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Research Article

Introgression of Temperate Material to Improve Grain Yield in a Tropical Maize Population

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ABSTRACT

The effect of introgression of the temperate maize population BUGARD on the grain yield of a low-yielding tropical maize population well appreciated for the quality of its grains, NCP80, was studied. NCP80 was crossed with BUGARD to obtain the F1. The BC1 obtained by backcrossing the F1 to NCP80 was random mated thrice. The tropical parent NCP80 and the BC1 (NBN) were evaluated in two tropical locations using a randomized complete block design with three replications. Introgression of the temperate population BUGARD into the tropical population NCP80 significantly increased grain yield. The resulting population, NBN, appeared, moreover, significantly earlier than NCP80 and not significantly different from it for resistance to rust, tropical blight and maize streak, ear height, husk cover and harvest index. NBN may, further, be improved for resistance to maize streak and grain yield by recurrent selection.

Keywords: *Exotic germplasm, Grain yield, Introgression, Temperate maize, Tropical maize.*

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop widely cultivated in the world. It is the main tropical crop domesticated in America (Edmeades et al., 2017). In Sub-Saharan Africa, the demand in maize may triple by 2050 due to rapid population growth (Ekpa et al., 2018). In Benin, maize is the most cultivated cereal crop; but, its production is limited by technical, biological, socio-economic and climatic constraints (Abadassi, 2014a). Improved varieties mainly introduced from the International Institute of Tropical Agriculture (IITA) and the International Maize and Wheat Improvement Center (CIMMYT) and traditional populations are cultivated in Benin. The traditional populations may derive from natural mating among maize populations introduced from America (Westengen et al., 2012; & Mir et al., 2013). They are the most cultivated varieties in Benin (Abadassi, 2014b). The high yielding improved varieties introduced from IITA and CIMMYT are little accepted by producers and consumers due to their deficiencies: poor husk cover, susceptibility to storage pests and inappropriate grain texture and format.

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Some cultivars are highly appreciated by producers and consumers for their adaptation to low-input farming systems, their good husk cover, their low susceptibility to storage pests and their good grain quality. But, their potential grain yields are low. Different methods including recurrent selection and introgression of exotic germplasm can be used to increase those potentials. Introgression of exotic germplasm into an adapted population permitted to increase significantly grain yield (Marandu, 1985; Mungoma & Pollak, 1988; Eagles et al., 1989; Hainzelin, 1998; Mushayi et al., 2020; & Musundire et al., 2021) but led also to grain yield decreases or not significant effect on grain yield (Albrecht & Dudley, 1987; Sauvaire & Sanou, 1989; Eagles & Hardacre, 1990; Abadassi et al., 1998; Hainzelin, 1998; & Abadassi & Hervé, 2000). The results may, then, vary with populations and methodology. This work was, therefore, initiated to evaluate the effect of the introgression of a temperate material on grain yield in a low yielding tropical maize variety well appreciated in Benin notably for the quality of its grains.

MATERIALS AND METHODS

Genetic material

The tropical population used was NCP80, a variety bred by the Agricultural Research Center of Niaouli (South Benin) from traditional maize populations. It is early, resistant to rust and tropical blight and moderately resistant to maize streak. Its grains (small white grains easy to grind) are well appreciated by Beninese consumers; but, its grain yield potential is low. The temperate material was BUGARD, a French white grains maize population. NCP80 was crossed with BUGARD to obtain the F1. The BC1 obtained by backcrossing the F1 to NCP80 was random mated thrice at Allada (southern Benin, latitude: 6°42’N; longitude: 2°7’E; altitude: 105 m) to constitute NBN.

Evaluation

The tropical parent NCP80 and the BC1 (NBN) were evaluated at Allada and Bembéréké (northern Benin, savanna zone; latitude: 9°58’N; longitude: 2°44′E; altitude: 358 m) using a randomized complete block design with three replications. Planting, fertilization and weeding were realized as described by Abadassi (2013). A few drought periods occurred at Allada; at Bembéréké, rainfall was sufficient and well distributed.

Earliness (days to 50% pollen-shed and 50% silking (days after planting)), plant height, ear height, diseases (rust caused by *Puccinia polysora*, tropical blight due to *Exserohilum maydis* and maize streak caused by maize streak virus), husk cover and harvest index were noted as indicated Abadassi (2013). Grain yield was recorded per plot at 15% moisture content.

Statistical analysis

Analyses of variance were effected for grain yield and the other agronomic traits observed per location. When a significant ($P<0.05$) population effect was noticed, the population means were compared using Newman- Keuls test.

RESULTS AND DISCUSSION

Significant population effect appeared for grain yield and the other traits observed in the two locations. For grain yield, the residual variances were not homogeneous at the 5% level. Hence, pooling analysis of variance was not permitted and the results were examined per location. Table 1 gives the population mean grain yields per site. Table 2 shows the introgression effects on grain yield. In both locations, NBN grain yield was significantly higher than that of NCP80. Introgression of the temperate population BUGARD increased, then, significantly, grain yield in the tropical population NCP80. The effects were consistent: +1102 kg/ha (+71%) at Allada; +1414 kg/ha (+67%) at Bembéréké. That grain yield increase can be explained by a high concentration of favorable alleles of grain yield in NBN and a low effect of non adaptation to tropical environment alleles. These results agree with those reported by Marandu (1985), Mungoma & Pollak (1988), Eagles et al. (1989), Hainzelin (1998), Mushayi et al. (2020) and Musundire et al.

(2021). Those authors obtained also significant grain yield increases through introgression of exotic material into adapted populations. The results are in discordance with the grain yield decrease or the non significant effect on grain yield noted by Albrecht & Dudley (1987), Sauvaire & Sanou (1989), Eagles & Hardacre (1990), Abadassi et al. (1998), Hainzelin (1998) and Abadassi & Hervé (2000). The dissimilarities observed may be due to the populations and the methodology utilized.

Table 1: Population mean grain yields (kg/ha)

Location	Population		cv (%)
	NBN	NCP80	
Allada	2654a	1552b	18.5
Bembéréké	3529a	2115b	16.8

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

Table 2: Introgression effects on NCP80 grain yield

Location	Effect (kg/ha)	Effect (%)*
Allada	+1102	+71
Bembéréké	+1414	+67

* Effect in % of NCP80 mean grain yield.

Table3. Population means for other agronomic traits

Trait	Location	Population	
		NBN	NCP80
Days to 50% pollen-shed	Allada	45b	49a
	Bembéréké	48b	53a
Days to 50% silking	Allada	48b	51a
	Bembéréké	51b	55a
Rust	Allada	1a	1a
	Bembéréké	2a	2a
Tropical blight	Allada	2a	2a
	Bembéréké	2a	2a
Maize streak	Bembéréké	3a	3a
Plant height (cm)	Allada	170a	140b
	Bembéréké	175a	166a
Ear height (cm)	Allada	82a	73a
	Bembéréké	101a	89a
Husk cover	Bembéréké	2a	2a
Harvest index	Bembéréké	0.46a	0.44a

For each trait and each location, means followed by the same letter are not significantly different at the 5% level.

CONCLUSION

Introgression of the temperate population BUGARD into the tropical population NCP80 significantly increased grain yield. The resulting population, NBN, appeared, moreover, significantly earlier than NCP80 and not significantly different from it for resistance to rust, tropical blight and maize streak virus, ear height, husk cover and harvest index (table 3). NBN may, further, be improved for resistance to maize streak and grain yield by recurrent selection.

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