Effect of Stake Priming with Nutrient Solution on Growth and Yield of Cassava Grown under Greenhouse and Field Conditions

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ABSTRACT: The effect of stake priming with macro-nutrients solution (N, P, K and combination) of two stakes nutritional status (good and poor) on the crop establishment, growth and yield of cassava were studied under greenhouse and field conditions. Cassava stakes soaked in P solution alone and N combined with P solution significantly increased root fresh biomass and cassava stakes soaked in P solution alone significantly increased shoot fresh biomass over nil-soaking. Good nutritional status of stakes significantly increased number of fine roots, root fresh biomass, number of sprouting and shoot fresh biomass over poor nutritional status of stakes under greenhouse conditions. Similarly, good nutritional status of stakes significantly increased leaf area, fine root length, above ground fresh biomass, number of tuberous root and tuberous root fresh yield over poor nutritional status of stakes under field conditions. Cassava stakes soaked with N, P, K and combination did not show any significant difference on tuberous roots yield. However, cassava stakes soaked in N combined with P and K tend to give the maximum tuberous root fresh yield under field conditions.
Keywords: cassava, stake, priming, soaking, macro-nutrients

Introduction

In cassava production, the crop is grown from section of stems, generally called stakes. After harvesting of the tuber, the stems are kept to be used as planting stakes in the next season. The farmers may store planting stakes for longer than 3-4 weeks before planting. Cassava planting materials lose their moisture during storage and this adversely influences stake viability. (Leihner, 1984). Furthermore, stored stakes continue to respire and losses of carbohydrates occur during storage, reducing reserves available to stakes after planting and thus diminishing sprouting vigor and establishment (Leihner,1984; CIAT, 1988). Presently in northeast Thailand, cassava is being increasingly cultivated in the paddy fields after the main crop of rice is harvested to generate farm income. Cassava can be planted using stored moisture during dry season after rice harvest, and the crop can be harvested by 6-7 months as a sequential crop. In some case, low soil moisture at planting cause that limits cassava growth and productivity besides low quality of cassava stakes. Priming is commonly referred to as a method to improve the performance before planting of plant propagules, such as seed or stake, by certain pretreatments before planting. Seed priming has reported to result in vigorous early seedling growth and better stand establishment (Arif et al.,2005; Ali et al.,2007). Priming rice seeds with KCl and $CaCl_2$ have been reported for early emergence and seedling growth (Farooq et al.,2006b; 2006c). Planting treated seeds of wheat and maize with phosphorus and zinc increased grain yield and yield components under conditions of nutrient deficiency (Ali et al., 2008). However, priming of vegetative cuttings is

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not well documented. The objectives of this study were to investigate the effect of priming cassava stakes with nutrient solution on growth and yield of cassava under greenhouse and field conditions.

Materials and Methods

Greenhouse experiment

Two pot experiments were conducted in a greenhouse, Faculty of Agriculture, Khon Kaen University in May 2014. Two sets experiment were arranged with different of soil moisture regimes. For the first set, pots were irrigated every 3 days to maintain soil moisture at field capacity throughout the growing season. For the second set, pots were irrigated once at planting with soil moisture 9.2% by weight at 0-15 cm and 9.8% by weigh at 15-30 cm soil depth. The available soil moisture at FC and PWP were 4.5 and 2.1 % by weight, respectively. Then, there was no irrigation to the crop throughout the growing season. The crops were harvested at seedling growth stage on day 21 after planting.

