EVALUATION OF DROUGHT RESISTANCE CAPACITY OF SUGARCANE PLANTS[1] /

*L. T. S. GERALD**
*O. O. S. BACCHI***
*S. MATSUOKA**

Resumen

Fue demostrada la capacidad de resistencia a la sequía de dos variedades y un clon. Tres métodos fueron empleados: adición de sal, extracción de agua y análisis de prolina. Los tres métodos indicaron el siguiente orden de capacidad de resistencia a la sequía: RB745464 > NA5679 > CB41-76.

Estos resultados corresponden con las observaciones de campo que indican la misma tendencia. También ha sido observado que plantas de la misma variedad de caña de azúcar, pero de diferentes edades, presentan reacciones diferente a la sequía.

Se discute en este trabajo el potencial de estos métodos, así como otros problemas asociados con ellos.

Introduction

Brazil is the largest sugarcane growing country in the world. With the world's energy crisis and with Brazil producing less than 30% of its petroleum needs, sugarcane growing in this country is not just for the purpose of producing sugar, but also for manufacturing alcohol as substitute for petroleum. With the expansion of sugarcane growing into new areas of Central Brazil, the drought problem as related to the cultivation of this crop gains added importance.

Irrigation systems are costly and practically inexistant in the new areas; therefore, it is essential that sugarcane varieties which are high yielding and drought resistant be planted. Results of work carried out in Hawaii indicate that sugarcane varieties differ widely in their sensitivity to drought conditions (6). This method has been used to characterize most of the available commercial varieties in Hawaii; tests were also run to corroborate the field-experiment relationships. The same test has been used to look at new selections. The drought resistance capacity of sugarcane varieties has also been tested by suspending the plant's water supply and recording the time lag between wilting and death under this drought condition (5).

Rao and Asokan (4) have recently indicated the potential of using the proline test to screen for drought resistance.

The three methods mentioned above were tested in this study. Two cane varieties and one clone representing, according to field records, a drought susceptible, a resistant and a very resistant type of cane, were used.

Materials and methods

Two sugarcane varieties (CB41-76 and NA56-79) and one clone (RB745464) were used. Single-eye cuttings were planted individually in a paper cup and after about two weeks they were transplanted to a 4-liter pot, containing a mixture of filter cake, soil, and sand (2:2:1). When the plants reached 1 month,

1 Received for publication in August 24, 1984

* Head of Plant Physiology section and of Plant Breeding section of IAA/PLANALSUCAR, Southern Regional Coordination Service, Araras, SP, Brasil.

** Supervisor, Plant Physiology section, IAA/PLANALSUCAR Piracicaba, SP, Brasil.

1.5 months, 2 months, 2.5 months, 3 months, and 4 months of age, they were tested by adding 0, 6, 9, 12, 15, 18, 21, 24, 27, 30, and 33 g of NaCl per pot to the soil medium, according to the method developed in Hawaii (6).

All plants were watered immediatelly after adding the salt, and daily thereafter until the test was completed. The salt level at which the young plants of each variety of clone was killed was recorded.

The test of sugarcane drought resistance by withdrawing the plant's water supply was made when the plants were 4 months of age. The drying percentage of the +1 leaf during the drying period and the percent of surviving plants after 14 days of drought were recorded. Cane survival was identified by rewatering the plant.

For proline analysis, 4-month old plants were separated into 3 groups. The first group was watered normally twice a day. The second group was watered only once (on the third day) during a 7 day drying period. The third group was kept without water for the whole seven day drying period. Leaf samples (+1 leaf middle 20 cm portion without midrios) were collected at 0, 3, 4 and 7 days. The samples were dried at 80°C for 3 days, powdered, and analyzed for free proline content, following the method of Bates (1). The whole experiment was conducted in the greenhouse with a mean temperature of 30°C and mean relative humidity of 70%.

Results

Figure 1 shows that at 4 months of age clone RB745464 is the most tolerant cane to the salt treatment, followed by varieties NA56-79 and CB41-76. The response was different when a plant younger than 2.5 months was used. Generally as plants became older they became more tolerant to the salt treatment.

Figure 2 shows that leaf (+1) of CB41-76 dries much faster than those of NA56-79 and RB745464. Once again, clone RB745464 was found to be the last one to dry completly. After 14 days drying, all three types of cane were rewatered. The surviving percentage of CB41-76, NA56-79, and RB745464 was found to be 0%, 25%, and 75%, respectivelly.

