International Journal of Research in Agriculture and Forestry
Volume 6, Issue 4, 2019, PP 43-51
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Improvement of P1 and P3 Populations of Corn by the Mass Selection with checking of the Pollen for Chadian Producers

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ABSTRACT

The objective of the test is to improve two local populations of corn by consistent two cycles of a performance selection test with the witness. The plant material is composed of P1 and P3 populations of corn gotten through the simple recurrent selection and P1A and P3A populations descended of the mass selection and witness T. The test is led with P1 and P3 populations of corn according to an experimental device of parcel subdivided into four. Followed by a test of performance of T1 and T2 treatments with witness T0 according to an experimental device in blocks of Fisher to 4 repetitions. The genetic gain of row number per ear of P1A is 2.32% ± 0.029 and P3A is 1.70% ± 0.026. The genetic gain of grain number per row of P1A is of 0.46% ± 0.013 and that of P3A is 0.95% ± 0.024. The genetic gain of weight of the grains of P1A is 6.42% ± 0.016 and that P3A is of 2.26% ± 0.035. The genetic gain of output in grain of P1A is of 7.64% ± 0.02 and P3A is of 5.11% ± 0.025. The best number of grain per row is registered on T1 (43.62 ± 0.135), the weak number of grain per row is noted on T0 (42.15 ± 0.212). The best grain output is obtained on T2 (3.21 t ha-1 ± 0.03), the weak grain output is registered on T1 (3.17 t ha-1 ± 0.062). The best performances of P1A and P3A will permit to increase the productivity of corn and improve the incomes of the Chadian producers.

Keywords: *Variety improvement, Zea mays L, genetic gain, improved populations, Chad*

INTRODUCTION

Corn is the most cultivated plant in the world and the first cereal produced before wheat (Tahir and al., 2009; Missihoun and al., 2012). It feeds directly or indirectly 15 to 20% of humanity (FAO; 2002).The world corn production in 2013 was 839million tons against 653 million tons for wheat (Kahndo and al., 2015). Corn, millet and sorghum constitutes the most cultivated and consumed cereals in Chad. The output of corn in Chad is estimated at800 Kg / ha without fertilizers and 3 to 6 t / ha with manure (Robert and al., 2010). The almost total production of corn is constituted of local varieties, mainly the white grains. Whereas the surfaces occupied by the corn crops keep increasing, showing that the increase of the production is dependent on the surfaces seeded (Nyembo and al., 2014). The outputs vary from one region to another but the national average output remains weak. Besides, with the climate change of these last years, the targeted genotypes must have a good tolerance both to drought and a good grain output.

In Chad, agriculture is especially rainfall and domestic-based-type of pluvial and based type (Nadjiam and Goalbaye, 2013). The agricultural production in Chad particularly the one of the corn, is insufficient (about 200 000 tons in 2009) for a population estimated to 9.5 million inhabitants in 2009 (ONDR, 2010).So the country faces the phenomena of food insecurity and the high cost of living (Goalbaye, 2014). Among the food crops, corn grain is a key element for the human food, particularly in Africa and in Latin America. It is certain that corn will continue to play an important role in the food security because the corn grain

demands as food should increase in a spectacular way in the years to come (Goalbaye, 2014). Indeed, FAO foresees that 60 million additional tons will be necessary in 2030 for human food. In tropical zones, the cereal projections for 2020 let appear in the horizon, a gap of several hundreds of millions tons (Islam, 1995).

To meet this new demand, the tropical farmers will have to increase their productions and their productivities. In Chad, agriculture is very often family based and exclusively dependent on rainfall. In addition, it is under the influence of the harmful effects of the drought.

The system of production is extensive, less productive and rests especially on a traditional agriculture of subsistence. Corn that was initially home crops is becoming a bush crops; consequently, it plays a more important role in food (Goalbaye, 2014).

The majority of the national production is achieved by small agricultural producers who only produce 2 tons of corn per rainy season. It is due to the large scale production of the traditional and rustic varieties potential strong person, adapted to the agro ecological conditions but with weak potential of production (Kahndo and al., 2015). By contrast, the peasants are complaining about a strong decrease of output and the cycle of some varieties are becoming long, the selection and the popularization of new varieties becomes a necessity.

The efforts led by research always seem insufficient because drought is truly one of the most complex problems agriculture is facing in Chad (Goalbaye and al., 2014). Paradoxically, the importance of this speculation in the food habits of the population keeps increasing in spite the extension of the cultivated surfaces (Nyembo and al., 2014).

