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Growth Characteristics of a Recommended Cassava Cultivar, Rayong 3, in Thailand*

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Abstract : Growth characteristics of Rayong 3, a recommended cultivar with sparse branching habit, were compared with those of Rayong 1, a traditional cultivar with tall and erect stems. Root production was largely influenced by the total dry matter production during the rainy season which was closely associated with a leaf area index (LAI). Rayong 3 showed some advantages in root production when compared with Rayong 1 ; i) high dry matter production during the rainy season, which was associated with a high LAI due to mainly the high leaf production rate per plant, ii) a high harvest index and iii) high dry matter and starch contents of storage roots. A moderate branching habit, represented by Rayong 3, could maintain a high harvest index when the total dry matter production and leaf area increased under the prevailing growth conditions of cassava in Thailand.

Key words : Dry matter production, Leaf production rate, Photosynthetic rate, Plant type, Root yield, Starch content, Thai cassava.

タイ国におけるキャッサバ改良品種 Rayong 3 の生育特性：岡　三徳・スパチャイ サラカーン*・チャルンシット リムシイラ*（熱帯農業研究センター・*タイ農業局ライヨン畑作研究センター）

要　旨：タイ国のキャッサバ栽培では，1975 年にタイ在来品種から選抜された品種，Rayong 1 が現在広く普及している．1984 年に CIAT の交配種子から育成された改良品種，Rayong 3 は分枝型の草型を示し，塊根の高い澱粉含有率とその多収性が注目されている．本研究では，Rayong 3 の乾物および収量生産特性に着目して普及品種 Rayong 1 と比較検討した．

全乾物重および塊根乾物重は，生育期を通じて Rayong 3 で Rayong 1 に比較して高く推移した．また，両品種の最終全乾物重の差は，雨期における乾物生産の違いによるものであった．得られた結果を総合すると，Rayong 1 と比較して Rayong 3 の優れた生産特性は，i) 雨期の高い葉面積展開力と結びついた高い乾物生産力，ii) 塊根部への高い乾物分配率，iii) 塊根の高い乾物率および澱粉含有率の 3 点に要約された．

キーワード：塊根収量，乾物生産，草型，光合成速度，タイ国のキャッサバ，澱粉含有率，葉身展開速度．

Cassava is the most important economic crop next to rice in Thailand. The original planting areas were in the eastern seaboard provinces where cassava has been cultivated continuously for a long time. Since 1950's, the production has spread to the provinces in the northeastern, western and upper central parts of Thailand[2]. Total production of fresh root as well as the total planted area had increased gradually since 1960's and rose steeply from 1976 to 1980. In recent years, the total production is about 15 million tons in planted area of more than one million hectare. Root yields have fluctuated between 13 and 15 t/ha after 1960. Average yield in Thailand is above the world average of 9 t/ha.

At present, the majority of cassava grown in Thailand are local cultivars. The first recommended Rayong 1 has been selected from local cultivars and released in 1975 and distributed throughout Thailand[15]. It is characterized by high yielding capacity, wide adaptability and good germination ability under water stress[5,8]. One of the shortcomings in Rayong 1, however, is its generally low starch content of roots.

Rayong 3 was selected from CIAT's hybrid seeds introduced to Thailand in 1975, and released by the Department of Agriculture, Thailand in 1984 because of its high yielding capacity and high starch content of roots[15]. However, the eco-physiological characteristics of Rayong 3 are poorly documented in spite of its high yield potential. In the present study, we identified the factors determining the dry matter and root production of Rayong 3 by comparing with those of Rayong 1.

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Materials and Methods

This study was conducted from 1983 to 1984 at Rayong Field Crops Research Center in Rayong Province, Thailand. Rayong 1 was an erect and Rayong 3 was a branching type. Cuttings of each cultivar were planted veritcally at 1×1 m spacing in the experimental field of one hectare on January 15, 1983 when it was the middle of dry season. Chemical fertilizer was not applied since sorghum had been planted as a preceding crop and incorporated in the same field. Germination rates of both cultivars were almost 100% due to the irrigation after planting, and plant materials grew well and uniformly.