Figures 3, 4 and 5 show the results of proline analysis under different conditions. Figure 3 shows that the proline content was consistently low for the three varieties tested under normal watering conditions during the whole 7 day period. RB745464 was found to have a higher proline content than

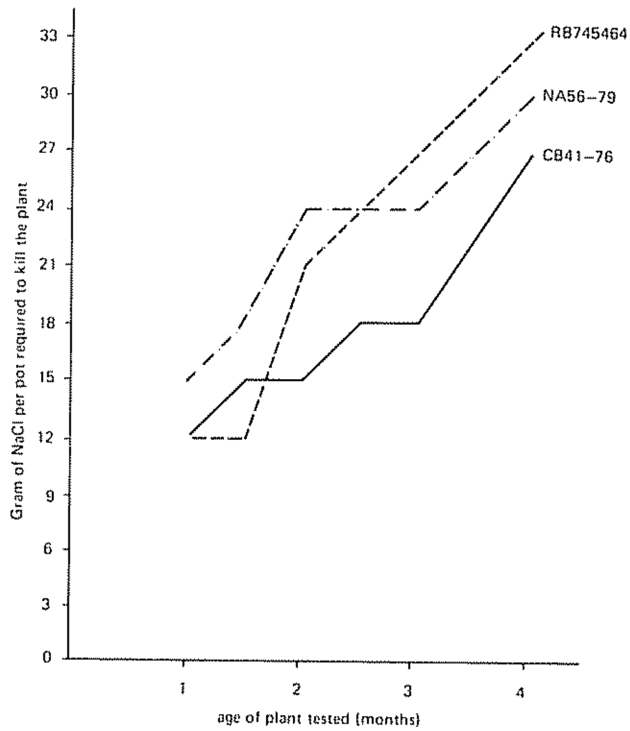

Fig. 1. Response of sugarcane plants of different ages to the addition of NaCl to soil. (Data were average of 3 replications).

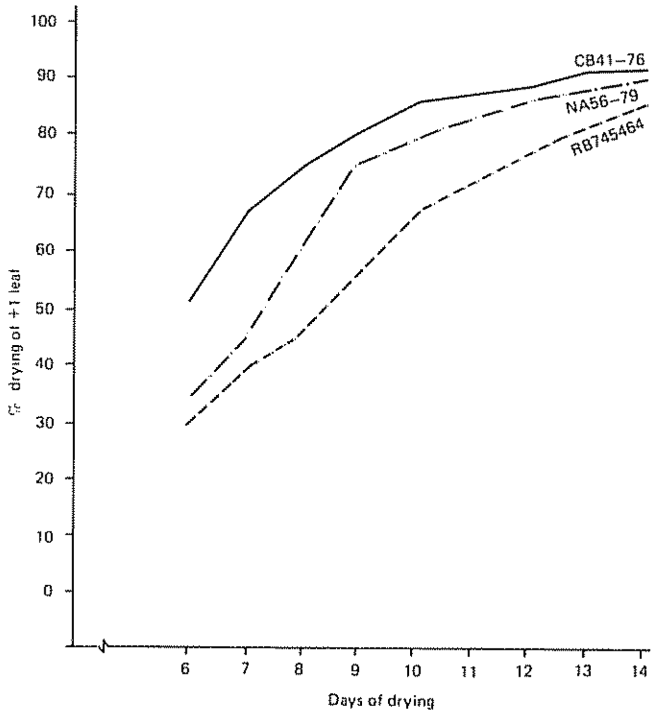

Fig 2. Percent drying of +1 leaf of sugarcane plant submitted to a drought condition. (Pots were covered with plastic film. Data were average of 4 replications).

