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Test to obtain complex hybrids of maize (Zea mays L.) by crossing eight fortified organic varieties and two local improved varieties (babungo3 and Katanga) in Lubumbashi, R.D. Congo.

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Abstrat: Malnutrition and food insecurity affects about three billion people worldwide, especially women and children, who are susceptible to disease, premature mortality and a poor quality of life because of vitamin A deficiency, iodine, iron and zinc. The use of fortified organic varieties is an important option to remedy this situation. The objective of this work is to obtain complex hybrids recombining the characters resulting from the crossing of eight fortified organic corn varieties and two improved local varieties of white maize (Babungo3 and Katanga).More specifically, this study continues the evaluation of the suitability for combination of local improved varieties used with fortified organic varieties. The test was installed following an experimental device in simple lines alternating two male lines (fortified organic varieties) and two female lines (local improved varieties). The results show that female parent varieties (local improved varieties) have higher growth in height compared to parent varieties (fortified organic varieties). Yield values and yield components obtained with the hybrids created all showed good expression of heterosis. Fortified organic varieties are an effective, inexpensive and sustainable alternative to addressing problems of low yield and micronutrient deficiency. As a result, the resulting hybrids could be used in the Lubumbashi region, where food and nutritional insecurity is rampant. Hybrid integration into the seed chain could be recommended for sustainable maize production. Nevertheless, the evaluation of F1 obtained is urgent to evaluate the durability of the characters and thus to select the genotypes adapted to the agro-ecological conditions similar to those of Lubumbashi.

Keywords: suitability, bio fortification, complex hybrid, micronutrient.

Introduction

Maize (Zea mays L.) is the most widely cultivated plant in the world, the first cereal grown in wheat (Tahir et al., 2009, Missihoun et al., 2012) and the most important traditional food crop for people in the United States. tropical regions, after wheat and rice (N'Guetta et al., 2005; Amiruzzaman et al., 2010). Maize production is growing in relation to its multiple uses: human consumption, animal consumption and biofuel, and direct or indirect incentives it has received (Soule & Gansar, 2010). In Africa, despite the emphasis on agriculture, malnutrition and undernutrition remain serious problems and the Democratic Republic of Congo is no exception. It is the only region in the world where the number and proportion of undernourished and malnourished children is high (Allen et al., 2006). About 1/3 of schoolchildren (about 140 million) have vitamin A deficiency (Allen et al., 2006, WHO, 2009, Sands et al., 2009). Mason & Gracia (1993); Welche et al (1997); WHO (1999) and World Bank (1994) have claimed that three billion people suffer from the insidious repercussions of micronutrient deficiencies, also known as "hidden famine", and the number is increasing because they do not have access to more food. nutritious because of poverty. However, the consequences of micronutrient malnutrition can be disastrous (Harvest Plus, 2015). Nearly two-thirds of all child deaths are associated with nutritional deficiencies, especially micronutrient deficiencies (Caballero, 2002). Failure to consume one of these nutrients will result in adverse metabolic disorders that lead to illness, poor health, weakened development of children, and high economic cost to society (Brancas and Ferrari, 2002, Grantham et al. 1999).Public health interventions to reduce micronutrient malnutrition (nutrients in low levels in the body) include fortification (flour with iron, salt with iodine, sugar with vitamin A) and supplementation in children (during vitamin A supplementation campaigns) and large women during prenatal consultations (administration of iron and / or zinc tablets). In addition to these two options, there is also dietary diversification (a balanced diet of meat-fish-fruits and vegetables) as a means of providing essential micronutrients (Kanyenga, 2012). Many governments have limited resources to place these programs on an ongoing basis. For example, bio-fortification is a novel complementary technique for combating malnutrition by increasing the micronutrient content of foods consumed through plant breeding or genetic modification (Stevens and Winter-Nelson 2008, Pillay et al. 2013, Chandeller et al., 2013). In the Democratic Republic of Congo (DRC).Maize is currently the second most important food crop after cassava (SENASEM / CTB, 2009). In Upper Katanga, particularly in Lubumbashi, large-scale production of white grain corn is consumed in the form of flour and is thus the staple food preferred by the majority of the population. The problem is that the varieties of white kernels that were grown contained very low levels of provitamin A (Bouis and Welch 2010, Pillay et al. Now the technique of bio fortification by the selection work conducted by Harvest Plus, led to the release of the first generation of beans rich in iron, cassava, cassava and sweet potato rich in vitamin A precisely in Rwanda, DRC, Uganda, in Nigeria and Zambia (Haskell, 2012). Organic fortified maize varieties are generally rich in micronutrients, but their yield is low and remains criticized by farmers (Sands et al., 2009). The crossing of fortified organic varieties with high-yielding local grain varieties is an alternative to the dual problem of low yield and micronutrient poverty (Howarth et al., 2009). Currently, the Harvest Plus Program (operational in 40 countries) in collaboration with international agricultural research centers (CIAT, IITA, CIMMYT, ICRISAT, ...), national centers or institutes for agronomic research and universities; focuses its interventions on the introduction, selection, production and dissemination of high-yielding varieties of seeds combined with high micronutrient tenures (Kanyenga, 2012). The objective of the present work was to obtain complex hybrids recombining the quantitative and qualitative traits by crossing eight fortified organic varieties and two improved local varieties. It pursues the specific objective of assessing the suitability of local varieties used with fortified organic varieties.

