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Responses of sago palm under water deficiency condition

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Abstract The response of sago palm under water deficiency conditions was determined. Results showed that plants which watered at 7 days interval gave low leaf water potential which resulted in low water content in the roots and plants. There was not affected on the growth of sago palm as determined by plant height, leaf number, green value of leaf (SPAD), chlorophyll concentration, leaf dry weight and dry weight of whole plant. The concentration of nitrogen, phosphorus, potassium, calcium and magnesium in leaves of plants treated with water deficiency treatment did not differed in comparison to the plants treated with the normal water supply treatments.

Keywords: sago palm, water deficiency, response

Introduction

As a result of energy shortage crisis, the discovery of renewable energy resources is an important topic in many countries. The energy from natural sources such as wind, waves and sunlight as well as biomass energy is a renewable energy resource for humans. In case of biomass energy, various crops could be used as a source of renewable energy such as rice, sugarcane, corn, jatropha, etc. However, some plants are the main food crops for human consumption. Therefore, if a large amount of these crops are used as an energy resource, it will cause food shortage problems and competition between the materials used for food production and energy. Therefore, it is very important to find new non-food crops as a source of alternative energy.

Sago palm (*Metroxylon sagu* Rottb.) is a species of palm in the genus *Metroxylon*. The first remarkable feature of this palm is the high powder

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content in the trunk (about 300 kg dry weight per plant). Because of this feature, sago palm is an important economic crop especially in Indonesia and Malaysia where sago starch is produced at the industrial level. Sago starch is exported and used as the main raw material for processing. The second important feature of sago palm is that it can grow well in swamp areas or canal area adjacent to the sea in southern Thailand. Most of soil in these areas are saline or acid soils, where other economic crops can not grow. There are many reports showing that sago palm can survive in growing media high in NaCl. (Ehara, Matsui and Naito, 2006; Ehara *et al*., 2008; Prathumyot *et al*., 2011). The salt resistant feature of sago palm indicates that this palm is a suitable crop to grow in saline soil for the utilization of soil problem areas and may also be used as a source of food and energy.

In former reports (Ehara, Matsui and Naito, 2006; Ehara *et al*., 2008; Prathumyot *et al*., 2011), sago palm was planted in growing media high in NaCl. In such condition, sago palm was stressed from salt only when it was compared with sago palm grown in the coastal area. However, the actual salt problem area is not only in the seashore area, but also some abandon shrimp farm land. Plants in this type of soil will be stressed by salinity and water deficiency condition. Presently, there are no reports on the growth of sago palm under water deficiency condition. Therefore, the objective of this research was to investigate the response of sago palm under water deficiency conditions.

Materials and methods

The experimental design was designed as a complete randomized design (CRD) consisted of 4 treatments; watering daily, every 3 days, every 5 days, and every 7 days. Each treatment was replicated 4 times. The sixteen sago palms used in this study were 2 years old with 5 leaves and plant height was averaged 64.17 cm. Sago palms were planted in 17 inch pots. The planting media was soil mixed with husk and husk ash at a ratio of 2:1:1. The pH and organic content of the mixed media was 5.52 and 2.41%, respectively. The nitrogen, phosphorus and potassium concentrations in mixed media were 0.006%, 0.272% and 0.304%, respectively (Attanandana and Chanchareonsook, 1999). The experiment was conducted at the Faculty of Agricultural Technology, Rambhai Barni Rajabhat University for 60 days. Plant height, green leaf number and SPAD value were recorded weekly. At the end of the experiment, the leaf water content (Williams and Araujo, 2002) and chlorophyll content in leaf (Mackinney, 1941) were determined. Then sago palm was separated into various parts and dried at 70 ℃ for 3 days to determine dry weight and water content of each plant part. The nitrogen, phosphorus, potassium, calcium and magnesium concentration in sago leaves was determined (Attanandana and Chanchareonsook, 1999).

Results

Growth of sago palm

Results showed that the height increment of sago palm which watered every 7 days was lower than other treatments. However, there was no significant difference in plant height increment among treatments. Similarly, the green leaf number, whole plant dry weight, leaf dry weight and chlorophyll concentration of sago palm which watered every 7 days did not statistically differed when compared with the other treatments (Table 1).

SPAD value and chlorophyll concentration in leaf of sago palm

There was no significant difference in SPAD value among treatments throughout the experiment (Table 2). Similarly, the chlorophyll concentration in sago leaf watered daily, every 3 days, every 5 days, and every 7 days did not differ and was 71.10, 67.75, 75.85 and 84.16 $\mu g/cm^2$, respectively (Table 2).

Leaf water potential and water content in plant parts

At the end of the experiment, the leaf water potential of sago palm which watered daily, every 3 days, every 5 days, and every 7 days did not statistically differed, however, the leaf water potential of sago palm watered every 7 days was lowest in comparison to the other treatments (Table 3). However, there was a significant difference in water content in roots and the whole plant. Namely, the water content in the roots and whole plant of sago palm which watered every 7 days was lower when compared to the other treatments (Table 3).

Nitrogen, phosphorus, potassium, calcium and magnesium concentrations in sago palm leaf

Nitrogen, phosphorus, potassium, calcium and magnesium concentrations in leaf of sago palm which watered every 7 days were 1.96%, 0.17%, 1.25%, 0.52% and 0.13%, respectively and there was not significant difference when compared with the other treatments (Table 4).

