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Effects of staggered planting periods and potassium fertilization on the performance of cassava cultivars in South-Kivu, Democratic Republic of Congo

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Abstract

Cassava is the most important crop in DRC, where it is serving as a staple and cash crop. Over the last years, cassava production seems increasingly constrained by disturbances due to climate change.
To respond to these more frequent climate disturbances, farmers adjust the planting period to cope with erratic events that are most crucial during the first 100 days after planting. While this period coincides normally with the most regular rainfall, even during these 100 days some untimely interruptions for fairly long periods can occur which affect the performance of cassava.
A full-factorial field experiment was conducted in South-Kivu (DR-Congo), Kalehe territory, a highland in the forest region. Effects of planting period (3 planting dates), two cultivars (landrace versus improved), and fertilizer (NP versus NPK) on yields of cassava were tested. Yield data were collected at 12 months after planting by determining the above ground biomass (stems and leaves), fresh storage roots yield, and harvest index.
Cassava yield was influenced by the cultivar, being larger for the improved cultivar coinciding with the better harvest index. The yield was also influenced by the planting periods. The earlier the planting was done, the larger was the yield. Interacting with planting time, the presence of K was able to mitigate the negative effect of late plating on yield. As far as fertilization was concerned, the presence of K led also to highest yield levels. We found that the presence of K could mitigate yield reductions due to late planting.

Key words: Biomass, Cultivar, Potassium (K), Planting period, Harvest index, Manihot esculenta Crantz (Cassava).

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Introduction

Among the major staple crops, cassava is known to be the least affected by climate change (Jarvis *et al.*, 2012). It is increasingly promoted as a strategic crop alternative low-input crop (Chitiyo and Kasele, 2005) which can tolerate stressful conditions. Currently, South-Kivu province faces frequent climate disturbances mainly expressed by late and sometimes sudden returns of rains, unusual droughts, and in any case strong disruptions in the agricultural calendar (Cirimwami *et al.* 2019). Hence, farmers face significant challenges due to rainfall uncertainty especially at the time of planting. Climate disturbances issues are weakening cassava, which already faces persistent threats by upcoming diseases like cassava mosaic and cassava brown streak virus. In response to the erratic rainfall patterns, farmers developed different strategies including more variation in the planting periods or more variation in the planting locations, but to date effects of such management strategies remain poorly documented. Since the most critical period for cassava in terms of water availability is the period of storage root initiation (Okogbenin *et al.*, 2013), which corresponds to the first three to four months after planting, farmers have to focus on this period while choosing the planting time to improve yields. Without predictable weather patterns, this becomes cumbersome. For many farmers, a possible strategy to overcome these disturbances is to spread the risk and implement staggered planting (planting on different periods) at different locations (Miderho, Mbeza and Dieudonné, 2016). When planting at different times, it follows that the plants will experience the coming dry season at different ages with an unknown influence on yield. Regarding the inevitable disturbances that can occur during the crucial 100 first days after planting, it is known that potassium makes cassava more resilient (Wang *et al.*, 2013); (Wasonga *et al.*, 2020). The main aims of this study can be summarized as to (i) unravel whether cassava can withstand rainfall disturbances by adjusting planting time in line with the onset of rains, and to (ii) assess the potential role of potassium in improving cassava's tolerance to these climate disturbances. Both will be assessed for two contrasting cassava cultivars. To this end a full factorial experiment was conducted in a split-plot design in Kalehe territory, the main supplier region of cassava in the Bukavu city, in South-Kivu.

Material and Methods

Figure 1: Experimental layout for P1 and P2 plots

The experiment was established in Kalehe territory (02°03'26,1" S; 28°54'13,8" E), at 1470 meters above sea level in the South-Kivu Province (Eastern DRC), from November 2018 to March 2020. A three factorial field experiment was installed in a split-plot design replicated 4 times (4 blocks). The factor 'Planting period' (P) was randomly assigned to the main plot and consisted of 3 planting dates separated by 2 months from each other (November 2nd, 2018, = P1; January 2nd, 2019, = P2 and March 2nd, 2019, = P3) as levels. The first date was determined based on the first 'good' rain (a "good rain" in the South-Kivu is the one resulting in mud after the dry spell, generally occurs after 3 to 4 consecutive rainfalls). Factorial combination of the factors 'Cultivar' (2 variants: M'Bailo and Obama cultivars, a landrace and improved cultivar respectively) and 'Fertilization' (2 levels: NP and NPK) were assigned to the sub-plots that were randomly distributed within each main plot. Fertilizer rates were 150-40-180 kg N-P-K ha^{-1}. N and K were split applied as urea and potassium chloride (KCl) respectively, 30 % at 1 month after planting (MAP), 35% at 2 MAP and the other 35 % at 3 MAP. The trial had 48 experimental units each containing 56 plants at 1 m x 1 m spacing. Single effects of cultivar, fertilizer, and planting period, or factor interactions up to three terms were assessed using a three-way Analysis of Variance.