But in spite of the extension of the surfaces seeded, we realize that the production of corn is experiencing an uneven development, what sometimes fluctuates the productivity the troubling proportions, and threatening so much food security as well as the incomes of the producers. One the contrary, the level of intensification of the traditional agriculture, especially of subsistence, was not sufficient enough to justify the use of hybrids.

Besides, the climatic warming up and the change of the pedological and climate conditions of the regions: the gradient of rainfall, the rise of temperature, the infertility of soils and flooding or humidity are very important in some regions of the country and make the agricultural production lower whereas the population keeps increasing. Corn, completely dependent on the man's care, doesn't grow spontaneously and cannot survive in the nature (Wilkes, 1985; Galinat, 1988; Dows well and al 1996). Indeed, the cultivated corn is completely a domestic plant: man and the corn lived and evolved together since very old times. Thus, several studies have been led to improve the production of corn (Darrah, 1986; Hallauer, 1992; Goalbaye and al., 2013; Goalbaye and al., 2014; Goalbaye, 2014; Goalbaye and al; 2017). Also, the activities of research have been oriented toward the high output varieties.

Indeed, the development of corn crop in Chad is handicaped by the infertility of soils and accentuated by:

- The insufficiency or even the unavailability of the inputs, the weak level of organization of actors of this sector (Robert and al., 2010);
- The large scale use of the local varieties which don’t meet the criteria of the peasants anymore (precocity, resistance to pours, good yield.);
- Bad spatial and temporal distribution of rainfall (Naitormbaidé and al., 2015);
- The soils are generally sandy, the farming methods evolve less and the outputs are on the whole weak (Bezot, 1963) and the peasants remain always distrustful improved varieties.
- exotic varieties non adapted to the pedological and climate conditions and the inaccessibility of seeds constitute the limiting factors corn production (FAO, 2005).So, the objective is to improve gradually and continually the local genetic resources of corn in order to put them at the disposal of the Chadian producers.

MATERIAL AND METHODS

Site of the Experimentation

The experimentation has been achieved three years consecutive June: 2016, 2017 and 2018 at the university of Sarh (UDS), site of Doyaba (09'081"89 °N, 18'42"947 °E, altitude of 360m). The site is impoverished by the loss of the organic matter and presenting a damaged structure (Bationo and al 2004). The climate is

of Sudan type, characterized by a dry and a hot season from November to April and an active humid and hot rainy season from May to October. The average temperatures vary from 24 to 38°c. Soils are washed ferruginous of red color, of uniformly clay-sandy to clay texture with a slightly acidic pH in surface and very acidic in depth (Naïtormbaïdé, 2012). Vegetation is characterized by clear forests and savannah trees in the south of Chad (DREM, 1998).

Variety Improvement

Plant Material

The plant material is composed of P1 and P2 corn populations from the simple recurrent selection (Goalbaye, 2014). A 100-day-cycle and restraints for their interesting agronomic characters. The average outputs of P1 and P3 from improved crops are respectively 3 t ha^{-1} and 2.93tha^{-1} (Goalbaye, 2014).

Methods

The test is led with the populations of P1 and P3 corn according to an experimental device of parcel subdivided into four (Eberhart, 1970; Gardner, 1961). The best ears of the selected feet of every population in free pollination are put in equal number in every subdivision, and then sowed. At the stage of male flowering, we conducted the castration of the plants presenting undesired phenotypes.

At the harvesting time, the seeds of the feet of every population presenting the best phenotypes (big ears) are mixed for the following cycle. The test is done during two vegetative cycles until the level of improvement needed is obtained.

Table1. *Performance of P1 and P3 before the two cycles of selection*

Corn populations	Number of row per ear	Number grains per row	Weight of 1000 grains (kg)	Grain output (t ha^{-1})
P1	17.2 ±1.09	43.4 ±1.81	0.289 ± 0.0089	3.01 ± 0.17
P3	17.6 ± 0.89	41.8 ±3.89	0.309 ± 0,0011	2.93 ±0.19

(Goalbaye, 2014)

Conduct of Culture

The two subdivided experimental parcels are ploughed to a depth of 15-20 cm, an organic manure equivalent to 5 tons /ha are brought before the ploughing. Then these two subdivided parcels underwent a harrowing in order to prepare the sowing bed. The sowing is done after a useful rain of at least 25 mm.

