Effect of Stake Priming with Complete Nutrient Solution on Cassava Root and Starch Yield

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ABSTRACT

Low quality of cassava stakes for planting is a major cause that limits cassava growth and productivity. Nutrient contents of the stakes are one possible key factor determining the stake quality. Priming refers to a method to improve the performance of plant propagules, such as seed or cutting, by a pretreatment before planting. This study evaluated the effect of soaking cassava stakes in nutrient solution on cassava root yield and quality. The effect of cassava stake priming was evaluated in 5 cassava varieties (Rayong 5, Rayong 7, Rayong 9, Rayong 72, and Kasetsart 50 (KU50)) that were grown in the field with and without soaking stake in a complete nutrients solution. Although stake priming had no effect on above ground biomass, it increased root number and root yield of all cassava varieties except KU50. Stake priming increased root yield by up to 25% and starch yield 30% as compared with without priming. In conclusion, cassava stake priming, by soaking in complete nutrient solution, offers a simple, easy and practical means to improve cassava root as well as starch yield.

Key words: Cassava, Stake soaking, Priming

INTRODUCTION

Cassava, manioc or yucca (*Manihot esculenta* Crantz) is grown in over 90 countries. It is the primary staple for more than 800 million people in the world, mostly in tropical and sub-tropical poorest countries (Lebot, 2009). In cassava production, the crop is grown from sections of stems, generally called stakes. Low quality of cassava stake is a major cause that limits cassava growth and productivity (Eke-Okoro et al., 2001). Nutrients content in stake is the key factor determining the stake quality. Stakes produced from high fertility soils grow better because they have more nutrients reserve (Cock, 1985; Molina and El-Sharkawy, 1995). However, cassava is generally grown under low input by poor farmers living in the marginal areas. After harvesting of the roots, the stems are kept to use as planting stakes in the next season. Therefore, the stakes used by farmers commonly contain low nutrients and grow poorly (Howeler, 2002 ; Leihner, 2002). To produce high quality stakes, farmers will have to apply fertilizer into the mother plant, which is not possible for many cassava farmers who are poor. Priming refers to a method to improve the performance of plant propagules, such as seed or stake, by a pretreatment before planting, and has been used in many crops, such as seeds and stakes. For example, Priming wheat and maize with phosphorus (P) and zinc (Zn) have been reported to increased grain yield and yield component of wheat and maize under conditions of nutrient deficiency (Ali et al., 2008). Planting treated rice seed with coated with with 1.0-4.7 g Zn kg^{-1} seed before sowing has more rapid and better germination, root length and shoot growth (Slaton et al., 2001). In case of cassava has been reported (Lozano et al., 1981; Leihner, 2002; Wargiono and Ispandi, 2007). However, the condition under which cassava stake priming is effective or ineffective is as yet unclear. This study evaluated how priming cassava stakes with nutrient solution influence performance of different cassava varieties.

MATERIALS AND METHODS

This experiment was conducted at the Mae Hia Research Station and Training Center, Faculty of Agriculture, Chiang Mai University, Thailand from September 2010 to August 2011. The field has an annual rain fall of 1589.8 mm and average daily temperature of 25.2°C. The soil at the site showed the following chemical properties as pH 5.8 (water, 1:1), N 0.07%, P 15.5 ppm and K 90.7 ppm. The treatments were arranged in factorial design in RCBD, with 4 replications. The first factor was two levels of stake soaking; nil-soaking (S-) and soaking with complete nutrient solution (S+) for 2 hours before planting. The nutrient solution was modified from Broughton and Dilworth (1971) and Mozafar (1987) with the following composition of KNO_3, 25,000 µM; $CaCl_2$, 5,000 µM; KH_2PO_4, 5,000 µM; $Mg(SO_4)_2.7H_2O$, 1, 250 µM; K_2SO_4, 1,250; Fe-citrate, 250 µM; H_3BO_3, 50; $MnSO_4.H_2O$, 5 µM; $ZnSO_4.7H_2O$, 2.5 µM; $CoSO_4.7H_2O$, 0.5 µM; $Na_2MoO_4.2H_2O$, 0.5 µM; and $CuSO_4.5H_2O$, 0.1 µM. The second factor was five varieties of cassava including Rayong 5, Rayong 7, Rayong 9, Rayong 72, and Kasetsart 50 (KU50). The stakes of 0.2 m length were planted vertically in 4 m x 5 m experimental units with 1 m x 1 m spacing. Weed control was done by hand. Six plants in each replicate were harvested at 12 month after planted (MAP). Root number per plant and root fresh weight was measured at the harvest. Then, sampling of above ground and root were oven-dried at 75°C for 72 hours before weighing. Starch content of fresh roots was estimated by determination of root specific gravity (Wholey and Booth, 1979, the method used commercially to determine starch content and price in selling and buying of cassava root). The starch content of fresh roots is calculated with the formula:

