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Maize Hybrids Agronomic Performance Using Lines by Testers in Mali Sudano-Sahelian Zone

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Abstract: Mali is a developing country where the agricultural sector occupies approximately more than 80% of the population. The lack of structure specialized in the production of improved seeds and the organization of producers, the irregularity and the poor distribution of the rains constitute a concern for all the actors concerned. This work is based on the agronomic performance maize hybrids. It is a question of producing hybrid varieties from lines resulting from the local populations of Mali. In this work, trials were conducted in Sotuba with 20 genotypes in two planting dates. Genotypes were composed of single cross hybrids having two testers in common, namely TZI1876 and V481-73. Proper choice of parents for hybridization is a necessity for the development of high yielding maize varieties. Twelve morphological and agronomic traits were studied in a lines/testers crossing scheme where the testers were females and the lines were males. The general objective of this study is to contribute to increase maize productivity in Mali Sudano-Sahelian zone. The experimental design was Randomized complete Block Design. The observations focused on following traits: Plant height, day to anthesis, day to silk, plant height, ear height, plants aspect, ears aspect, and grain yield. The analysis of variance showed a significant difference for ear height, day to anthesis, day to silk, grain yield, plant aspect. The best hybrid was TZI1876/1368+PAC.

Keywords: Performance, Hybrids, Lines, Mali

1. Introduction

Cereals are the staple food of populations and play an important role in world agriculture. According to FAO [7] 720 million hectares of cereals are cultivated in the world, whose 51% of arable land, 14.6% of the world's agricultural area and 5.5% of the world's emerged land. Among cereals, maize (*Zea mays* L) has the largest cultivation area. It extends over 132 million hectares from latitude 40° South in Argentina and South Africa, to latitude 58° North in Canada in the Andes. It culminates at 4000 meters above sea level. Corn is the third cereal that enters the diet after wheat and rice. Its world production amounts to about 500 million tons per year Marchand et al [10]. Maize is the most produced cereal in the world Marchand et al [10], with a yield of two to six tons, on 210 million hectares. In Africa, maize, rice and tubers are the main staple foods in the diet of urban populations DABIRE [4]. In Eastern and Southern Africa, it represents 41% of areas planted with cereals and 21% in Western and Central Africa [9].

The economy of the majority of developing countries is essentially based on the primary sector. Economic growth in Mali is mainly attributable to the primary sector (agriculture, livestock, fishing and forestry) which contributes about 40% of GDP and provides nearly 80% of export earnings [7]. Agriculture is based on cereals (millet, sorghum, maize, rice and *Digitaria exilis*). These cereals occupy 80% of the sown areas and constitute the staple diet of the majority of the

population [7].

In consideration of this strategic position that the authorities have decided to make the agricultural sector the engine of economic development in Mali. To achieve this objective, the government is committed to allocating 15% of the national budget to the agricultural sector each year and supporting a subsidy program for agricultural equipment. Thus, the results obtained during the 2019-2020 agricultural campaign are encouraging, according to the authorities [11]. The sector was able to achieve a production of 10,544,068 tons of cereals with a cereal surplus of 4,583,510 tons. The agricultural area was 43.7 million hectares [3].

Cereal production for the 2017/2018 growing season is estimated at 9,295,974 tones, for all cereals. It is up by 5.04% compared to 2016/2017 growing season which was 8,849,551 tones [7].

In Mali in 1960, maize was grown only as home fields and the national production was 50,000 tons. It is the traditional cereal with the highest yield potential. Agricultural statistics show an increase in maize production in Mali. Indeed, this production increased from 50,000 tons in 1960 to 4,248,916 tons in 2019 [5], compared to a production of 3,624,950 tons in 2018 [5]. Maize represents around 35% of the country's 10 million tons (Mt) of cereal production, alongside millet, *Digitaria exilis*, sorghum and rice.

