Vegetative growth and monitoring of diseases and pests of cassava *(Manihot esculenta Crantz)* hybrids

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Abstract
Cassava (Manihot esculenta) is grown in all regions of Côte d'Ivoire and is the second largest food crop after yam with a volume of 4.24 million tons. It is consumed and sold in various forms (attiéké, cassava paste, foutou, placali, flour, starch, etc.) locally and outside. However, the white flesh landraces represent over 90% of cassava area while varieties with colored flesh occupy 10 %. The white ones are poor in provitamin A (beta-carotenes) while varieties with colored flesh are rich in provitamin A. It is in this context that research has been undertaken to create new high-yielding varieties, rich in provitamin A and with multipurpose uses. The present study was to analyze vegetative vigor, pests and diseases and the root production of 13 456 hybrids coming from free and controlled crosses. Results showed that hybrids which came from controlled and free crosses, between improved varieties colored and white flesh, have been more vigorous with a vigor rate of 7% to 100% overall than those which were from free crosses (6% to 50%). In addition, hybrids derived from controlled crossings with an improved variety as a parent were unless attacked by virus diseases with an incidence of 0-3 % than free crossings with a cultivar as a female parent (0-20 %). The different types of shape and color of aerial organs on the hybrids were the same as those described in the CNRA cassava collection. At harvest, the shortlisted hybrids is 224 hydrids with orange flesh, 364 with dark yellow flesh, 332 with light yellow, 152 cream and 54 white flesh.

Key words: Cassava, Manihot esculenta, crossing, hybrid, provitamin A

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Résumé
Le manioc (Manihot esculenta) est cultivé dans toutes les régions de la Côte d'Ivoire et occupe le deuxième rang des productions vivrières après l'igname avec un volume de 4,24 millions de tonnes. Il est consommé et commercialisé sous diverses formes (attiéké, pâte de manioc, foutou, placali, farine, amidon, etc.) localement et à l'extérieur. Cependant, les variétés cultivées à chair blanche représentent plus de 90 % des surfaces cultivées en manioc alors que les variétés à chair colorée en occupent 10 %. Les variétés à chair blanche sont pauvres en provitamine A (ou béta-carotènes) alors que les variétés à chair colorée sont

riches en provitamine A. C'est dans ce contexte que des travaux de recherche ont été entrepris pour créer de nouvelles variétés à haut rendement, riches en provitamine A et polyvalentes. La présente étude a consisté à analyser la vigueur végétative, les comportements vis-à-vis des maladies et ravageurs et la production racinaire de 13 456 hybrides issus de croisements libres et contrôlés. Les résultats indiquent que les hybrides, qui provenaient de croisements contrôlés entre des variétés améliorées à chair colorée et blanche, ont été plus vigoureux avec un taux de vigueur de 7 % à 100 %, dans l'ensemble, que ceux qui étaient issus de croisements libres (6 % à 50 %). En outre, les hybrides issus de croisements contrôlés avec une variété améliorée comme géniteur ont été moins attaqués par les viroses avec une incidence de 0 à 3 % que ceux provenant de croisements libres avec un cultivar comme géniteur femelle (0 à 20 %). Les différents types de forme et de couleur des organes aériens observés chez les hybrides ont été les mêmes que ceux décrits dans la collection de manioc du CNRA. A la récolte, les hybrides sélectionnés sont composés de 224 hybrides à chair orange, 364 à chair jaune foncée, 332 à chair jaune clair, 152 à chair crème et 54 à chair blanche.

Mots-clés : Manioc, Manihot esculenta, croisement, hybride, provitamine

Introduction

In Côte d'Ivoire, cassava comes second place after yam (5.8 million tons), with a production of 4.2 million tons in 2014 (FAOSTAT, 2015). It is cultivated throughout the national territory with increased production in the south of the country (N'zué, 2007). Cassava is both a subsistence and a cash crop for producers. However, cassava is confronted with several constraints such as decrease soil fertility, irregular rainfall, land pressure, low productivity. In addition, white fleshed varieties are widespread and represent more than 90 % of the cultivated area of cassava. They are well known to producers, processors, traders and consumers. They are poor in provitamin A or beta-carotenes. On the other hand, the varieties with coloured flesh, are very less cultivated and very less known. They are rich in beta-carotenes. According to the work of Shrimpton (1989) and WHO (1995), vitamin A deficiency is a major public health problem in 37 countries of the world where cassava is a staple food. It is in this context that genetic improvement work has been undertaken in Côte d'Ivoire to create new varieties of cassava rich in provitamin A and polyvalent. From 2012 to 2014, the first step was to create genetic variability by crossing (free and controlled) coming from CNRA's (Centre National de Recherche Agronomique) parents collection. This survey is focused on the preliminary assessment of hybrids in field.