Results and Discussions

The soil texture of the experimental field was classified as “Sandy clay” according to the USDA textural triangle classification (Groenendyk *et al.*, 2015). The cumulative total rainfall during the experimental period was 2260 mm. It appeared that the later the cassava was planted, the more it was exposed to more regular and more intense rains for the first 4 months after planting. Considering the whole year, the same trend was observed for the total amount of rainfall, but regularity trend became opposite as it was lower in P2 and lower in P3.

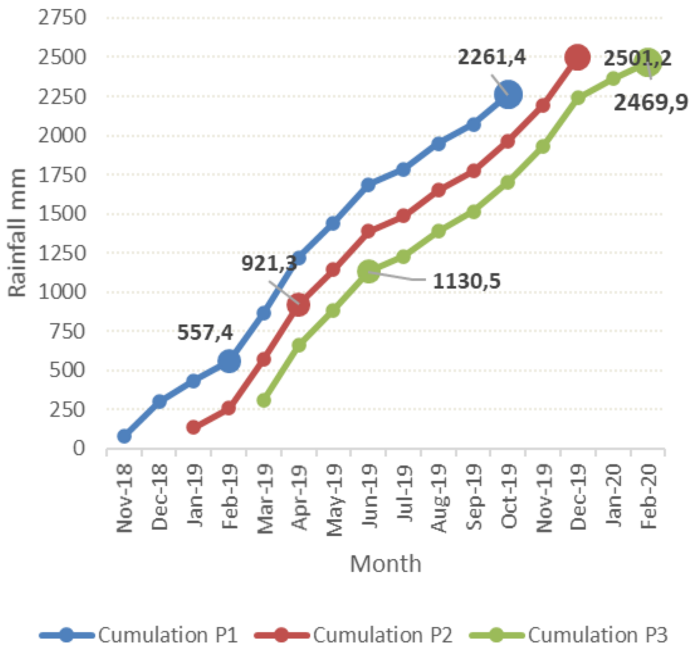

Figure 2: Cumulative monthly precipitation in function of plating periods. Data labels presents cumulations at 4MAP and 12MAP values for each planting period.

The production performance of the cassava drops as much as the planting is made late. The storage biomass yield drops by 29.0% when planting in period P2 instead of P1 and can achieve 78.8% if we linger until period P3. From P2 to P3 the drop is 70.1%. The above ground biomass and the total biomass yield follows the same trend. While planting late had a better exposure to rainfall during the 4 MAP, it resulted in the lowest growth and yield as if a permanent saturation of the soil by water during the early stages can prove detrimental to the normal growth of cassava. With 18.3 T/Ha (10 T/Ha for M’Bailo and 26.6 T/Ha for Obama), the average yield in fresh storage roots was higher than the average yield in Africa which is 10.0 T/Ha or the country average of 8.1 T/Ha (FAOSTAT, 2019). While it is often stated that cassava can be planted throughout the year, the planting should be done at the beginning of the rainy season, as mentioned by Janssen (2001). It seems contradictory to obtain the best results with P1 planting period which is characterized by smaller amounts and more irregular patterns of rainfall while the choice of this planting time targets the contrary during the first 100 days after planting, but it has been established in West Africa that exposition to flood can reduce 8% of the yield in fresh storage roots (Schlenker and Lobell, 2010). (Jude *et al.*, 2015) have established that a short-term exposure to excess rainfall can present positive effects on yield while a long term will be negative. Also, exposure to high temperatures will produce negative effects. The improved cultivar Obama had presented the highest values for all these parameters ($P<0.001$). The storage roots biomass was 2.7 times higher for the improved cultivar while its above ground biomass was 1.3 higher. The presence of K had significantly increased the storage roots yield ($P<0.001$) by 15.5% and so the total biomass yield by 14.2%. The presence of K had significantly ($P<0.001$)

and negatively influenced the leaf size by influencing both its width and length. In this way K can be useful when the plants are facing water stress either as an excess (Setter and Waters, 2003) or as a shortage (Egilla, Davies and Drew, 2001).