Material and methods

Experimental site

This study was carried out at the KASAPA Farm in one of the research stations of the Faculty of Agricultural Sciences of the University of Lubumbashi (UNILU), located 18 km from the city center of Lubumbashi. The site is 1243 m above sea level, 11 ° 39 'south latitude and 27 ° 28' east longitude. This study site is subject to a climate punctuated by two well-marked seasons of type Cw6 (Koppen) with two seasons: one rainy, from late October until the end of March, the other being dry . The average annual rainfall is about 1200 mm of water (Mujinya et al., 2011). The average annual temperature is 20 ° C, with a minimum of 8 ° and a maximum of 32 ° C. The months of October and April are transitions between the dry season and the rainy season (Mpundu et al., 2014).

Table 1. Climatic parameters during the experiment (National Agency for Meteorology and Remote Sensing Satellite (METTELSAT) / Luano station) 2013-2014.

climatic parameters		**December**	**January**	**February**	**March**	**April**	**May**
Precipitation	Amount (mm)	247,5	277,5	331,6	157,8	113,5	-
	Number of rainy days	16	18	22	13	8	-
Temperature (°C)	Maximum	31,5	32,0	29,8	30,5	29,1	-
	Mean	21,2	21,3	21,9	21,4	20,8	-
	Minimum	16,0	15,6	14,8	16,0	14,8	-
Relative humidity (%)		84	87	88	85	81	-

Vegetation consists of three types of vegetation: savannah, steppe and forest. More than 80% of the forest is forest and has three aspects: the forest, the edaphic forest and the dry forest (Mujinya et al., 2011). At the time of opening, the following species were inventoried: *Imperata Cylindrica* (bloody grass or Japanese blood herb), *Euleusine indica* (Euleusine of India), *Tithonia diversifolia* (Mexican sunflower), *Cyperus esculenta* (yellow nutsedge) or ground almond), *Panicum maximum* (Guinea grass), Cynodon dactylon (quack grass or hound's foot) and *Pennisetum purpureum* (Elephant grass).The soils of Lubumbashi and its surroundings are dominated by ferralitic soils yellow, ocher yellow and red. The soil cover is of the ferralitic type with a ph with oscillating water around 5.2 (Kasongo et al., 2013).

Materials

Biological material

Ten varieties of maize used in our experiment came from three sources: International Maize and Wheat Improvement Center (CIMMYT) through the project Harvest plus provided us with eight fortified organic varieties. It is: (Sam4 (Vita) BC1C3F2-B) (bio 1), (Cmi 489 (Betasyn) RC1-2-1113) (bio 2), AC8730SR-124-1-5-1- (Betasyns) BC-1 (bio 3), AC8730SR-124-1-5-B-1 (bio 4), CML344 (bio 5), MAS (206/3/2) -23-2-1-1-BB (bio 6), MAS (206 / M2) -23-2-1-1-BB (Bio7), CML438 (BETASYN) BC1-18-5 (Bio8). Then, the National Institute for Agricultural Research and Research (INERA) KIPOPO station in the province of Upper Katanga has arranged us an improved local variety: Babungo3 and finally, the Faculty of Agricultural Sciences of the University of Lubumbashi we also disposed of an improved local Katanga variety.These locally improved varieties, used as female parents in this study, are more preferred for their resistance to diseases (Helminthosporiosis, Sigatoka and streak), pests and their high yield potential (7.5 to 8.5 t.ha-1). at a density of 53.333 plants ha-1). In contrast, fortified organic varieties have been used for their micronutrient richness and since they produce two to three ears per foot. Urea (46%, nitrogen) and NPK10-20-10 were used as fertilizers. During the planting of maize, NPK was spread by location as a base fertilizer with a dose of 6g by Piet and urea at 35 days with a dose of 6g per Foot at 30 days, amounts of elements. fertilizers and mineral fertilizers equivalent to 122 N-60 P-30 K (300 kg NPK + 200 kg urea) (Nyembo et al., 2012; Useni et al., 2012).

