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Mass Selection to Improve Grain Yield in a Traditional Tropical Maize Population

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ABSTRACT

This study was undertaken to evaluate the effectiveness of mass selection to improve grain yield in a traditional tropical maize population widely cultivated in Benin, PTMB3 (HOLLIKOUI). PTMB3 was subjected to two cycles of stratified mass selection for grain yield in southern Benin. The selection intensity was 5%. The two populations obtained after selection and the source population were evaluated in field in two locations of South Benin. The experimental design was a randomized complete block design with four replications. No significant difference was observed among the three populations for grain yield. That method did not, therefore, appear effective to improve grain yield in PTMB3. Other methods are suggested to improve significantly grain yield in PTMB3 and other traditional maize populations.

Key words: *grain yield, maize, mass selection, traditional tropical population.*

1. INTRODUCTION

Maize is the most important cereal crop in Benin on the basis of area cultivated and production (FAO, 2013). It is cultivated throughout the whole country; but, the highest producing zone is the south (ONASA, 2013). The most cultivated maize varieties in Benin are traditional populations. They possess, at the opposite of the improved varieties introduced, characteristics generally well appreciated by producers and consumers such as adaptation to low-input farming systems, excellent husk cover, low susceptibility to storage pests, and good grain quality. But, their potential grain yields are relatively low (Abadassi, 2014).
The increase of grain yield potential of the most cultivated traditional maize populations in Benin without modification of the characteristics needed by producers and consumers will generate higher yielding populations very close to the initial populations for other traits. Such improved populations should be easily and durably accepted by producers and consumers. As a result, maize production will increase substantially in Benin.

The improvement needed can be achieved by intrapopulation recurrent selection. Gallais (1990, 2011) distinguished two groups of intrapopulation recurrent selection methods: phenotypic recurrent selection (individual phenotypic recurrent selection or mass selection, family phenotypic recurrent selection, combined phenotypic recurrent selection (individual + family)) and descent recurrent selection (half-sib family recurrent selection, full-sib family recurrent selection, S1 family recurrent selection, doubled haploid (DH) or single seed descent (SSD) family recurrent selection, descent recurrent selection with tester). Mass selection is the oldest plant breeding method (Allard, 1960) and probably the most used over time (Abreu et al., 2010). It is simple, rapid and low costing. It permitted to obtain substantial grain yield gains in maize (Gardner, 1961, 1969; Johnson, 1963; Lonnquist, 1967; Arboleda-Rivera and Compton, 1974; Taran et al., 2004; Rahman et al., 2007) although it is usually lowly efficient for lowly heritable traits like grain yield. It is therefore judicious, in the first phase of improvement of traditional maize populations for grain yield, to determine the efficiency of mass selection.
The objective of this study was to evaluate the effectiveness of mass selection to improve grain yield in a traditional tropical maize population widely grown in Benin.

2. MATERIALS AND METHODS

Source Population

The source population is PTMB3 (HOLLIKOUI), a traditional maize population widely cultivated in Benin and highly appreciated by producers and consumers notably for its adaptation to low-input farming systems, its resistance to the main diseases of the zone, its low susceptibility to storage pests, its excellent husk cover and the good quality of its grains (small white grains easy to grind). Its potential grain yield is relatively low.

Selection

PTMB3 was subjected to 2 cycles of stratified mass selection in southern Benin, forest zone, at Abomey (latitude: 7°11'N; longitude: 1°59'E; altitude: 260 m). For each cycle, seeds of the initial population (PTMB3 for the first cycle and PTMB3C1 for the second cycle) were sown in field during the great rainy season in rows in isolation. Spacing was 0.80 m between rows and 0.50 m in each row. The plot was overplanted and thinned to 2 plants per hill (50000 plants.ha^{-1}) two weeks after planting. Each plot contained more than 1000 plants and was surrounded by 2 rows of the population planted. Fertilization and weeding were optimal.

The selection plot was divided into relatively homogeneous subplots in order to minimize environment variability, especially soil heterogeneity. Selection was applied at complete maturity for grain yield at 15% moisture within each subplot. The selection intensity was 5%.

