PHYSIOLOGICAL VARIABILITY IN THE MINERAL NUTRITION OF FOUR CASSAVA CULTIVARS IN FLOWING SOLUTION CULTURE

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SUMMARY

Results obtained since 1972 at the University of Queensland indicate substantial differences between cultivars Ceiba, UQ2, UQ5 and Nina in the rates of root development from stem tip cuttings in response to changes in substrate calcium concentrations and temperature in liquid culture. When rooted cuttings were grown in flowing solution culture, large differences were observed between cultivars in their response to calcium and to ammonium and nitrate nitrogen concentrations in the culture solution. Our data provide evidence of differences between genotypes in responses to nutrients and there may be some relationship, as yet undetermined, that would allow such methods to be of use in breeding cassava cultivars adapted to specific nutritional environments.

RESUME

Les résultats obtenus depuis 1972 à l'Université de Queensland révèlent qu'il existe des différences non négligeables entre les cultivars Ceiba, UQ2, UQ5 et Nina dans le taux de développement des racines à partir des boutures d'extrémité de tige en réponse aux changements dans les concentrations du substrat de calcium et aux changements de température dans une culture liquide. Lorsqu'on a cultivé des boutures de racine dans une solution de culture flottante, on a noté de grandes différences entre les cultivars dans leur réponse aux concentrations de calcium, d'ammonium et d'azote dans la solution de culture. Les données disponibles prouvent qu'il existe des différences entre génotypes en réponse aux élements nutritifs et il doiy y avoir une relation encore indéterminée permettant d'utiliser de telles méthodes pour la sélection et l'amélioration des cultivars de manioc adaptés à des milieux de nutrition spécifiques.

RESUMEN

Los resultados obtenidos desde 1972 en la Universidad de Queensland indican diferencias substanciales entre los cultivares Ceiba, UQ2, UQ5 y Nina en el grado de desarrollo de raíces, a partir de estacas terminales, como respuesta a cambios en la concentración ce calcio y temperatura en el sustrato líquido. Cuando se hicieron crecer estacas ya enraizadas en soluciones nutritivas recicladas se observaron amplias diferencias, entre cultivares, en cuanto a su respuesta a las concentraciones de calcio, amonio y nitratos presentes en la solución nutritiva. Nuestros datos proveen evidencias sobre diferencias entre genotipos, en respuesta a nutrientes y puede haber alguna interrelación, si bien no determinada todavía, que pudiera permitir que tales métodos fuesen usados en la adaptación de cultivares de yuca a ambientes nutricionales específicos a través de mejoramiento genético.

INTRODUCTION

The importance of cassava (*Manihot esculenta* Crantz) for food as a potentially cheap source of carbohydrate for livestock and for industrial purposes is now widely recognized. However, although considerable attention has been given to improving the overall agronomy of the crop and to the breeding of superior lines, relatively little attention has been paid to the physiology of cassava. Morphological differences between cassava cultivars are well known[2] and provide outward evidence of the genetic diversity among cultivars. Less is known about physiological variation, although limited evidence available suggests that this too may be substantial[3]. Large differences between cassava cultivars in their response to fertilizers, observed in Ghana (S.H. Evelyn, personal communication), provide further evidence for physiological differences in cassava.

MATERIALS AND METHODS

In order to investigate physiological differences between cultivars in nutrient response, studies were commenced at the University of Queensland in early 1972. We have mostly used culture techniques

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employing flowing solution since this permits precise control to be maintained over nutrient ion concentrations, pH and root temperature[1]. We have used small stem tip cuttings for assaying responses since these have lower nutrient reserves than large stem cuttings, and so might be expected to be more sensitive to changes in the medium.

We have also readily propagated stem tip cuttings, lateral buds, and even detached leaves in mist culture, and we have constructed mist propagators in which both root temperature and nutrient supply can be varied.

RESULTS AND DISCUSSION

Effect of substrate calcium concentrations on root development

Root development by stem tip cuttings grown in mist propagation chambers was markedly affected by the concentration of calcium in the root medium (Fig. 1). When no calcium was supplied root development of the three cultivars in the trial was greatly retarded and the roots were stunted and had brownish-black tips.

In Ceiba, root growth appeared to be healthy at 15 uM calcium, but in Nina and UQ2, the roots still showed obvious symptoms of calcium deficiency. Marked differences in response to calcium supply were noted at higher concentrations. Thus Ceiba was relatively insensitive to substrate calcium concentrations over the range 15 to 1500 uM, root yields increasing gradually throughout this range while in Nina and UQ2, substantial increases in root yield occurred when the calcium concentration was increased from 15 to 150 uM, and yields tended to decrease at higher calcium concentrations.