Methods

The test was conducted as a single line device with two blocks 50 m long and 5 m wide each. Treatments included 8 fortified organic varieties and 2 improved local white maize varieties at the beginning of the trial, while at the end of the experiment, observations were made on 26 treatments (16 hybrids and 10 parents). The two blocks were separated from each other by 1m. The seeds were sown at 75 cm x 25 cm spacings. Each block consisted of 64 lines including 16 for the Katanga variety, 16 for the Babungo 3 variety and 32 for the organic fortified varieties with two male lines for two female lines. Fortified organic varieties were male relatives (donors) and local varieties were female relatives (receivers). The ground was plowed, harrowed, the plots plotted and staked before sowing. Potted seedlings were carried out on November 10, 2013, at a depth of 5 cm, due to one grain per plant. With regard to cultivation techniques, weeding was carried out three weeks after sowing. Then, ridging was done to favor the development of adventitious roots and to fight against lodging.At the crossing, ten inflorescences of the female parents were isolated before the appearance of the styles using the painted papers soaked in a solution resulting from candles in order to make them resistant to the dew and the waters of rain. After isolation, pollination was carried out before the styles degenerated. Pollen grains were collected in the envelopes on the pollinating day in the morning before they were shaken by the wind (Nyembo, 2010). After crossing, female inflorescences remained isolated for 21 days to avoid accidental crossing (Nyembo, 2010).At the beginning and in the course of experimentation, the observations made on local and fortified organic parents, focused on the emergence rate, the height at the insertion of the spike, the total height of the plant and the harvest, the average grain weight per head, the weight of 1000 grains and the yield were measured on all varieties, including hybrids.The raw data obtained were subjected to variance analysis with the Tukey pots hoc test. For normally undistributed data, the raw results were tested by Kruskal Wallis. Analysis of variance (ANOVA) and the Kuala-Wallis test were used to determine the differences between varieties (male and female parents) and hybrids with their parents.

Results

The growth of male and female parent varieties

Plant emergence was 5 to 8 days after planting and weights were evaluated 10 days after sowing. They indicate that not all the varieties used are of good quality because their germination capacity is less than 80%. The results of the emergence rate showed after the Kruskal Wallis test that the different varieties showed similar emergence rates (Figure 1).

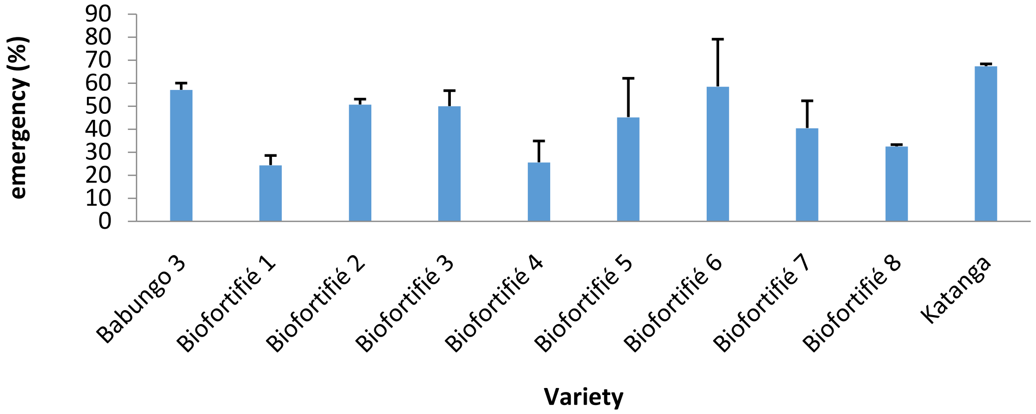

Figure 1. Variation of emergence rate by variety

The results of one-way ANOVA on head-on height indicate that there is a significant difference between average varieties (p = 0.011, Figure 2). The Tukey test made it possible to classify the averages obtained in five groups (a, bc, ab, c, d). The results show that the highest height was obtained on the babungu3 variety and the low height on the variety CML438 (Betasyn) BC1-18-5.

