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Comparison of two types of improved tropical maize populations in Benin

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Two types of improved tropical maize populations, ABY1 (an improved traditional population) and DMRESRW (an elite introduced improved population) were compared for important agronomic traits during 2 years in South Benin (tropical lowland zone) in two locations corresponding to two different types of growing conditions: Abomey-Calavi (favourable conditions) and Abomey (unfavourable conditions). A randomized complete block design with four replications was used. ABY1 was significantly later than DMRESRW and showed plant and ear heights significantly greater. The two populations were very mildly infected. Husk cover was excellent in ABY1 and intermediate in DMRESRW. ABY1 grain yield was significantly lower than that of DMRESRW in favourable growing conditions and not significantly different from it in unfavourable conditions. ABY1 harvest index was significantly lower than that of DMRESRW. Recommendations related to the use of the two varieties are formulated.

Key words: Benin, improved traditional populations, maize, tropical populations, tropical zone, varieties.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa and, with rice and wheat, one of the three most important cereal crops in the world. It is a staple food for an estimated 50% of the people in sub-Saharan Africa (IITA, 2009). In Benin, maize is the most widely cultivated food crop. More than half of the production, however, is obtained in the south (ONASA, 2011).

Improved maize varieties cultivated in Benin are of two types according to origin: introduced improved varieties and improved traditional populations. During the last three decades, several improved maize varieties bred by the International Institute of Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Center (CIMMYT) have been introduced and popularized in Benin. Fajemisin (1991) gave a list of those varieties. They include: EV8443SR, DMRESRW, EV8430SR for the south and TZBSR and TZPBSR for the north. They are open pollinated varieties, have high grain yield potentials, but are little accepted by growers and consumers due to their deficiencies: poor husk cover, susceptibility to storage pests and inappropriate grain texture and format. They are, therefore, little cultivated. During the last 5 years, six drought tolerant open pollinated varieties bred by IITA and CIMMYT were released for cultivation in Benin (Abate et al., 2012).

Among them appear: TZECOMP3DT, MVDC2SYNF2, DTSRWC2 and EV97DTSTRW. Improved traditional populations have been bred recently from the most widely grown traditional populations. This work was undertaken to compare an elite improved traditional population to an elite improved tropical population introduced in Benin and cultivated in many other countries of tropical Africa. The traits studied were:

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Table 1. Population means per trait (pooling analysis for locations in 2003).

Trait	Population		$LSD_{0.05}$	cv (%)
	ABY1	DMRESRW		
Days to 50% pollen-shed	62	53	2	1.9
Days to 50% silking	65	55	2	1.8
Plant height (cm)	233	182	30	7.7
Ear height (cm)	136	80	26	12.2
Husk cover	1	3	0.4	16

cv, Coefficient of variation; $LSD_{0.05}$, least significance difference at the 5% level.

earliness (days to pollen-shed, days to silking, days to maturity, number of leaves), plant height, ear height, reaction to diseases (rust caused by *Puccinia polysora*, tropical blight caused by *Exserohilum maydis* and maize streak caused by maize streak virus), husk cover, grain yield components (number of ears per plant, number of grains per ear, grain weight), grain yield and harvest index.

MATERIALS AND METHODS

Populations evaluation

The two improved evaluation compared are: (1) ABY1, an improved traditional population bred in Benin by phenotypic selection within a traditional population, HOLLIKOUI, widely grown in the south of the country. (2) DMRESRW, an elite tropical population bred by IITA and cultivated in several countries of tropical Africa. It is the most widely popularized maize improved variety in Benin.

The two populations were evaluated in 2003 and 2004 in two locations in South Benin, forest zone: Abomey-Calavi (latitude: 6°27'N; longitude: 2°22'E; altitude: 10 m) and Abomey (latitude: 7°11'N; longitude: 1°59'E; altitude: 260 m). A randomized complete block design with four replications was used in each trial. Soils were fertile at Abomey-Calavi and poor at Abomey. Each entry was grown in six 4.5 m rows separated by 0.80 m. Hills along the row were 0.50 m apart. Plots were overplanted and thinned to 2 plants per hill (50000 plants.ha^{-1}). Fertilisation consisted of 200 kg/ha of NPKSB (14-23-14-5-1) before planting and 25 kg/ha of urea (46% N) 2 and 6 weeks after planting. Weeding was optimal. Rainfall was sufficient and well distributed except in 2004 at Abomey where a long drought period prevented the evaluation.

