watered for 3 weeks. Experimental plots were raised beds measuring 2 m x 4 m, for both hybrids and the parents. The experiment was arranged in 3 replications in a Randomized Complete Block Design. Treatments consisted of four parents and six hybrids. 24 seeds of each hybrid and parent were sown at a rate of 2 seeds per hill on a 2 m x 4 m bed on the 8th of March 2022.

Observation and data collection

Data was collected during pre-harvest and post-harvest on quantitative and qualitative traits, including Stand count at harvest, Plant heights at tasseling (cm), Leaf length at tasseling (cm), Leaf width at tasseling (cm), Days to 50 % tasselling, Days to 50% silking, Days to 95 % maturity, Cob length (cm), Cob circumference (cm), Number of kernel rows per cob, Number of kernels per row, Number of cobs per plant, Weight of 100 kernels (g) and Unshelled cob weight (kg/ha).

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using GenStat 64 bit release, 2019 version. Significant means were separated using Duncan's multiple range test (DMRT).

Mid parent heterosis for measured parameters of hybrids was estimated using the following relation (https://imp.center/agri/methods-for-estimation-of-heterosis/):

Mid Parent Heterosis = (F_1- MP) / 100 x MP
Where F_1 is the first filial generation and MP is the mean value or average of the two parents.

Results and Discussion

Analysis of Variance showing the Performance of Maize Hybrids Evaluated in Makurdi

Table 1 shows the Analysis of Variance for the performance of maize hybrids under evaluated. The result shows that there were highly significant differences among hybrids evaluated for days to 95 percent maturity (D 95% M) and days to 50 percent tasselling (D 50 % T). Also, significant differences were observed for plant heights at tasselling, leaf length at tasselling, number of kernel rows per cob, number of kernels per row, cob length, weight of 100 kernels, days to 50 percent silking (D 50 % SK) and unshelled cob weight (kg/ha). On the contrary, there were no significant differences among the genotypes for leaf width at tasselling (LW@T), number of cobs per plant and cob circumference.

One of the key benefits of genetic diversity is that it provides breeders with a range of traits and characteristics to select from, enabling them to develop hybrids that have improved yield potential, disease and pest resistance, tolerance to abiotic stress, and enhanced quality (Swarup *et al.,* 2020). In the present study, the analysis of variance showed that there was significant variation between the parents and hybrids tested for measured parameters. This result is in agreement with the findings of Soza *et al.* (1996); Sallah *et al*. (2001) and Ram *et al*. (2013) who also reported significant differences for days to 95 percent maturity, days to 50 percent tasselling, plant heights at tasselling, leaf length at tasselling, number of kernel rows per cob, number of kernel per rows, cob length, weight of 100 kernels, days to 50 percent silking in maize and unshelled cob weight (kg/ha).

The genotypic variations found were likely due to the diverse backgrounds from which the hybrids used in the study were developed. This result is in agreement with findings by Sallah *et al*. (2001) and Soza *et al*. (1996), who also used open-pollinated varieties and hybrids as parents for hybrid development in their study and reported significant variation among the hybrids.

The variation observed for almost all the traits measured among the tested genotypes, is an indication of the presence of sufficient variability which can be exploited through selection. Maize breeders can use the high-yielding and early maturing hybrids from this study as base populations in developing new and improved hybrids through conventional breeding techniques like pedigree selection, mass selection, and recurrent selection (Andorf *et al.,* 2019). Development of new genotypes with high production capacity that requires genetic distance between parents who participate in the breeding program (Morgan, 1998). Singh *et al*. (2004) also suggested that the heterosis could be useful to optimize heterozygous combination.

Mean performance of Parents and Hybrid Lines of Maize Evaluated in Makurdi for some selected parameters.