Starch content (%) = 210.8 Specific gravity – 213.4;

When Specific gravity = Weight sample in air / (Weight sample in air – Weight sample in water)

RESULTS

Fresh and dry root weights of all varieties were increased by stake soaking with complete nutrient solution except KU50. Especially, Rayong 72 produced double root dry weight (Table 1).

Although there were genotypic variations of above ground dry weight, there was no significant effect of stake soaking (Table 2). On the other hand, root number per plant was increased by stake soaking (Table 2). Stake soaking did not only increase root yield and root number, but it also increased starch content and starch yield. Starch content of Rayong 9 was the highest, whereas Rayong 7 and Rayong 72 were the lowest. Yet, low starch content of Rayong 72 was compensated by root weight which improved its starch yield to the same level as Rayong 5, Rayong 9, and KU 50 (Table 3). Average starch yield of all varieties were increased about 30% by stake soaking as compared with nil-stake soaking (Table 3). The starch content was significantly correlated with starch yield (R =0.96**; $P<0.01$ and dry root weight (R=0.97**; $P<0.01$); likewise, starch yield was also positively correlated with root dry weight (R=0.94**; $P<0.01$).

Table1. Effects of stake soaking on root fresh and dry weight (t ha^{-1}).

Variety	Root fresh weight		Mean	Root dry weight		Mean
	S-	S+		S-	S+	
Rayong 5	56.8	73.8	65.3^{ab}	14.2^{cd}	19.4^{abc}	16.8
Rayong 7	37.8	51.5	44.6^{c}	11.3^{d}	13.0^{cd}	12.1
Rayong 9	49.5	56.2	52.8^{c}	11.7^{d}	21.7^{ab}	16.7
Rayong 72	60.6	75.6	68.1^{a}	12.8^{cd}	23.9^{a}	18.4
KU 50	61.8	58.2	60.0^{ab}	19.8^{abc}	14.9^{bcd}	17.3
Mean	53.3^{b}	63.1^{a}		14.0	18.6	
F-test	$LSD_{0.05}$			F-test	$LSD_{0.05}$	
Var*	13.0			Var^{NS}	(-)	
S*	8.7			S**	8.7	
Var x S^{NS}	-			Var x S*	7.2	

S = Stake soaking, Var = Varieties, *, ** = Significant (P< 0.05 and 0.01), NS = Not significant.

Table2. Effects of stake soaking on above ground dry weight (t ha^{-1}) and root number $plant^{-1}$.

Variety	Above ground dry weight		Mean	Root number $plant^{-1}$		Mean
	S-	S+		S-	S+	
Rayong 5	7.4	6.6	7.0^{ab}	7.9	10.5	9.2
Rayong 7	6.2	7.3	6.8^{c}	9.1	11.7	10.4
Rayong 9	7.4	9.4	8.4^{ab}	9.7	11.8	10.7
Rayong 72	8.0	7.3	7.6^{abc}	9.0	10.5	9.7
KU 50	10.3	12.6	11.4^{a}	10.9	10.3	10.6
Mean	7.8	8.6	8.2	9.3^{b}	11.0^{a}	
F-test	$LSD_{0.05}$			F-test	$LSD_{0.05}$	
Var*	3.8			Var^{NS}	-	
S^{NS}	-			S*	1.4	
Var x S^{NS}	-			Var x S^{NS}	-	

S = Stake soaking, Var = Varieties, * = Significant (P< 0.05), NS = Not significant

Table 3. Effect of stake soaking on starch content (%) and starch yield (t ha^{-1}).

