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Development of a yellow grains improved maize variety in Benin

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Abstract

A yellow grains improved maize variety, EVMBY1, was developed in Benin. It derived from the cross between an elite tropical maize population, EV8443SR and an American temperate inbred line B73. The F1 of the cross EV8443SR × B73 was backcrossed to EV8443SR to obtain the BC1. Two cycles of random mating followed and led to EVMBY1. EVMBY1 was evaluated during two consecutive years in two tropical agroecological zones (South and North Benin). It appeared medium maturing, mildly infected by diseases, relatively high grain yielding (up to 5.9 t/ha) and had an intermediate husk cover. Compared to the improved variety DMRESRW introduced and popularized in Benin, EVMBY1 was later, not significantly different for grain yield, reaction to diseases, and husk cover and showed lower harvest index; but, it has the advantage of possessing yellow grains. Those grains contain appreciable levels of carotenoids (pro-vitamin A) at the opposite of the white grains of DMRESRW. EVMBY1 still needs to be improved notably for husk cover and harvest index. But, its cultivation and consumption can already contribute to the reduction of vitamin A deficiency in Benin.

Keywords: Benin, maize, variety, vitamin A, yellow grains.

Introduction

Maize (*Zea mays* L.) is a main food crop cultivated in several countries of the globe and used for human consumption, animal feeding and industries. The world top three producing countries in 2012 were the United States of America, China and Brazil with respectively 43%, 26% and 9% of the world production. In Africa, about 69 millions tons of maize (8% of the world production) were harvested on more than 33 millions hectares in 2012 (FAO, 2013). Maize is the most important cereal crop and a staple food for about half of the people in sub-Saharan Africa (IITA, 2009) The demand is increasing and strong technological interventions are needed to satisfy it (Shiferaw et al., 2011).

In Benin, maize is one of the most important food crops. It is a staple food for most people. Traditional populations obtained from natural mating between maize populations introduced from Americas (Westengen et al., 2012; Mir et al., 2013) and improved varieties mainly introduced from the International Institute of Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Center (CIMMYT) are grown. But, the most cultivated and consumed varieties are white grains populations (Abadassi, 2014; 2015a). The white grains of maize are poor in carotenoids (pro-vitamin A) whereas the yellow grains can contain appreciable levels of pro-vitamin A (Chandler et al., 2013; Ranum et al., 2014). The development and popularization of yellow grains improved maize varieties can, therefore, contribute to reduce the risks of vitamin A deficiency in Benin. This work was undertaken to develop a yellow grains improved maize variety for Benin.

Materials and Methods

Development of the variety

EVMBY1 derived from the cross between an elite tropical maize population, EV8443SR and a temperate inbred line B73. EV8443SR was bred by IITA and CIMMYT. It is a late, white grains, relatively high yielding variety resistant to the major maize diseases prevailing in Benin. B73 is an American yellow grains inbred line. The F1 of the cross EV8443SR × B73 was backcrossed to EV8443SR to obtain the BC1. The BC1 was random mated twice at Allada (South-Benin, degraded forest zone; latitude: 6°42'N; longitude: 2°7'E; altitude: 105 m) to constitute EVMBY1. During the two cycles of random mating, a low selection pressure was applied: the plants showing disease symptoms were discarded.

Evaluation

EVMBY1 was evaluated during two consecutive years in two locations of Benin: Allada and Bembéréké (North-Benin, savanna zone, latitude: 9°58'N; longitude: 2°44'E; altitude: 358 m). A randomized complete block design with three repetitions was used. DMRESRW, the most popularized maize variety in Benin during the last three decades, was used as check. Six 5 m rows separated by 0.80 m constituted each plot. Spacing between consecutive hills along a row was 0.50 m. Planting density was 50000 plants.ha^{-1}. Two types of fertilizer were applied: NPKSB (14-23-14-5-1) (200 kg/ha before planting) and urea (46% N) (25 kg/ha two and six weeks after planting). Weeding was adequate. At Allada, few drought periods were noted whereas at Bembéréké, rainfall was sufficient and regular.