To avoid all limiting factors, seeds are impregnated a mixture of insecticide and fungicide named thioral (thiram and heptachlor). Sowing is carried on by placing two to three seeds, in a depth of about 4 cm. The spacing of 80 cm x 30 cm is needed.

A first weeding is done the 12^{th} day after levee and a second weeding the 21st days after levee. The thinning to one plant per mound is done the 15th day after levee. The doses of fertilizer of complex N cereal, P, K (20 - 10 -10) are brought as bottom fertilizer to an equivalent quantity of 100 kg / ha, they are buried in the furrows at 10 cm from the line of seeding.

The cover fertilizer, urea is brought in two fractions at the 10 leaves stage and at the male flowering respectively to the equivalent quantities of 50 kg / ha and 30 kg / ha. No sanitary treatment is applied. The experimental subdivision area is 10 m x 5 m = 50 $m^{2,}$ approximately 50 m^2 x 4 = 200 m^2 for a subdivided parcel and 200 m^2x2 = 400 m^2 for the both (2) subdivided experimental parcels. A border of 50 cm for the passage between the subdivisions and a space of 2 m between the two parcels is necessary. The previous crop is the fallow.

The Morphological, Physiological and Agronomic Parameters

The observations were about the following parameters:

- Dates to 50% of levee, dates to 50% of flowering (male and female), physiological maturity.
- The agronomic parameters were about the measures of the number of grains per row, number of grains by ear, the weight of 1000 grains and the grain output.
- 2.3 test of performance of corn populations with T1 and T2, T0 witness
- The objective is to compare two (2) new populations of corn through the mass selection with control of pollen, with witness T, the effective variety of corn, Mexican most common Early 17 of the region.

Material

The plant material is composed of the P1A, P3A populations from the mass selection and witness T. The cycle of 100 days for the two first and 105 days for the last is compatible with the climatic conditions of the site. The Mexican variety Early 17 has been chosen because of its good adaptation in our agro ecological experimental site. It is from Mexico with its synthetic variety formula (hybrid poly), its basic seed performance (G4) is 3, 5 t ha^{-1} on average in of Research progress in Chad. The level of intensification for this variety is improved (preparation of soil, ploughing, 25-30 kg $ha^{-1}$of seed, 100kg ha^{-1} N - P - K, 50 kg ha^{-1} urea, sanitary protection if need be).

Methods

The test is done according to an experimental device in blocks of Fisher to three treatments T0, T1, and T2 in four repetitions. Three treatments, T1, correspond with T2 respectively to Witness T0, in P1A and P3A populations. The studied factor is the genetic potential of each population.

Conduct of Culture

The experimental parcels are ploughed to a depth of 15-20 cm, an organic manure equivalent to 5 tons ha^{-1} is brought before the ploughing. Then these parcels underwent a harrowing in order to prepare the sowing bed. The sowing is done after a useful rain of at least 25 mm to avoid all factors limiting, seeds are impregnated with a mixture of insecticide and fungicide name dthioral (thiram and heptachlor). The sowing is carried by placing two to three seeds, in a depth of about 4 cm.

The spacing of 80 cm x 40 cm is needed. A first weeding is done the 10th day after levee and second weeding 19th days after levee. The thinning to one plant per mound is done the 15th day after levee.

The doses of fertilizer of complex N cereal, P, K (20 - 10 -10) are brought as bottom fertilizer to an equivalent quantity of 100 kg / ha, they are buried in the furrows at 5 cm from the line of seeding.

The cover fertilizer, urea is brought in two fractions at the 10 leaves stage and at the male flowering respectively to the equivalent quantities of 50 kg / ha and 30 kg / ha. No sanitary treatment is applied. The elementary parcel surface is: 10 m x 8 m = 80 m^2, either a surface of 80m^2x 3 X 4 = 960 m^2 for the whole experimental parcels. A 50 cm border between the elementary parcels and a space of 1.5 m between the blocks are needed. The previous crop is the fallow.

The Physiological and Agronomic Parameters

The observations were about the following parameters:

- Dates to 50% of levee, dates to 50% of flowering (male and female), physiological maturity.
- The agronomic parameters were about the measures of the number of grains per row, grains number per year, the weight of 1000 grains and the grains output.