Variety	Starch content		Mean	Starch yield		Mean
	S-	S+		S-	S+	
Rayong 5	13.1	13.8	13.5^{ab}	7.6	10.1	8.8^{a}
Rayong 7	12.5	13.6	13.1^{cd}	4.1	7.0	5.5^{b}
Rayong 9	16.0	16.4	16.2^{a}	6.6	9.2	7.9^{a}
Rayong 72	11.7	13.0	12.4^{d}	7.1	10.0	8.6^{a}
KU 50	13.7	14.9	14.3^{b}	8.5	8.7	8.6^{a}
Mean	13.4^{a}	14.4^{b}		6.3a	9.1b	
F-test	$LSD_{0.05}$			F-test	$LSD_{0.05}$	
Var**	1.1			Var*	2.3	
S**	0.7			S**	1.4	
Var x S^{NS}	-			Var x S^{NS}	-	

S =Stake soaking, Var = Varieties, *,** = Significant (P< 0.05 and 0.01), NS = Not significant

DISCUSSION AND CONCLUSION

Stake soaking was an effective method to improve nutrient status in cassava production when nutrient deficiency was the limiting factor of cassava production. Many experiments of stake soaking focused on single nutrient application such as Fe and Zn (Watananonta et al., 2004; Wargiono and Ispandi, 2007; Paisancharoen et al., 2010), but differential responses among varieties have not been evaluated.

This experiment was focused on stake soaking with complete nutrient solution on five cassava varieties. The complete nutrient solution is a way to improve cassava yield for many locations that sometime we may not know exactly which nutrient was limiting. Our result showed that stake soaking increased root number and root yield (Table 1 and 2). However, there was interaction between varieties by stake soaking. Four from five varieties; Rayong 5, Rayong 7, Rayong 9 and Rayong 72 responded positively to stake soaking while KU50 showed no response. Although KU50 was unaffected by stake soaking, it produced the yield as same as other varieties with soaking. As previous work showed that KU50 was adapted and produced stable yield in many regions such as Thailand, Laos and Cambodia (Aye et al., 2010; Klakhaeng and Vongkasem, 2010; Sopheap et al., 2010). Although yield of Rayong7 was increased by stake soaking, it still had the lowest yield as compared to the others.

The starch contents of all varieties in this experiment were quite lower than other work [average 25% by Prammanee et al. (2010) and average 24% by Watananonta et al. (2008)] as the result of very high root water content as the crop was harvested in the middle of the rainy season. Nevertheless, stake soaking promoted the starch content.

In conclusion, cassava stake soaking with complete nutrient solution, offers a simple, low cost and practical means to improve cassava yield as well as starch yield.

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REFERENCES

Ali, S., A. R. Khan, G. Mairaj, M. Arif, M. Fida, and S. Bibi. 2008. Assessment of different crop nutrient management practices for yield improvement. Australian Journal of Crop Science 2(3): 150-157.

Aye, M. T., V. Phimphachanhvongsod, and P. Khanthavong. 2010. The Nippon Foundation Cassava Project in Lao PDR. p. 425-434. In R.H. Howeler (ed) Proceedings of the 8^{th} Regional Workshop on A New Future for Cassava in Asia: Its Use as Food, Feed and Fuel to Benefit the Poor. 20-24 Oct 2008. Vientiane, Lao PDR.

Broughton, W.J., and M.J. Dilworth. 1971. Control of leghaemoglobin synthesis in snake beans. Biochem. J. 125: 1075-1080.

Cock, J.H. 1985. Cassava: New potential for a neglected crop. Westview Press, Boolder and London.

Eke-Okoro, O.N., O.U. Okereke, and J.E. Okeke. 2001. Effect of stake sizes on some growth indices and yield of three cassava cultivars (*Manihot esculenta*). The Journal of Agricultural Science 137: 419-426.