Days to 50% pollen-shed, 50% silking and 50% maturity (dried husks) (days after planting) and number of leaves were recorded on a plot basis. Plant or ear height was measured on a plot basis as the distance from the soil surface to the panicle base (plant height) or the superior ear insertion point (ear height). Diseases were scored after silking under natural infection with a 1 to 5 scale (1 = very mild infection; 5 = very high infection). Husk cover was scored at maturity using a 1 to 5 scale [1 = excellent (tight husk going beyond the ear tip); 5 = very poor (naked ear tip)]. Grain yield and 1000 grain weight were recorded per plot at 15% moisture. Number of ears per plant (nep) and number of grains per ear (nge) were calculated as follows:

$$nep = ne/nph$$

Where ne = number of ears harvested on the plot; nph = number of plants harvested on the plot

$$nge = (gwe/tgw) \times 1000$$

where gwe = grain weight per ear, tgw = 1000 grain weight.

Harvest index (hi) was estimated after complete withering of the plants using the formula:

$$hi = ew/epw$$

With ew = weight of all the ears harvested on the plot; epw = weight of all the plants harvested on the plot.

Statistical analysis

Analyses of variance were carried out for each trait. Pooling analyses were permitted when residual variances were homogeneous at the 5% level. When significant ($P < 0.05$) differences among entries were noted, the means of the two populations studied were compared using the least significant difference (LSD) test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Significant differences among populations appeared for all traits in all trials except plant and ear heights, number of grains per ear, 1000 grain weight at Abomey, number of ears per plant at Abomey in 2003 and Abomey-Calavi in 2004 and grain yield at Abomey in 2003 and Abomey-Calavi in 2004. A significant population effect was noted in pooled analyses for all traits listed in Tables 1 and 2. Population means are shown in Tables 1 to 4.

Earliness

The variety ABY1 was significantly later than DMRESRW. Differences ranged from 4 to 12 days and 3 to 5 leaves depending on variable, location and year. Variations with location and year are probably due to genotype × environment interaction. That interaction was significant in many cases as shown in Tables 5 and 6. Growth duration was longer at Abomey (highest location). Growth duration increase with altitude has been also reported by Ayuk-Takem (1978) and Abadassi (2001).

Table 2. Population means per trait (pooling analysis for years at Abomey-Calavi.

Trait	Population		$LSD_{0.05}$	cv (%)
	ABY1	DMRESRW		
Days to 50% pollen-shed	58	50	2	2.2
Days to 50% silking	62	52	1	1.4
Number of leaves	24	21	2	4.5
Ear height (cm)	150	97	21	10.5
Grain yield (kg/ha)	4315	5706	1062	15.8

Table 3. Population means per trait at Abomey.

Trait	Population		$LSD_{0.05}$	cv (%)
	ABY1	DMRESRW		
Days to 50% maturity	100	88	6	2.9
Number of leaves	22	17	1	3.3
Number of ears per plant[a]	1.27	1.04		15.7
Number of grains per ear[a]	255	235		10.5
1000 grain weight (g)[a]	225	242		5.5
Grain yield (kg/ha)[a]	3690	2975		28.7
Rust	1	1		
Tropical blight	1	1		
Maize streak	1	1		
Harvest index	0.35	0.57	0.07	9.7

[a]Population effect was not significant.

Plant and ear height

ABY1, the latest population, had plant and ear heights significantly greater than those of DMRESRW. Differences were 50 or 51 cm for plant height and 53 to 56 cm for ear height. Positive correlation between plant height and growth duration (Jacquot, 1970) and plant and ear heights (Kim and Hallauer, 1989) in maize may explain that result. Heights varied with location and year, probably due to genotype × environment interaction. Nevertheless, that interaction was not significant in the pooled analyses permitted (Tables 5 and 6). Heights at Abomey were lower than those noted at Abomey-Calavi. This was not expected on the basis of positive correlation between plant height and growth duration. It may be due to the low fertility of soils at Abomey.

Reaction to diseases, husk cover

The two populations showed very mild infection (Score 1). Husk cover was excellent in ABY1 and intermediate in DMRESRW. Kossou et al. (1993) compared two international improved maize varieties with an improved local variety and found also that the international improved varieties had significantly poorer husk cover. A good husk cover confers resistance to the maize weevil *Sitophilus zeamais* (Kossou et al., 1993; Meikle et al., 1998, Demissie et al., 2008).

Grain yield components

ABY1 had a number of ears per plant significantly higher than or not significantly different from that of DMRESRW. The two populations were not significantly different for number of grains per ear. One thousand (1000) grain weight in ABY1 was significantly inferior to that of DMRESRW or not different from it. The variations with location and year are probably due to genotype × environment interaction.