Statistical Analyses

The typing of the data and the graphic representation of the agronomic parameters measured have been done with the help of the Excel calculator (2007). The data have been analyzed with the software SPSS (Statistical Package Heart Social Sciences 16.0). The average of the different parameters have been separated by the multiple relation test of Student-New mann-Keuls (SNK)

RESULTS

Variety Improvement

The performances of new P1A and P3Apopulations are reported on the picture 2. The genetic gain of P1A and P3A is expressed in percentage (%) and it is determined in relation to P1 and P3 (picture 1). After two cycles of variety improvement on P1A, 17.6 ± 0.09 the number of row per ear is mentioned. On the other hand, on P3A, 17.9 ± 1.62 the number of row per ear is observed.

The genetic gains of row number per ear of P1A and P3A after improvement are respectively 2.32% ± 0.029 and 1.70% ± 0.026 (picture 3). In relation to the number of grains per row, P1A recorded the average number of 43.6 ± 2.89 and P3A got the average number of 42.2 ± 1.09 (picture 2).

The genetic gains of grains number per row of P1A and P3A are respectively of 0.46% ± 0.013 and of 0.95% ± 0.024 (picture 3). As for the weight of 1000 grains, the P1A got 0.305 kg ± 0.0012 and the P3A recorded 0.316 kg ± 0.89, either for the genetic gains of 6.42% ± 0.016 and of 2.26% ± 0.035 respectively. In relation to

the output in grain, P1A got 3.24 t ha^{-1} ± 0.22 whereas on P3A 3, 08 t ha^{-1} ± 0,24is observed. And the genetic gains of grain output are respectively 7.64% ± 0.02 and 5.11% ± 0.025.

Table2. *Performance of P1 and P3 after the two cycles of selection P1A nominee and P3A*

Corn populations	Number of row per ear	Number of grain per row	Weight of 1000 grains (kg)	Grain output (t ha -1)
P1A	17.6 ± 0.09	43.6 ± 2.89	0.305 ±0.0012	3.24 ± 0.22
P3A	17.9 ±1.62	42.2 ±1.09	0.316 ± 0.89	3.08 ± 0.24

Table3. *The genetic gain after the improvement of P1 and P3 after the two cycles of selection P1A nominee and P3A3*

Corn populations	Number of row per ear (%)	Number grains per row (%)	Weight of 1000 grains (%)	Grain output (%)
P1A	2.32 ± 0.029	0.46 ± 0.013	6.42 ± 0.016	7.64 ± 0.02
P3A	1.70 ± 0.026	0.95 ± 0.024	2.26 ± 0.035	5.11 ± 0.025

Test of Performance with T1 and T2 Treatments T0 Witness

The number of grains per row is represented on the figure1. The best number of grains per row is registered on the T1 treatment (43.62 ± 0.135) follow-up of the T2 treatment (42. 48 ± 0.115) and of T0 (42.15 ± 0.212). The statistical analysis of the variance revealed that highly meaningful difference exists between the averages of the treatments with regard to the number of grains per row in the threshold of 1% (F = 86.874; P < 0.01).

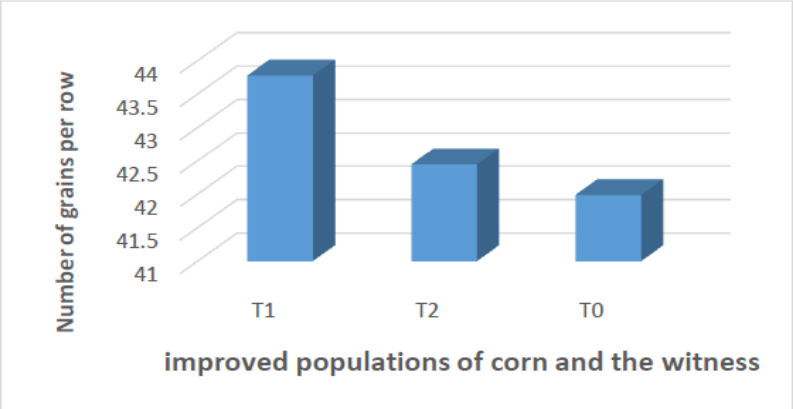

Figure1. *The number of grains per row of improved corn populations and the witness*

The number of grains per ear is reported on the figure 2. The best number of grains per ear obtained is T2 (516 ± 12), the weak number of grains per ear is observed on T0 treatment (499.5 ± 14.5). The analysis of the variance showed that meaningful difference exists between the averages of the treatments with regard to the number of grains per ear in the threshold of 5% (F = 5.690; P=0.457).