Materials and Methods

Presentation of the site

The work was carried out at the Research Station on food-producing culture (7 ° 4 'N and 5 ° 2' W) of CNRA in Bouaké. The region of Bouaké is located in the Guinean savanna, in the center of Côte d'Ivoire. The moderately desaturated ferrallitic soils dominate the region (Monnier, 1979). The rainfall regime is limited to two rainy seasons (April to July and September to October) and two dry seasons (August and November to March). The annual rainfall average is between 1100 and 1200 mm (Ndabalishye, 1995).

Plant material

The plant material consisted of 23 762 seeds, including 195 seeds from controlled crossing (manual) and 23 567 seeds from free crossing between 15 varieties of coloured flesh and 13 varieties with white flesh.

Seed immersion test
A seed immersion test was done to retain viable seeds. It consisted of soaking 30,257 seeds in a bucket of water. Seeds that floated, and found unfit for germination were rejected. The seeds that remained submerged (23762), were selected for direct sowing in the field.

Experimental design
The Fisher device with a single block was used. The block was divided into two bands. Each band was subdivided into 5 sub-bands. After plowing and harrowing, the seeds were sown directly into the depth of 5 cm at the rate of one grain per hole. The spacing was 0.4 m between plants, 0.6 m between rows, 1.5 m between sub-bands and 2 m between bands

Observations and measurements.
Observations and measurements were made on the following variables:
The number of sprouted plants was counted from 12th and 30th day; then the growth rate has been estimated by reporting the number of growth foot according to those the of beginning seeds;

The number of viable hybrids (vegetative viguor)
Diseases (viruses, 3 months after planting) and pests (mites, during the dry season):

The morphological characteristics related to the colour and form of the aerial organs were observed (stems, leaves, petioles, apexes, plant ports, straight stem or zigzag);

Conformation of tubers roots (shape, skin colour, texture) as observations were made on each harvested hybrid.

Statistical analysis
The means of the variables observed were calculated using the Excel software. The graphs were developed with the same software.

Results and Discussions
Sprouting rate
The germination rate was estimated at 62 %. Ndubuisi *et al.* (2015) obtained an average leaf rate of 43 % with seeds sown in pots. Also, according Njoku *et al.* (2014) and Ceballos *et al.* (2004), cassava seeds have a low germination rate in both tree nursery and field. The high rate of emergence recorded in this study can be explained by the viability of the seeds retained during the immersion method. Seed emergence rates from traditional varieties, improved varieties or controlled crosses were comparable and ranged from 30 % to 100 % (Fig. 1).

Vegetative vigour of plants
Cassava hybrids from controlled crops had greater vegetative vigour than hybrids from free crosses. This could be explained by the fact that in controlled crossings, removal of pollen grains came from vigorous male flowers and the choice of viable female flowers to fertilize (Fig. 2).

Aerial morphological characters.
The observed hybrids presented the following morphological characteristics:
Green or purple apex
About 76% of broad leaves and 24% of narrow leaves
The young apical green stem, bicolor or purple
The red petioles, two-colour (red dominant, green dominant) or green
Stem blackish gray, yellow and orange
The spreading habit, semi-erect or spread
The straight stem (13,448 hybrids) or zigzag (8 hybrids).
The morphological variability observed on the hybrids is similar to that observed by N'Zué (2007) in the CNRA collection in Côte d'Ivoire.

