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Rootstocks: A key tool in adapting to climate change

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ABSTRACT

Cocoa cultivation currently faces scenarios that compromise the sustainability of the crop, both agronomically and commercially, a determining factor is climate change, which can provide conditions such as a higher incidence of pests and diseases, climatic disorders, among others. In Colombia, the productive chain has been growing in response to national policies, in this sense, during the year 2021 Colombia obtained a production of 69,040 tons, thus achieving a record production figure; Colombian cocoa has been recognized by the ICCO as fine flavor and aroma cocoa.

However, the high demand imposes the need to constantly face challenges in terms of material handling, selection of new genotypes with favorable attributes in terms of production, health, adaptation, evaluation of rootstock materials, evaluation of abiotic factors that limit the agricultural production and can generate negative effects on growth, productivity, and can cause damage to cell walls and membranes, stressing the root, restricting the absorption of water and nutrients, such as: drought, salinity, pH, high and low temperatures.

Given this background, the National Federation of Cocoa Growers, with resources from the National Cocoa Fund through the Research Program, has been working on the search for new rootstock materials tolerant to water deficit that help genetic improvement and contribute to the expansion and conservation of the genetic basis of cocoa. This is how the evaluation of materials began, where from an initial preliminary selection, 4 materials were prioritized, which demonstrated adaptation to abiotic stress conditions, water deficit.

Different patterns of water stress tolerance were identified between the evaluated rootstocks, however, FSV80 showed better tolerance levels to drought and a high adaptability to different water availability conditions. IMC67, FSA20, FSV80 showed the best adaptation and tolerance to water excess suggesting a potential use in soils exposed to water excess or flooding risks. Observed results could be used as an orientative resource for farmers, however, they must be correlated into the field and under different conditions like altitude, temperature, etc. The presented results represent an approach for adaptation and mitigation of the climate change effects, to ensure and Smart-climate agricultura, climatic resilience and food safety.

Keywords: Rootstocks, Fedecacao, water availability, dryness tolerance.

1. Introduction

Natural systems, human health, and agricultural production have been badly affected by devastating environmental changes (Arunanondchai, 2018). With the rapid increase in the world's population, there is a corresponding increase in food demand owing to concerns about the stability of the global environment. Water availability, air pollution, and soil fertility have a large impact on agriculture productivity (Noya, 2018). With abrupt changes in environmental conditions, the harsh impacts on plant productivity are progressing in great intensities owing to direct and indirect effects of abiotic stresses. The effects of climate change and environmental variation are mainly estimated by the number of stress spells, their impact on daily life, and damage to agricultural crops (FAO, 2018). In developing countries, agricultural yield is predominantly suffered due to adverse environmental conditions, therefore high temperature and excess of CO2 accumulation forced scientists to devise new strategies to cope with less predictable challenges (Rosenzweig, 2014). To tackle these limitations and guaranteed food security there is a need for production of new climate-smart crop cultivars (Wheeler, 2013). Plant growth and yield are greatly influenced by abiotic stresses. Under natural climate conditions, plants often experience numerous stresses like waterlogging, drought, heat, cold, and salinity (Ashraf, 2018; Benevenuto, 2017). The abiotic factors also include UV-B, light intensities, flooding, gas emissions, and physical and chemical factors which induce more stresses (Suzuki, 2014).

Plant physiology has been greatly influenced by climate variability by several means. Environmental extremes and climate variability enhanced the chances of numerous stresses on plants (Thornton, 2014). Climate change affects crop production by means of direct, indirect, and socio-economic effects as described in Figure 1. Furthermore, climate change (drought, flood, high temperature, storm etc.) events are increased dramatically as reported by Food and Agriculture Organization (FAO).

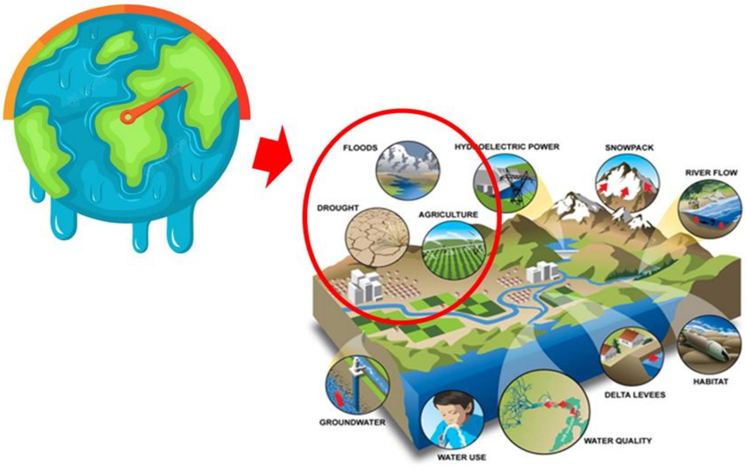

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Figure 1. Climate change effects and its impact on agriculture.