Despite its productivity, maize is confronted with several constraints in Mali, namely diseases (helminthosporiose, viruses and rust), insects, striga irregular rains, flooding, rainfall deficit, low soil fertility, inappropriate cultivation practices such as late sowing, drought, low productivity of landraces, etc.

Among all these constraints, the low productivity of landraces, the rainfall deficit and the presence of Striga hermonthica cause more damage to maize COMBARI [2]. This is how the Rural Economic Institute and its partners (International Institute of Agriculture Tropical, and International Maize and Wheat Improvement Center), through its maize program, are working hard to make these three major constraints a priority; to provide farmers with high-performance varieties that are tolerant and resistant to drought and striga hermonthica.

In this present work, it is a question of determining the agronomic performance of maize hybrids using line/tester.

2. Objectives

2.1. Overall Objective

Contribute to improving the productivity of maize varieties in the Sudano-Sahelian zone in Mali.

2.2. Specific Objectives

1) Determine the ideal date for sowing corn.
2) Determine the best tester.
3) Determine the performance of hybrids.

3. Materials and Methods

3.1. Experimental Sites

This study was established at Sotuba research station.

The Sotuba agronomic research station is located at left of Niger River and covers an area of two hundred and sixty-eight (268) ha. The Geographic Coordinates are 12°39'47" North, 7°55'02" West.

The average annual rainfall is from one thousand (1000) to one thousand two hundred (1200) millimeters.

3.2. Plant Material

TZI1876 and V481-73 testers were used with ten (10) lines to generate twenty (20) table 1 hybrids.

Table 1. *List of hybrids.*

Testeurs (T) femelle	Lignées (L) Mâle	Hybrides (T X L)
TZI1876	CML442	TZI1876 X CML442
	S6 7-14	TZI1876X S6 7-14
	EXP124-1	TZI1876 X EXP124-1
	9071	TZI1876X 9071
	J 16-1	TZI1876 X J16-1
	CML538	TZI1876X CML538
	S6 1-6	TZI1876X S6 1-6
	CLQ6315	TZI1876X CLQ6315
	1368+PAC	TZI1876X 1368+PAC
	S6 82-86	TZI1876X S6 82-86
V481-73	CML442	V481-73 X CML442
	S6 7-14	V481-73 X S6 7-14
	EXP124-1	V481-73 X EXP124-1
	9071	V481-73 X 9071
	J 16-1	V481-73 X J16-1
	CML538	V481-73 X CML538
	S6 1-6	V481-73 X S6 1-6
	CLQ6315	V481-73 X CLQ6315
	1368+PAC	V481-73 X 1368+PAC
	S6 82-86	V481-73 X S6 82-86

These materials were planted at two planting dates. The first planting date was 09/06/2017 and the second date was 22/07/2017.

3.3. Experimental Design

The experimental design was Randomized complete Block Design with three (3) replications. The trials were established at the Sotuba research station. The distance between rows was 75 cm 5m long and 25 cm between hill giving a plant population density of 53000 plants/ha.

4. Results and Discussion

4.1. First Planting Date

Genotypic mean squares were significant for ear aspect, days to silk and grain yield. Table 2.

Table 2. *Mean square of evaluated traits.*

Sources of Variation	D.f	Ear Aspect	Aspect Plant	Day to silk	Day to anthesis	Ear height	plant height	Grain yield
Replications	3	1.0615	0.6708	88.48	89.30	807.3	2495.2	9996300
hybrids	19	1.2334*	0.7770	45.32**	39.15	314.8	416.1	5925932*
Residual	57	0.6777	0.5809	14.02	28.32	189.3	270.9	2211195
Total	79							

D.f: Degree of Freedom * Probability = .05 ** Probability = .001

The best grain yield was obtained with TZI1876/1368+PAC (5467 kg/ha). Hybrid TZI1876/J16-1 was early. ZI1876/CLQ6315 was tallest (182.5cm). Hybrid TZI1876/S6 1-6 had short ear height (63.3 cm). The best plant and ear aspect were obtained with TZI1876/1368+PAC Table 3.

