The Effects of Stake Priming and Planting Method on Early Growth of Cassava Grown under Greenhouse Conditions

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Abstract

The objective of this research is to evaluate the effects of stake priming and planting position on shoot and root growth of cassava, and to improve planting material quality for the early crop establishment period. Three pot experiments were conducted with different bio-activators, soil moisture regimes, and genotypic variations. Results revealed that stake priming increased shoot and root growth of cassava at 21 days after planting (DAP). Stakes soaked in chitosan at a concentration of 10 ml, diluted in ten liters of water for two hours, showed to be the most effective priming method for improving stake quality. Soil moisture regimes applied once at planting at 10% by weight (tension 0.075 bars) and 20% by weight (tension 0.05 bars), had significant effect on root growth of cassava at 21 DAP. Root length and root dry weight were observed higher at 10% level than those of soil moisture at 20% level. Horizontal planting method had a significant effect on root number, and produced greater root length and dry weight of cassava than those of vertical planting method. Shoot and root growth developed different responses to planting method regardless of the cassava's genotypic variations.

Keywords: cassava, chitosan, planting method, priming, stake soaking, wood vinegar

Introduction

Cassava is one of the most important crops in northeastern Thailand, and plays an important role in the incomes of many smallholder farmers. The success of cassava production is largely based on its ability and capacity to provide high yields even in drought prone areas under poor management conditions where other crops would fail. In cassava production, the crop is grown from sections of the stem called stakes. After harvesting the roots, the stems are stored for use as planting materials in the next season. During storage, stems suffer from loss of moisture which influences stake viability (Liehner, 1984). Moreover, stems continue respiration during storage and thus losing carbohydrates, reducing reserves available to the stakes and therefore diminishing sprouting vigor and establishment (CIAT, 1988; Liehner, 1984). Priming refers to a method developed to improve the performance of plant propagules such as seed or stakes by a treatment prior to planting. Seed priming has been reported to result in vigorous early seedling growth and better stand establishment (Arif, Ali, Shah, Javed, & Rashid, 2005; Ali et al., 2007; Sungwal, Jothitiyangkoon, Wanapat, & Polthanee, 2010). Sprouting vigor provides essential influences upon subsequent growth and yield of cassava. Many past experiments in seed or stakes soaking focused on nutrient application (Watananonta et al., 2004; Paisancharoen, Nakviroj, & Amonpol, 2010; Khantavong, Phattarakul, & Jamjod, 2012). Stakes soaking in chitosan or wood vinegar solution improved germination rate and percentage of cassava cuttings (Taweekul, Thippayrags, Sriwai, & Sorawat, 2012). In general, there are two different planting methods in which cassava stakes are planted in the field. It may be planted upright in a vertical method

or horizontally beneath the soil on the top of ridges. Therefore, the purpose of this study was to evaluate the effects of stake priming with bio-activators, different soil moisture regimes at planting and planting methods on early growth of cassava grown under greenhouse conditions.

Materials and Methods

Three pot experiments were conducted in sequence in a greenhouse at the Faculty of Agriculture, Khon Kaen University, Thailand in 2013. The pot trials were established using the same soil type with a sandy loam texture with 5.9 pH, 0.038% total N, 29 mg/kg available P and 53.38 mg/kg exchangeable K. Field capacity (FC) and permanent wilting point (PWP) of the soil were 13.15% and 2.76%, respectively. The soil was pulverized and sieved to remove all debris and filled into plastic pots at 6 kg of dry weight per pot.