Table 2 shows the mean performance of parents and hybrid lines of maize evaluated. The results showed significant difference for plant height, which ranged from 187.9 cm (SAMMAZ 27 X SC 645) to 246.0 cm (SC 645 X SAMMAZ 51). Hybrid SC 645 X SAMMAZ 51 had taller plants (246.0 cm) followed by SC 645 X SAMMAZ 27 (241.1 cm) while hybrid SAMMAZ 27 X SC 645 had shorter plants (187.9 cm). Leaf length at tasselling (LL@T) varied significantly and ranged from 89.80 cm (SAMMAZ 27 X SC 645) to 102.30 cm (SC 645 X SAMMAZ 27). Hybrid SC 645 X SAMMAZ 27 had the higher leaf length at tasselling (102.30) this was followed by SC 645 X SAMMAZ 51 (97.80 cm) while SAMMAZ 27 X SC 645 had shorter leaves at tasselling (89.80 cm).

Leaf width at tasselling (LW@T) showed non-significant variation and ranged from 9.43 cm (SAMMAZ 27) to 10.25 cm

(SAMMAZ 51 X SAMMAZ 50). Hybrid SAMMAZ 51 X SAMMAZ 50 had higher leaf width at tasselling (10.200 cm) followed by SC 645 X SAMMAZ 27 (10.200 cm), while SAMMAZ 27 had the least value of 9.43 cm. There was highly significant variation for days to 95 % maturity and ranged from 65.00 (SAMMAZ 51 X SAMMAZ 50 and SAMMAZ 27 X SC 645) to 67.50 (SAMMAZ 50, SAMMAZ 51 X SAMMAZ 50 and SAMMAZ 27).

Table 1: Analysis of Variance for the Performance of Parents and Hybrids of Maize Evaluateded in Makurdi

SOV	DF	PH@T	LL@T	LW@T	D 95%M	NC/P	NKR/C	NK/R
Replication	2	508	22.47	0.173	0.8	0.1	0.03	3.87
Genotypes	9	720.9*	29.25*	0.15ns	2.31**	0.19ns	1.74*	32.32*
Error	9	136.8	9.02	0.02	0.13	0.03	0.32	6.18
Total	20							

SOV	DF	CL	CC	W100 K	D50%T	D50%SK	UNCW kg/ha
Replication	2	1.87	0.03	0.34	0.05	0.2	954356
Genotypes	9	5.07*	0.79ns	5.98*	6.94**	6.47*	9986047*
Error	9	1.47	0.49	1.58	0.49	o.87	1738871
Total	20						

* = Significant at P <0.05, ** = Highly Significant at P <0.05, ns = Not significant at P <0.05, PH@T = Plant heights at tasseling (cm), **LL@T** = Leaf length at tasseling , **LW@T** = Leaf width at tasseling, D50% = Days to 50 % tasselling, D50%SK = Days to 50% silking, D95%M = Days to 95 % maturity, CL= Cob length (cm), CC = Cob circumference (cm), NKR/C = Number of kernel rows per cob, NK/R = Number of kernels per row, NC/P = Number of cobs per plant, W100K = Weight of 100 kernels (g) and UNCW (kg/ha) =Unshelled cob weight (kg/ha).

Table 2: Mean Performance of Parents and Hybrid Lines of Maize Evaluated in Makurdi for some Parameters

Population	PH@T	LL@T	LW@T	D 95%M	NC/P	NKR/C	NK/R
SC 645 X SAMMAZ 51	246.0a	97.80ab	9.750a	65.00d	1.20a	16.60ab	36.75 ab
SC 645 X SAMMAZ 27	241.1a	102.30a	10.200a	66.50bc	1.60a	17.00a	37.40 ab
SAMMAZ 51 X SC 645	211.3b	93.00bc	9.740a	67.00ab	1.50a	15.6abc	35.15 ab
SC 645	209.6b	93.30bc	9.730a	66.00c	1.00a	15.30bcd	33.00 ab
SAMMAZ 50	209.5b	92.50bc	9.490a	67.50a	1.00d	14.80cd	32.65b
SAMMAZ 51 X SAMMAZ 50	204.8b	92.50bc	10.250a	67.50a	1.80a	16.00abc	38.95a
SAMMAZ 27 X SAMMAZ 50	201.7b	91.30bc	9.640a	65.00d	1.20a	16.20bc	38.30ab
SAMMAZ 51	196.7b	91.10bc	9.740a	67.00ab	1.10a	14.00d	34.70ab
SAMMAZ 27	195.2b	90.60bc	9.430a	67.50a	1.00a	14.90cd	25.45c
SAMMAZ 27 X SC 645	187.9b	89.80c	9.640a	65.00d	1.70a	16.40ab	38.05ab