Table 1. Height increment ,green leaf number ,whole plant dry weight ,leaf dry weight and chlorophyll concentration in leaf of sago palm grown under water deficiency condition

Watering Frequency	Height increment (cm)	Green leaf number	Whole plant dry weight (g)	Leaf dry weight (g)	Chlorophyll concentration in leaf($\mu g/cm^2$)
Daily	12.67	5.67	53.27	16.29	71.1
Every 3 days	12.17	6.33	55.05	19.04	67.75
Every 5 days	13.00	6.33	58.76	21.24	75.85
Every 7 days	11.50	6.33	64.84	18.94	84.16
F-test	ns	ns	ns	ns	ns
C.V. (%)	33.98	13.45	36.85	34.37	10.54

ns = not significant

Table 2. SPAD value of sago palm grown under water deficiency condition

Watering Frequency	SPAD value								
	0 day	7 days	14 days	21 days	28 days	35 days	42 days	49 days	56 days
Daily	69.04	67.98	67.87	71.63	59.72	63.89	61.6	62.49	61.28
Every 3 days	66.99	73.32	68.92	62.3	61.18	67.5	60.66	60.34	60.03
Every 5 days	67.98	66.86	66.05	61.91	60.62	62.39	58.56	56.78	58.48
Every 7 days	67.92	72.06	68.68	66.22	65.62	63.5	61.02	61.3	60.41
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	3.73	8.49	3.86	9.76	6.91	7.90	6.65	5.18	6.33

ns = not significant

Table 3. Leaf water potential and water content in plant parts of sago palm grown under water deficiency condition

Watering Frequency	Leaf water potential (bar)	Water content (%)			
		Root	Petiole	Leaf	Whole plant
Daily	-3.83	86.34[a]	87.62	66.16	83.35[a]
Every 3 days	-3.47	86.23[a]	87.82	66.11	83.58[a]
Every 5 days	-3.61	85.25[a]	87.79	68.43	83.44[a]
Every 7 days	-6.19	75.65[b]	86.05	66.80	79.00[b]
F-test	ns	**	ns	ns	**
C.V. (%)	39.48	6.23	1.56	4.13	2.61

Means with different letters in each column are significantly different (P≤ (0.01according to DMRT. ** = significant, ns = not significant

Table 4. Nitrogen, phosphorus, potassium, calcium and magnesium concentrations in leaf of sago palm grown under water deficiency condition

Watering Frequency	Nutrient concentration in leaf (%)				
	Nitrogen	Phosphorus	Potassium	Calcium	Magnecium
Daily	1.93	0.19	1.24	0.39	0.13
Every 3 days	1.79	0.15	1.06	0.45	0.12
Every 5 days	1.77	0.16	1.71	0.40	0.11
Every 7 days	1.96	0.17	1.25	0.52	0.13
F-test	ns	ns	ns	ns	ns
C.V. (%)	5.35	6.51	4.22	8.18	8.33

ns = not significant

Discussion

Water is essential in the structure of plant cells and necessary for plant growth. The water content in plants is normally about 80-95% (Suksawat, 2001; Techapinyawat, 2001). Many experiments reported that leaf water potential decreases when plants are grown under water deficiency condition (Good and Maclagan, 1993; O'toole and CRUZ, 1980; Gomes *et al*., 2004). Results of this study found that the leaf water potential of sago palm watered every 7 days was lowest compared to plants watered more frequently. This indicates that the water-deficient condition of sago palm watered every 7 days was more severe than more frequent watering. The water-deficient condition of sago palm watered every 7 days also effected the water content in the roots of sago palm while it did not effect the water content in petiole and leaf of sago palm. In other words, sago palm was able to maintain the water content in petiole and leaf under water-deficient condition.

The nutrients in the soil are necessary for plant growth and survival. Nitrogen, phosphorus, potassium, calcium, and magnesium are essential nutrients for plant growth (Techapinyawat, 2001). Nitrogen and magnesium are also important components of chlorophyll which is the major pigment for photosynthesis (Feungchan, 2013). The results of this experiment showed that the concentration of nitrogen, phosphorus, potassium, calcium and magnesium in the leaves of sago palm were not significantly different among treatments. The SPAD value of sago leaf from the experiment initiated until the end of the experiment and the chlorophyll concentration in sago leaf at the end of experiment, also did not differ between 4 treatments. It maybe concluded that sago palm could absorb and transport the important nutrients for growth under water-deficient condition for 2 months, especially nitrogen and magnesium that are the important components of chlorophyll. The result of SPAD value and chlorophyll concentration in sago leaf of this research was similarly with the reports of Ehara *et al.* (2008) and Prathumyot *et al*. (2011) who found that sago palm grown under stress conditions maintained SPAD value and chlorophyll concentration in leaves.

Results showed that sago palm which watered every 7 days preserved the important nutrients in the leaves, chlorophyll concentration in leaf, and the water content in the petiole and leaf at the same level with plants watered daily, every 3 days, and every 5 days. Finally, this may be caused the height increment, green leaf number, dry weight of whole plant and dry weight of leaf of sago palm which watered every 7 days when compared to the remaining treatments during 60 days experiment. Sago palm whch watered every 7 days grew well as sago palm which watered daily, every 3 days, and every 5 days for 2 months.

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