Experiment 1

This experiment was conducted to evaluate the effects of stake priming using a bio-activators solution at different concentrations on shoot and root growth of the cassava. The planting material (stake) from the cassava cultivar Kasetsart 50 (KU-50) contained a nutrient content of 0.86% total N, 0.18% total P, 0.82% total K, and moisture content of 60%. The treatments in this study were combined 2x3 factorial + control arrangement in RCBD with four replications. The first factor involved soaking the stakes of two bio-activators, chitosan and wood vinegar in comparison with nil-soaking (control). The second factor contained three concentrations (5, 10 and 15 ml) of chitosan and wood vinegar, diluted in 10 liters of water. Stakes were soaked for 1 hour of all treatments. The stakes of 20 cm long were inserted vertically into the moist soil. The trial was manually irrigated with 1 liter of water every four days. Crop growths parameters were measured at 21 DAP.

Experiment 2

This experiment was conducted to evaluate the effect of stake soaking in chitosan solution (selected as the most viable bio-activator from experiment 1) under different soil moisture regimes on shoot and root growth of the cassava. The planting material (stake) from cultivar KU-50 used in this study which contained a nutrient content of 1.053% total N, 0.322% total P, 0.326% total K and moisture content of 62%. Again, the two treatments were combined in factorial arrangement in RCBD and replicated four times. The first factor contained two levels of soil moisture at 10% by weight (tension 0.075 bars) and 20% by weight (tension 0.05 bars) which applied once at planting. The second factor involved soaking the stakes period for 1 and 2 hours which chitosan at a concentration of 10 cc, diluted in 10 liters of water and nil-soaking. The stakes of 20 cm long were inserted vertically into the moist soil. The crop was not irrigated until harvest at 21 DAP. Crop growth parameters were recorded at early growth stage at 21 DAP.

Experiment 3

This experiment was conducted to evaluate the effects of planting method on shoot and root growth of two cassava cultivars. The treatments were arranged in factorial in RCBD with four replications. The first factor consisted of two cassava cultivars; Kasetsart 50 (KU-50) and Rayong 7 (RY-7). The second factor involved two planting methods; horizontal and vertical (stake end cut slant on one side and stake end cut slant two sides). The stakes were soaked in chitosan in a concentration of 10 cc, diluted in 10 liters of water for 2 hours. The stake of two cassava cultivars contained moisture content 54% and 58% for RY-7 and KU-50, respectively. The stakes were inserted at one-third length (20 cm)

into the moist soil in the vertical planting method. Stakes were also placed in the furrow and covered with soil in the horizontal planting method. The crop was manually irrigated with one liter of water per pot every four days until harvest. Crop growth parameters were recorded at 21 DAP.

Data analysis was conducted using MSTATC analytical software (Tallahassee, Florida, USA) for all experiments. The Least Significant Difference (LSD) was used to compare means where treatments results were significantly different.

Results

Experiment 1

Stakes treated with bioactivator had significant effects on root length, but had no significant difference on leaf area, leaf dry weight, stem dry weight and root dry weight of cassava at 21 DAP (Table 1). Chitosan treated gave the highest root length of cassava at 21 DAP. Irrespective of bio-activator types, bioactivator at different concentrations had significant effects on root length and root dry weight, but not significant difference on leaf area, leaf dry weight and stem dry weight of cassava at 21 DAP (Table 1). The stakes treated with bioactivator at 10 cc produced maximum root length and root dry weight in the present experiment. Chitosan soaking the stakes improved seedling growth better than those of wood vinegar.

Table 1 Effect of soaking cassava stakes in chitosan and wood vinegar solutions at different concentrations on leaf area (LA), leaf dry weight (LDW), stem dry weight (SDW), root length (RL) and root dry weight (RDW) at 21 days after planting

