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Growth, Yield and Starch Content of Cassava Following Rainfed Lowland Rice in Northeast Thailand

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ABSTRACT

The objectives of this study were to investigate growth, yield, starch content and economic return of cassava cultivars grown following rice. Five cassava cultivars including Rayong-7, Rayong-11, Rayong-72, Kasetsart-50 and Huaybong-80 were tested in randomized complete block design with 4 replications. The results showed that at 6 months after growing. Rayong-11 gave the highest of leaf area index as well as leaves and stems dry weight. Rayong-7 produced the maximum fresh tuber roots yield, while Rayong-72 gave the highest dry roots yield. The starch content was not significantly affected by cassava cultivars. Kasetsart-50 tended to give the highest starch content. Cassava grown following rice as a bonus crop provided net income over materials cost 1,163-1,810 US dollars ha^{-1}, depending on the cultivar.

Key words: Cassava, rice-based cropping systems, climate change

INTRODUCTION

Rain-fed lowland occupy about 80% (4.8 million ha) of all rice growing areas in Northeast Thailand. Seasonal rainfall is bi-modal, usually beginning in May and ending around mid October. Traditionally, rain-fed lowland rice crops in the region are grown only once a year in the wet season as mono-culture. The fields are fallowed during the dry season. However, some areas of the rain-fed lowlands rice farmers grown peanut following rice in the post-rainy season with the stored soil moisture (Polthanee and Marten, 1986). Today, peanut fails to grow, due to global warming. The farmers replaced peanut crop with cassava (Polthanee and Promkhambut, 2012). A new double cropping system of growing cassava following rice had more rapidly practiced by the farmers in the northeast to generate farm income (Polthanee *et al*., 2014). The present study was carried out to investigate the growth, yield and starch content, as well as cash income of five cassava cultivars grown following rain-fed lowland rice with non-irrigation in northeast Thailand.

MATERIALS AND METHODS

Location and soil properties: Field experiment was conducted during December 2012 to June 2013 at the faculty of Agriculture farm, Khon Kaen university, (latitude 16°28'N and longitude 102°48'E) Khon Kaen, Thailand in a lowland rain-fed rice. The soil of the research site is a loamy sand with pH 5.54 and is characterised by low organic matter (0.22%), low available P (6.81 mg kg^{-1}) and low exchangeable K (16.78 mg kg^{-1}). The site is tropical monsoon climate, with a dry season from November to April and a wet season from May to October.

Experimental design and plant culture: Five cassava cultivars (long-duration) namely Rayong-7, Rayong-11, Rayong-72, Kasetsart-50 and Huaybong-80 were evaluation for growth, yield and starch content in a randomized complete block design with 4 replications.

Soil moisture content and weather observation: The stem cuttings of 15-20 cm in length were planted vertically on a 100×75 cm spacing. Chemical fertilizer grade 15-15-15 (N, P_2O_5, K_2O) at 156 kg ha^{-1} was applied at the time of planting. Plots were manually weeded once at 1 month after planting.

Soil moisture content was determined by gravimetric measurements at 0-15, 15-30 and 30-45 cm depth at 7 days interval (Fig. 1). Field capacity and permanent wilting point were estimated with pressure plate equipment. The plant subjected to long water stress at 85 days after planting for about 60 days. The total amount of rainfall during the growing period was 183.6 mm and the means of daily temperature maximum and minimum were 34.9 and 22.3°C, respectively. Weather parameter during crop growth period was shown in Table 1.

Plant growth measurement: Biomass measurements were done at 40, 90, 150 and 200 Days After Planting (DAP) by cutting the stem base of three plants at random per plot at each stage outside harvesting area. Plants were separated into leaves and stems. The leaf area was measured using leaf area meter. (Win Dias 3, Delta-T Devices, USA). The Leaf Area Index (LAI) was calculated from leaf area/ground area. The stems and leaves were oven dried at 70°C to constant weight.

