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Research Article
Effects of Methods and Duration Storage on Cassava Stake Characteristics

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Abstract

Objective: The purpose of the study was to investigate the effect of planting material storage method and storage duration on stake characteristics and germination percentage in 3 cultivars of cassava under rain-fed conditions. **Methodology:** The study was laid out in a split-split plot design with 3 replications. The main plots were comprised of 4 storage durations of planting material: 0, 15, 30 and 45 days after the planting material was harvested. The sub-plot treatments consisted of 3 storage methods of planting material: (1) Placing outdoors by digging a hole approximately 15-20 cm deep, (2) Placing under the tree shade and (3) Placing outdoors covered with hemp sacks. The sub-sub-plot treatments consisted of 3 cassava varieties: Kasetsart 50, Rayong 7 and 72. **Results:** The results illustrated that among cultivars, significant differences were observed in the following characters: Percentage stake moisture, total K content after storage duration for 15 and 45 days, total P and K content after storage duration for 30 days, percentage germination and percentage survival. Rayong 72 had the greatest percentage stake moisture and percentage total K content after storage duration for 15 and 45 days and percentage survival rate after storage duration for 15 days (98.15%). Planting material storage methods significantly affected percentage stake moisture and percentage total K content after storage duration for 45 days. The storage methods of placing outdoors by digging a deep hole of approximately 15-20 cm and covering with hemp sacks resulted in greater percentage stake moisture (70.51-71.37 and 0.94-1.11%, respectively) than the storage method of placing under tree shade. For storage duration, the result indicated that 45 days of storage reduced the percentage germination and percentage survival rate. **Conclusion:** The storage duration of planting material should not exceed 30 days with placing outdoors covered with hemp sacks and placing under the shade of a tree were superior to have fast and higher germination and survival percentage.

Key words: Cassava, cultivars, germination, macronutrients content, storage methods and times, planting material

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an economic crop for more than 500,000 farming families in Thailand[1]. Thailand produces a 3rd of the world's cassava after Nigeria and Brazil, but Thailand is the No. 1 exporter of cassava products in the world[2]. Cassava brings income into the country totalling more than 30,000 million baht in each year[3]. Cassava is easy to grow and drought resistant, although the soil is poor. Despite a few insect-related problems, there has been a steady, reliable market. Generally, 7.4 million hectares of cassava planting area in Thailand can produce 27.4 million tonnes of fresh tuber or an average yield of 3.7 t ha^{-1}. The demand for cassava fresh roots may increase as root prices have increased since July, 2007[4]. Farmers who grow other crops, such as sugarcane and corn may split their plots to plant cassava[1].

Good quality planting materials are the main propagation tools, which will be the determining factors of survival and yield per unit area[5]. There are various factors influencing the quality of planting material: (1) A harvesting period, which should be from the age of 8 months and not more than 12 months, (2) The number of buds on stem cuttings, at least 7-10 eyes, (3) The length of stem cuttings: 20 cm for planting cassava during the rainy season, but 25-30 cm for planting at the end of the rainy season, (4) Planting of material that is completely free of disease and insects and (5) Consistent use of planting material planted immediately[6]. Moreover, defoliation significantly affects the quality and quantity of mineral and food component of cassava cultivars. Different cultivars respond differently to defoliation at different stages of growth[7]. The substance planting material with bacteria suspention KPS 46 before plantation will be increase the germination percentage, growth and yield of cassava[8]. Finally, water stress also the main problem during cassava growth by affecting on germination, growth and yield components[9].

After the cassava harvest, farmers tend to keep planting material and wait for complete tillage and planting in the next season. The cassava cultivars can keep for different periods of preservation over a long time. If keeping for a long time, cassava planting materials lose their moisture, carbohydrates and reducing reserves available to stakes after planting. Cassava planting by the stakes stored for 1 month, germinate and survive may reduce less than 60%[5]. These problem tend to the reducing of cassava yield and income. The objectives of this study were to investigate the effect of timing and storage methods use for cassava planting material to encourage farmers to undertake a good practice and protect the quality of planting material.

