EVALUATION OF CASSAVA (*Manihot esculenta* Crantz) GENOTYPES UNDER DROUGHT-FIELD CONDITION

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Abstract

Cassava genotypes that experienced seven months of drought in the field had significant decrease in total plant biomass, shoot biomass, root biomass, root-shoot biomass ratio, plant height, number of leaves, number and total length of adventitious roots, and total root yield. A decline in midday transpiration rate of the the plants was also noted. While the midday stomatal resistance and leaf water potential were found to increase during drought.

Identified drought resistant genotypes like Golden Yellow and Rayong 5 performed better under drought condition particularly in terms of biomass, yield and harvest index. These two genotypes were associated with some drought adaptive traits/mechanisms which include: more number and longer length of adventitious roots, high midday stomatal resistance and high midday leaf water potential.

Introduction

Cassava is known to be tolerant to drought (Cock, 1985). This could be the reason why the crop is commonly planted in areas that have been marginalized due to frequent occurrence of water shortage. However, the crop showed sensitivity to drought during the establishment period, i.e., first three months of growth from planting (Pardales et al., 2001). Drought stress during this period significantly reduces the growth and development of both roots and shoots, which in turn affect the succeeding development of the plant including storage root development, even if the stress is alleviated. This generally results to either low yield at the normal maturity time of the crop or delays the harvest to allow increase in yield.

The potential of genetic improvement in cassava has been clearly demonstrated by improving root yield, dry matter content and harvest index (Mariscal and Bergantin, (1998). While traits conferring drought tolerance are also assumed to be improved in order to come up with genotypes that would perform well under drought condition. It is postulated that different genotypes show different reaction to drought and that the mechanism of drought tolerance varies from one genotype to another. Hence, a basic understanding on the drought response of different cassava genotypes is therefore important so that traits that give the crop the ability to withstand drought and thus help stabilize its productivity be known.

Objectives

1. To screen cassava genotypes under drought-field condition.
2. To identify plant traits that relate resistance to drought in cassava under field condition.
3. To establish index of drought tolerance in cassava.

Methodology

1. Test Materials and Plant Establishment

Five cassava genotypes namely: PSB Cv-19, PSB Cv-11, VC-4, GoldenYellow and Rayong 5 were used in this study. Sixty four stem cuttings (20 cm long) of each genotype were planted uprightly at one cutting per hill in a distance of 100 cm between furrows and 75 cm between hills. The plants were established for about one month and a half under rainfed condition. Afterwards, half of the total number of the plants was subjected to drought under an acetate-covered rain shelter (Fig. 1). This condition was maintained until harvest.

Fig.1. Experimental plants under rainfed and drought-treated conditions.

2. Data Collection

During the course of drought imposition the leaf water potential (MPa), stomatal resistance (s cm^{-1}) and transpiration rate (µg cm^{-2} s^{-1}) were measured in situ from the middle of the third open leaves of the plants with the use respectively of a dew-point microvoltmeter (HR-33T, WESCOR, USA) (Fig. 2) and a steady state porometer (Li-Cor 1600, Li-COR, USA) (Fig. 3).

Fig. 2. Gathering leaf water potential using HR-33T microvoltmeter.

Eight and a half months after planting, all plants were harvested. Yield and other growth parameters were obtained.

3. Treatments and Experimental Design

The experiment was laid-out in split plot arranged in a randomized complete block design with four replications. Water regimes (rainfed and drought-treated) serves as mainplot while the genotype serves as subplots.

Fig. 3. Gathering leaf transpiration and stomatal resistance using Li-Cor 1600.