Treatment	LA (cm^2/plant)	SEM	LDW (g/plant)	SEM	SDW (g/plant)	SEM	RL (cm/plant)	SEM	RDW (g/plant)	SEM
Bio-activator (B)										
Chitosan	283.9	±93.29	1.04	±0.28	0.46	±0.14	1358.0a	±268.02	0.31	±0.13
Wood vinegar	250.2	±64.76	0.89	±0.15	0.38	±0.08	980.2ab	±404.54	0.26	±0.06
Nil-soaking	229.5	±43.18	0.78	±0.19	0.34	±0.08	934.4b	±278.94	0.25	±0.06
Concentration (C)										
5 cc	229.5	±86.74	0.73	±0.24	0.34	±0.08	723.5b	±176.45	0.18b	±0.04
10 cc	283.9	±43.32	1.11	±0.19	0.4	±0.06	1488.0a	±226.03	0.32a	±0.04
15 cc	250.2	±24.89	0.87	±0.04	0.46	±0.11	1061.2ab	±176.59	0.26ab	±0.03
F-test										
B	ns		ns		ns		*		ns	
C	ns		ns		ns		*		*	
B x C	ns		ns		ns		ns		ns	

ns = Not significant; * = Significantly different at $p \leq 0.05$

Mean in the same column with different letters are significantly different at $p \leq 0.05$ by LSD.

SEM = Standard error of mean

Experiment 2

The soil moisture regime (S) as well as the stake soaking period (P) had significant effects on root length (RL) and root dry weight (RDW) of cassava at 21 DAP (Table 2). RL and RDW were observed higher at 10% level (F.C. 13.15%) than those of soil moisture at 20% level. Stakes soaked for two hours gave the highest RL and RDW of cassava at 21 DAP (Table 2). Soaking treatments exhibited greater all growth parameters over nil-soaking. There was an interactive effect between soil moisture regime and soaking period on root

length of the cassava (Figure 1). Stakes soaked for two hours exhibited significant higher root length at 10% soil moisture level than those of 20% soil moisture level. While, it did not showed significant effect on root length for soaking one hour between soil moisture regime at 10% and 20% level. Similarly interaction effect between soil moisture regime and soaking period was observed on leaf dry weight in the present experiment (Figure 2).

Table 2 Effect of soil moisture regimes and stake-soaking period on leaf area (LA), leaf dry weight (LDW), stem dry weight (SDW), root length (RL) and root dry weight (RDW) at 21days after planting

Treatment	LA (cm^2/plant)	SEM	LDW (g/plant)	SEM	SDW (g/plant)	SEM	RL (cm/plant)	SEM	RDW (g/plant)	SEM
Soil moisture regime (S)										
10% by weight	263.6	±68.23	0.544	±0.13	0.259	±0.06	689.3a	±342.41	0.084a	±0.04
20% by weight	239.8	±75.84	0.435	±0.14	0.24	±0.07	442.5b	±162.18	0.069b	±0.03
Soaking period (P)										
0 hour	220.9	±26.60	0.439	±0.06	0.231	±0.06	410.9b	±51.29	0.058b	±0.01
1 hour	245.9	±46.11	0.479	±0.13	0.256	±0.07	532.6ab	±1.78	0.079ab	±0.03
2 hours	272.4	±83.98	0.549	±0.20	0.262	±0.07	754.1a	±1.00	0.094a	±0.05
F-test										
S	ns		ns		ns		*		*	
P	ns		ns		ns		*		*	
S x P	ns		*		ns		*		ns	

ns = Not significant; * = significantly different at $p \leq 0.05$.

Mean in the same column with different letters are significantly different at $p \leq 0.05$ by LSD.

SEM = Standard error of mean; 0 hour = nil-soaking

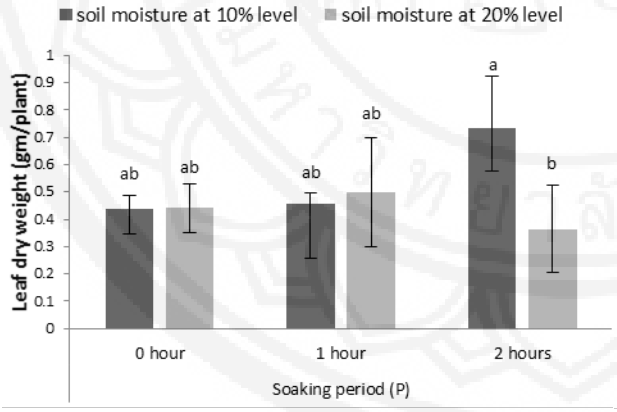

Figure 1 Interaction between soil moisture regimes and soaking periods on root length of cassava at 21 days after planting