Table 1: Weather parameter during crop growth period

Month	Rainfall (mm)	Relative humidity (%)	Evaporation (mm/day)	Sun light (h)	Temperature (°C) Maximum	Temperature (°C) Minimum
December	0.0	84.3	4.9	8.5	33.4	20.9
January	5.4	83.5	4.4	7.5	31.5	17.9
February	0.0	78.4	5.9	8.2	34.8	19.0
March	43.9	81.1	6.5	8.1	36.4	23.3
April	3.4	77.6	7.3	7.4	37.9	25.1
May	81.3	86.2	5.9	6.9	36.3	25.0
June	49.8	86.6	5.2	5.6	33.9	25.1

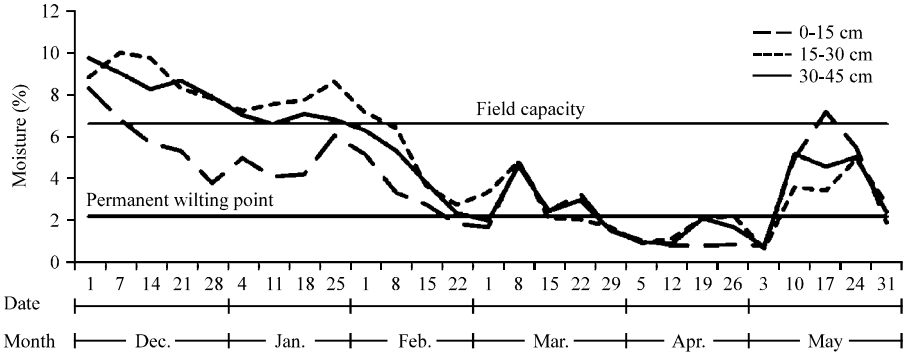

Fig. 1: Soil moisture content (%) at depth during the growing period

At harvest the number of tuber roots per plant and the fresh tuber root yield (ton ha^{-1}) were computed based on the data taken from the net plants (8 plants). The contents of starch in tuber roots were determined by specific gravity method. The Harvest Index (HI) was calculated from tuber roots dry matter/total dry matter.

Statistical analysis: Analysis of variance (ANOVA) for all data was performed using MSTATC software (Analytical Software, Tallahassee, Florida, USA). The Least Significant Difference (LSD) was used to compare means.

RESULTS

Plant growth characters: The stem dry weight was significantly different among cassava cultivars at 90, 150 and 200 days after planting, but it was not significant at 40 DAP (Table 2). Rayong-11 gave the maximum stem dry weight at harvest (200 DAP). The Leaf Area Index (LAI) was significantly different among cultivars at 90 and 150 DAP, but it was not significant at 40 DAP and 200 DAP (Table 3). Rayong-11 gave the highest LAI. The leaf dry weight was not significantly at 40 DAP, 90 DAP and 200 DAP, but significantly different at 15 DAP (Table 4). Rayong-11 produced maximum leaves dry weight.

Yield and yield component: The number of tuber roots per plant and starch content (%) was not significant affected by cultivars (Table 5). There were significantly differences among cassava

Table 2: Stem dry weight per plant of cassava following rice as affected by cultivars at 40, 90, 150 and 200 days after planting (DAP)

	Stem dry weight (g $plant^{-1}$)			
	40	90	150	200
Cassava cultivars	(DAP)			
Rayong-7	2.1	9.5^{b}	68.3^{b}	264.5^{b}
Rayong-11	2.9	17.8^{a}	106.7^{a}	401.1^{a}
Rayong-72	3.0	11.4^{ab}	56.7^{b}	257.3^{b}
Kasetsart-50	2.3	8.4^{b}	51.6^{b}	286.2^{b}
Huaybong-80	2.6	10.8^{ab}	60.8^{b}	267.6^{b}
F-test	ns	*	**	**
CV(%)	34.1	35.4	16.2	13.3

ns, *, ** = Not significant, significantly different at $p \leq 0.05$, 0.01, respectively. Means in the same column with different letters are significantly different at $p \leq 0.05$ and $p \leq 0.01$ by LSD

Table 3: Leaf area index of cassava following rice as affected by cultivars at 40, 90, 150 and 200 days after planting (DAP)