Howeler, R.H. 2002. Cassava mineral nutrition and fertilization. p.115-147. In R.J. Hillocks, J.M. Thresh and A.C. Bellotti (eds) Cassava: Biology, production and utilization. CAB International, Wallingford.

Klakhaeng, K., and W. Vongkasem. 2010. The impact of the Nippon Foundation Cassava Project in Thailand: Five year on. p. 401-107. In R.H. Howeler (ed) Proceedings of the 8^{th} Regional Workshop on A New Future for Cassava in Asia: Its Use as Food, Feed and Fuel to Benefit the Poor. 20-24 Oct 2008. Vientiane, Lao PDR.

Lebot, V. 2009. Cassava tropical root and tuber crops: cassava, sweet totato, yams and aroids. CAB International, Wallingford.

Leihner, D. 2002. Agronomy and cropping systems. p. 91-113. In R.J. Hillocks, J.M. Thresh and A.C. Bellotti (eds) Cassava: Biology, production and utilization. CAB International, Wallingford.

Lozano, J.C., A. Bellotti, J.A. Reyes, R.H. Howeler, D. Leihner, and J. Doll. 1981. Nutritional deficiencies and toxicities. Field problems in cassava. International Center for Tropical Agriculture (CIAT). Cali, Colombia.

Lozano, J.C., J.C.S. Toro, A. Casttro, and A.C. Bellotti. 1984. Selection and preparation of cassava cuttings for planting. International Center for Tropical Agriculture (CIAT). Cali, Colombia.

Molina, J.L., and M.A. El-Sharkawy. 1995. Increasing crop productivity in cassava by fertilizing production of planting material. Field Crops Research 44: 151-157.

Mozafar, A. 1987. Effect of boron on ear formation and yield components of two maize (*Zea mays* L.) hybrids. Plant and Nutrient 10(3): 319-332.

Paisancharoen, K., C. Nakviroj, and W. Amonrnpol. 2010. Thirty two year of soil fertility for cassava in Thailand. p. 246-262. In R.H. Howeler (ed) Proceedings of the 8^{th} Regional Workshop on A New Future for Cassava in Asia: Its Use as Food, Feed and Fuel to Benefit the Poor. 20-24 Oct 2008. Vientiane, Lao PDR.

Prammanee, S., K. Kamprerasart, S. Salakan, and K. Sriroth. 2010. Growth and starch content evaluation on newly released cassava cultivars, Rayong 9, Rayong 7 and Rayong 80 at different harvest times. Kasetsart J. (Natural Science) 44: 558-563.

Slaton, N.A., C.E. Wilson, S. Ntamatungiro, R.J. Norman, and D.L. Boothe. 2001. Evaluation of zinc seed treatments for rice. Agronomy J. 93: 157-163.

Sopheap, U., O. Makara, R.H. Howeler, and T.M. Aye. 2010. Enhancing cassava production and its utilization though the Nippon Foundation Cassava Project in Cambodia. p. 460 - 469. In R.H. Howeler (ed) Proceedings of the 8^{th} Regional Workshop on A New Future for Cassava in Asia: Its Use as Food, Feed and Fuel to Benefit the Poor. 20-24 Oct 2008. Vientiane, Lao PDR.

Wargiono, J., and A. Ispandi. 2007. Cassava agronomy research and its contribution to a secure food system in Indonesia. p.174-182. In R.H. Howeler (eds) Proceedings of the 7th Regional Workshop on Cassava Research and Development in Asia: Exploring New Opportunity for an Ancient Crop. 28 Oct – 1 Nov 2002. Bangkok, Thailand.

Watananonta, W., S. Tungsakul, M. Kamhung, C. Kogram, S. Chompunukulrat, S. Ratanasriwong, S. Ratanarat, P. Phetprapi, and R.H. Howeler. 2004. The response of micronutrients on cassava root yield of Rayong 72 and Kasetsart 50. Thai Agricultural Research 22: 24-38. (in Thai with English abstract)

Wholey, D.W., and R.H. Booth. 1979. A comparison of simple methods for estimating starch content of cassava roots. J. Sci. Food Agric. 30: 158-164.