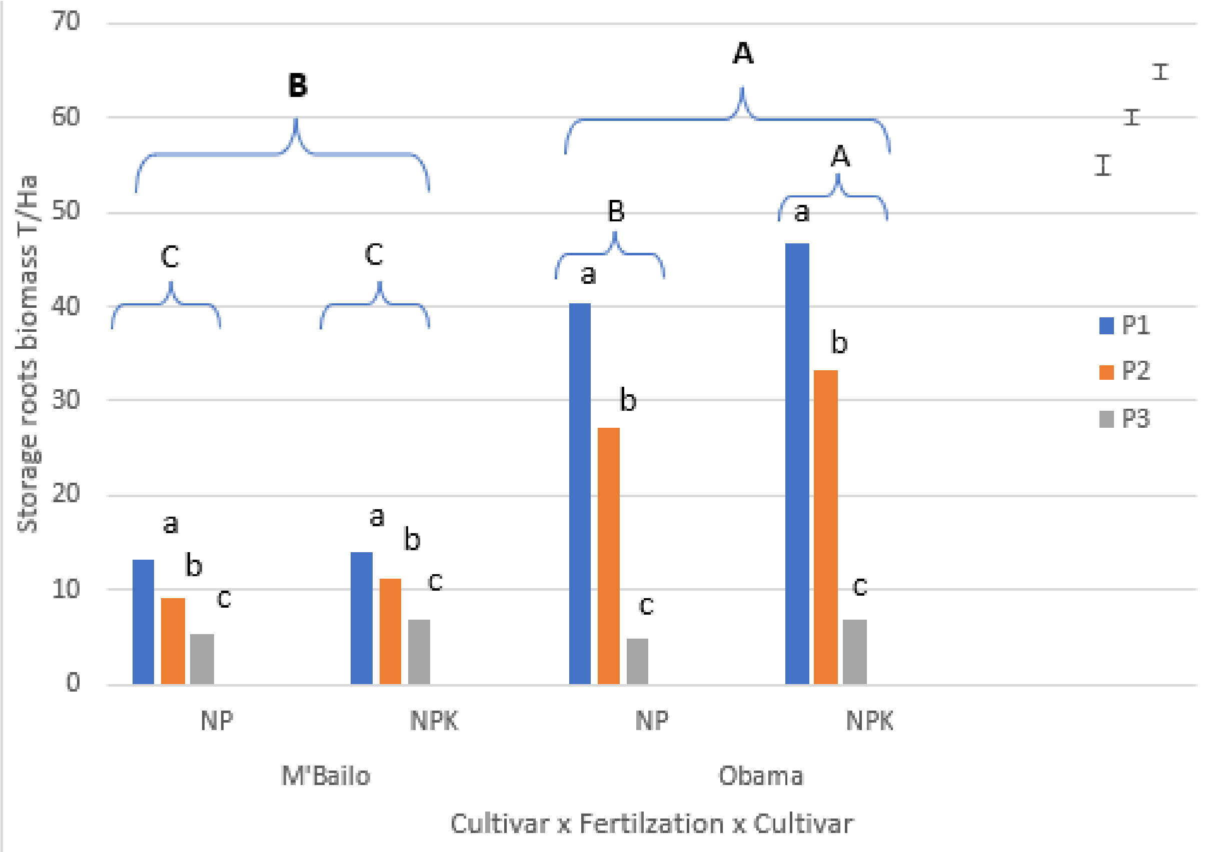

Figure 3: Means of total storage roots biomass yields by planting period x fertilization x cultivars. The error bars represent the standard error for comparison at 5% respectively for the planting period, the cultivars and fertilization from left to right.

Conclusions and Outlook

This study demonstrated that delaying the planting date of has led to the loss of yields in both the storage roots and above ground biomass. Delaying these planting periods by 2 months or 4 months led to losses of respectively 80.2 and 86.2% of potential in comparison of planting early even if it exposed the plants to more regular and abundant rainfall. The performance of the improved cultivar, Obama, was higher for both the above ground and storage roots biomass. The aerial development measured at four month after planting (canopy development) was also higher for Obama. The omission of potassium has led to the drop of fresh storage roots yield by inducing more the drop of the weight of the storage roots than their number per plant. Thus, the omission of potassium had reduced total biomass production. It was found that when the planting of cassava is delayed in South-Kivu, the plant becomes exposed too early to the dry season and are also exposed to flooding risks at early stages of cassava. It therefore emerges from this work that the best time to plant cassava is the onset of the rains with acceptable regularity, whatever the form of climate disturbances that appear. We must therefore target the earliest dates of the rainy season with regular rainfall while waiting for the formulation of better rainfall forecasts needed to sustainably help farmers. Nevertheless, the question which remains would be to clearly define the limits hidden in the word "regularity".

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