	Leaf area index (DAP)			
Cassava cultivars	40	90	150	200
Rayong-7	0.07	0.42^{ab}	1.6^{ab}	4.9
Rayong-11	0.10	0.57^{a}	1.7^{a}	5.3
Rayong-72	0.09	0.44^{ab}	1.2^{bc}	4.5
Kasetsart-50	0.09	0.54^{b}	1.6^{c}	5.2
Huaybong-80	0.08	0.41^{ab}	1.3^{abc}	4.3
F-test	ns	*	*	ns
CV(%)	39.20	30.40	15.70	17.3

ns, * = not significant, significantly different at $p \leq 0.05$, respectively. Means in the same column with different letters are significantly different at $p \leq 0.05$ by LSD

Table 4: Leaves dry weight per plant of cassava following rice as affected by cultivars at 40, 90, 150 and 200 days after planting (DAP)

	Laves dry weight (g plant^{-1})			
	40	90	150	200
Cassava cultivars	(DAP)			
Rayong-7	0.84	14.9	60.4^{ab}	184.5
Rayong-11	1.60	21.4	71.1^{a}	22.8
Rayong-72	1.53	16.4	49.4^{bc}	181.2
Kasetsart-50	1.16	11.8	44.9^{c}	211.6
Huaybong-80	1.31	14.3	50.6^{bc}	169.5
F-test	ns	ns	*	ns
CV(%)	32.6	33.3	14.7	17.9

ns, * = not significant, significantly different at p≤0.05, respectively. Means in the same column with different letters are significantly different at p≤0.05 by LSD

Table 5: Tuber roots number, yield, starch content and harvest index (HI) of cassava following rice as affected by cultivars at harvest

Cassava cultivars	Tuber roots number	Fresh root yield (t ha^{-1})	Dry root yield (kg ha^{-1})	Starch content (%)	HI
Rayong-7	7.0	28.2^{a}	723.8^{ab}	19.6	0.43^{b}
Rayong-11	6.3	21.3^{ab}	720.6^{ab}	23.7	0.38^{c}
Rayong-72	5.3	27.8^{a}	955.1^{a}	19.1	0.50^{a}
Kasetsart-50	4.8	23.2^{ab}	642.9^{ab}	25.9	0.38^{c}
Huaybong-80	6.8	19.2^{b}	613.4^{b}	25.7	0.40^{bc}
F-test	ns	*	*	ns	**
CV(%)	26.4	17.1	17.2	16.9	13.70

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

Table 6: Gross income and net income over material cost of five cassava cultivars following rice

Cultivars	Fresh root yield (t ha^{-1})	Gross income	Material	Net income
		(USD ha^{-1})		
Rayong-7	28.2	2,027	217	1,810
Rayong-11	21.3	1,531	217	1,314
Rayong-72	27.8	1,998	217	1,781
Kasetsart-50	23.2	1,668	217	1,451
Huaybong-80	19.2	1,380	217	1,163

Cassava price 70 USD ton^{-1}, Chemical fertilizer cost 0.59 USD kg^{-1} (92 USD ha^{-1}) and planting material cost 125 USD ha^{-1}

cultivars on fresh tuber roots yield, dry tuber roots yield and Harvest Index (HI) (Table 5). Rayong-7 produced the maximum fresh tuber roots yield, while cultivar Rayong-72 gave the highest dry tuber roots yield (Table 5). The maximum HI value was obtained with cultivar Rayong-72 (Table 5).

Economic return: In the present experiment, cassava provided net income over materials cost (stem cutting and chemical fertilizer) about 1,163-1,810 US dollars ha^{-1}, depending on cultivar (Table 6). The cultivar Rayong-7 provided the highest net income and Huaybong-80 gave the lowest net income.

DISCUSSION

A key factor for success of the cassava grown following rice was store soil moisture during the dry season and supplementary rainfall during the early wet season (Fig. 1). Another key factor for

success was cassava regarded as a relatively-drought resistant crop (Cock, 1985). It reduces water use by following an avoidance strategy of stomatal closure during drought (Ike, 1982) and leaf area reduction (Connor and Cock, 1981). In the present trial, stomatal conduction was not significantly difference among cultivars measured at 85 DAP during soil imposed to water stress (data not shown). Cassava cultivar Rayong-7 tended to give the highest stomatal conductance. This indicates that cultivar Rayong-7 is able to remain photosynthetic activity more than that of the other cultivars during prolonged drought. In this experiment, Rayong-11 produced the maximum LAI, stem dry weight and leaf dry weight. However, the cultivar Rayong-11 did not provide the highest tuber yield, resulted in a low HI. The HI is the measure of distribution of dry matter to the economically useful plant parts. This dry matter allocation to the tuber roots in cassava is low when growth rates are high (Ramanujam and Birader, 1987).