Ten plants of both cultivars were harvested at one month intervals from May 1983 to June 1984. Measurements included the weight of leaves, stems, roots and fallen leaves, leaf area and apex number per plant. Sub-samples of each plant organ were weighed after drying by an air-forced oven for more than 3 days to estimate the dry matter contents. Leaf production rate was measured at weekly interval in the middle of rainy season. Nitrogen content of leaves was measured by the semi-micro Kjeldahl method. Starch content of roots was determined by using the Reimann Scale[16]. Leaf area was measured with an automatic area meter (AAM−7, Hayashi Denko, Tokyo). The photosynthetic rate of a single leaf was measured by the chamber method with an infra-red gas analyzer (ZRC, Fuji Electronic, Tokyo) under conditions of more than 1,000 μE/m^2 sec photosynthetically active radiation, 32±2°C air temperature and approximately 80% R.H.. Solar radiation was used as a light source for the measurement of photosynthetic rate.

Results

Agronomic characteristics of the two cultivars in the later growth stages are shown in Table 1. All the characteristics were presented as the means of four values obtained during the dry season from January to April in 1984, since Thai cassava is generally harvested about one year after planting in dry season[15]. Rayong 3 showed lower plant height and more branches than Rayong 1. There was a little difference in fresh root yield between the two cultivars, whereas the difference of dry root yield more increased between them due to higher dry matter content of roots in Rayong 3. An apparent difference in starch content was also observed between the two cultivars.

The changes in total dry weight including fallen leaves of Rayong 1 and Rayong 3 are shown in Fig. 1. The total dry weight increased during the rainy season and remained stationary during the dry season. The total dry weight was greater in Rayong 3 throughout the growth cycle. Leaf area index (LAI) was high in the rainy season and markedly low in the dry season ; Rayong 3 showed higher LAI than Rayong 1, especially in the early growth stages (May to July, the beginning of rainy season). Rayong 3 showed a higher crop growth rate (CGR) than Rayong 1 during the period from 200 to 300 days after planting when LAI exceeded three. The maximum CGRs of Rayong 1 and Rayong 3 were about 13 and 18 g/m^2 day, respectively.

Table 2 lists physiological leaf characteristics of both cultivars in the middle of the first rainy season in relation to leaf development. There was a large difference in the leaf layer thickness between the two cultivars, but the thickness was the same with the plant height of Rayong 1 (145 cm) and Rayong 3 (109 cm). The result showed that leaves distributed in all leaf layers from the top to lower parts of plants and conspicuous leaf fall did not take place in the middle of rainy seaon. Area of the

Table 1. Agronomic characteristics of Rayong 1 and Rayong 3 at Rayong Field Crops Research Center.

Cultivar	Plant height (cm)	Apex number (No/plant)	Root yield (t/ha)		Root number (No/plant)	Starch content (%)
			Fresh	Dry		
Rayong 1	340	2.0	34.3	10.6	7.2	20.5
Rayong 3	220	12.1	36.9	14.4	7.6	24.1

Note: All parameters indicate the means of four data obtained monthly during the dry season from January to April in 1984.