Results and Discussion

Table 1. Drought-treated/Rainfed Ratio on Different Plant Traits

Genotypes	Total Biomass	Shoot Biomass	Root Biomass	R-S Ratio	Total Yield	Harvest Index	Plant Height	No. of Leaves	Total No. Adv. Roots	Total Length Adv. Roots
Golden Yellow	0.47	0.47	0.48	1.03	0.48	1.16	0.83	1.13	0.58	0.76
Rayong 5	0.40	0.42	0.40	0.96	0.40	0.94	0.90	1.05	0.60	0.59
PSB Cv-11	0.32	0.37	0.27	0.75	0.27	0.66	0.94	0.44	0.56	0.55
PSB Cv-19	0.26	0.31	0.19	0.61	0.19	0.64	0.79	0.61	0.46	0.52
VC-4	0.14	0.18	0.10	0.55	0.10	0.52	1.03	0.61	0.58	0.39
Average	0.32	0.35	0.29	0.78	0.29	0.78	0.90	0.77	0.56	0.56

1. Drought Effects on Biomass and Yield Production

Drought significantly reduced biomass production. The ratio of biomass of drought-treated plants to that of the control (rainfed) was used to quantify drought tolerance. The ratio was 0.32 on average and ranged from 0.14 to 0.47 among the 5 genotypes which varied markedly in their responses (Table 1). Genotypes with larger biomass under drought showed significantly higher values in that ratio (more tolerant to drought).

Among the genotypes tested, Golden Yellow and Rayong 5 obtained higher biomass under drought (Fig. 4). This was largely contributed by high production of both roots and shoots under drought-treated condition. In addition, under drought, root production was more favored in Golden Yellow which resulted to obtain higher root yield and harvest index at harvest.

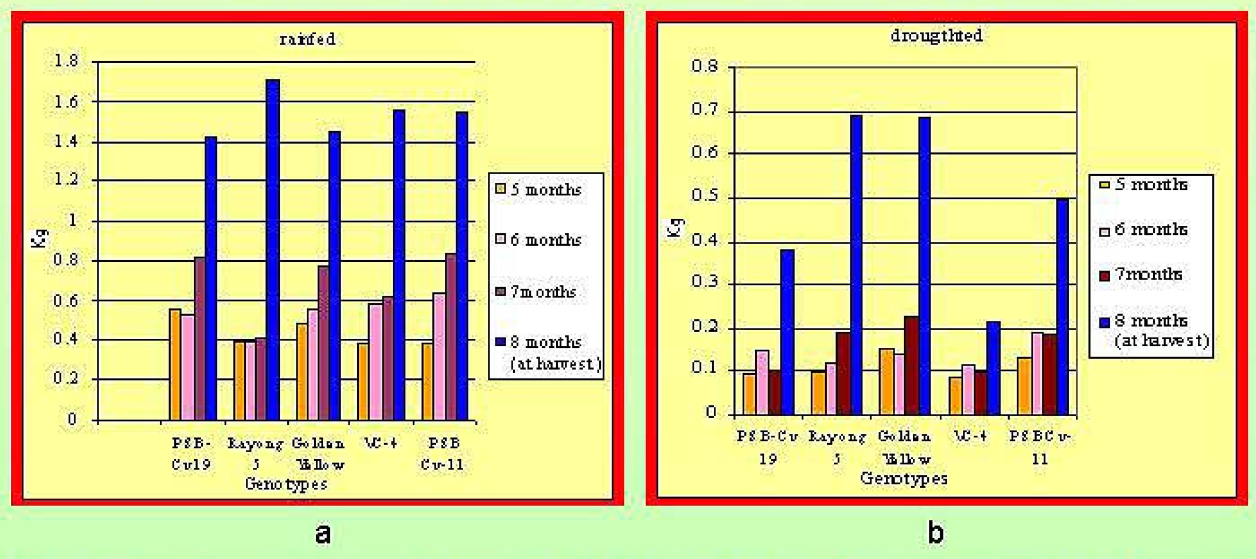

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Fig. 4. Biomass production of cassava under rainfed (a) and drought-treated (b) regimes.