The following traits were considered: earliness (days to 50% pollen-shed, days to 50% silking, days to 50% maturity, number of leaves), plant and ear heights, reaction to diseases (rust caused by *Puccinia polysora*, tropical blight due to *Exserohilum maydis* and maize streak caused by maize streak virus), husk cover, grain yield and its components, harvest index, and grain colour. Observations and calculations were performed as described by Abadassi (2016).

Statistical analysis

Analyses of variance were effected per trait. Pooling analyses were permitted when residual variances were homogeneous at the 5% level. When significant ($P<0.05$) entry effect appeared, variety means were compared using Newman-Keuls test.

Results and Discussion

Significant variety effect was obtained for all traits analysed in all trials. Tables 1 and 2 give variety means.

Earliness

For the variety EVMBY1, days to 50% pollen-shed, silking and maturity varied from 53 to 59, 54 to 60 and 89 to 98 respectively depending on location and year. The number of leaves varied from 16 to 19. On the basis of flowering and maturity, EVMBY1 appeared later than DMRESRW. Differences ranged from 2 to 8 days. Variations with location and year may be explained by genotype × environment interaction. However, that interaction was not always significant (tables 3 to 6). Cycle duration was longer at Bembéréké, the highest location. That result agrees with those recorded by Ayuk-Takem (1978) and Abadassi (2016). Those authors reported also cycle duration increase with altitude.

Plant and ear heights

EVMBY1 plant and ear heights varied from 207 to 235cm and 91 to 125 cm, respectively. DMRESRW shows plant and ear heights lower than those of EVMBY1; but the differences were not always significant. Variations with location and year probably due to genotype × environment interaction were observed. That interaction was significant in the pooling analyses permitted. Heights were greater at Bembéréké. That can be explained by the positive correlation between cycle duration and plant height (Jacquot, 1970; Abadassi, 2015b) and plant and ear heights (Kim and Hallauer, 1989; Abadassi, 2015b) in maize.

Table 1. Variety means per trait at Allada

Trait	Year	Variety		cv (%)
		EVMBY1	DMRESRW	
Days to 50% pollen-shed	1	52.9a	49.8b	3.1
	2	54.7a	48.1b	4.5
Days to 50% silking	1	53.8a	50.7b	2.9
	2	55.9a	47.9b	5.0
Days to 50% maturity	1	91.7a	87.6b	2.1
	2	88.9a	86.8b	1.9
Number of leaves	1	16.3a	16.1a	3.4
	2	18.9a	16.7b	6.2
Plant height (cm)	1	215a	205a	7.8
	2	207a	158b	8.1
Ear height (cm)	1	91a	87a	15.1
	2	98a	75b	14.9
Rust	1	1a	1a	25.8
	2	1a	1a	26.1
Tropical blight	1	2a	2a	22.9
	2	2a	2a	17.2
Number of ears per plant	2	0.92a	1.0a	16.1
Number of grains per ear	2	328a	370a	23.7
1000 grain weight (g)	2	259a	267a	12.2
Grain yield (kg/ha)	1	2901a	2401a	21.2
	2	3017a	3524a	19.4

For each trait, means followed by the same letter are not significantly different at the 5% level.
cv = coefficient of variation.

Table 3. Pooling analysis for locations in the first year

Trait	Pooled error MS	Variety× location interaction	
		MS	F
Days to 50% silking	3.04	3.42	1.12ns
Plant height	109.68	702.14	6.40**

* * Highly significant ($P<0.01$); ns non significant ($P>0.05$).

Reaction to diseases and husk cover

EVMBY1 showed very mild or mild infection (score 1 or 2). Its husk cover was intermediate as was that of DMRESRW.