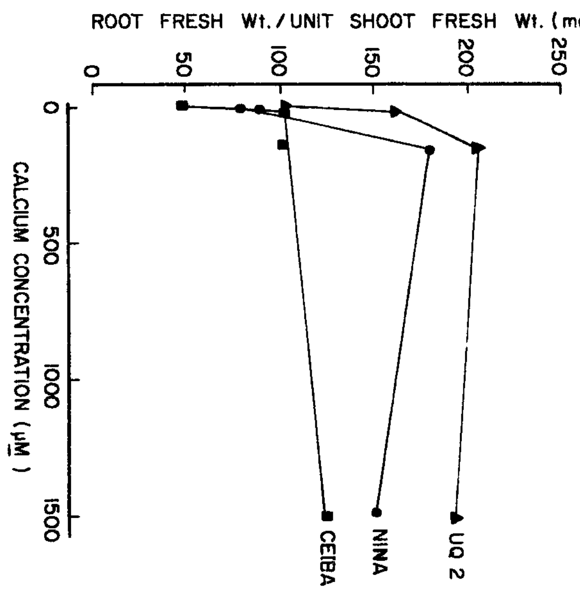

Figure 1. *Effect of substrate calcium concentrations on root development by tip cuttings of three cassava cultivars at a mean root temperature of 25°C. Root yield data represent means of four replications; calcium concentrations are means of analyses on alternate days for the 14 day experimental period.*

Effect of substrate temperature on root development

When stem tip cuttings were supplied with 155 uM calcium, large effects of temperature on root development were obtained in the root propagation chambers and there were again substantial differences between responses of individual cultivars (Fig. 2). At 20° C, root growth was severely retarded in all three cultivars, and increasing the temperature to 25° C caused a four-to-nine-fold increase in root yields.

At 25° C, Nina produced its greatest root growth, whereas with UQ2, greatest growth was obtained at 30° C. For Ceiba however, root growth was greatest at the highest temperature of 35° C. At this latter temperature, the root growth of Nina and UQ2 was retarded in comparison with that at 30° C.

The data obtained in this experiment relate to optimum root temperatures for root initiation and development, rather than to optimum root temperature for prolonged growth. Nevertheless, substantial differences may exist between cultivars in root temperatures required for optimum growth. For the following studies, the root temperatures of all cultivars were maintained at 25° C to avoid possible heat injury.

Effect of calcium concentration on growth of rooted cuttings

In a flowing culture experiment conducted at a range of controlled calcium concentrations, large differences were found in the responses of individual cultivars. Figure 3 shows the results for two cultivars studied. In the three lowest treatments (0.3, 3 and 10 uM Ca), the growth of both Nina and UQ5 was severely retarded and root growth was particularly stunted. However, above 100 uM, there was little effect of calcium concentration on the growth of Nina, but for UQ2, yields continued to increase up to 1000 u M. Beyond this, further increases in calcium concentration caused substantial yield reduction of UQ5. However, since calcium was supplied as calcium chloride, the yield depression in UQ5 may have been due to a greater sensitivity in this cultivar to high chloride concentrations.

Effect of nitrate and ammonium nitrogen concentrations on the growth of rooted cuttings

Quite large differences were observed between cultivars in response to nitrogen, but the response to various nitrogen concentrations depended upon whether nitrogen was supplied as nitrate or ammonium. Much higher concentrations of nitrate than ammonium nitrogen were needed for maximum growth (Figs. 4, 5).

When nitrogen was supplied solely as the ammonium ion, the growth of Ceiba was best at 29 uM, and was depressed at higher concentrations. In contrast to this, UQ2 responded to ammonium concentrations up to 490 uM (Fig. 4).

The response to nitrate however was somewhat different. Although the growth of both Ceiba and UQ2 was severely retarded at low nitrate concentrations (0.5 to 5uM), Ceiba was much more responsive to intermediate concentrations of nitrate than UQ2. Thus an increase in nitrate concentration from 16 to 52 u M resulted in a 30 percent increase in the growth of Ceiba but only a 2 percent increase in the growth of UQ2. By contrast, at hign concentrations the situation was reversed, thus there was a 47 percent increase in the growth of UQ2 between the 560 and 5050 u M nitrate treatments, compared with only a 15 percent increase in the growth of Ceiba.

CONCLUSIONS

The existence of major differences in the response of small stem tip cuttings of different cassava cultivars to nutrient elements in liquid culture may indicate that fertilizer recommendations for one cultivar may not necessarily be suitable for other cultivars. Also, that, with further knowledge of physiological variation in cassava, it may be possible to select for specific nutrient responses in cassava breeding programmes.