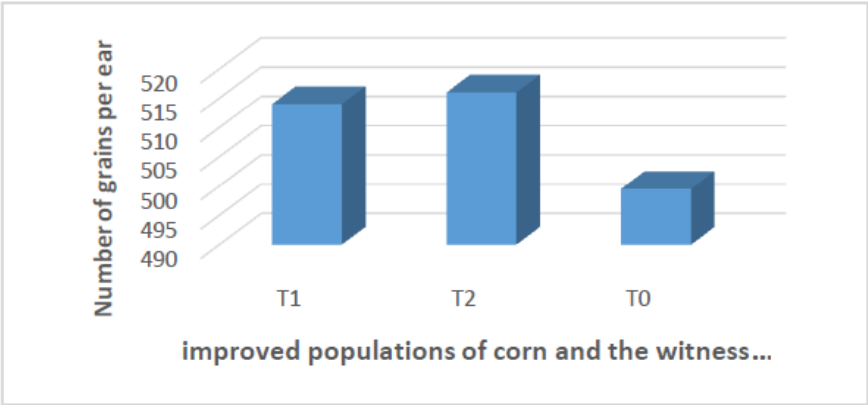

Figure2. *The number of grains per ear of improved populations of corn and the witness*

The weight of 1000 grains is represented on the figure 3. The best weight of grains is recorded by the T0 treatment (0.298 kg ± 0.005) follow-up by T2 treatment (0.289 kg ± 0.0115) and T1 (0.288 kg ± 0.006). The statistical analysis of the variance revealed that meaningful difference doesn't exist between the averages of the treatments with regard to the weight of grains in the threshold of 5% (F = 1.212; P = 0.982).

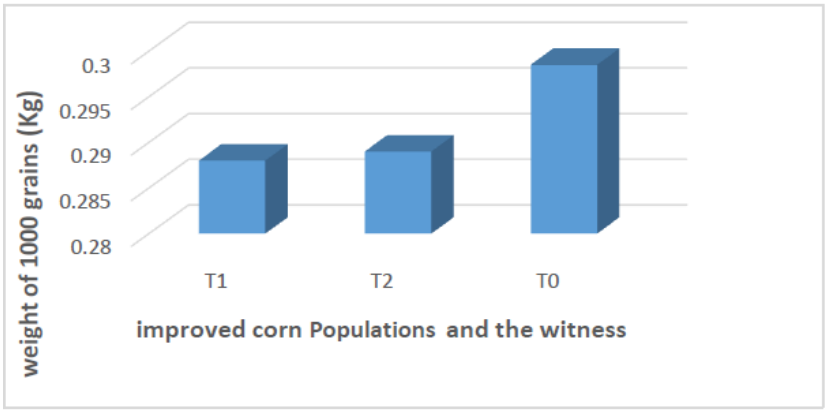

Figure3. *Weight of grains of populations improved of corn and the witness*

The output in grains is reported on the figure 4. The best output in grains is recorded on the T2 treatment (3.21 t ha^{-1} ± 0.03) T0 follow-up (3.20 t ha^{-1} ± 0.027). On the other hand, the weak output in grains is observed on the T1 treatment (3.17 t ha^{-1} ± 0.062). The statistical analysis of the variance revealed that meaningful difference doesn't exist between the averages of the treatments to the point of view of output grains in the threshold of 5% (F=0 .311; P = 0.964).

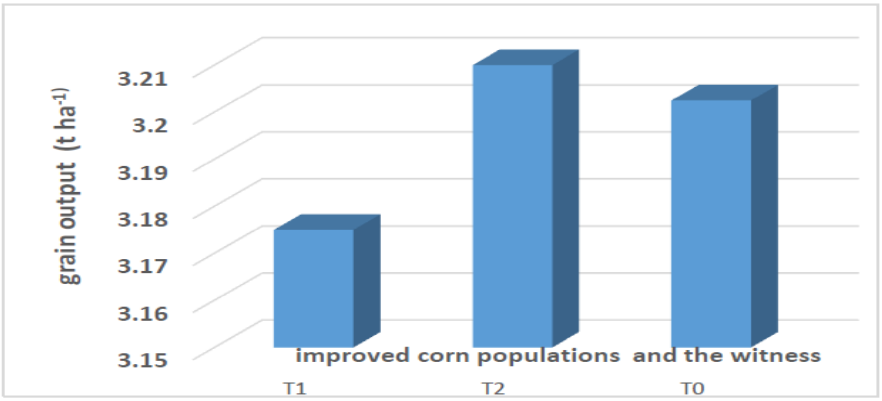

Figure4. *Grain output of improved corn populations and the witness*

Table4. *Number of grains per row, number of grains per ear, the weight of grains and the output in grains (t ha -1)*