Means within a column with similar alphabets are not statistically different at P <0.05, PH@T=Plant heights at tasseling (cm), **LL@T** = Leaf length at tasseling, **LW@T** = Leaf width at tasseling, D95%M= Days to 95% maturity, NC/P = Number of cobs per plant, NKR/C = Number of kernel rows per cob, NKR = Number of kernels per row

There was highly significant variation for number of days to 95 % maturity, and ranged from 67.50 for SAMMAZ 50, SAMMAZ 51 X SAMMAZ 50 and SAMMAZ 27, followed by 67.00 for SAMMAZ 51 X SC 645 and SAMMAZ 51, while least number of days to 95 % maturity was recorded for SAMMAZ 51 X SAMMAZ 50 and SAMMAZ 27 X SC 645 (65.00).

Non-significant higher number of cobs per plant (NC/P) was recorded by hybrid SAMMAZ 51 X SAMMAZ 50 (1.80) this was followed by hybrid SAMMAZ 27 X SC 645 (1.70) while lower number of cobs per plant was recorded by SC 645, SAMMAZ 50 and SAMMAZ 27 (1.00). A significant higher number of kernel rows per cob (NKR/C) was recorded by hybrid SC 645 X SAMMAZ 27 (17.00) followed by SC 645 X SAMMAZ 51 (16.60) while lower number of kernel rows per cob was recorded by SAMMAZ 51 (14.00). Also, a significant higher number of kernels per row (NK/R) was recorded by hybrid SAMMAZ 51 X SAMMAZ 50 (38.95) followed by SAMMAZ 27 X SC 645 (38.05) while lower number of kernels per row was recorded by SAMMAZ 27 (25.45) (Table 2).

Mean performance of Parents and Hybrid Lines of Maize Evaluated in Makurdi for some selected parameters

Table 3 is the results for the mean performance of parents and hybrid lines of maize evaluated for selected parameters. The results show significant differences for cob length (CL) and ranged from 14.90 cm (SAMMAZ 27) to 19.25 cm (SAMMAZ 27 X SAMMAZ 50). Hybrid SAMMAZ 27 X SAMMAZ 50 had longer cobs (19.25 cm) followed by SAMMAZ 51 X SC 645 (19.20 cm) while SAMMAZ 27 had shorter cobs (14.90 cm). Result for cob circumference (CC) showed no significant difference and ranged from 14.30 cm (SAMMAZ 51 X SC 645) to 16.15 cm (SAMMAZ 27 X SC 645). Hybrid SAMMAZ 27 X SC 645 had the higher cob circumference (CC) (16.15) followed by SC 645 X SAMMAZ 27 (16.11 cm) while SAMMAZ 51 X SC 645 had least cob circumference (14.30 cm).

Significant higher weight of 100 kernels (100kw g) was recorded by hybrid SC 645 X SAMMAZ 51 and SAMMAZ 51 X SC 645 (29.65 g) followed by SAMMAZ 27 X SAMMAZ 50 (27.95 g) SC 645 had least weight of 100 kernel (25.00 g).

Table 3: Mean Performance of Parents and Hybrid Lines of Maize Evaluated in Makurdi for some selected parameters

Population	CL	CC	100KW g	D50%T	D50%SK	UNCW kg
SC 645 X SAMMAZ 51	19.15a	15.95a	29.65a	44.00c	46.50def	7673bcd
SC 645 X SAMMAZ 27	19.10a	16.11a	27.30abc	44.00c	46.50def	10449ab
SAMMAZ 51 X SC 645	19.20a	14.30a	29.65a	46.00ab	49.00abc	10910a
SC 645	17.15ab	14.83a	25.00c	46.50ab	48.00bcde	5228de
SAMMAZ 50	15.65b	14.65a	26.35b	47.00a	50.50a	7037cde
SAMMAZ 51 X SAMMAZ 50	18.80a	15.43a	25.75c	46.00ab	48.50abcd	7830abcd
SAMMAZ 27 X SAMMAZ 50	19.25a	15.19a	27.95abc	44.00c	46.00ef	6715cde
SAMMAZ 51	17.55ab	15.51a	26.20bc	47.00a	50.00ab	5607de
SAMMAZ 27	14.90b	15.05a	25.80c	45.00bc	47.00cdef	4350e
SAMMAZ 27 X SC 645	18.80b	16.15a	29.15ab	41.00d	45.00f	9738abc