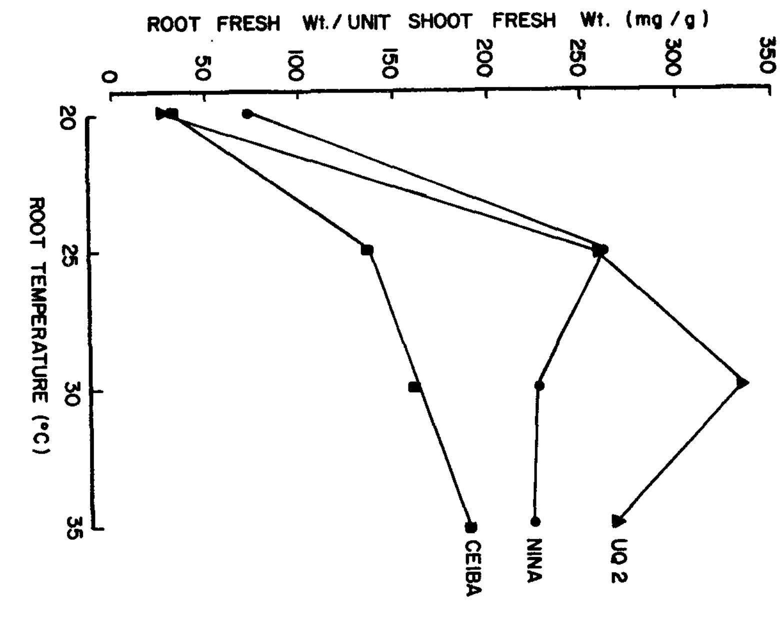

Figure 2. *Effect of temperature of the rooting medium on root growth by tip cuttings of three cassava cultivars at a mean substrate calcium concentration of 155 uM. Root yield data represeht means of four replications; root temperatures are means of hourly recordings at five locations in the rooting medium for the 14 day experimental period.*

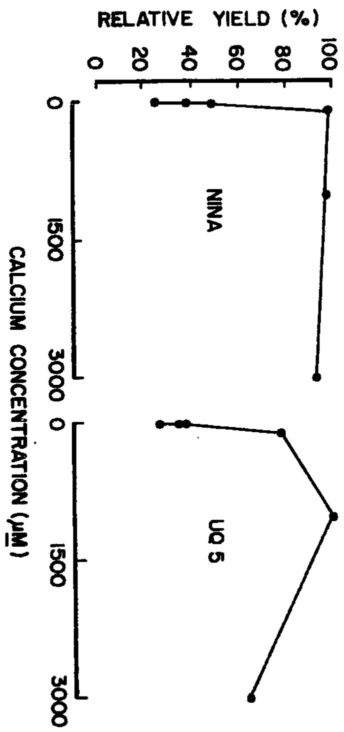

FIGURE 3.

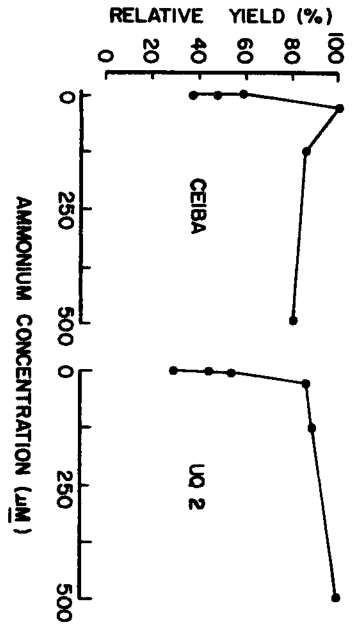

FIGURE 4.

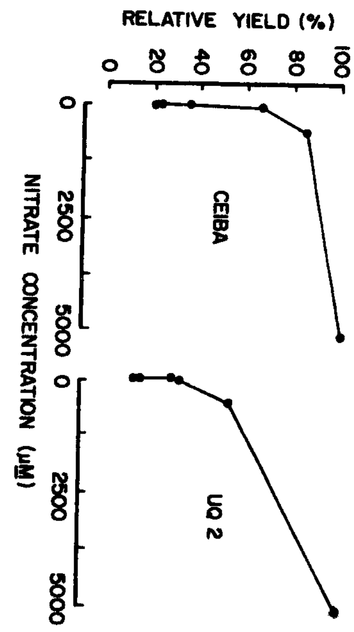

FIGURE 5.

Figure 3. *Effect of calcium in flowing solution culture on the growth of two cassava cultivars at a solution temperature of 25°C and pH 5.8. Whole plant yield data represent means of three replications; calcium concentrations are means of daily analyses for the 30 day experimental period.*

Figure 4. *Effect of ammonium-nitrogen in flowing solution culture on the growth of two cassava cultivars at a solution temperature of 25°C and pH 5.8. Whole plant yield data represent means of three replications; ammonium concentrations are means of analyses made twice daily for the 20 day experimental period.*

Figure 5. *Effect of nitrate-nitrogen in flowing solution culture on the growth of cassava cultivars at a solution temperature of 25°C and pH 5.8. Whole plant yield data represent means of three replications; nitrate concentrations are means of daily analyses for the 20 day experimental period.*

REFERENCES

1. Asher, C.J., Ozanne, P.G. and Loneragan, J.F. (1965) A method for controlling the ionic environment of plant roots. *Soil Sci.* 100, 149-56.

2. Fleming, H.S. and Rogers, D.J. A classification of *Manihot esculenta* Crantz using the information carrying content of a character as a measure of its classificatory rank. In *Tropical Root and Tuber Crops Tomorrow.* Vol. I. Proc. Second International Symp. Trop. Root and Tuber Crops. 1970. pp. 66-71.

3. Williams, C.N. (1971) Growth and productivity of tapioca (*Manihot utilissima*). II. Stomatal functioning and yield. *Experimental Agric.* 1, 49-62.