The cultivar Rayong-72 gave the highest HI, indicating that it was highly efficient in translocation of assimilates for storage in tuber roots. The fresh tuber roots yield was ranged from 19.2-28.2 t ha^{-1}, depending on the cassava cultivars. Panyangnoi *et al.* (2012) reported that cultivar Kasetsart-50 and Rayong-72 grown following rice in farmers field gave fresh roots yield 13.8 and 13.6 t ha^{-1} (150 days harvest). In the present experiment, cassava cultivars Kasetsart-50 and Rayong-72 produced fresh roots yield 23.2 and 27.8 t ha^{-1} (200 days harvest), respectively. The cultivar Rayong-7 gave the highest fresh roots yield 28.2 t ha^{-1}. This was probably due to Rayong-7 is better drought tolerance than the other cultivars. In case of starch content, Panyangnoi *et al.* (2012) found that Kasetsart-50 and Rayong-72, gave the starch content 20.5 and 21.0%, respectively. In the present experiment, the starch content was noticed 25.9 and 19.1% for Kasetsart-50 and Rayong-72, respectively. In general, local markets buy cassava based on tuber fresh weight. Therefore, the cultivar Rayong-7 provided the maximum net income. In the present experiment, five cassava cultivars tested were long maturity period (8-12 months harvest) but it was selected for early harvest. Today, short duration cassava cultivar (6-7 months harvest) in Thailand is still working under breeding research program. Short-duration period cultivars would provide opportunities to smallholder farmers for effective utilization of resources such as land, moisture and nutrients or as well as diversification of enterprise and income (Suja *et al.*, 2010). Short duration cassava (7 months harvest) recommended for growing in India provided the tuber yield 25-35 t ha^{-1}, depending on cultivar (Nedunchezhiyan *et al.*, 2006).

REFERENCES

Cock, J., 1985. Cassava, New Potential for a Neglected Crop. Westview Press, London, ISBN: 9780813301389, Pages: 191.

Connor, D.J. and J.H. Cock, 1981. Response of cassava to water shortage II. Canopy dynamics. Field Crops Res., 4: 285-296.

Ike, I.F., 1982. Effect of water deficits on transpiration, photosynthesis and leaf conductance in cassava. Physiol. Plant., 55: 411-414.

Nedunchezhiyan, M., S.K. Naskar, N. Ranasingh and A. Saurabh, 2006. A new food crop for dry farming: Cassava. Orissa Rev., 63: 41-42.

Panyangnoi, K., Y. Supama, S. Chanyakorn and P. Pangjan, 2012. Test on cropping systems in paddy rainfed area in Khon Kaen province. Nakhon Phanom Univ. J., 2: 161-167.

Polthanee, A. and A. Promkhambut, 2012. Impact of global warming on cropping system at Prasat district, Surin province. Syst. Approaches Agric. Newslett., 1: 1-5.

Polthanee, A. and G.G. Marten, 1986. Rainfed Cropping Systems in Northeast Thailand. In: Traditional Agriculture in Southeast Asia, Marten, G.G. (Ed.). Westview Press, London, pp: 103-131.

Polthanee, A., A. Promkhumbut and J. Bamrungrai, 2014. Drought impact on rice production and farmer's adaptation strategies in Northeast Thailand. Proceedings of the 5th International Conference on Environmental and Rural Development, January 18-19, 2014, Thailand.

Ramanujam, T. and R.S. Birader, 1987. Growth analysis in cassava (*Manihot esculenta* Crantz). Indian J. Plant Physiol., 30: 144-153.

Suja, G., K.S. John, J. Sreekumar and T. Srinivas, 2010. Short-duration cassava genotypes for crop diversification in the humid tropics: Growth dynamics, biomass, yield and quality. J. Sci. Food Agric., 90: 188-198.