Grain yield

ABY1 grain yield was significantly lower than that of DMRESRW at Abomey-Calavi. No significant difference was observed at Abomey. These results agree with those obtained by Kossou et al. (1993) and Abadassi (2001). Kossou et al. (1993) found also that an improved local variety had a grain yield significantly lower than those of two international maize varieties in Benin. Abadassi (2001) evaluated four introduced improved maize varieties and one improved local variety in southern and northern Benin and noted that the improved local variety

Table 4. Population means per trait at Abomey-Calavi.

Trait	Year	Population		$LSD_{0.05}$	cv (%)
		ABY1	DMRESRW		
Days to 50% maturity	2003	88	82	1	1
	2004	90	86	2	1.7
Number of ears per plant	2003	1.20	1.09	0.10	5.1
	2004[a]	1.01	1.00		5
Number of grains per ear	2003[a]	375	365		12.7
	2004[a]	350	339		18
1000 grain weight (g)	2003	221	326	41	10.6
	2004	208	296	17	4.8
Rust	2003	1	1		
	2004	1	1		
Tropical blight	2003	1	1		
	2004	1	1		
Maize streak	2003	1	1		
	2004	1	1		
Plant height (cm)	2004	229	179	35	10.1

[a]Population effect was not significant.

Table 5. Pooling analysis for locations in 2003.

Trait	Pooled error MS	Population × location interaction MS	F
Days to 50% pollen-shed	1.32	2.12	1.61^{ns}
Days to 50% silking	1.26	4.85	3.85*
Number of leaves	0.53	2.96	5.58*
Plant height	284.02	249.96	0.88^{ns}
Ear height	217.71	425.73	1.95^{ns}
Husk cover	0.062	0.197	3.18*
Grain yield	531489	2357555	4.44*

*Significant ($P<0.05$); ^{ns}, non significant ($P > 0.05$).

Table 6. Pooling analysis for years at Abomey-Calavi.

Trait	Pooled error MS	Population × year interaction MS	F
Days to 50% pollen-shed	1.52	7.52	4.95*
Days to 50% silking	0.71	8.79	12.38**
Days to 50% maturity	1.50	7.87	5.25**
Number of leaves	1.10	2.24	2.04^{ns}
Ear height	200	628.25	3.14^{ns}
Number of ears per plant	0.0033	0.0184	5.58**
Grain yield	510799	121183	0.24^{ns}

*Significant ($P<0.05$); **highly significant ($P < 0.01$); ^{ns}, non significant ($P > 0.05$).

had always the least grain yield or was not significantly environment interaction may explain variations with different from the least yielding variety. Genotype x environment interaction may explain variations with location and year. It was significant in 2003 (Table 5). Growing conditions especially soil fertility were favourable at Abomey-Calavi and unfavourable at Abomey. Those environmental differences may explain higher yields obtained at Abomey-Calavi. The results suggest:

(1) DMRESRW has probably a potential grain yield higher than that of ABY1,
(2) The two populations may not be significantly different for grain yield in unfavourable growing conditions.

Further work involving more locations may permit to refine the conclusions.

Harvest index

Harvest index was estimated after complete withering of the plants. It was assumed that at that stage, the whole plants and the ears were at the same moisture content. That may not be always exact. Biases could, therefore, have occurred; but, varieties comparison should be valid since the same bias applied to all varieties. ABY1 harvest index was significantly lower than that of DMRESRW. It is, nevertheless similar to the harvest index reported by Yamaguchi (1974), Goldsworthy et al. (1974) and Bjarnason et al. (1985) for most tropical maize varieties. Further work using drying ovens will permit to obtain more precise values.

Conclusion

The improved traditional population ABY1 appeared significantly later than the introduced improved population DMRESRW in South Benin (lowland tropical zone). It had greater plant and ear heights. The two populations were very mildly infected by diseases. Husk cover was excellent in ABY1 and intermediate in DMRESRW. Grain yield of ABY1 was significantly lower than that of DMRESRW in favourable growing conditions and not significantly different from it in unfavourable growing conditions. ABY1 harvest index was significantly lower compared to the one of DMRESRW.

On the other hand, the type of grain of ABY1 (small white grain easy to grind) is highly appreciated by consumers in Benin at the opposite of the big white difficult to grind grain of DMRESRW.

ABY1 still needs to be improved for reduced plant and ear heights, harvest index and grain yield. However, the following recommendations can be made for South Benin and similar environments in tropical lowland zone:

(1) In favourable growing conditions, if grain type is not an essential criterion, DMRESRW should be preferred to ABY1,
(2) If grain type is an essential criterion (production destined to human consumption, for example) and the grain type preferred is, as in Benin, small white grain easy to grind, ABY1 should be chosen,
(3) In unfavourable growing conditions, if grain type is not an essential criterion, any of the two varieties can be chosen. But, ABY1 has the advantage of possessing an excellent husk cover which can prevent grain infection by storage pests in field.

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