MATERIALS AND METHODS

Planting material preparation: Planting material preparation was conducted at Mahasarakham Research and Development Agriculture Centre, Mahasarakham province, Thailand from 2014-2015. The soil type is sandy loam with pH 5.6, total N 0.047%, available P 10.25 mg kg^{-1}, exchangeable K 57.50 mg kg^{-1} and organic matter 0.94%. A total rainfall of 1543 mm occurred during the crop growth period of 10 months. The maximum and minimum temperature were recorded as 30.64 and 20.79°C, respectively. The cassava cultivars Kasetsart 50, Rayong 7 and 7 2 were used in these studies. The stakes of 25 cm length were planted vertically with 1×0.8 m spacing. Chemical fertilizer (15-7-18 kg NPK) was applied at rates of 312.5 kg ha^{-1} before sowing and 3-4 months after the sowing date.

Field experiment: The field experiment was conducted at the experimental farm, Faculty of Agriculture, Khon Kaen University, Thailand from June, 2015 to August, 2015. The soil type is sandy loam with pH 5.92, total N 0.03%, available P 69.58 mg kg^{-1}, exchangeable K 50 mg kg^{-1}, exchangeable Ca 327.32 mg kg^{-1}, Cation Exchange Capacity (CEC) 3.47 C mol kg^{-1} and organic matter 0.59% from the soil surface to a depth of 30 cm. A total rainfall of 801.6 mm occurred during the period of crop growth. The maximum and minimum temperatures were recorded as 34.12 and 22.78°C, respectively. The study was laid out in a split-split plot design with 3 replications. The main plots were comprised of 4 storage durations of planting material: 0, 15, 30 and 45 days after the planting material was harvested. The sub-plot treatments consisted of 3 storage methods of planting material: Placing outdoors by digging a deep hole of approximately 15-20 cm, placing under the shade of a tree and placing outdoors covered with hemp sacks. The sub-sub-plot treatments consisted of 3 cassava varieties: Kasetsart 50, Rayong 7 and 72. Stakes were soaked with imidacloprid at a concentration of 3 g/20 L of water for 10 min for all treatments. The stakes of 20 cm length were planted vertically with 1×1 m spacing. Weed control was carried out using pre-emergence herbicide S-metolachlor at a rate of 175 mL/80 L of water and flumioxazin at a concentration of 10 g/80 L of water and hand weeding at 1 month after planting. Soil and stake moisture contents were determined at different planting dates. The germination percentage was measured in each week for 30 days after planting. The survival rate was counted at 30 days after planting.

Macronutrient content of stem cuttings: After the planting material was stored for 0, 15, 30 and 45 days planting material was harvested from each of the following storage conditions: Placing outdoors by digging a deep hole of approximately 15-20 cm, placing under the shade of a tree and placing outdoors covered with hemp sacks. The planting material of 3 cassava varieties: Kasetsart 50, Rayong 7 and 72 was cut into 20 cm pieces for nitrogen (N), phosphorus (P) and potassium (K) content analysis. For each sample of stem cutting, N biomass content was measured by the micro-Kjeldahl method with indophenol blue, P content by wet oxidation and spectrophotometry and K content by wet oxidation and flame photometry at Plant Nutrition Analysis, Department of Plant Science and Agricultural Resources, Faculty of Agriculture, Khon Kaen University.

Statistical analysis: An analysis of variance was conducted on data obtained for each parameter in each treatment. All analyses were carried out using statistix version 8.0. Least Significant Differences (LSD) were calculated at a significance level of 0.05 to test for significant differences among treatments.

RESULTS AND DISCUSSION

Effect of planting material storage duration and method on stake characteristics of 3 different cassava cultivars: The cassava production, generally was planted at the beginning of rainy season by planting stakes after harvesting of the tuber. The farmers may store planting stakes for 1-2 months before planting. Reducing of stake moisture, K content and carbohydrate storage during planting material stored may lead to the diminishing sprouting vigour and establishment of cassava[5]. This results founded that the planting material storage methods and cassava cultivars were significantly different in percentage stake moisture at 30 and 45 days of storage duration (Table 1). The storage method of placing under the shade of a tree reduced percentage stake moisture by more (62.97 and 62.26%, respectively) than either of placing outdoors in an approximately 15-20 cm hole or covering with hemp sacks. When planting material are placing outdoors may lead to the absorption of soil moisture. Shoots and roots are growing during storage duration, tend to preserve percentage stake moisture more than placing under the shade of a tree. Similar to the study of Boonma *et al.*[6], the results showed that the storage method of placing under the shade reduced percentage stake moisture by more (62.80 and 66.10%, respectively) than either of placing outdoors in 3 cassava varieties. With respect to cultivar, Kasetsart 50 decreased significantly in percentage stake moisture (62.76 and 64.00%, respectively) compared with Rayong 7 and 72. Stake moisture content was reduced by 5.05 and 6.12% in the storage method of placing under the shade of a tree as compared with the untreated control at 30 and 45 days of storage, respectively. This result is in agreement with a previous investigation by Boonma *et al.*[6] who reported that in cassava cultivars, planting material storage method and planting material storage durations differed significantly in percentage stake moisture and percentage germination.