El Niño and La Niña events denote sea-surface temperature (SST) conditions in the tropical Pacific that are, respectively, warmer and colder than average (McPhaden, 2006). El Niño, Southern Oscillation (ENSO), corresponds to a natural climatic event that occurs in the equatorial Pacific Ocean central, the warm phase of ENSO known as El Niño is manifested mainly by a increase in Sea Surface Temperature (TSM) and a decrease in trade winds on the eastern side of the Pacific Ocean. Are anomalous conditions generate strong precipitation and noticeable changes in weather and fisheries, both in the riparian countries Southeast Pacific, as in other parts of the world. The reverse or cold phase of ENSO, known as La Niña, is characterized by present SST colder than normal, intensification of trade winds in the east of the Pacific Ocean and periods of drought (Hernández, 2002).

Productivity of agricultural systems is the most used indicator of climate impacts, and in the current literature, there has been the utilization of the yield gap concept to evaluate climate and soil effects (Licker et al. 2010; Egli and Hatfield 2014a, b; van Brussel et al. 2015; Hatfield et al. 2018). This approach allows for a quantitative assessment of the ability of the crop to achieve its potential yield and the inability of closing the yield gap is ascribed to climatic stress.

According to Vergara et al. (2014), climate change has strong effects on agricultural activities. Considering that cocoa crops are susceptible to changes in environmental conditions, the occurrence of this variation has adverse effects on it. These extreme phenomena could cause an alteration in the development stages and rates of pests and diseases related to cocoa, a decrease in the incubation periods and development of harmful organisms, and high ease of introduction of invasive species as well as changes in their geographical distribution (Schroth et al., 2016).

Recent research found tremendous effects on cocoa cultivation due to drought events, reporting losses in production yields between 10 and 46% in Indonesia (Schwendenmann et al., 2010). Gateau-Rey et al. (2018) found in farms, chosen randomly in Brazil, a high mortality of cocoa trees (15%) and a severe decrease in cocoa yield (89%), as well as an increase in the rate of infection of the chronic fungal disease Moniliophthora perniciosa after the environmental conditions imposed by the Niño phenomenon between 2015 and 2016. These findings, in the opinion of the authors, demonstrate that cocoa producers are at risk, and the increasing frequency of strong weather events will likely cause a decline in cocoa yields in the coming decades. Besides, cocoa and other crops can be the warning of the next important effects of the climate change on the natural and semi-natural vegetation.

2. Materials and methods

Materials: 7 Colombian Cacao varieties were used to perform the experiment. All the varieties were recovered and previously studied by Fedecacao-FNC and codified as following: EET96, IMC67, FSV86, FSA20, CAU43, FBO1, FSV80.

Technical procedure (The schematic procedure is shown in figure 2):

1. Plants of each clone were numbered from 1 to 25, plus the control plants per material**.**

2. A general irrigation was done to bringing the plants to field capacity.

3. Measuring the tension daily until it marks a value of 20 on its scale. When the tensiometer marks 20, to the plants marked from one to 5, water will be added slowly with a volumetric container, until it begins to drain.

4. Water was added, the volumes used in the 5 plants and divide it by 5, to obtain the average amount of water required to return the substrate to field capacity.

5. To the plants marked from 6 to 10, 75% of the average volume obtained in the previous calculation will be added.

6. For plants numbered from 11 to 15, 50% will be added

7. For plants marked from 16 to 20, 25% will be added

8. Plants labeled 21-25 have not water added.

9. The variables was measured daily according to the form prepared for daily data collection.

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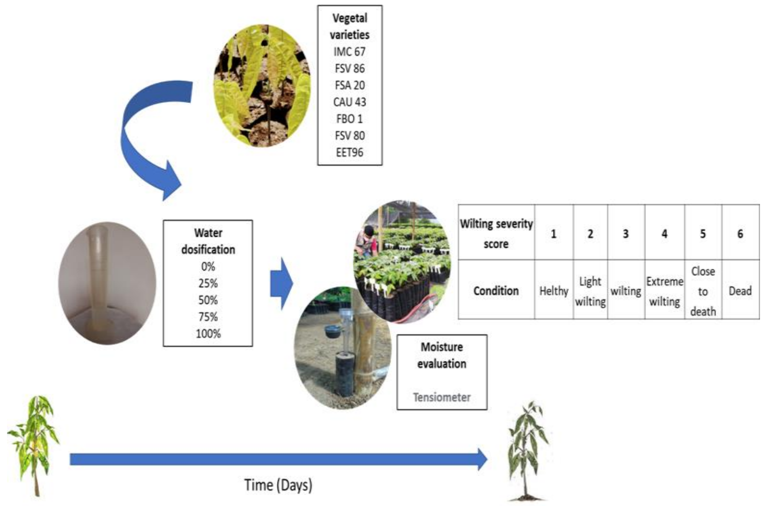


Figure 2. Schematic representation of the experimental procedure for Submission to water deficit (controlled deficit irrigation) and measurement of variables.