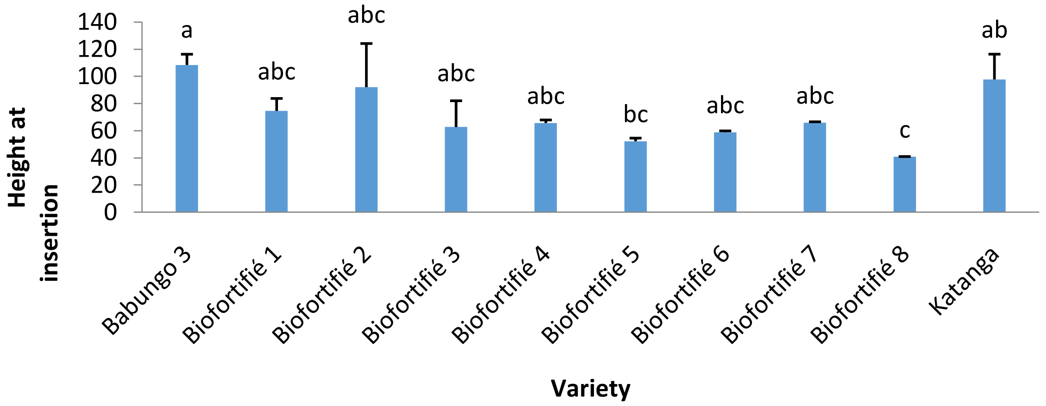

Figure 2. Influence of the variety on the height at the insertion of the ear.

The results of one-way ANOVA on plant height show that there are significant differences (p = 0, 000) between varieties. Nevertheless the Tukey test shows that the highest height was obtained with the babungo3 variety, followed by the Katanga variety and all the fortified organic varieties showed the low height (Figure 3).

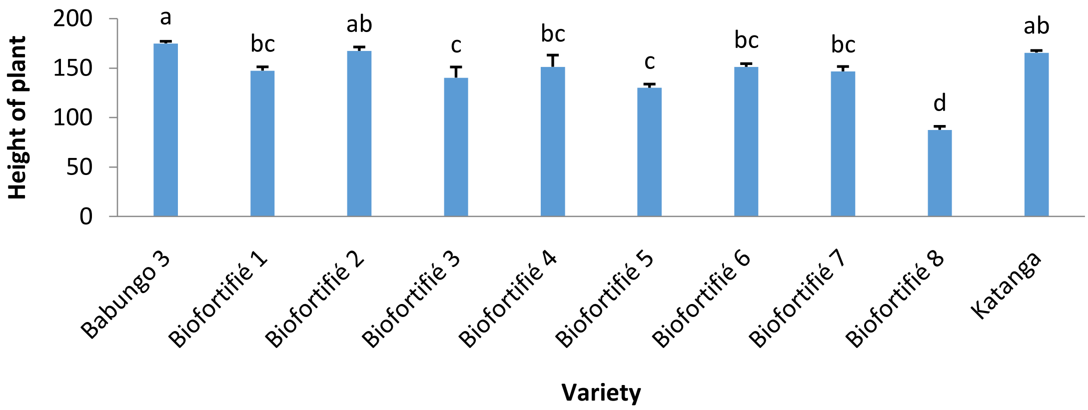

Figure 3. Height of the plant according to the varieties.

Performance parameter: parents and their hybrids

The results of the analysis of the variance show that there are significant differences between the parental varieties both between the parents and their hybrids for the grain weight per head and yield per tonne per hectare parameters, as well as non-significant differences in been observed on the weight of 1000 grains.

Table 2. Summary of the results obtained on the yield parameters according to the parents and their hybrids. Averages plus standard deviation. The different letters indicating the numbers between the averages after comparison by the Ppds (p = 0.05).