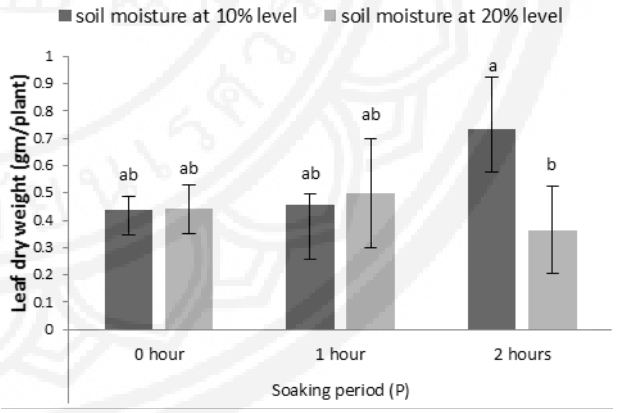

Figure 2 Interaction between soil moisture regimes and soaking periods on leaf dry weight of cassava at 21 days after planting

Experiment 3

The cultivar (C) had a significant effect on sprouting number, shoot dry weight, root number, root length and root dry weight of cassava at 21 DAP (Table 3). The cultivar KU-50 produced the highest sprouting number and shoot dry weight of

cassava, while RY-7 produced the highest root number, root length and root dry weight of cassava. The planting methods proved significant effect on sprouting number and root number, but not showed significant effect on shoot dry weight, root length and root dry weight (Table 3). The horizontal planting method produced the greatest sprouting number and root number in the present experiment. Vertical planting with stake end cut two sides exhibited significant higher sprouting number and tend to gave higher root length per plant than those of stake end cut one side using as planting material.

Table 3 Effect of cultivar and planting method on sprouting number (SN), shoot dry weight (SDW), root number (RN), root length (RL) and root dry weight (RDW) of cassava at 21days after planting

Treatment	SN (no.)	SEM	SDW (g/plant)	SEM	RN (no.)	SEM	RL (cm/plant)	SEM	RDW (g/plant)	SEM
Cultivar (C)										
KU-50	8.83a	±0.90	1.77a	±0.24	31.0b	±4.60	2028.0b	±388.27	0.612b	±0.11
RY-7	3.00b	±2.23	1.20b	±0.22	49.8a	±3.84	3010.4a	±378.81	1.098a	±0.12
Planting method (P)										
Horizontal planting	8.38a	±1.02	1.38	±0.34	46.75a	±6.75	2783.9	±257.15	0.89	±0.13
Vertical planting[1]	3.13c	±2.10	1.67	±0.21	37.00b	±6.12	2178.8	±561.61	0.802	±0.21
Vertical planting[2]	6.25b	±2.64	1.48	±0.26	37.38b	±5.60	2594.8	±482.63	0.873	±0.18
F-test										
C	**		**		**		**		**	
P	**		ns		*		ns		ns	
C x P	ns		ns		ns		ns		ns	

ns = Not significant; * = Significantly different at $p \leq 0.05$.

Mean in the same column with different letters are significantly different at $p \leq 0.05$ by LSD.