2. Physiological Traits as Affected by Drought

When taken across genotypes, results showed that the highest transpiration rate occurred during the third month of growth when plants under both rainfed and drought-treated regimes reached their maximum vegetative stage (Fig. 5). High transpiration, even under declining soil water is an adaptive mechanism of the plant in order to maintain adequate water level thereby avoiding leaf dehydration (Ike, 1982). On the other hand, the stomatal resistance increased during the later stage of growth (Fig. 6) when soil moisture was already scarce. Stomatal resistance was found to be an important adaptive mechanism in cassava during the time when soil water potential decreases (El-Sharkawy and Cock, 1984). The midday leaf water potential was decreased during the later period of drought. Golden yellow was able to maintain higher leaf water potential during drought period compared to the rest of the genotypes tested (Fig. 7).

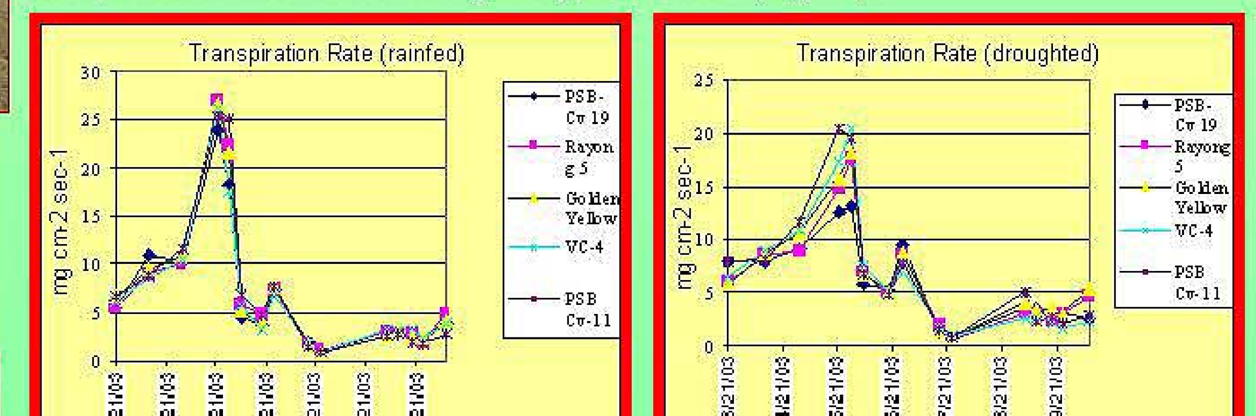

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Fig. 5. Transpiration rate of cassava under rainfed (a) and drought-treated (b) regimes.

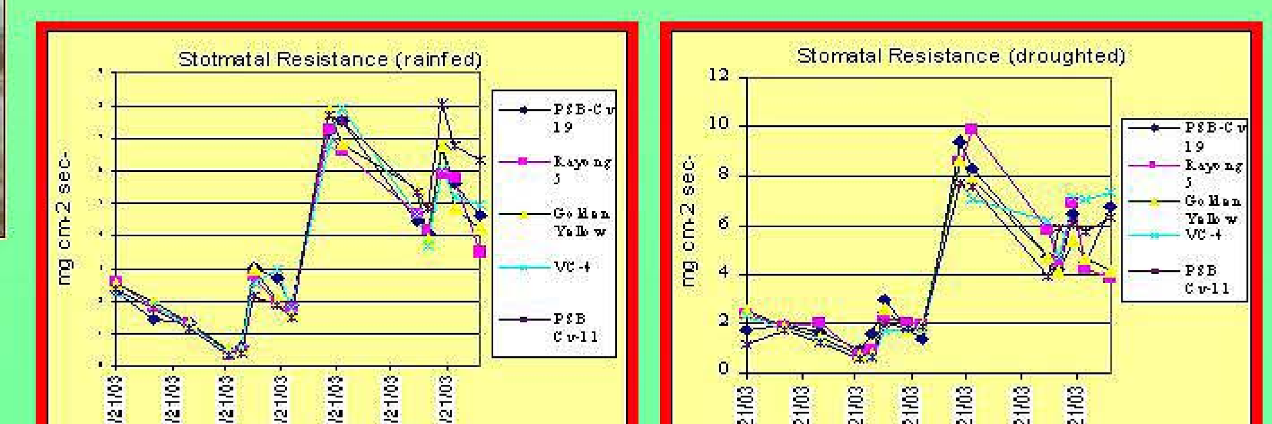

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Fig. 6. Stomatal resistance of cassava under rainfed (a) and drought-treated (b) regimes