Treatments	Average weight of grain / ear	Weight 1000grains	Yieldt/ha
Babungo3 x SAM4(VITA)BC1C3F2-B	92,9±50,8 abc	350,8±208,14	4,95±2,7 abc
Babungo3 x Cmi 489(Betasyn) RC1-2-1113)	101,4±2,0 abc	276,1±1,5	5,41±0,1 abc
Babungo3 × AC8730SR-124-1-5-1- (Betasyn) BC-1	58,10±2,2 c	263,5±146,3	3,10±0,1 c
Babungo3 x AC8730SR-124-1-5-B-1	151,5±8,9	417,1±11,4	7,91±0,7 a
Babungo3 x CML344	90,13±4,5abc	272,9±170,9	4,81±1,8 abc
Babungo3 x MAS(206/3/2)-23-2-1-1-B-B	76,1± 3,4 abc	300,0±36,8	4,06±0,1 abc
Babungo3 x MAS(206/M2)-23-2-1-1-B-B	66,1±9,0bc	274,9±12,8	3,52±0,4 bc
Babungo3 x CML (BETASYN) BC1-18-5	50,7bc	530,2	2,70±0,1abc
Katanga x SAM4(VITA)BC1C3 F2-B	91,8±37,5abc	236,3±26,2	4,90±2,0 abc
Katanga x CMI 489 (Betasyn) RC1-2-1113)	67,6±29,9abc	340,0±146,8	3,60±1,5 abc
Katanga x AC8730SR-124-1-5-1-(Betasyn) BC-1	102,4±9,2abc	354,7±61,8	5,46±0,4 abc
Katanga x AC8730SR-124-1-5-B-1	91,8±2,0abc	334,5±8,1	4,90±0,1 abc
Katanga x CML344	91,5±20,4abc	347,1±10,4	4,88±1, Oabc
Katanga x MAS(206/3/2)-23-2-1-1-B-B (bio 6)	92,4±12,4abc	385,1±75,4	4,93±0,6 abc

Katanga x MAS(206/M2)-23-2-1-1-B-B	72,3±8,8 abc	266,8±0,08	3,85±0,4 $Aabc$
Katanga x CML (BETASYN) BC1-18-5	72 ± 19,1abc	226,1 ± 12,0	3,8 ± 1,0abc
SAM 4(VITA)BC1C3F2-B	68,9±11,4 bc	197,6±1,4	3,67±0,6abc
CMI 489(BETASYN) RC1-2-1113	84,0±15,8abc	283,2±16,2	4,48±0,8 abc
AC8730SR-124-1-5-1- (Betasyn) BC-1	72,9±24,1abc	244,8±56,7	3,88±1,2abc
AC8730SR-124-1-5-B-1	89,9±0,0abc	226,8 ± 56,7	4,79±0,0 c
CML344	46,9±9,2c	244, 4 ± 78,9	2,50±0,4 abc
MAS(206/3/2)-23-2-1-1-B-B	79,9±29,1abc	245,7±24,0	4,23±1,5 abc
MAS(206/M2)-23-2-1-1-B-B	83,5±7,8abc	347,4 ± 118,0	4,45±,4 abC
CML (BETASYN) BC1-18-5	31,0 ±4,1c	272,0+22,6	1,65+0,2c
Katanga	111,5±15,8abc	230,7±1,5	5,95±0,8 abc
Babungo3	140,6±7,9ab	272,4±61,9	7,50±0,3 ab
P VALUE	**0,002**	**0,167**	**0,002**

Discussion

The Katanga variety was most preferred for its early maturity, resistance to lodging and various diseases and for its yield of 7-8t / ha in a controlled environment compared with 5-6t / ha in the peasant environment (Nyembo et al., 2012; Useni et al., 2012). The Babungo3 variety was also selected for its semi-late maturity, resistance to lodging and various diseases and for its yield of 6-8t / ha in a controlled environment compared with 4-6t / ha in the peasant environment. In contrast, organic fortified varieties were chosen for their micronutrient richness (Banziger, 2000). For example, the protein composition of white corn wall grains, per 100 g of edible portion, is 9.4g for white corn against 14g for fortified organic varieties (Sands et al., 2009). Thus to recombine the desired characters of the various varieties, we resort to hybridization. Nyembo (2010) has shown that the purpose of hybridization is to recombine dissociated and self-fertilized traits by collecting two stocks of characters belonging to different individuals in the same individual. As a result, fortified organic maize varieties and local improved maize (Katanga and Babungo3) were crossed to recombine their traits. The arrangement of two male lines for two female lines has been adopted for a male foot to cross a female foot. On the other hand, to improve the yield of allogamous plants by hybridization, it is necessary to know how to preserve the improved seeds by mechanisms such as the isolation of the seed fields, the previous crop, the size of the plot, the mother seed, control pollination, to name just a few. Fran Ngoie (2012) indicates that the non-respect of one of these factors can lead to the deviation of several desired characters. To avoid any influence of pollens from other fields, the experimental field has been isolated in time and space. Several authors advocate isolation to reduce the risk of cross-pollination (Baudouin et al., 2002, Nyembo, 2010).