Discussion

In experiment 1, stakes soaked in chitosan and wood vinegar solution showed greater shoot and root growth than those of nil-soaked treatment at early growth stages. This was due to a chitosan induced photochemical process of plant and resulting in more vigorous growth (Reddy, Arul, Angers, & Coutue, 1999). Enhancing crop growth induced by soaking seeds in chitosan solution has been reported by numerous researchers (Katsumi, Toshiki, & Takashi, 2001; Ohta, Morishita, Suda, Kobayashi, & Hosoki, 2004; Kim, Chen, Wang, & Rajapakse, 2005; Uthairatanakij & Obsuwan, 2007). Cassava stakes soaked in chitosan solution improved both rate and percentage of germination as recently reported by Taweekul et al. (2012). Wood vinegar (pyroligneous acid) comprised primarily of acidic compounds and butenolide enhanced seed germination and growth in several crops were reported (Flematti, Ghisalberti, Dixon, & Trendgove, 2004; Amat & Brand, 1993; Jun, Qiang, & Wu, 2006; Katoda & Niimi, 2004; Sungwal et al., 2010). The butenolide contained in wood vinegar solution enhanced root growth of corn and tomato crops when the seeds were soaked in wood vinegar prior to planting was reported by Staden, Van, Sprag Kulkarni, and Light (2006). In the present experiment, chitosan promoted shoot and root growth at early growth stage greater than those of wood vinegar. This might be chitosan contains N about 8.7% was reported by Ohta et al. (1999). Chitosan

increased key enzymes activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen in the functional leaves which enhanced photosynthesis in leaves (Khan, Pritiviraj, & Smiyh, 2002; Chibu, Shibayama, & Arima, 2002; El-Tantawy, 2009). In case of wood vinegar, the main components are organic acid, phenolic, alcohol and ester compounds with acetic acid being a main component. It lack of nutrients contain in the component.

In experiment 2, chitosan (selected as the most viable bio-activator from experiment 1) at 10 cc concentration diluted in 10 liters of water was used in stake priming at different soil moisture regimes and soaking periods. Soil moisture regimes applied at planting had significant effect on root growth of cassava at 21 DAP. Soil moisture applied at 10% level (F.C. 13.1%) produced greater root growth than those of the soil moisture at 20% level. This was due to the soil being to wet, thus prevent adequate aeration and root formation. This indicated that stakes planted under wet soil (at 20% level) in order to provide longer soil moisture during crop establishment did not give an advantage in this study. Stakes soaked in chitosan solution for one and two hours gave higher shoot and root growth than those of nil-soaked treatments. In comparison of soaking period, stakes soaked in chitosan solution for two hours tend to produce higher shoot and root growth than those of soaking for one hour. This agrees with the findings reported by Liehner (1984) who reported that stakes subjected to long soaking periods in bio-activator solution grow more vigorously and taller than those of short rehydration periods or none at all.

In experiment 3, the horizontal planting method produced significantly higher sprouting number and fibrous root numbers than those of the vertical planting method. This was due to fibrous roots arose not only from cut ends, but also from the nodes of stem cuttings (stakes) in horizontal planting. Similar results were obtained by Legese, Gobeze, Shegro, and Geleta (2011) where horizontal planting produced a significantly greater number of stems per hill than those of the vertical planting method. In contrast, shoot dry weights tend to be lower in the horizontal planting method, due to a slower rate of germination was reported by Tongglum, Suriyaporn, and Howeler, (2001).

The cassava cultivar KU-50 produced significant higher sprouting numbers and shoot dry weight than those of the RY-7 cultivar. However, the RY-7 proved superior in greater root number, root length, and root dry weight. This indicates large genotypic differences in fibrous root growth and development. The cultivar RY-7 is generally recommended as drought tolerant cassava cultivar by DOA (2009).

Further research, field experiment is suggested to evaluate the economic tuber yield of cassava in both planting time at early rainy season and late rainy season in northeast Thailand.

Conclusion

Cassava stake priming, by soaking in chitosan or wood vinegar solution, improved fibrous root growth in the early stages of growth development. Soaking stakes in a bio-activator of chitosan at a concentration of 10 cc, diluted in 10 liters of water for two hours has proven to be the most effective method in improving planting materials. The horizontal planting method resulted in greater performance of fibrous root growth than in the vertical planting method.

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