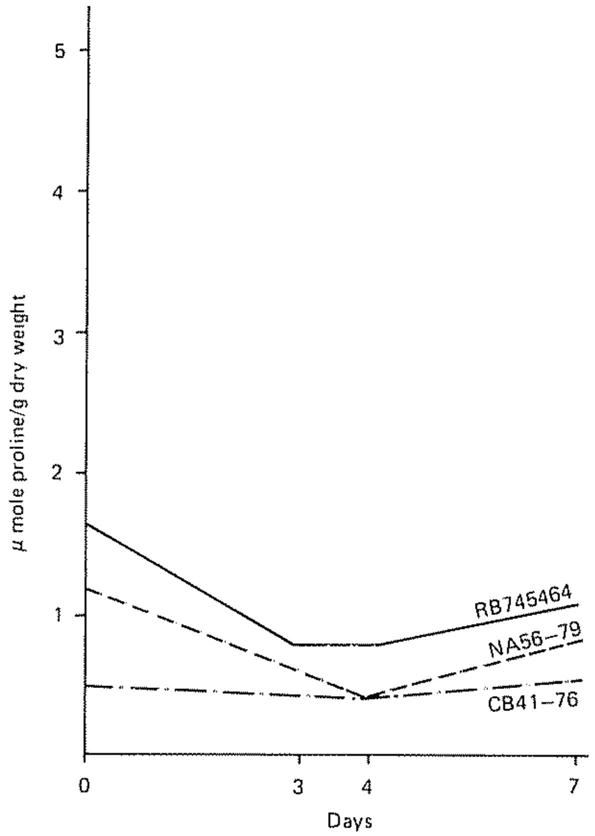

Fig 3 Proline concentration in −1 leaves from sugarcane grown in greenhouse with normal irrigation (Pots were not convered with plastic film) Data were average of 3 replications

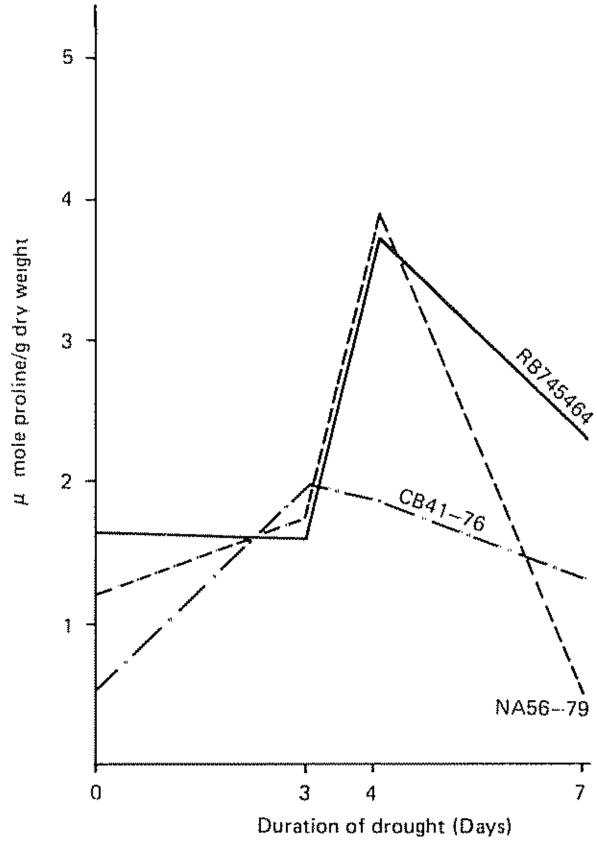

Fig. 4 Proline concentration in −1 leaves from sugarcane submitted to drought condition. (Pots were not convered with plastic film. Data were average of 3 replications).

both NA56-79 and CB41-76 under normal conditions. Accumulation of free proline occurred when the plant was under water stress conditions (Figure 4). Once again, the two drought resistant varieties, RB745464 and NA56-79, accumulated much more proline than the drought susceptible CB41-76. However, the proline content decreased when the plants were almost completely dry which occurred after seven days without watering under greenhouse conditions. Figure 5 shows that the proline content decreased immediately after the water stressed plants were irrigated. However, the accumulation of proline occurred when stress conditions started again The drought resistant varieties RB745464 and NA56-79, once submitted to a water stress condition, (which in our case might be called a "hardening" process), showed a tendency to accumulate a greater amount of proline in the case of a second stress; this was not true for susceptible variety CB41-76.

Discussion

Drought resistance of plants is based on water stress avoidance and/or water stress tolerance Water stress avoidance is achieve by reduction of transpiration, higher root suction potential, or a deeper root system, etc On the other hand, water stress tolerance is related to cell protoplasm, and indicates the ability of the cell to survive under suboptimal water supply conditions. RB745464 is a clone that arose great attention because of its special drought resistance capacity, as observed in the field. It was the only cane that remained green during a severe 4-month drought which occurred in 1979 at the Experiment Station of Cristalina, State of Goiás, near Brasilia (Central Brazil), in a field where 224 varieties and 392 RB clones were planted in 1 m x 5 m plots for local selection The clone was found to have a very deep root system which reached more than three meters of depth (Tokeshi, H.; Matsuoka, S.; and