Table 3. *Mean of evaluated traits.*

Hybrids	Ear Aspect	Plant Aspect	Days to silk	Days to anthesis	Ear height	Plant height	Grain yield Kg/ha
V481-73/CML442	2.7	3.25	61	58	75	166.5	2191
9071/CML442	2.8	3.37	62	60	64.8	171.2	2420
TZI1876/EXP124-1	3.2	3	56	53	72	157.2	1245
TZI1876/CML442	3.5	3.62	64	60	69	159	1605
Tieba	2.8	2.87	63	59	77.3	173.5	1299
TZI1876/9071	2.1	2.62	61	58	88	172.2	2336
V481-73/J16-1	2.5	2.25	60	56	76.5	165.8	3972
V48173/CML538	1.75	3.12	60	56	80.3	159.5	3159
TZI1876/S6 1-6	2.75	2.62	60	57	63.3	177.8	1986
V481-73/9071	2.62	3.12	61	56	76.8	174	4192
Hypo	2.5	2.5	53	57	88.8	164.8	3538
TZI1876/J16-1	2.75	2.62	54	49	64	150.8	5379
V481-73/S6 1-6	1.62	2.62	56	53	65.8	181.5	4084
ZI1876/CLQ6315	2	2.5	62	55	84.5	182.5	3703
TZI1876/CML538	1.87	2.5	63	60	79.8	176.2	4030
TZI1876/S6 7-14	2.25	2.37	62	55	83	172.5	4103
TZI1876/1368+PAC	1.75	1.75	56	51	75.3	178.5	5467
V481-73/1368+PAC	2.37	3.25	63	59	64.3	162.5	2984
V481-73/EXP124-1	2.25	2.75	65	61	92.8	194	2816
V481-73/CLQ6315	3.5	3	59	57	79	165.2	3069
Mean	2.4	2.78	60	57	76	170.3	3179
Probability Probability	.05	-	.001	-	-	-	.05
LSD	1.16	-	5.3	-	-	-	2105
CV%	33	27.3	6.2	9.4	18.1	9.7	46.8

LSD: Least significant difference
CV: Coefficient of variation

4.2. Second Planting Date

Genotypic mean squares were significant for plant and, ear aspect, days to silk, days to anthesis, and grain yield Table 4.

Table 4. *Mean square of evaluated traits.*

Sources of Variation	D.f	Ear Aspect	Plant Aspect	Days to silk	Days to anthesis	Ear height	plant height	Grain yield
Replications	3	3.6448	1.9528	25.746	41.033	204.4	590.6	6888950
Hybrids	19	0.7952*	2.0395**	32.586**	25.721**	237.2	311.8	6742310**
Residual	57	0.3049	0.6524	7.500	7.025	197.8	183.8	1687138
Total	79							

D.f: Degree of Freedom * Probability = .05 **Probability = .001

The best grain yield was obtained with hybrid V481-73/1368+PAC (7489 kg/ha). The TZI1876/1368+PAC hybrid was the tallest (186.8 cm) and came second in terms of grain yield. TZI1876/J16-1 and Tieba had the best Ear height (63.2 cm) however the best plant and ear aspect was observed with TZI1876/S6 1-6 (1.12). The hybrid TZI1876/J16-1 was early (58 days for day to silk and 53 days for days to anthesis) Table 5.