Means within a column with similar alphabets are not statistically different at P <0.05, **CL=** Cob length (cm), CC = Cob circumference (cm), D50% = Days to 50 % tasselling, D50%SK = Days to 50% silking, 100KW g = Weight of 100 kernel and UNCW kg/ha =Unshelled cob weight (kg/ha).

Highly significant number of days to 50 % tasselling (D50%T) was recorded by genotypes SAMMAZ 50 and SAMMAZ 51 (47.00 days) this was followed by genotype SC 645 (46.50 days) while least number of days to 50 % tasselling was recorded by hybrid SAMMAZ 27 X SC 645 (41.00). A significant higher number of days to 50 % silking (D50%SK) was recorded by genotypes SAMMAZ 50 and SAMMAZ 51 (50.50 days) this was followed by SAMMAZ 51 X SC 645 (49.00 days) while lower number of days to 50 % silking were recorded by hybrid SAMMAZ 27 X SC 645 (45.00 days). Also, higher weight of unshelled cob (kg/ha) was recorded by hybrid SAMMAZ 51 X SC 645 (109110 kg/ha) followed by SC 645 X SAMMAZ 27 (10449 kg/ha) while lower weight of unshelled cob was recorded by SAMMAZ 27 (4350 kg/ha) (Table 3).

Heterosis for Yield and Yield related Parameters of Maize Hybrids Evaluated in Makurdi

Table 4 shows heterosis for yield and yield related traits. All evaluated hybrids exhibited no heterosis for Number of cobs per plant, while they exhibited positive heterosis for Cob length (cm), Cob circumference (cm), Number of kernels per row, Number of kernels per cob, Unshelled cob weight (kg/ha). Cross 4 (SAMMAZ 51 X SAMMAZ 50.) showed negative heterosis for Weight of 100 kernels (g). Cross 1,2,5 and 6 (SC 645 X SAMMAZ 51, SC645 X SAMMAZ 27, SAMMAZ 27 X SAMMAZ 50 and SAMMAZ 27 X Sc645.) showed negative heterosis for Days to 95% maturity, while all evaluated hybrids showed negative heterosis for Days to 50% tasselling and Cross 1,2 5 and 6 exhibited negative heterosis for Days to 50% silking.

The highest positive heterosis for number of cobs per plat was observed for Cross 1 SC 645 X SAMMAZ 51) (0.75 %), followed by Cross 3 (SAMMAZ 51 X SC 645) (0.45 %), while cross 5 gave the least positive heterosis for number of cob per plants (0.2). For cob length, Cross 2 (SC 645 X SAMMAZ 27) showed highest positive heterosis (3.08 %) followed by Cross 6 (SAMMAZ 27 X SC 645) (2.78 %) while least positive heterosis was observed for Cross 3) (1.95 %). Cross 6 (SAMMAZ 27 X SC 645) exhibited the highest positive heterosis (1.22 %) for cob circumference, followed by Cross 2 (SC 645 X SAMMAZ 27) with 1.17 % while Crosses 4 (SAMMAZ 51 X SAMMAZ 50) and 5 (SAMMAZ 27 X SAMMAZ 50) gave least value of heterosis (0.35 %). Highest positive heterosis for number of kernels per row (NK/R) was recorded for Cross 5 (SAMMAZ 27 X SAMMAZ 50) (9.25 %) followed by Cross 6 (SAMMAZ 27 X SC 645) (8.86 %) while least heterosis was recorded for Cross 3 (SAMMAZ 51 X SC645) (1.3 %).