Different nutritional status of cassava stakes had significant effects on root length, leaf area and above ground biomass after planting[5]. An abundant K^+ supply favours the primary processes of photosynthesis. It also regulates the

Table 1: Effect of planting material storage method and cultivar on stake moisture content after different days of storage

	Stake moisture content (%)		
Treatments	15 days of storage	30 days of storage	45 days of storage
Storage method (S)			
Control	66.32	66.32^{ab}	66.32^{ab}
Placing outdoors by digging a deep hole of approximately 15-20 cm	68.32	70.69^{a}	70.51^{a}
Placing under the shade of a tree	66.59	62.97^{b}	62.26^{b}
Placing outdoors covered with hemp sacks	65.09	63.96^{b}	71.37^{a}
Cultivar (C)			
KU-50	63.65	62.76^{b}	64.00^{b}
R-72	69.91	68.15^{a}	71.17^{a}
R-7	66.18	67.05^{ab}	67.68^{ab}
F-test			
Storage method (S)	ns	**	**
Cultivar (C)	*	**	**
S×C	ns	**	**
CV (a) (%)	7.63	5.02	6.64
CV (b) (%)	8.02	7.97	9.57

Ns: Not significant, *,**Significantly different at p<0.05, 0.01, respectively. Means in the same column with different letters are significantly different at p<0.05 and p<0.01 by LSD

balance between assimilation and respiration in a way that improves net assimilation[10]. The translocation of photosynthates from the green parts of the plant (leaf) to the storage root is of the utmost importance in the building up of the storage organs (tubers). For percentage stake nutrient content, the planting material storage duration, method and the cassava cultivar were significantly different in percentage total K at storage durations of 15 and 45 days (Table 2). The storage methods of placing outdoors by digging a deep hole of approximately 15-20 cm and placing outdoors covered with hemp sacks gave higher percentage total K (0.81 and 0.74%, respectively) than the storage method of placing under the shade of a tree. These storage methods tend to increase percentage total K compared with the control (no storage duration). Cassava shoots were induced from the bud when placing outdoors by digging a deep hole of approximately 15-20 cm and placing outdoors covered with hemp sacks during planting storage durations. The K^+ accumulation in the guard cells when the plants open their leaves stomata and it would be affect to the water absorption into the cells. With regard to the cassava cultivars, Rayong 72 and 7 was significantly different in percentage total P (0.19 and 0.20%, respectively) and K (0.84 and 0.81%, respectively). Finally, the interaction between planting material storage method and cassava cultivar was significantly different in percentage total K^+ content (Table 2).

Effect of storage duration, planting material storage method and cultivar on germination and survival rate: Germination and survival rate percentage will decrease when the storage duration increasing especially with the storage methods of placing outdoors[11]. However, germination and survival rate percentage at the early growth stage are different in cassava cultivars[6]. The storage methods of placing outdoors covered with hemp sacks and placing under the shade of a tree were superior to the method of placing outdoors by digging a deep hole of approximately 15-20 cm for germination and survival rate percentage. Placing outdoors covered with hemp sacks and placing under the shade of a tree were significantly different in percentage germination at 30 days after planting. Rayong 7 differed significantly from Rayong 72 in percentage germination (93.22 and 88.62%, respectively) (Table 3). According to the influence of cassava cultivars, storage duration and planting material storage method are affected in germination percentage. The results showed that cassava planting material should not storage longer than 30 days. A longer storage duration especially placing outdoor method may link to the auxin-cytokinin balance which it promoting of axillary bud. This would be a topic issue to evaluate with the storage duration, planting material storage method and cultivar on germination and survival rate. Moreover, planting material continues to respire and losses of carbohydrates occur during storage[12,5],