Table 5. *Mean of evaluated traits.*

Varieties	Ear aspect	Aspect plant	Day to silk	Day to anthesis	Ear height cm	Plant height cm	Yield Kg/ha
V481-73/CML442	1.62	2.37	62	57	73.5	176.5	3567
V481-73/S6-7-14	1.5	3	64	60	72	165.8	3370
TZI1876/EXP124-1	2.37	1.87	58	54	78.2	175	3592
TZI1876/CML442	1.87	3.5	64	59	70.2	165.5	2882
Tieba	2.12	2.62	62	57	63.2	158.2	2345
TZI1876/9071	2.12	3.25	67	62	83.8	169.8	2562
V481-73/J16-1	2.75	2.37	62	58	83.8	171.2	3869
V48173/CML538	1.75	3.62	59	57	80.8	180.5	4739
TZI1876/S6 1-6	1.12	1.12	68	62	85	180.5	4542
V481-73/9071	1.5	2	60	56	75.5	169.2	5535
Hypo	1.5	2.37	58	55	89.8	176	4497
TZI1876/J16-1	1.75	2.5	58	53	63.2	147.8	4318
V481-73/S6 1-6	1.25	2	58	54	66.8	173	4526
ZI1876/CLQ6315	1.75	1.37	63	59	82.8	175.8	5283
TZI1876/CML538	1.37	2	63	58	75.2	173	5195
TZI1876/S6 7-14	1.87	2.25	62	56	88.5	172.8	3758
TZI1876/1368+PAC	1.12	1.37	60	55	77.8	186.8	6770
V481-73/1368+PAC	1.12	1.35	59	55	75.5	176.8	7489
V481-73/EXP124-1	1.5	2.37	63	60	83	182.5	3401
V481-73/CLQ6315	2.25	3	58	55	72.8	164.8	4015
Mean	1.7	2.31	61	57	77.1	172.1	4313
Probability	.05	.001	.001	.001	-	-	.001
LSD	0.78	1.14	3.9	3.8	-	-	1839.2
CV%	32.1	34.9	4.5	4.6	18.3	7.9	30.1

CV%: Coefficient of variation LSD: Least significant difference.

The hybrids performed well in second planting date with a 4313 kg/ha against 3179 kg/ha in second planting date in term of mean. The best yield was V481-73/1368+PAC with 7489 kg/ha. The combined analysis of the two planting dates shows that the hybrid TZI1876/1368+PAC the best in term of yield (6118 kg/ha) followed by V481-73/1368+PAC (5237kg/ha). We found that line 1368+PAC were common for both hybrids.

4.3. Combined Analysis Two Planting Dates

The combined analysis for two planting dates showed a significant difference between the hybrids for ear aspect, plant aspect, day to silk, day to anthesis, ear height, plant height and plant aspect Table 6.

Table 6. *Mean square of evaluated traits.*

Source of Variation	Df	Ear aspect	Plant Aspect	Day to silk	Day to anthesis	Ear height	plant height	Yeld
Date	1	24.0250	8.8360	54.06	14.40	46.1	129.6	51418764.
Varieies	19	1.4477**	1.9903**	61.57**	51.44*	432.3*	535.2*	9968248**
Residual	139	0.5839	0.6753	13.52	19.14	196.9	279.4	2332091.
Total	159							

D.f: Degre of freedom * Probability = .05 **Probability = .001

The TZI1876/1368+pac hybrid had the best yield (6118 kg/ha), the best plant aspect and the best ear aspect table 7. The earliest hybrid was TZI1876/J16-1 with 52 day for day to anthesis and 61 days for day to silk. The shortest hybrid was TZI1876/J16-1 (149.2 cm) with ear height was 63.6 cm.

Table 7. *Mean of evaluated traits for both planting date.*

Hybrids	Ear Aspect	plant Aspect	Day to silk	Day to anthesis	Ear height (cm)	Plant height (cm)	Yield (kg/ha)	Rank
V481-73/CML442	2.188	2.812	61	58	74.2	171.5	2879	16
9071/CML442	2.188	3.188	63	60	68.4	168.5	2895	15
TZI1876/EXP124-1	2.812	2.437	57	59	75.1	166.1	2418	19
TZI1876/CML442	2.688	3.562	64	58	69.6	162.2	2244	18
Tieba	2.500	2.750	62	58	70.2	165.9	1822	20
TZI1876/9071	2.125	2.938	64	60	85.9	171.0	2449	17
V481-73/J16-1	2.625	2.312	61	57	80.1	168.5	3921	11
V48173/CML538	1.750	3.375	60	56	80.580.5	170.0	3949	9
TZI1876/S6 1-6	1.938	1.875	64	59	74.1	179.1	3264	13
V481-73/9071	2.062	2.562	60	56	76.1	171.6	4863	3
Hypo	2.000	2.437	56	56	89.2	170.4	4017	8
TZI1876/J16-1	2.312	2.562	56	52	63.6	149.2	4848	4
V481-73/S6 1-6	1.438	2.312	57	54	66.2	177.2	4305	7