The cassava cultivar Kasetsart 50 was used in these studies. The planting stakes were stored for three weeks before planting. The soil type was sandy loam with pH 5.4, total N 0.017% available P 38.11 mg/kg and exchangeable K 39.27 mg/kg. The treatments were arranged in factorial experiment in CRD with 4 replications. The first factor was two levels of stake nutritional condition; good nutritional status which achieved by application of chemical fertilizer 15-15-15 (N, P_2O_5, K_2O) at rate of 313 kg/ha (nutrients content of stake with total N 1.267%, total P 0.344% and total K 0.435% , stake moisture 65%, stake diameter 2.3 cm and stake weight 88.99 gm/stake) and poor nutritional status of stake which achieved by non-fertilization (nutrients content of stake with total N 0.927%, total P 0.111% and total K 0.290%, stake moisture 54%, stake diameter 1.3 cm and stake weight 56.9 gm/stake). The second factor was stake priming; nil-soaking and soaking with N (Urea 46% N at rate of 3 gm/liter), soaking with P (superphosphate 42% P_2O_5 at rate of 3 gm/liter), soaking with N and P (Urea and superphosphate at rate of 3 gm/liter). Stakes were soaked for 4 hours of all treatments. Pots having 34 cm diameter and 27 cm height were filled with 16 kg air-dry soil. The stakes of 15 cm length were planted vertically in pots. There is no fertilizer application in these studies. The number of fine roots per plant, root fresh biomass, number of sprouting per plant, shoot fresh biomass were measured at 21 days after planting. For the second set, soil moisture contents were determined by gravimetric measurement at 0-15 and 15-30 cm depth every 5 days after planting until harvest at 21 days (**Figure 1**). Field capacity (FC) and permanent wilting point (PWP) were estimated using pressure plate equipment.

Field experiment

Field experiment was conducted at experimental farm, Faculty of Agriculture, Khon Kaen University, Thailand from December 2012 to June 2013. The soil type is sandy loam with pH 5, total N 0.019% , available P 6.4 mg/kg, exchangeable K 17.64 mg/kg and organic matter 0.21%. A total rainfall of 184 mm occurred during the crop growth period 6 months. The maximum and minimum temperatures were recorded as 34.9 and 22.3 °C, respectively. The study was laid out in a split-plot design with three replications. The main-plots comprised of the two levels of stake nutritional condition; good nutritional status (nutrient content of stake with total N 0.386%, total P 0.110% and total K 2.648% ; stake moisture 64%, stake diameter 2.4 cm and stake weight 92.6 gm/stake) and poor nutritional status (nutrient content of stake with total N 0.274%, total P 0.091% and total K 1.115% ; stake moisture 60% , stake diameter 1.7 cm and stake weight 60.8 gm/stake) . The sub-plot treatments consisted of five soaking treatments ; nil-soaking and soaking with water, N (urea 46% N at rate of 3 gm/liter), NP (urea 46% N + superphosphate 42% P_2O_5 at rate of 3+3 gm/liter) and NPK (urea 46% N + superphosphate 42% P_2O_5+ potassium chloride 60% K_2O at rate of 3+3+3 gm/liter). Stakes were soaked for 4 hours of all treatments. The cassava cultivars kasetsart 50 was used in this study. The planting stakes were stored for three weeks before planting. The stakes of 15 cm length were planted vertically with 1m×1m spacing. Weed control was done by hand at 1 month after planting. There was no insecticide use in this experiment. Five plants were randomly sampled from each treatment 1 month after planting. The leaf area per plant, above ground fresh biomass per plant, root length per plant were measured. Ten plants of each treatment located in harvesting area were sampled to determine the number of tuberous root per plant, above ground fresh biomass and tuberous root fresh yield at 6 months after planting. Soil moisture content was determined by gravimetric measurements at 0-15, 15-30 and 30-45 cm depth with seven-day interval (**Figure 2**). The available soil moisture at FC and PWP were estimated with pressure plate equipment. In the present experiment, cassava crop subjected to water stress at 80 days after planting for 55 days (**Figure 2**).