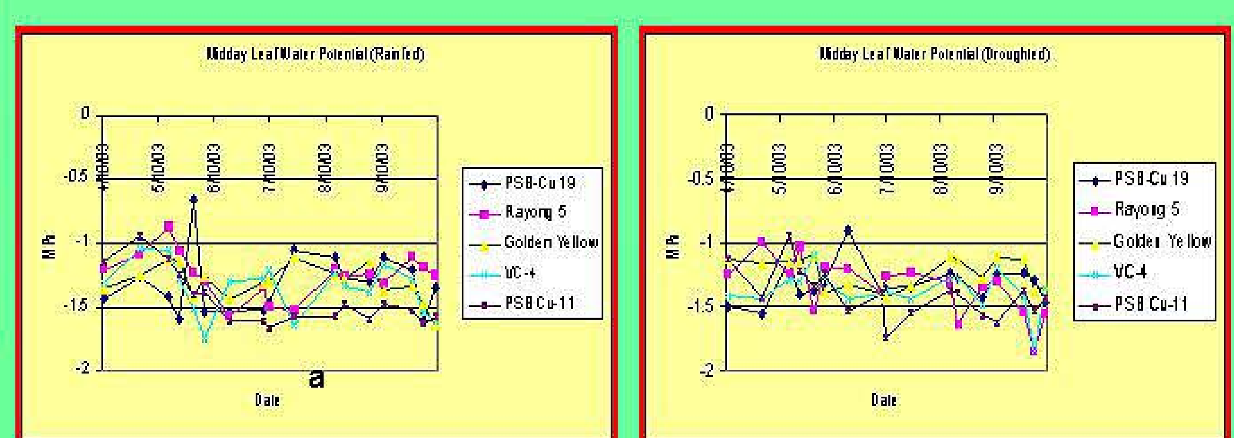

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Fig. 7. Midday leaf water potential of cassava under rainfed (a) and drought-treated (b) regimes.

3. Morphological traits as affected by drought

Irrespective of genotypes, development of leaves was inhibited during drought period. This suggest the sensitivity of cassava to water shortage. Plant height was also reduced by drought (Fig. 8). Golden Yellow was least affected in terms of leaf production and stem elongation, thus, producing the highest shoot biomass under drought condition. Reductions in the number and length of adventitious root were noticeable in drought-treated plants. Moreover, the storage roots of drought-treated plants were smaller and woody. There could be a shift of root function from storage of assimilates to mainly serving as channel of water and nutrients that would be delivered to the shoots in order to perform photosynthesis and respiration in the midst of water shortage. Golden Yellow and Rayong 5 (Fig. 9) developed a unique root characteristic of extending their adventitious roots longer and farther as compared to the rest of the genotypes. This adaptive trait was allowing these genotypes to absorb more water and nutrients in the soil which eventually resulted to higher biomass and yield production under drought condition.

a b

Fig. 8. Cassava plants under rainfed (a) and drought-treated (b) regimes at five and a half months of growth (four months of drought imposition).

a b

Fig. 9. Golden Yellow (a) and Rayong 5 (b) roots under drought-treated regimes.

Conclusion

A seven-month of drought period in the field had caused a significant decreased in the following traits of cassava: total plant biomass, shoot biomass, root biomass, root-shoot ratio, total yield, harvest index, plant height, number of leaves, total number and length of adventitious root. Leaf water potential and transpiration rate were also reduced, while stomatal resistance was increased by drought. Golden Yellow and Rayong 5 were found to be more tolerant to drought, while VC-4 was identified susceptible. Drought tolerant genotypes had exhibited more number and longer length of adventitious roots as important adaptive mechanisms during drought. These genotypes also increased their stomatal resistance and lowered their midday transpiration rate as drought progressed, thus, allowing them to maintain higher leaf water potential during drought period.

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