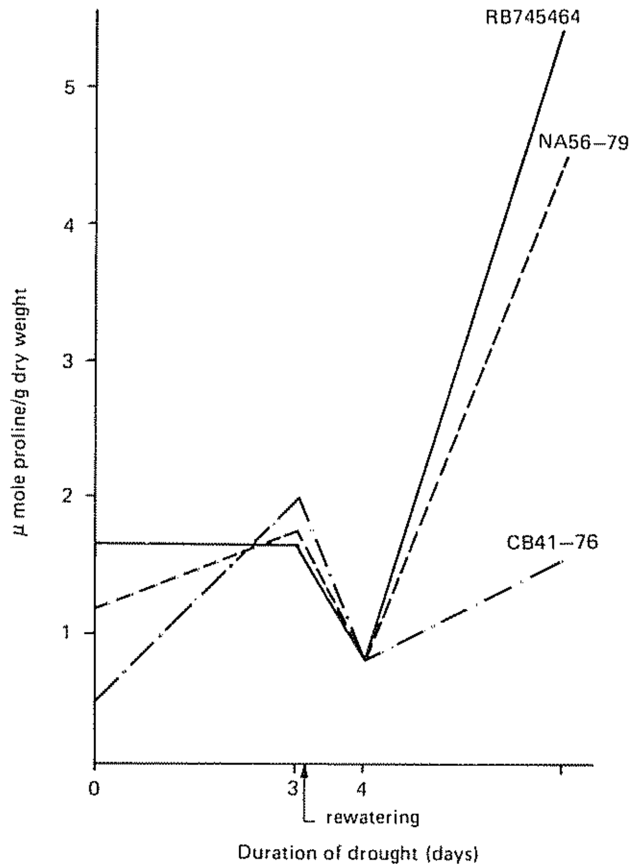

Fig. 5. Proline concentration in +1 leaves from sugarcane submitted to drought condition. (Pots were not convered with plastic film. Data were average of 3 replications).

Velho, P., unpublished data). Varieties NA56-79 and CB41-76 are the most planted in Brazil. NA56-79 has generally been recognized as a more drought resistant variety than CB41-76. It also has a better root system than CB41-76. The three methods used in this study to test drought resistance indicate the following order of resistance: RB745464 > NA56-79 > CB41-76, which was in general accord with Brinholi's *et al.* (2, 3) findings. The shoot/root ratios of these three varieties determined at 4 months of age were 2.43 for RB745464, 2.60 for NA56-79, and 3.71 for CB41-76, which also indicates a better chance for RB745464 and NA56-79 to overcome a drought condition. The proline analysis showed that the better root system was not the only factor contributing to the drought resistance capacity of RB745464 and NA56-79; higher water retention ability were also important factors. The higher proline content of the more resistant sugarcane varieties found after a "hardening" process probably indicates an even greater drought resistance capacity of these varieties under fields conditions since in non-irrigated fields plants are constantly submitted to a slight water stress during their life cycle

Since drought resistance is a reflection of special anatomical, morphological, physiological, and bio-chemical features of the plant, the selection for this capacity on the basis of only one or two characteristics may be misleading, althought in this study the two resistant varieties exhibited consistently favorable results in the characteristics analyzed, whereas the non-resistant variety did not. Plant age is an important factor which deserves more attention in a drought resistance selection program. As observed in our NaCl studies, plants of the same variety but different ages reacted differently to the drought test. Unpublished data of Lee T. S. Gerald indicate the same results when a drought condition was induced by withdrawing water. The best way to choose the suitable age for this type of selection program is to correlate the results of laboratory test at different plant ages with field data for varieties whose drought resistance characteristics are well known. From this study it seems that sugarcane plants older than 3 months are safe for a drought resistance testing program. Each of the three methods tested in this study has some shortcomings. For example, in the salt adding method there is the danger of NaCl leaching out through the pot, especially when the plants become older and the roots have filled the pot. The toxic effect of NaCl on plants may also influence the results.

Although the method of withdrawing the water supply is simple and cheap compared to the methods used, it is questionable whether the leaf drying percentage can completely represent the plant drought resistance capacity. The proline content seems to be a useful index in the selection of drought resistant varieties; however, this method requires a chemical analysis and, furthermore, the correct drying period in which the leaf sample is to be collected for analysis should be determined more precisely. Further studies involving more varieties will be carried out to observe the potential of these 3 methods in more detail.

Abstract

The drought resistance capacity of two varieties and one clone was tested. Three methods were used: addition of salt, withdrawal of water, and proline analysis. The three methods used indicated the following order of drought resistance capacity: RB745464 > NA56-79 > CB41-76.

These results are well in accord with field data, which indicate the same tendency. It was also observed that plants of the same sugarcane variety, of different ages, present different reactions to drought.