Results

Greenhouse experiment

In the greenhouse experiment 1, There were significant effects of nutritional status of stakes on number of fine roots, root fresh biomass, number of sprouting and shoot fresh biomass of cassava at 21 days after planting. Good nutritional status of stakes produced higher number of fine root per plant, number of sprouting per plant and shoot fresh biomass per plant as compared to those of poor nutritional status of stakes (**Table 1**). Stakes soaking in different nutrient solution did not show any significant difference in number of fine roots per plant and number of sprouting per plant, but stake soaking had significant effects on root fresh biomass and shoot fresh biomass at 21 days after planting (**Table 1**). Stakes soaked in phosphorus (P) solution gave the maximum root fresh biomass and shoot fresh biomass. However, there was no significant difference in root fresh weight and shoot fresh weight between P solution soaking and P combined with N solution soaking treatments (**Table 1**).

In the greenhouse experiment 2, experimental design and stake soaking treatments were similar to those in experiment 1, except no water supplementation after the initial watering at planting with soil moisture 9.2% by weight. In the present experiment, some stakes lost their viability due to a rapid decline in soil moisture (**Figure 1**). Good nutritional status of stakes, nil-soaking resulted in 25 sprouting percentage while stakes soaked with N, P, and NP produced 100 sprouting percentage (data not shown). Poor nutritional status of stakes, nil soaking gave 25 sprouting percentage and stakes soaked with N, P and NP gave 50 sprouting percentage. Due to a large variation in sprouting percentage, statistically different could not be applied to compare treatment means.

Field experiment

Different nutritional status of stakes had significant effects on leaf area, root length and above ground fresh biomass of cassava taken 1 month after planting. Cassava with good nutritional status produced higher leaf area per plant, fine root length per plant and above ground fresh biomass per plant than those of poor nutritional status of stakes (Table 2).

Soaking stakes in different nutrient solution had no significant effect on leaf area per plant, fine root length and above ground fresh biomass per plant taken 1 month after planting (Table 2). However, stakes soaked with N combined with P solution tend to give the highest leaf area and fine root length per plant. Stakes soaked with N combined with P and K solution tend to produced the maximum above ground fresh biomass (Table 2).

At harvest 6 months after planting, cassava grown with different nutritional status of stakes had significant effect on above ground fresh biomass, number of tuberous root and tuberous root yield of cassava (Table 3). Good nutritional status of stakes resulted in greater above ground fresh biomass per plant, number of tuberous root per plant and tuberous root yield than those of poor nutritional status of stakes.

Soaking stakes in different nutrient solution had significant effects on above ground fresh biomass and number of tuberous root per plant, but did not have significant effect on tuberous root fresh yield (Table 3). There was no interaction effect between nutritional status condition of stake and stake soaking on above ground fresh biomass, number of tuberous root and tuberous root fresh yield in the present experiment.

Discussions

One important process that occurs in cassava planting material during storage is a decline in moisture and carbohydrates during storage which has adverse influence on stake viability (Leihner, 1984). Stake soaking was an effective method to improve nutrient status of planting material. This experiment was focused on stake soaking with macro-nutrient solution N, P and K on nutritional status of stakes. Stake priming with nutrient solution promote root and shoot growth at early growth stage both under greenhouse and field conditions. It seems that stakes soaked with P solution promote greater root growth. This was probably due to high concentration of P provided by soaking of the stakes. The increase in seedling root and shoot dry weight due to P fertilizer application is in general agreement with the work of other investigators (Sheard et al.,1971; Christopher et al; 2000). Tuberous root fresh yield tend to increase with stake soaking in all nutrient solution treatments before planting. This was due to the fact that stake priming produced better in plant growth, and higher in number of tuberous root per plant as compare to those without soaking. Stake priming with complete nutrient solution increased root yield by up to 25% as compared to those without priming due to it increased root number per plant although stake priming had no effect on above ground biomass were reported by Khanthavong (2012).

Good nutritional status of stake significantly increased root and shoot growth at early growth stage, as well as increased number of tuberous root as compared. to those of poor nutritional status of stake. Good nutritional of stake resulted in significant higher tuberous root fresh yield than that of poor nutritional of stake treatment. These results are in agree with that of Leihner (1984) who reported that early crop growth in terms of plant height, total plant dry weight and leaf area taken 2 months after planting was significantly greater in good nutritional status stakes as compared to those of poor nutritional status of stake.