Table 2. Variety means per trait at Bembéréké

Trait	Year	Variety		cv (%)
		EVMBY1	DMRESRW	
Days to 50% pollen-shed	1	56.9a	54.9a	2.3
	2	58.8a	53.7b	2.0
Days to 50% silking	1	58.9a	56.9a	2.5
	2	59.7a	54.8b	1.9
Days to 50% maturity	1	98.1a	93.9b	2.5
	2	92.8a	86.8b	2.1
Number of leaves	1	18.1a	16.9a	4.1
	2	18.9a	17.8a	5.9
Plant height (cm)	1	235a	222a	5.5
	2	232a	201b	7.0
Ear height (cm)	1	110a	103a	11.9
	2	125a	105b	12.1
Rust	1	1a	1a	21.8
	2	1a	1a	22.7
Tropical blight	1	1a	1a	23.2
	2	1a	1a	27.9
Maize streak	2	2a	1a	22.1
Husk cover	2	3a	3a	28.6
Number of ears per plant	1	0.88a	1.02a	9.9
	2	0.94a	1.03a	17.1
Number of grains per ear	1	412a	465a	10.9
	2	458a	439a	26.7
1000 grain weight (g)	1	337a	292a	9.1
	2	318a	310a	9.0
Grain yield (kg/ha)	1	5201a	5462a	14.1
	2	5910a	6402a	28.8
Harvest index	2	0.35b	0.53a	18.2

For each trait, means followed by the same letter are not significantly different at the 5% level.
cv = coefficient of variation.

Grain yield components

The number of ears per plant, the number of grains per ear and 1000 grain weight of EVMBY1 varied from 0.88 to 0.94, 328 to 458 and 259 to 337 g, respectively. EVMBY1 was not significantly different from DMRESRW for the three grain yield components studied.

Table 4. Pooling analysis for locations in the second year

Trait	Pooled error MS	Variety× location interaction	
		MS	F
Days to 50% maturity	2.95	10.81	3.66**
Plant height	228.98	432.01	1.89*

* Significant (P<0.05); * * highly significant (P<0.01).

Table 5. Pooling analysis for years at Allada

Trait	Pooled error MS	Variety × year interaction	
		MS	F
Days to 50% maturity	0.92	1.19	1.29ns
Plant height	92.90	193.01	2.08*

* Significant (P<0.05); ns non significant (P>0.05).

Table 6. Pooling analysis for years at Bembéréké

Trait	Pooled error MS	Variety × year interaction	
		MS	F
Days to 50% silking	1.19	67.89	57.05**
Plant height	99.97	3798.21	37.99**

* * Highly significant (P<0.01).

Grain yield

EVMBY1 gave a grain yield of 2.9 and 3.0 t/ha at Allada. Its grain yield at Bembéréké was higher: 5.2 and 5.9 t/ha. EVMBY1 and DMRESRW were not significantly different for that trait. Environmental conditions can explain grain yield differences noted between Allada (degraded forest zone) and Bembéréké (savanna zone): Bembéréké conditions are more favourable for maize production than those of Allada.

Harvest index

EVMBY1 harvest index (0.35) was significantly lower than that of DMRESRW. It is, nevertheless, close to the harvest indexes noted by Yamaguchi (1974), Goldsworthy et al. (1974), Bjarnason et al. (1985) and Abadassi (2013, 2016) for many tropical maize varieties.

Grain colour

EVMBY1 has yellow grains. Such grains contain appreciable levels of carotenoids (pro-vitamin A) at the opposite of the white grains of DMRESRW (Chandler et al., 2013; Ranum et al., 2014). The consumption of EVMBY1 grains can, therefore, contribute to reduce vitamin A deficiency.

Conclusion

A yellow grains improved maize variety, EVMBY1, was developed in Benin. It appeared medium maturing, mildly infected by diseases, relatively high grain yielding (up to 5.9 t/ha) and had an intermediate husk cover. Compared to the improved variety DMRESRW, EVMBY1 was later, not significantly different for grain yield, reaction to diseases (rust, tropical blight and maize streak), and husk cover and showed lower harvest index; but it has the advantage of possessing yellow grains. Those grains contain appreciable levels of pro-vitamin A at the opposite of the white grains of DMRESRW. EVMBY1 still needs to be improved notably for husk cover and harvest index. But, its cultivation and consumption can already contribute to the reduction of vitamin A deficiency in Benin.

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