Hybrids	Ear Aspect	plant Aspect	Day to silk	Day to anthesis	Ear height (cm)	Plant height (cm)	Yield (kg/ha)	Rank
ZI1876/CLQ6315	1.875	1.937	63	57	83.6	179.1	4493	6
TZI1876/CML538	1.625	2.250	63	59	77.5	174.6	4613	5
TZI1876/S6 7-14	2.062	2.312	62	56	85.8	172.6	3930	10
TZI1876/1368+PAC	1.438	1.562	58	53	76.5	182.6	6118	1
V481-73/1368+PAC	1.750	2.300	61	57	69.9	169.6	5237	2
V481-73/EXP124-1	1.875	2.562	64	61	87.9	188.2	3109	14
V481-73/CLQ6315	2.875	3.000	59	56	75.9	165.0	3542	12
Mean	2.106	2.552	61	57	76.5	171.2171.2	3746.	
Probability	.005	.005	.005	.005	.005	.05	.005	
LSD	0.7554	0.8124	3.6	4.3	13.87	16.52	1509.7	
CV%	36.3	32.2	6.1	7.7	18.3	9.8	40.8	

CV%: Coefficient of variation LSD: Least significant difference.

5. Discussion

For the first planting date the best yield was obtained with TZI1876/1368+PAC (5467 kg/ha). The best yield for the second date was obtained with V481-73/1368+PAC, (7489 kg/ha). This yield is higher than that obtained on the first planting date. These results do not support the theory of Richards, [13] who says that early sowing has better yield potential than late sowing. Andrade et al. [1]; Tsimba et al. [14]; Parker et al. [12] went in the same way. However, early sowing is not synonymous with good yield because other factors may come into play during the plant's growth [6]. The best yield for the two planting dates combined was 6118 k/ha with TZI1876/1368+PAC. This hybrid performed well for the second planting date than the first planting date thus contradicting the idea of Richards, [13] and reinforcing the idea of Parker et al [12] which say that sowing early increases the probability of poor sowing conditions. The best hybrids for the two dates in terms of yield and ear aspect, namely TZI1876/1368*PAC and V481-73/1368+PAC, had the 1368+PAC line in common, which seems to be a good parent.

The early maturing hybrid for both planting dates was TZI1876/J16-1. Day to anthesis was 49 days and day to silk was 54 for the first planting date. For the second planting date there was 53 days and 58 days for day to anthesis and silk respectively. The interval between male and female flowering was the same for both planting dates (5 days). This interval is close to that found Fleury [8], who maintains that the required interval between male flowering and female flowering is less than 5 days. The latest hybrid for both planting dates was TZI1876/9071 with 60 days for day to anthesis and 64 days for day to silk that confirme again Fleury [8] work.

The TZI1876/1368+PAC hybrid had the best plant and ear aspect for the two combined dates. The choice of a variety can be made on plant and ear aspect data.

6. Conclusion

The combined analysis of the two planting dates showed that there was a difference between hybrids for plant aspect, ear aspect, day to silk, day to anthesis, plant height, ear height and yield. The best grain yield, the best plant and ear aspects were obtained with the two testers having the 1368+PAC line in common. The best hybrid was TZI1876/1368+PAC.

7. Recommendations

Hybrid TZI1876/1368+PAC will be produced for on-farm testing and demonstration plot. Inbred line TZI1876 and 1368+PAC will be multiplied for seed increase. Other inbred lines extracted from Mali maize population will be crossed with 1368+PAC to get high yielding adapted hybrid. Inbred lines early and extra early maturing group will be developed to face climate change.

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