In the present experiment, stakes with good and poor nutritional status differ in stake sizes. The greatest stake weight significantly increased growth and yield. Leaf area index, crop growth rate, assimilation rate, leaf area duration and harvest yield were higher at the stake weight of 88gm as compared to those of 75, 63 and 50 gm/stake were reported by Eke-Okoro et al. (2001). Difference in weight of stem cuttings (stake) result in difference in food reserve and it is that the initial growth of the plant depends (Okeke, 1994).

Stakes with good nutritional status showed better crop establishment (sprouting percentage and seedling growth) than that of poor nutritional status of stake, especially under dry soil condition after planting. Sprouting and establishment could also be improved by rehydration and soaking in nutrient solution. This indicates that priming with nutrient solution could maintain viability of stake for longer under dry soil condition after planting before receiving water from the next rain come in rainfed farming.

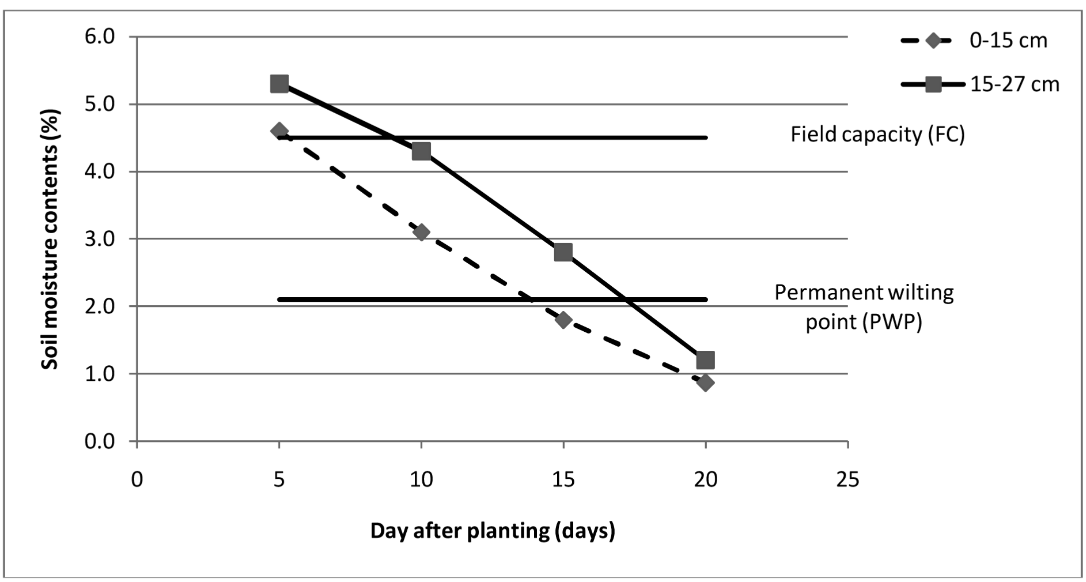

Figure 1 Soil moisture content (% by weight) at 0-15 cm (------) and 15-27 cm (_____) depth during the growing period, greenhouse experiment