Table 2: Effect of planting material storage durations and methods on stake nutrient content of 3 different cassava cultivars at planting

Treatments	Total N (%)	Total P (%)	Total K (%)
Storage duration (D)			
0	0.50^{b}	0.19	0.52^{c}
15 days	0.56^{a}	0.16	0.76^{ab}
30 days	0.51^{ab}	0.17	0.68^{bc}
45 days	0.45^{b}	0.18	0.91^{a}
Storage method (M)			
Placing outdoors by digging a deep hole of approximately 15-20 cm	0.51	0.19	0.81^{a}
Placing under the shade of a tree	0.50	0.15	0.60^{b}
Placing outdoors covered with hemp sacks	0.50	0.18	0.74^{a}
Cultivar (C)			
KU50	0.50	0.13^{b}	0.49^{b}
R7	0.48	0.20^{a}	0.81^{a}
R72	0.52	0.19^{a}	0.84^{a}
F-test			
D	*	ns	*
M	ns	ns	*
C	ns	*	*
D×M	ns	ns	*
D×C	*	*	ns
M×C	ns	ns	*
D×M×C	ns	*	*
CV (%)			
CV (a)	18.61	45.22	36.87
CV (b)	19.23	46.25	31.82
CV (c)	19.57	38.49	33.50

Ns: Not significant, *Significant different at $p<0.05$. Means in the same column with different letters are significantly different at $p<0.05$ by LSD

Table 3: Effect of planting material storage durations and methods on germination of 3 different cassava cultivars at 14 days after planting and survival rate at 30 days after planting

Treatments	Germination (%)	Survival rate (%)
Storage duration (D)		
0	95.37[a]	98.43[a]
15 days	89.10[b]	98.15[a]
30 days	97.44[a]	93.45[b]
45 days	81.27[c]	83.26[c]
Storage method (M)		
Placing outdoors by digging a deep hole of approximately 15-20 cm	85.63[b]	88.36[b]
Placing under the shade of a tree	93.00[a]	95.89[a]
Placing outdoors covered with hemp sacks Placing outdoors covered with hemp sacks	93.75[a]	95.73[a]
Cultivar (C)		
KU50	90.55[ab]	92.42[b]
R7	93.22[a]	90.82[b]
R72	88.62[b]	96.74[a]
F-test		
D	*	*
M	*	*
C	*	*
D×M	*	*
D×C	*	*
M×C	*	*
D×M×C	*	ns
CV (%)		
CV (a)	6.32	6.36
CV (b)	4.57	6.30
CV (c)	6.90	5.24

Ns: Not significant, *Significant different at p<0.05. Means in the same column with different letters are significantly different at p<0.05 by LSD

reducing the reserves available to stakes after planting and thus diminishing sprouting vigour and establishment[13].

CONCLUSION

Planting material storage methods, cultivars and storage durations were significantly different in percentage stake moisture, percentage total K and percentage germination of cassava. According to the results of the experimental, a good practice of cassava planting materials storage before growing in the next season, should not keeping longer than 30 days after cassava harvest. To protect the quality of cassava planting materials, placing outdoors covered with hemp sacks and placing under the shade of a tree were superior to the method of placing outdoors by digging a deep hole of approximately 15-20 cm for germination and survival percentage. Although planting material storage methods and storage durations were affected on percentage stake moisture and percentage total K of cassava. Moreover, the percentage stake moisture and percentage total K are affected in the cassava survival rate. An abundant percentage stake moisture and K^+ supply favours the primary processes of photosynthesis and the translocation of photosynthates for plant growth. However, the knowledge of carbohydrate storage and auxin-cytokinin balance in planting material are necessary to evaluate.

SIGNIFICANT STATEMENTS

The farmers who grow cassava have a good practice of cassava planting materials keeping before growing in the next season (at the beginning of rainy reason around May-June). To protect the quality of cassava planting materials, should not keeping longer than 30 days after cassava harvest. The storage methods of placing outdoors covered with hemp sacks and placing under the shade of a tree were superior to the method of placing outdoors by digging a deep hole of approximately 15-20 cm for germination and survival percentage.

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