Treatment	number of grains by row	number of grains by ear	weight of 1000 grains (kg)	Output in grains (t ha^{-1})
T1	43.62 ± 0.135 a	514 ±14 a	0.288 ± 0.006 a	3.17± 0.062 a
T2	42. 48 ± 0.115 b	516 ± 12 a	0.289 ± 0.011 a	3.21 ± 0.03 a
T0	42.15 ± 0.212 b	499.5 ± 14.5 b	0.298 ± 0.005 a	3.20 ± 0.027 a

The values of a same column followed by a same letter are not meaningfully different to the threshold from 1% or 5% according to the test of Student Newman Keuls

DISCUSSION

Variety Improvement

The objective of the survey is to improve two local populations of corn by the mass selection with control of pollen and then to compare them with an effective witness. Of 2.32% ± 0.029 are respectively in comparison to the number of row by ear, the genetic gains of P1A and P3A after the improvement and of 1.70% ± 0.026. These results join those gotten by Pandey and Gardner (1992). These authors got the interesting genetic gains while using the mass selection on the corn for the improvement of different characters. As

for the number of grains by row, the genetic gains of P1A and P3A are respectively of 0.46% ± 0.013 and of 0.95% ± 0.024. These results correspond with the findings of the similar studies done by Paterniani (1990) and Goalbaye and al. 2013. Indeed, they could get genetic gains while improving the different varieties of corn.

Talking about the grains weight, the genetic gains of P1A and P3A are respectively of 6.42% ± 0.016 and of 2.26% ± 0.035. Hallauer and al (1988), Juvik and al. (1993), Morello (1994) showed that the mass selection gives better results for the improvement of the grains weight.

In relation the grain output, the genetic gain of P1A and P3A are respectively 7.64% ± 0.02 and 5.11% ± 0.025. Arboleda-Rivera and Compton (1974) led with success the mass selection for the improvement of the corn grain yield.

Test of Performance with T1 and T2 Treatments T0 Witness

In compared the number of grains per row, the statistical analysis showed that highly meaningful difference exists between the averages of the treatments with regard to the number of grains per row. These results show that the populations of corn have been improved. Some similar results have been obtained by Attiey (1991) that worked on local varieties of corn. As for the number of grains per ear, the analysis of the variance showed that meaningful difference exists between the averages of the treatments with regard to the number of grains per ear.

Indeed, Diallo and al. 2016, succeeded in getting the similar results while valuing the behavior of different varieties of soft corn. In relation to the weight of corn grains, the analysis of the variance revealed that meaningful difference doesn't exist between the averages of the treatments to the point of view the grains weight.

These results don't join those obtained by Goalbaye and al. 2017, Hallauer (1992), Attiey (1991) and Jugenheimer (1985) that signaled the increase of the weight of grains of corn while doing the similar studies. As for the grains output, the statistical analysis of the variance revealed that meaningful difference doesn't exist between the averages of the treatments as par as grains output is concerned. Therefore, the local populations of corn improved, have the same performances as the witness.

These results don't have to do the findings of the similar research of Diallo and al. 2016 and Goalbaye and al. 2013. These authors got some grain yield of the varieties of corn that are superior to the witness while doing the similar studies.

Conclusion

The objective of the survey is to improve the local genetic resources of corn then to identify the best populations of corn after having valued them with the Witness. From the results, we note genetic gains of the components of output of P1A and P3A in relation to the P1 and P3 after two cycle's selections also the performances of T1 and T2 are statistically the same as Witness T0.These results show well that the genetic potential of T1 populations corresponding with T2 respectively in P1A and in P3A has been improved.

Therefore, the performances of output of the P1A populations and P3A have also been improved and estimated. Indeed, the best performances of P1A populations and P3A of corn will permit to increase the productivity of corn and to improve the incomes of the producers to weak intensification level or improved in Chad. Also these new populations of corn will act as basis to the program of variety improvement in Chad.

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Citation: *Touroumgaye Goalbaye, Mariamadalanda Diallo, Madjimbé Guiguindibaye etal, "Improvement of P1 and P3 Populations of Corn by the Mass Selection with checking of the Pollen for Chadian Producers", International Journal of Research in Agriculture and Forestry, 6(4), 2019, pp 43-51.*