Highest positive heterosis for number of kernels per cob was obtained from Cross 2 (SC 645 X SAMMAZ 27) (2.18 %), followed by Cross 1 (1.95 %), Cross 3 (SAMMAZ 51 X SC645) recorded least heterosis value of 0.95 %. Highest positive heterosis for weight of unshelled cobs was obtained for Cross 2 SC 645 X SAMMAZ 27) (5660.00 %) followed by Cross 3 (5492.5 %), while Cross 4 recorded the least value (1508 %). The Cross 1 recorded the highest positive heterosis for weight of 100 kernels (4.05 %) followed by Cross 6 (3.75 %) while the Cross 4 gave a negative heterosis value (–0.53 %).

Table 4: Heterosis for Yield and Yield related parameters for Hybrids Evaluated in Makurdi

Crosses	NC/P	CL	CC	NK/R	NK/C	USCW (kg)	100KW g	D95%M	D50%T	D50%SK
1	0.15	2	0.78	3.9	1.95	2,255.50	4.05	-1.5	-2.75	-2.5
2	0.6	3.08	1.17	8.18	2.18	5,660.00	1.9	-0.25	-1.75	-1
3	0.45	1.95	0.87	1.3	0.95	5492.5	3.38	0.5	-0.75	0
4	0.75	2.3	0.35	5.28	1.6	1508	-0.53	0.25	-1	0.5
5	0.2	2.4	0.35	9.25	1.35	1021.5	1.88	-2.5	-2	-1.75
6	0.7	2.78	1.22	8.86	1.3	4949	3.75	-1.75	-4.75	-2.5

NCP = Number of cobs per plant, CL = Cob length (cm), Cob circumference (cm), NK/R = Number of kernels per row, NK/C = Number of kernels per cob, UNCW kg/ha =Unshelled cob weight (kg/ha), 100WK g = Weight of 100 kernels (g), D95%M= Days to 95% maturity, D50%T=Days to 50% tasselling and D50%SK= Days to 50% silking. Cross 1 =SC 645 X SAMMAZ 51, Cross 2 = SC 645 X SAMMAZ 27, Cross 3= SAMMAZ 51 X Sc645, Cross 4= SAMMAZ 51 X SAMMAZ 50, Cross 5= SAMMAZ 27 X SAMMAZ 50, Cross 6 = SAMMAZ 27 X SC 645.

Cross 5 gave the highest negative heterosis for Days to 95 % maturity (-2.5 %) followed by hybrid Cross 6 (-1.75 %), Cross 1 (-1.5 %), while the least negative heterosis was recorded for hybrid Cross 2 (-0.25 %). Cross 3 and Cross 4 recorded positive heterosis for days to 95 % maturity. For days to 50 % tasselling, the highest negative heterosis was recorded for hybrid Cross 6 (-4.75 %), followed by Cross 1 (-2.75 %), hybrid Cross 5 (-2 %), while the least negative heterosis value was recorded for hybrid Cross3 (-0.75 %). cross 4 gave a positive heterosis value of 0.25 for number of days to 50 % maturity. The highest negative heterosis was observed in Cross 1 and Cross 6 for number of days to 50 % silking (-2.5 %), followed by Cross 5 (-1.75 %), while the least negative heterosis was recorded for hybrid Cross 3 (-1). Positive heterosis for number of days to 50 % silking was obtained for hybrid 4 (0.5) (Table 4).

The concept of heterosis or hybrid vigor has been widely studied in plant breeding, particularly in the development of hybrid varieties. Heterosis refers to the phenomenon where the offspring of two genetically diverse parents have superior qualities, such as increased yield potential, greater resistance to pests and diseases, and improved tolerance to abiotic stress, relative to the average performance of their parents. However, in some cases, hybrids may not display any significant heterotic effect, resulting in zero heterosis. Zero heterosis is a situation in which the performance of a hybrid is the same as the average performance of its parents for a given trait.