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Evaluation

The populations derived from the 2 cycles of selection (PTMB3C1 for the first cycle and PTMB3C2 for the second cycle) and the source population PTMB3 were evaluated at Abomey and Abomey-Calavi (Southern Benin, forest zone, latitude: 6°27'N; longitude: 2°22'E; altitude: 10 m) during the great rainy season in a randomized complete block design with 4 repetitions. Six 4.5 m rows constituted each plot. Planting density, fertilization and weeding were as described for the selection plots. Rainfall was abundant and well distributed in the 2 locations. Grain yield was recorded per plot at 15% moisture.

Statistical Analysis

Analysis of variance was performed for grain yield per location. Since residual variances were homogeneous at the 5% level, pooling analysis for the two locations was completed. When a significant (P<0.05) population effect appeared, population means were compared using the least significant difference (LSD) test (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

Table 1 gives the results of the analysis of variance per location. No significant difference among populations was noted at Abomey. At Abomey-Calavi, a highly significant (P<0.01) population effect appeared. Pooling analysis for the two locations showed a significant population × location interaction for grain yield (table 2). This indicates that the populations behave differently from one location to the other. The results were, therefore, examined per location. Population means and selection effects on grain yield are shown in tables 3 and 4 respectively. The 3 populations studied (PTMB3, PTMB3C1 and PTMB3C2) were not significantly different for grain yield in any location. The effects given by table 4 were not, then, significant. The two cycles of mass selection were not effective to improve grain yield in the population PTMB3. This result may be due to:

- the low heritability of grain yield: mass selection is generally lowly effective for lowly heritable traits
- a low genetic variability of the population PTMB3 for grain yield.

The results agree with those obtained by Muchena (1972) and Bletsos and Goulas (1999). Those authors worked on three maize populations and found also that mass selection for grain yield was not effective. The results are in discordance with those reported by Gardner (1961, 1969), Johnson (1963), Lonnquist (1967), Arboleda-Rivera and Compton (1974), Taran et al. (2004) and Rahman et al. (2007). Those authors noted substantial grain yield gains in maize populations following mass selection. Differences in the source populations may explain that dissimilarity.

Table 1. Analysis of variance per location for grain yield (kg/ha)

Location	Population MS	Error MS	F	cv (%)
Abomey	415278	818435	0.51 ns	29.0
Abomey-Calavi	3309922	422787	7.83**	12.7

cv = coefficient of variation
ns non significant (P > 0.05)
** highly significant (P < 0.01)

Table 2. Pooling analysis of variance for the 2 locations for grain yield (kg/ha)

Error MS	Population × location interaction	
	MS	F
531489	2357555	4.44*

* significant (P < 0 .05)

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Table 3. Mean grain yield (kg/ha) of PTMB3 and the populations obtained after 2 cycles of mass selection

Location	Population			$LSD_{0.05}$
	PTMB3	PTMB3C1	PTMB3C2	
Abomey	2849	3694	3100	(1)
Abomey-Calavi	4423	4962	4662	1040

PTMB3C1 = population obtained after the first cycle of mass selection.
PTMB3C2 = population obtained after the second cycle of mass selection.
$LSD_{0.05}$ = least significant difference at the 5% level.
(1) Population effect was not significant ($P > 0.05$).

Table 4. Mass selection effects on grain yield (kg/ha) (1)

Location	Cycle		
	First cycle	Second cycle	Global (the 2 cycles)
Abomey	+845 (+30%)	-594 (-16%)	+251 (+9%)
Abomey-Calavi	+539 (+12%)	-300 (-6%)	+239 (+5%)

(1) Effect in % of grain yield of the initial population is indicated in brackets.

4. CONCLUSION

Two cycles of stratified mass selection were not effective to improve grain yield in the traditional tropical maize population PTMB3. Recurrent selection methods using families as tested units (family or descent selection) are more effective than mass selection for lowly heritable traits like grain yield. They may permit to obtain significant improvement of grain yield in PTMB3 and other traditional maize populations.

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