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Research Article

Stimulation of Cassava Germination through the Application of Electrochemical Treatments

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Abstract: The aim of this study was to evaluate the effects of electrochemical treatments in the germination of cassava stakes, variety MCol 2066 (Chiroza), under the effect of different AC voltages and exposure times.The electrochemical treatment was held out in an electrochemical cell made of ice with two stainless steel electrodes located on two parallel sides of the cellular telephone. KNO_3at 0.05M dissolved in water was used as electrolytic solution.The results show that the electrochemical treatments affected the germination time of the stakes favorably. The best voltages for the application of the treatments were 6, 9, 13 and 20 V AC, with an exposure time of 5 min. Treatment with 6 V AC showed better global results with respect to the variable responses.

Keywords: Cassava, electrochemical stimulation, germination, KNO_3

INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO, 2013), cassava is considered the food of the 21st century, transforming it into a multi-purpose crop that responds to the priorities of developing countries, to the trends of the world economy and to the challenge of climate change. Specially, it is one of the primary crops in the northern Colombian zone, due to characteristics such as easy handling, great hardiness, resistance to the attack of pests and/or diseases, easy adjustment to different types of soils, great demand in international markets, among others. (Aristizábal and Sánchez Autoras, 2007; FAO, 2013).

Referable to the particular characteristics of cassava such as: Its easy manipulation, its great rusticity, its high resistance to pest attack and/or diseases, its easy adaptation to different type soils, its relative resistance to drought and high demand in international markets, its culture has risen considerably in Colombia (Aristizábal and Sánchez Autoras, 2007; FAO, 2013).

Both themes and leaves of cassava are suitable for human consumption, forming an important source of sugars, proteins, minerals and vitamins (particularly carotenes and vitamin C) (Hernán, 2012).

Nowadays experiments in the germinative phase are taken out in laboratories, exposing the seeds of various species to electromagnetic fields, demonstrating an increase in the germinative efficiency of the treated plants (Sudsiri *et al*., 2017; Tang *et al*., 2016; Hincapie *et al*., 2010), even so, on that point is no literature on the effect of electrochemical treatments applied to a sexual cassava seed.

Studies carried out on cassava are basically focused on nutritional aspects,crop fertilization, pest and disease management, production costs, flour processing plants for human and animal feed, among others (Aguilera Diaz, 2012; Soto Veiga *et al*., 2016) leaving aside the effects that can produce an electrochemical treatment (Ezui *et al*., 2016).

In this study, a study on the influence of electrochemical treatments at the germination time of cassava stakes was carried out exposing cassava stakes to different voltages and exposure times. This study is presented as an option to get relevant information mainly in the agrarian and food sector.

MATERIALS AND METHODS

The present study was borne out in the farm Villa Amelita, Lorica-Córdoba-Colombia, situated at 54 m above sea level, (N: 9° 27' 11.3" and W: 0.75° 48' 29.8"). The property is located in the tropical dry forest with 1300 mm of average annual precipitation, 28°C of temperature and 85% of relative humidity. Anarea of

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Fig. 1: The assembly used for the application of electrochemical treatments

500 m^2 was used, fenced with saran mesh and under nursery conditions.

For the establishment of the crop, the Chiroza variety (MCol 2066) was selected because in these, ideal conditions were met and there was enough planting material. The selection of planting material was carried out in the company of expert cultivators of the area, classifying matter stems from healthy plants of the same age, as recommended in the literature (FDA, 1997; López, 2015). The cuttings were obtained from the middle part of the stem, each containing 2 knots.

For the application of the treatments, a rectangular electrochemical cell (CE) made of 4 mm thick glass, measuring 25 cm long, 15 cm wide and 10 cm high was constructed. Two stainless steel electrodes (250 cm^2) were placed at the sides of the cell. A transformer with 110 V AC input and outputs: 6, 9, 13, 20, 26, 30, 36, 47, 55, 64, 71, 80, 90, 102, 112, 125 and 132 V AC were also manufactured and 0.05 M KNO_3 dissolved in water was used as the electrolyte solution.

The electrochemical system used for the application of the treatments is shown in Fig. 1.