All Hybrids evaluated in this study showed no significant advantage over their parents for number of cobs per plant as shown by zero heterosis. This means that the hybrids did not exhibit any hybrid vigor or superior performance compared to their parents. Research has shown that zero heterosis may occur due to several factors, including genetic similarity between the parents, dominance gene effects, epistasis gene effects, and environmental factors. Studies by Chen *et al*. (2016) and Chhabra *et al*. (2017) on maize hybrids showed that genetic similarity between the parents could result in zero heterosis. In the same vein, Ma *et al*. (2015) reported that epistasis gene effects were a major contributor to zero heterosis in rice hybrids.

Negative heterosis is considered as desirable for days to 50 % tasselling and silking (Chandel et al., 2020), and days to 95 % maturity for developing hybrids with early maturity. These results are in conformity with earlier reports of Appunu *et al*. (2007), Saidaiah *et al*. (2008), Avinashe et al. (2013), Shah *et al*. (2014) and Nagarajan and Nallathambi (2017). A benefit of early maturing maize hybrids is the potential for higher yield per unit area. Because early maturing hybrids have a shorter growing season, they can be planted and harvested earlier, allowing farmers to plant a second crop within the same growing season. This can lead to higher yield per unit area and increased income for farmers, as they can produce more than one crop per season.

Heterosis is fundamental to the improvement of the maize growth and productivity. In this study positive heterosis was recorded for many traits including unshelled cob weight in Kg/ha. The analysis of heterosis for several characters in a small set of crosses showed that corn hybrids exhibit heterosis for almost all the traits, these findings are agreeing with Flint Garcia *et al*. (2009), who analyzed a large set of hybrid maize for heterosis.

Several studies have demonstrated the significance of positive heterosis on crop improvement in maize. For instance, Hernandez *et al.* (2013) conducted a study on maize hybrids in Mexico and reported that positive heterosis was associated with improved yield potential. In the same vein, Kassa *et al.* (2019) reported that positive heterosis was the primary factor driving improved grain yield in maize hybrids in Ethiopia. Furthermore, Riedelsheimer *et al.* (2012) showed that hybrids with higher positive heterosis possessed specific genetic variants that contributed to improved maize yield. Generally, Flint-Garcia *et al.* (2009) who reported that the application of heterosis is extremely effective for the genetic improvement of different traits and is the fundamental tools for enhancing productivity of different crops in the form of F_1 hybrids. The results of the current experiment detected that heterosis increases yield potential in maize and these result is in line with Araus *et al*. (2010) who reported that the underlying mechanisms of heterosis is an important tool to increases yield potential.

Other studies have also shown that positive heterosis is desired in the selection for yield and its components (Lamkey and Edwards, 1999). The results are in harmony with Fetahu *et al*. (2015) who evaluated mode of inheritance level of heterosis for plant height and grain weight from parents into the F1 generation, in order to create and develop desired genotypes for particular purposes.

High and significant heterosis for cob weight was accompanied by significant heterosis for one or more yield contributing characters. Amiruzzaman *et al*. (2013), Izhar and Chakraborty (2013), Hiremath *et al*. (2013), Kage *et al*. (2013), Kumar *et al*. (2014) and Ruswandi *et al*. (2015) reported positive and significant economic heterosis in maize for grain yield. Rosa *et al*. (2002) also reported similar findings that in their study there was significant level of heterosis for the yield. Gadad (2003) found significant and positive standard heterosis for test weight in inter-varietal crosses of maize. Gurung (2006) indicated that -22 to 63.1% heterosis for grain yield in maize populations. Also, Sharma *et al*. (2016) reported that there was more than 20% standard heterosis in single cross hybrids of maize.

Conclusion

The study shows that significant genetic variation for useful traits of maize can be generated from making single cross hybrids. The cross combinations that gave high yielding hybrids were SC 645 X SAMMAZ 51, SC 645 X SAMMAZ 27. These cross combinations also exhibited remarkable earliness. Thus, SC 645, SAMMAZ 51, SAMMAZ 27 can be used for hybrid production to improve yield and earliness in maize.

The hybrids evaluated exhibited useful heterosis for measured traits in the positive and negative direction, except for number of cobs per plant for which there was no heterosis exhibited by all hybrids.

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