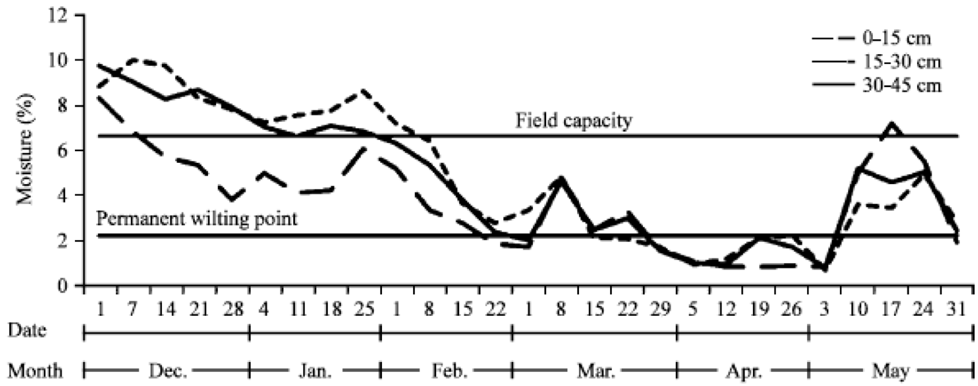

Figure 2 Soil moisture content (%) at 0-15 cm (- - - -) and 15-30 cm (_____) and 30-45 cm (-----) depth during the growing period, fiend experiment

Table 1 Effect of stake nutritional status and soaking in nutrient solution on fine root number per plant, root fresh biomass, number of sprouting and shoot fresh biomass at 21 day after planting, greenhouse experiment

Treatments	Number of fine root per plant	Root fresh biomass (gm/plant)	Number of sprouting per plant	Shoot fresh biomass (gm/plant)
Nutritional status (N)				
Good	32.3a	5.8a	5.1a	5.4a
Poor	15.6b	1.9b	3.3b	1.9b
Stake soaking (S)				
Nitrogen	21.9	2.9b	4.3	2.9ab
Phosphorus	28.1	5.5a	3.4	5.2a
Nitrogen + Phosphorus	24.4	4.9a	4.9	3.8ab
Nil-soaking	21.5	2.2b	4.1	2.6b
F-test				
Nutritional status (N)	**	**	**	**
Stake soaking (S)	Ns	**	ns	*
NxS	Ns	ns	ns	ns

Means followed by different letter within columns are significantly different at 5% level (*), at 1% level (**) and ns = not significant

Table 2 Effect of stake nutritional status and soaking in nutrient solution on leaf area, fine root length and above ground fresh biomass of cassava at 1 month after planting, field experiment

Treatments	Leaf area (cm^2/plant)	Fine root length (cm/plant)	Above ground fresh biomass (gm/plant)
Nutritional status (N)			
Good	611.9a	225.2a	13.6a
Poor	285.5b	148.9b	5.4b
Stake soaking (S)			
Water	382.5	161.9	8.8
Nitrogen	415.9	197.2	9.5
Nitrogen + Phosphorus	564.9	227.8	11.7
Nitrogen + Phosphorus + Potassium	550.8	203.2	13.7
Nil-soaking	329.6	155.2	6.9
F-test			
Nutritional status (N)	**	**	**
Stake soaking (S)	Ns	ns	ns
NxS	Ns	ns	ns

Means followed by different letter within columns are significantly different at 1% level (**) and ns = not significant

Table 3 Effect of stake nutritional status and soaking in nutrient solution on above ground fresh biomass, number of tuberous root and tuberous root fresh yield of cassava at harvest, field experiment.

Treatments	Above ground fresh biomass (t/ha)	Number of tuberous root per plant	Tuberous root fresh yield (t/ha)
Nutritional status (N)			
Good	16.6a	5.2a	21.8a
Poor	9.8b	8.1b	17.1b
Stake soaking (S)			
Water	11.6c	7.2b	18.7
Nitrogen	12.4bc	8.5ab	19.6
Nitrogen + Phosphorus	15.2ab	8.8a	20.4
Nitrogen + Phosphorus + Potassium	15.9a	9.1a	21.2
Nil-Soaking	10.9c	6.8b	17.4
F-test			
Nutritional status (N)	**	*	**
Stake soaking (S)	*	*	ns
N×S	ns	ns	ns

Means followed by different letter within columns are significantly different at 5% level (*), at 1% (**) and ns = not significant

Conclusions

Cassava stake soaking with macro-nutrient solution improved seedling establishment, and tend to promote root and shoot growth at early growth stage and consequently increased cassava yield. Stakes with good nutritional status used as planting material significantly increased, growth and tuber yield over poor nutritional status of stake.

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