As independent variables, the applied voltage and the time of exposure of these voltages were consideredand as main dependent variables were considered the germination time (time in days in which germination of at least 50 of the treatments is given) and survival of the plants (percentage of plants that survive the treatment one month after sowing).

The electrochemical treatment was carried out in two stages:

- Application of 18 voltages: (6, 9, 13, 20, 26, 30, 36, 47, 55, 64, 71, 80, 90, 102, 112, 125 and 132 V AC) and a 5 min exposure time.
- Application of 7 voltages (0, 6, 9, 13, 20, 26 and 30 V AC) and 8 exposure times (0, 5, 8, 12, 15, 20, 25 and 30 min).

For the bioassay, a plot design was used, divided into randomized complete blocks with 17 electrochemical treatments (main plots) and 8 subplots corresponding to the duration times of the exposure of said treatments. Two replicates were used with eight stakes each as an observation unit (each piece contributed 12.5% of the information per repetition).

For each response variable, ANOVA was utilized to identify trends, performing simple and multiple linear correlations.

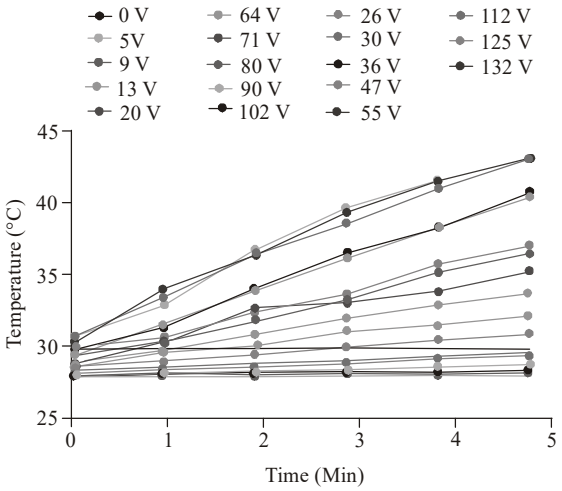

Fig. 2: Temporal evolution of the temperature of the electrochemical system for different cell voltages

RESULTS AND DISCUSSION

The characterization of the electrochemical system was performed by recording the current and the system temperature for the different voltages and exposure times. The demeanor of the temperature of the electrochemical system as a subroutine of the applied voltages and the exposure time is depicted in image 2. The temperature values of the system were between 27.8°C and 43°C with a coefficient of variation of 13,133.

The ANOVA showed significant differences in the temperatures obtained. The temperature registered in the system is variable with the voltages supplied in such a way that the highest temperatures were obtained with voltages of 112, 125 and 132 V, being similar statistically. For voltages of 6, 9, 13 and 20 V, temperatures similar to each other are reached, but lower than those obtained for voltages higher than 30 V, according to the Tukey test for the comparison of averages.

The analysis of divergence of the temperature obtained with the system shows significant differences with respect to the elapsed time, in which the higher temperatures are associated with longer times, as argued by the examination of multiple ranges of comparison of averages of Tukey.

The analysis of variance and the Tukey test (>0.01) indicated that the current intensity significantly influences the system temperature, obtaining higher temperatures for higher current flows (Fig. 2).

Table 1 shows the total weekly precipitation records in mm during the research development period. It was not necessary to provide irrigation for regular rainfall in the area.

The behavior of the germination time of the stakes as a function of the applied voltage for a time of exposure of 5 min is shown in Fig. 3 and 4.

Table 1: Weekly precipitation (mm) during the observational period

	Week			
Month	1	2	3	4
August	14	67	29	69
September	18	24	37	61
October	58	43	15	53

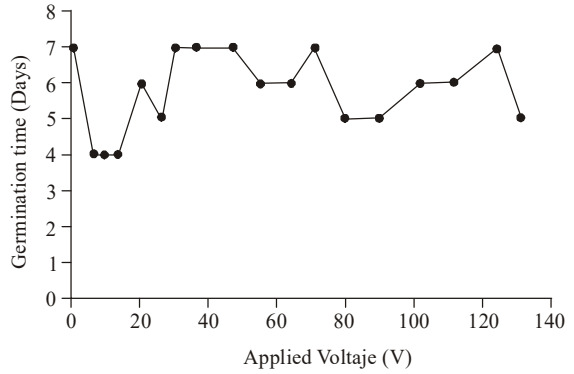

Fig. 3: Germination time of the stakes in function of the applied voltages, Replica I