The potential of these methods as well as the problems associated with them are discussed.

Literature cited

1. BATES, L. S. Rapid determination of free proline for water stress studies. Plant and Soil 29:205-207. 1973.

2. BRINHOLI, O. e GODOY, O. P. Resistência à seca de variedades de cana-de-açúcar (*Saccharum* spp). Brasil Açucareiro 86(4):65-71. 1975.

3. BRINHOLI, O.; BRASIL, O. G. E DALBEN, L. C. Estudo entre os teores de prolina das folhas e a resistência à seca de algumas variedades de cana-de-açúcar (*Saccharum* spp). Brasil Açucareiro 96(6):48-51. 1980.

4. RAO, K. C. and ASOKAN, S. Studies on free proline association to drought resistance in sugarcane. The Sugar Journal 40(8):23-24. 1978.

5. SINGH, S. Studies in the drought endurance capacity of cane varieties the time lag between wilting and death under drought condition. Indian Sugar, 13:717-720. 1964.

6. TANIMOTO, T. and NICKELL, L. G. Estimation of drought resistant of sugarcane varieties. **In** Congress of the ISSCT, 12, Puerto Rico. 1965. pp. 893-896.

Reseña de libros

ASHBURNER, J., SIMS, B. Elementos de diseño del tractor y herramientas de labranza. Serie de Libros y Materiales Educativos No. 56. IICA 1984. 473 p

Este libro es uno de los pocos que recopila una valiosa información aplicable a la labranza de tierras en el trópico. De gran utilidad para el estudiante y profesional en Ingeniería Agronómica y Agrícola, le permite realizar una serie de cálculos teóricos que podrá ajustar en la práctica a las diferentes condiciones agronómicas presentes en la agricultura tropical.

Consta de diez capítulos, describiendo los tres primeros la resistencia, propiedades físicas y dinámicas y la mecánica de suelo aplicada a las herramientas o implementos agrícolas. Enfoca ampliamente características técnicas a tomar en cuenta en la labranza de suelos al seleccionar las herramientas agrícolas o implementos apropiados.

El capítulo cuatro analiza, de acuerdo a las características físicas de los suelos, las operaciones realizadas por diferentes implementos lo que permite formar un criterio valioso para selección de las herramientas agrícolas.

La relación de las propiedades físicas del suelo con los sistemas de labranza es evaluada en el capítulo cinco. Permite un análisis agronómico de las condiciones óptimas para el desarrollo de cosechas con el sistema de preparación de suelos más eficiente.

El tractor como fuente de fuerza es descrito en el capítulo seis en el cual se definen aquellas fuerzas aplicadas al suelo, usadas en el diseño de tractores agrícolas.

El capítulo siete describe los sistemas de enganche o acople de implementos al tractor, incluyendo fórmulas parte el cálculo de las fuerzas actuantes en los implementos agrícolas en diferentes condiciones de suelo, dando énfasis a los arados de discos y vertedera y en equipos de subsuelado. Menciona los sistemas modernos de fuerza controlada y su relación con el torque, punto básico en la tracción de implementos acoplados a los tractores.

El acople de carretas de uno y dos ejes, de gran importancia en el transporte agrícola, es evaluado en el capítulo ocho, analizando las fuerzas actuantes en esos remolques, así como aquellos implementos de tiro excéntrico de gran uso en labores de labranza.

El capítulo nueve explica ampliamente de acuerdo a la mecánica de suelos, la teoría de tracción y sistemas de rodaje, llantas y orugas, lo que permite seleccionar el tipo de rodaje apropiado para la agricultura; este capítulo incluye siete cuadros que describen: presión en llantas, requerimientos de fuerza, energía y potencia, así como valores de eficiencia de campo, estimación de repuestos, y aún cuando son figuras aplicables en los Estados Unidos y Gran Bretaña, se pueden usar como una guía para establecer los propios de cada explotación agrícola.

El rendimiento de tractores agrícolas en el campo es tratado en el capítulo diez, incluyendo mención de las pruebas internacionales, tal como la Prueba de Nebraska. Explica los costos de posesión y operación, básicos para la selección apropiada del equipo agrícola aplicable a las características propias de cada explotación agrícola.

El libro recopila fórmulas, gráficos, cuadros, fotografías, que complementan en una forma muy positiva y clara la solución a un gran número de problemas que se presentan en la labranza mecánica del suelo.

MAURO MOLINA
FACULTAD DE AGRONOMIA
UNIVERSIDAD DE COSTA RICA