Analysis of variance (ANOVA) and the test of kruskal wallis were used to determine differences between varieties (male and female parents) and hybrids with their parents. In the past 40 years, agricultural research for developing countries has been focused on increasing cereal production. Recently, there has been a change: now, agriculture must not only produce more calories to reduce hunger, but also produce nutrient-rich foods to reduce hidden hunger. (Kennedy et al., 2003). For example, a test was set up at the Kassapa farm experimental field and will be called the test of obtaining complex hybrids by crossing eight fortified organic varieties and two improved local varieties (Katanga and Babungo3). At 10 days after sowing, the emergence rate was low for all treatments. The results obtained in this work indicate that the different varieties showed the similar emergence rate, based on the results of the analysis of the variance. Similar results were obtained by Nyembo et al (In press) comparing Pannar's varieties to each other. The sowing period was favorable for good seed germination (Table 1). Apart from the climatic parameters, it is probable that the germinative power can also explain this fact, since seed germination is not only environmental conditions, but also conditions intrinsic to the seed. As for the height of the plant and the height at which the spike is inserted, the results show that the fortified organic varieties have different sizes than the improved local varieties (Babungo3 and Katanga).This is related to the varietal characteristics. Musaw, 2009 found significant results on the creation of complex composite varieties from the Babungo and Kasaï 1 genotypes in the same region. Brieger (1950) indicates that plant height characters are important in the choice of varieties, as it influences the susceptibility of plants to lodging; the higher the height, the more susceptible it is to the worm. In the Lubumbashi region, Useni et al (2012) obtained results which showed that the large varieties of maize were the most affected by lodging. The small size of the plant is desirable in the region of Lubumbashi, to fight against the worm caused by heavy rains accompanied by strong winds. These different sizes obtained in the present work will be linked, on the one hand, to climate change, wind direction variation and the risks of water stress. The behavior of a variety is variable between environments, these changes will pose new questions to the performance of hybrids, but also their selection, their choice in the system of various crops and subject to greater uncertainties (Baudouin et al., 2002). Regarding the behavior of all fortified organic parent varieties compared to local improved varieties, the results show that the fortified organic variety and local varieties behave similarly. The results of the analysis of variance made it possible to classify the means of the varieties in five groups (a, ab, bc, abc, c) for the height at the insertion of the ear.