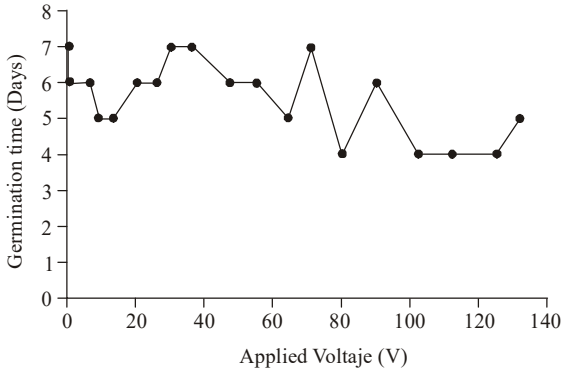

Fig. 4: Germination time of the stakes in function of the applied voltages. Replica II

The days between sowing and germination of cassava stakes showed significant differences between electrochemical treatments, as was shown by ANOVA. The Duncan's multiple-rank comparison test at 5% pointed to the control as the later germination. The average value of the germination time corresponded to 5 days, with values ranging from 3 to 7 days; The coefficient of variation obtained was 21.726% with SD corresponding to1, 1506 days (n = 214). 52% of the electrochemical treatments tested required 3 to 5 days to achieve germination, a value lower than that reported by Pavón *et al*. (2004) and Navarro (1983) cited by Moisés *et al*. (2005), this may be due to electrochemical treatment activating reactions of precocious growth of meristems, a fact consistent with Igarza *et al*. (2001), in *Xanthosoma sagitifolia Schott* (Malanga) and Lozoya-Saldana *et al*. (1996) in *in-vitro* potato cultivation (*Solanum tuberosum*) that besides germination stimulation obtained cleaning of pathogenic viruses in

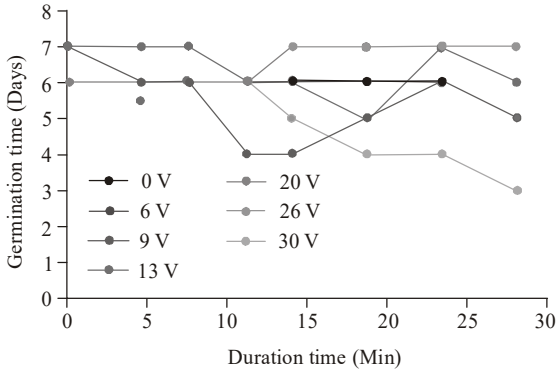

Fig. 5: Germination time of the stakes according to the duration of the treatments

those species of economic and cultural importance. It should be noted that the germination time obtained in this study is lower than those obtained by the cultivators in the region.

The behavior of the germination time of the stakes as a function of the duration time of the treatments is shown in Fig. 5. On the other hand, survival measures as a function of the applied voltage and a five minutes exposure time revealed that the survival of the electrochemically treated stakes corresponded on average to 73.55%, a coefficient of variation of 36.268% and the median corresponded to 75% of survival, average values that differ from those reported by Segura (1996) and Ospina Patiño and Ceballos (2012), possibly due to the use of two-knots stakes in the present work while in studies reported on cassava, stakes of 5 and more knots and longer lengths than those used in the present bioassay are used.

The ANOVA performed on the survival results for voltages of 0, 6, 9, 13, 20, 26 and 30 V and exposure times of 0, 5, 8, 12, 15, 20, 25 and 30 min showed highly significant differences between the electrochemical treatments evaluated, especially at voltages greater than 13 V. The Tukey averages 5% comparison range test indicated the 6V treatment as the best.

CONCLUSION

The results obtained allowed to establish the following conclusions:

Electrochemical treatments affect the germination time of the asexual cassava seeds.

The best voltages for the application of the treatments were: 6, 9, 13 and 20 V AC, with an exposure time of 5 min.

Treatment with 6 V AC showed better global results with respect to the variable responses.

For application times of treatments less than or equal to 5 min, voltages can be applied without significant mortality of stakes.

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