Diseases and pests
Viruses

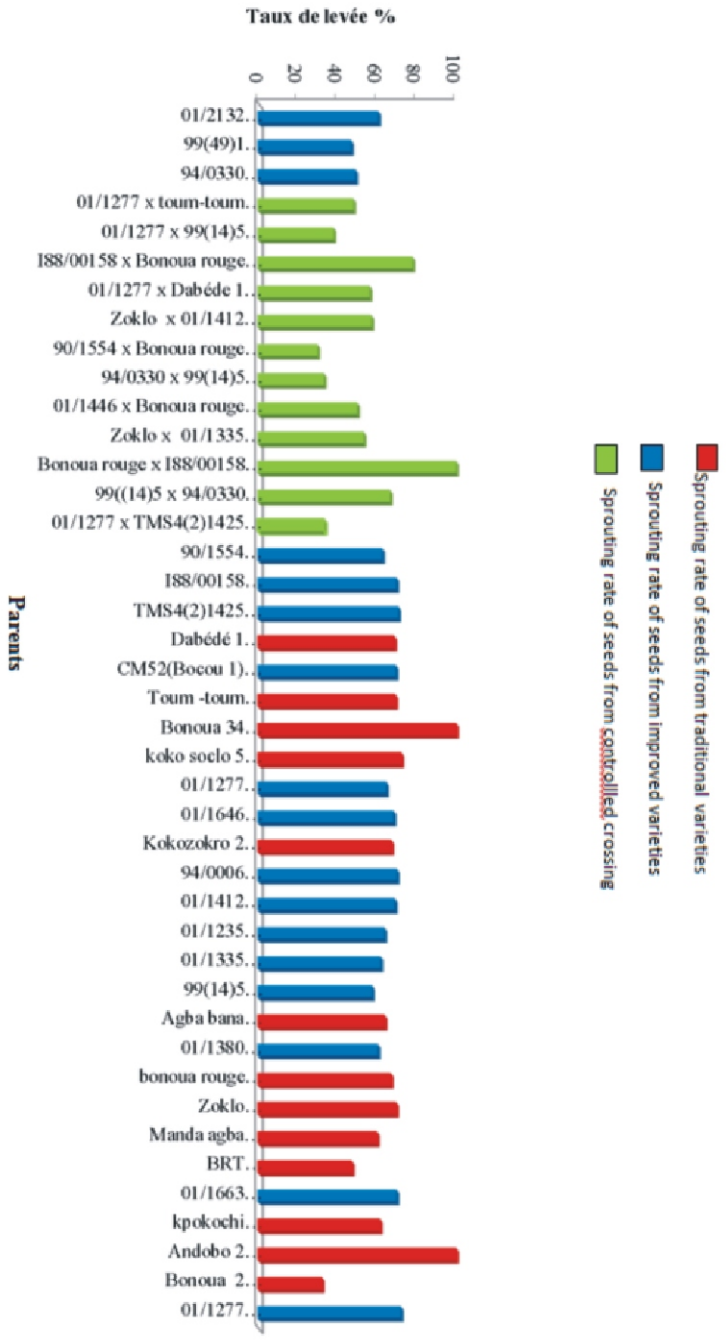

Figure 1: Germination rate of seeds from free and controlled crosses of cassava traditional and improved varieties

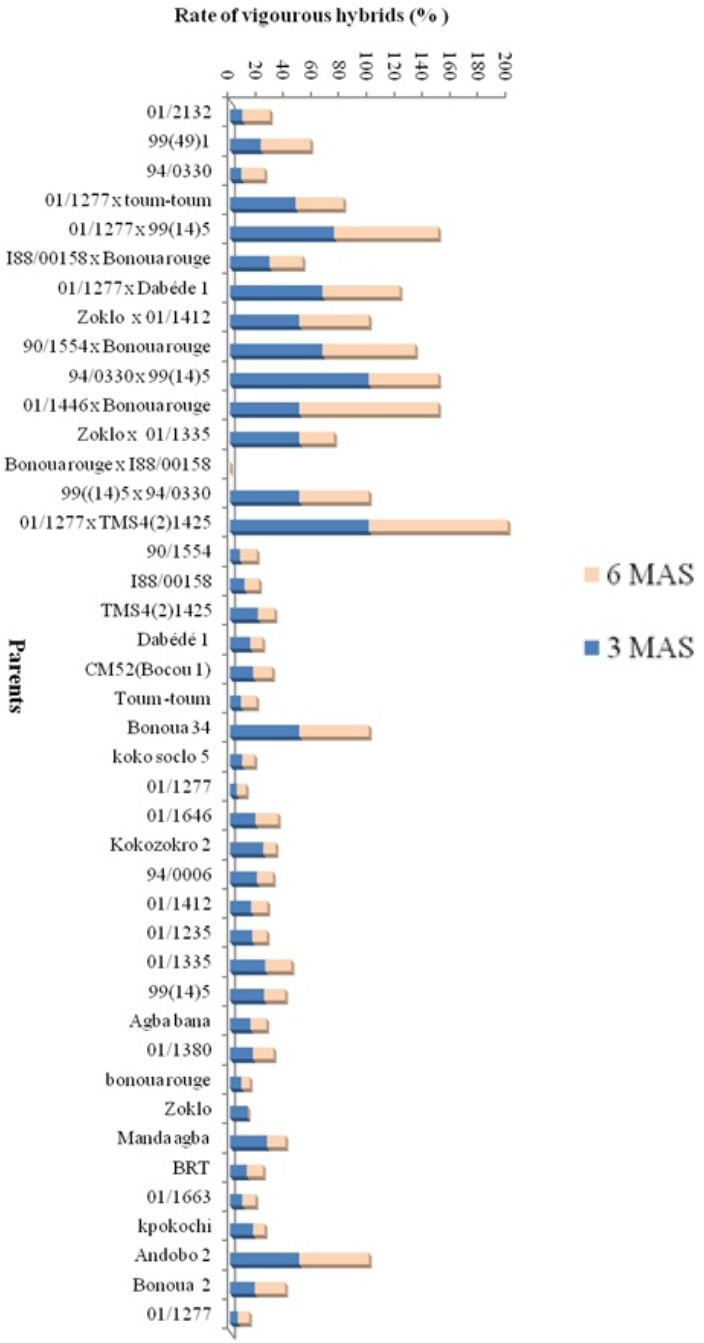

Figure 2: Vegetative vigor of cassava hybrids from free and controlled crosses cassava improved and traditional varieties