This shows that all maize varieties will require different settings in mechanized harvesting machines. In addition, the average weight per ear varies from 31.0 to 89.9g for fortified organic varieties and 111.5 to 140.6g for locally improved varieties. Regarding the weight of 1000grains, the results of the ANOVA show that the weights of 1000 grains for all parent varieties vary between 197.6 and 347.4 g for fortified organic varieties and 272.4g for 230,7g for locally improved varieties. With regard to the yield of parent varieties on the one hand and hybrids in them, the results show that the yield of parent varieties varies from 1.65 to 4.79t / ha for fortified organic varieties. and 5.95 to 7.50t / ha for locally improved varieties and from 2.70t / ha to 7.91t / ha for hybrids. In addition, all the hybrids obtained have a weight of grains per spike, a weight of one thousand grains greater than that of parent improved parent and fortified organic varieties. This parameter is important, indicating the amount of seed to use per hectare. For all the parent and hybrid varieties obtained, the results show that the one thousand grain weights for the whole are about 197.6 and 530.2g. This combination of fortified organic traits and improved local varieties allows the use of small amounts of seeds per hectare and fixes the micro nutrient (Minerals and Vitamins) thus opening a path of food and nutritional security (Shetty, 2009). . According to Anzala (2006), the weight of a grain is about 0.3g which has 300g for 1000grains. On the other hand, the higher the weight of a thousand grains, the greater the quantity of seed to be used per hectare; thus fortified organic varieties will require similar amounts of seed as the improved local varieties, with regard to sowing.In terms of hybrid yield, the results show that hybrid vigor, good combination of fortified organic varieties, and improved local varieties have been suppressed, resulting in an increase in average weight per ear. weight of 1000grains and yield of hybrids relative to the national average of 0.8 to 1 t.ha-1 (SENASEM / CTB, 2009), showing the importance of creating new maize varieties (Morris, 2002 Koutsika-Sotiriou and Karagounis, 2005, Issa et al., 2011, Haq et al., 2013, Nyembo, 2010). The superiority of hybrids over their parents indicates good combination ability (Baudouin et al. 2002) and heterosis effect (Nyembo 2010). Shehata et al. (1972) indicated that the best inter-varietal crosses give yields that are often equal to and sometimes even higher than the best suited double hybrids in a given region. If these new hybrids are combined with the improvement of farming techniques and the choice of an adequate environment (where certain quantitative genes can best express themselves) as suggested by Tayeb et al. (1994), Nyembo (2010) and Kanyenga (2012), a good technical support for agricultural producers, the yield will increase from the current level of 0.97 tons to about 3 tons with the current area of 514,964 hectares. Bernardo (2002) indicates the heterosis is maximum between pure lineages in F1 but it decreases by 50% in F2. These hybrids obtained have the advantage of improving the quality and quantity of corn in the province of Upper Katanga while opening the path of socio-economic development of all layers of the province. The creation of hybrids with yields greater than or equal to parent varieties, presents an added value in terms of improving the quality of corn, given their high micronutrient content. Micronutrients, including trace elements and vitamins, are essential for human health and are needed in small quantities for good development (Meenakshi et al., 2010). The availability of fortified organic varieties has advantages in achieving food and nutritional security. Indeed, currently micronutrient deficiency, particularly vitamin A, I, Zn and Fe, is one of the major problems in developing countries in general and in sub-Saharan Africa in particular (WHO, 2009).In addition, sub-Saharan Africa is one of the world's most important regions in terms of consumption of white maize, which is considered low in vitamin A, protein and mineral salts (Pillay et al., 2014). In this region, white maize is an important crop for the direct or indirect feeding of humans (Nyembo et al., 2014; Useni et al., 2014). Not only does this white corn pose a quantitative problem, it also poses a qualitative problem. Indeed, its yield is low in several regions of Africa 800 to 1000 kg in the DRC (Nyembo et al., 2014) and nearly 1800 kg in Cameroon (Kaho et al., 2011) compared to those obtained in the countries like the United States, Canada and China (more than 5000 kg). The combination of fortified organic varieties and improved white varieties helps to combat micronutrient deficiency, which affects ½ to ¼ of the world's population, mainly in sub-Saharan Africa (Allen et al., 2006).

Conclusion

The present work was initiated to obtain complex corn hybrids (Zea mays L) by crossing eight fortified organic varieties from CIMMYT Mexico through the Harvest Plus program and two local improved varieties (Babungo3 and Katanga). Eight fortified organic varieties, compared to two improved local varieties were sown in a single line device comprising two replicates. The technique of hybridization by non-reciprocal crossing has been adopted. The fortified organic varieties consisted of male parents and the improved local ones constituted female parents. After crossing each male parent to the female parents, 16 hybrids are obtained on the entire experimental surface. Observations focused on vegetative parameters and yield. Fortified organic corn varieties were considered male parents and both local as female parents. For all varieties (male and female parents), the results showed that parental varieties differ in their growth.For the parent varieties and their hybrids, the results show that there is a similarity for the weight of 1000 seeds and the behavior is not the same as for the weight of the kernels per ear and the yield of corn kernels.Nevertheless all the hybrids showed a good expression of the heterosis, because having new characters superior to the parents. This implies the best suitability, which is a key criterion in the creation and selection of hybrids. Hybrid integration into the seed chain could be recommended for sustainable maize production. Nevertheless, the evaluation of F1 obtained is urgent to evaluate the durability of the characters and thus to select the genotypes adapted to the agro-ecological conditions similar to those of Lubumbashi.

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