3. Results

Wilting severity associated with excess was measured according to the previously mentioned protocol. Different patterns of water stress tolerance were observed between the evaluated rootstocks, however, FSV80 showed better tolerance levels to drought and a high adaptability to different water availability conditions. In addition, IMC67, FSA20, FSV80 showed the best adaptation and tolerance to water excess suggesting a potential use in soils exposed to water excess or flooding risks (Figures 3 and 4).

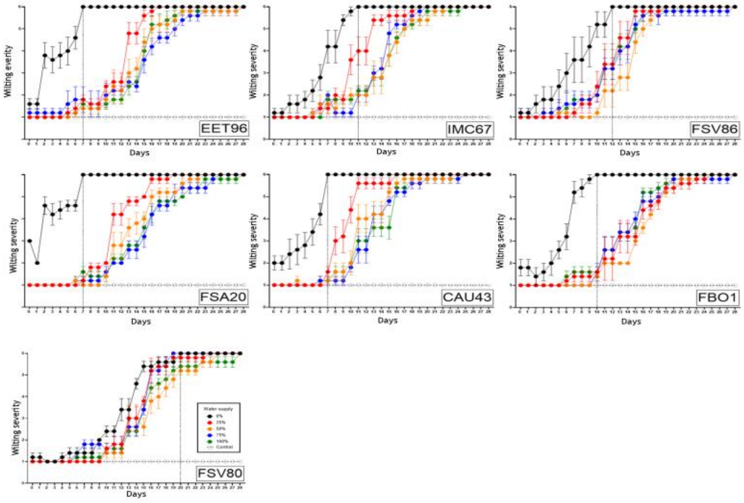
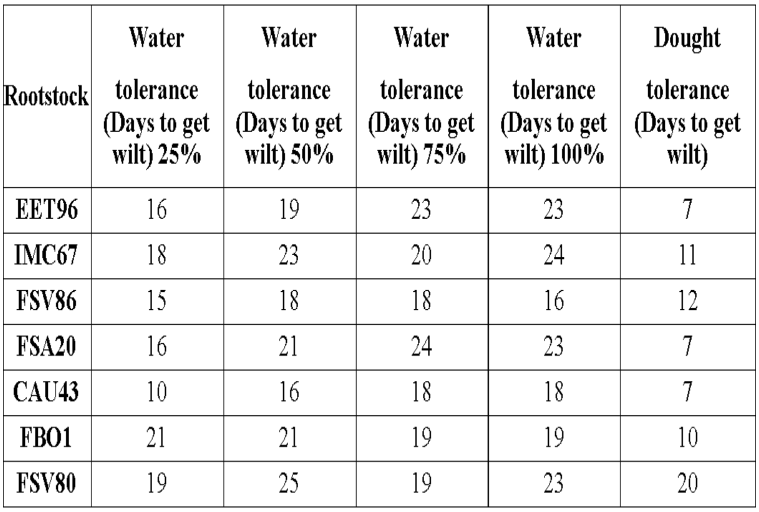


Figure 3. Wilting severity kinetics of different water stress conditions in T. cacao rootstocks. Dotted line is showing plant death with no water supplement to evaluated extreme dryness tolerance. Red, yellow, blue and green lines shown 25%, 50%, 75%, 100% of water supply.



Rootstock	Water tolerance (Days to get wilt) 25%	Water tolerance (Days to get wilt) 50%	Water tolerance (Days to get wilt) 75%	Water tolerance (Days to get wilt) 100%	Dought tolerance (Days to get wilt)
EET96	16	19	23	23	7
IMC67	18	23	20	24	11
FSV86	15	18	18	16	12
FSA20	16	21	24	23	7
CAU43	10	16	18	18	7
FBO1	21	21	19	19	10
FSV80	19	25	19	23	20

Figure 4. Wilting severity kinetics of different water stress conditions in T. cacao rootstocks.

4. Conclusions

Different patterns of water stress tolerance were identified between the evaluated rootstocks, however, FSV80 showed better tolerance levels to drought and a high adaptability to different water availability conditions.

IMC67, FSA20, FSV80 showed the best adaptation and tolerance to water excess suggesting a potential use in soils exposed to water excess or flooding risks.

Observed results could be used as an orientative resource for farmers, however, they must be correlated into the field and under different conditions like altitude, temperature, etc.

The presented results represent an approach for adaptation and mitigation of the climate change effects, to ensure and Smart-climate agricultura, climatic resilience and food safety.

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