With a total of 13 456 hybrids, 223 showed symptoms of virus diseases. Hybrids generated by at least one improved varieties parent seemed to be virus resistant with an incidence less than 3 %. On the contrary, landraces or traditional varieties progenies appeared to be more attacked by virus diseases with incidence reaching to 20 % (Fig. 3). Whiteflies *(Bemiscia tabaci)* vectors are viral diseases vectors of transmission on hybrids. In addition, the incidence of viruses on hybrids from traditional female parent was greater than that observed in hybrids from improved female parent. This can be explained by the fact that the improved genotypes have benefited from a selection effort against viruses. According to Theberge (1985), yield losses from these pests can reach 80 %.

More than 5,000 hybrids have been attacked by mites. These pests cause enormous yearly damage to cassava plants in Côte d'Ivoire; Very few improved or traditional varieties resist it. Kotun *et al.,* (1990) reported that some improved varieties had 45% losses due to mites, depending on plant age and season. According to the same authors, mites belonging to Phytoseiidae's family are used as main agents against green mites.

Characteristics of selected hybrids

Of a total of 13 456 hybrids harvested, 1126 hybrids were selected, a selection rate of 8%. Selection rates varied from 0 to 67 % depending on the breeding species or the type of crosses. Controlled crosses had the highest selection rates, while hybrids from free crosses varied between 4 % and 10 %. In total, the hybrids selected were composed of 224 orange-fleshed genotypes, 364 yellow-fleshed, 332 light yellow fleshed, 152 cream-fleshed and 54 white-fleshed.

Conclusion

Research on cassava hybrids was at a stage in the process of breeding to select productive varieties rich in provitamin A and for multiple uses. A total of 1126 hybrids were selected on the basis of disease and pest tolerance, vegetative vigour, colour of the flesh and tuberous root conformation. Hybrids from controlled crosses or improved female offsprings were more vigorous and less susceptible to viruses than those from free crosses. In addition, morphological characteristics observed in the hybrids were the same as those described in the CNRA cassava collection. Successful hybrids will go through a series of clonal evaluations, and selection each cycle.

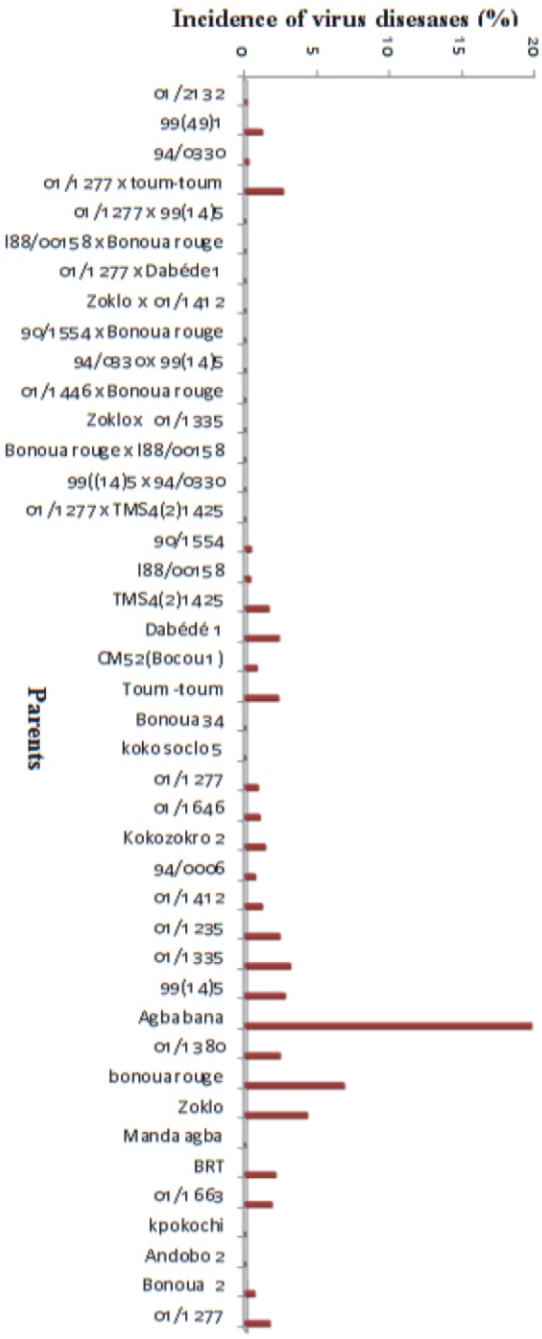

Figure 3: Incidence of virus diseases on cassava hybrids from free and controlled crosses cassava improved and traditional varieties

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