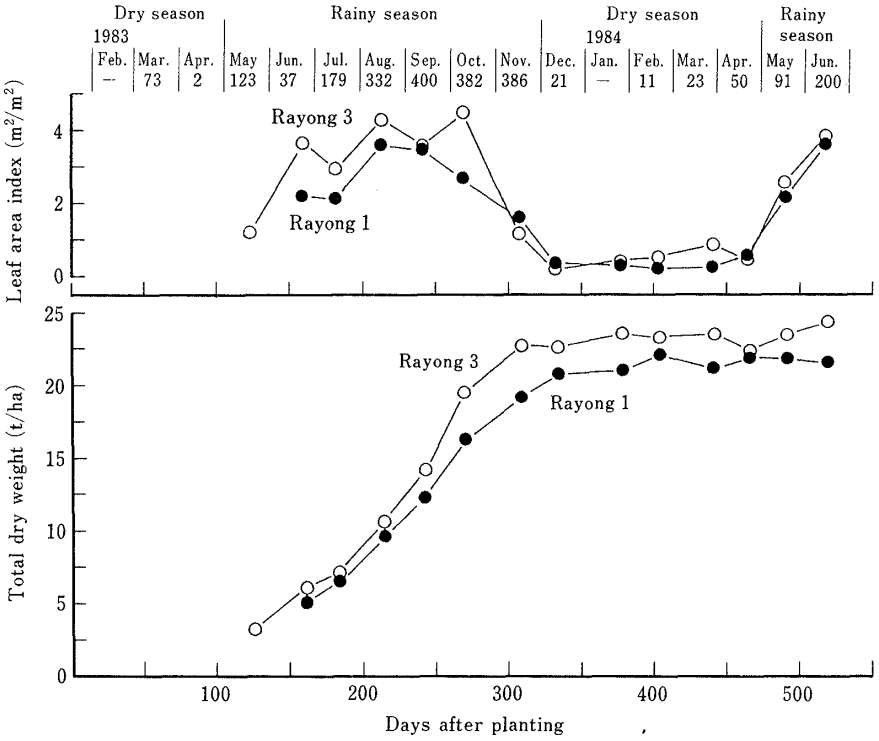

Fig. 1. Changes in total dry weight including fallen leaves and leaf area indices of Rayong 1 and Rayong 3 at Rayong Field Crop Research Center (1983—84).
Note: Numeral in the upper figure indicates monthly rainfall (mm).

tenth single leaf from the top expanded leaf, apex number and leaf producton rate per plant per day of Rayong 3 were significantly greater than those of Rayong 1. The photosythetic rates were 24–25 $mgCO_2/dm^2$ h in both cultivars, though the nitrogen content of leaves was 19% higher in Rayong 1. The large difference in LAI between the two cultivars in the rainy season was due mainly to the leaf production rate per plant related to branching habit and partly to the single leaf area, which indicated that Rayong 3 was advantageous for the increase of dry matter production.

Fig. 2 shows the changes in fresh weight and dry root yields, and dry matter content of roots. Until 8 months after the planting there was no difference in fresh root yield between the two cultivars, but thereafter the difference increased and Rayong 3 had higher values. However, the difference in fresh root yield between the two cultivars was noly 2.6 t/ha in the later growth stages corresponding to the dry season. On the other hand, there was a large difference in dry matter content of roots between the two cultivars throughout the

Table 2. Physiological leaf characteristics of Rayong 1 and Rayong 3 in the middle of the first rainy season.

Cultivar	Leaf layer thickness (cm)	Single leaf area (cm^2)	Apex number (No/plant)	Leaf production rate (No/plant day)	Nitrogen content of leaf (mg/dm^2)	Photosynthetic rate ($mgCO_2/dm^2$ h)
Rayong 1	145	338	2.0	1.80	15.2	24.9
Rayong 3	109	398	4.8	2.83	12.8	24.0
Significance	—(1)	**(5)	**(5)	**(5)	*(3)	ns(5)

Notes: Leaf layer thickness is the depth of leaves from the top to lower parts of plant canopy. Single leaf area was measured for the tenth leaf from the top expanded leaf to main shoots.
**, *significant at the 5 and 10% levels, respectively.
Numeral in parenthesis indicates the number of replications.

growth stages ; dry matter content of Rayong 3 was higher and less variable than that of Rayong 1 when the value of Rayong 3 at 210 days after planting was excluded. As a result, the dry root yield of Rayong 3 was significantly higher than that of Rayong 1, especially in the later growth stages (Fig. 2). Since the majority of cassava harvested is processed for dry chipping and pelleting, dry root yield reflects the yield potential better than fresh root yield. Harvest indices, calcuated on dry matter bases, also showed large differences between the two cultivars after the end of the first rainy season (Fig. 3).

Discussion

Research works[4,6,14] carried out in various places suggest that cassava root production in largely affected by the leaf development and maintenance. A large leaf area tends to develop in branching type rather than in non-branching type[3,12]. The present study showed that the sparse branching Rayong 3 produced larger leaf area than the non-branching Rayong 1 due to its branching habit. Photosysthetic rates of single leaves ranged 24 to 25 $mgCO_2/dm^2$ h and were similar to the results elsewhere[7,10]. However, the photosynthetic rate was not a limiting factor for dry matter production in the rainy season. In the dry season, there was little increase in total dry weight in both cultivars, since the rate of dry matter production markedly decreased in accordance with the decrease of total leaf area (Fig. 1). Under water stress conditions as observed in the dry season, the marked differences in the decrease of single leaf area and the dieback of young shoots were observed in hoth cultivars. The single leaf areas of Rayong 1 and Rayong 3 decreased to 46.2 and 27.2% of those expanded in the rainy season. The dieback of young shoots was observed in Rayong 3 in the middle of dry season. Above observations suggest that the tolerance of Rayong 3 to water shortage is inferior to that of Rayong 1.

Previous reports[1,11,12,13] showed that the yields of a profuse branching type of cassava were inferior to those of a non-branching type because the former accumulated more dry matter in the aerial parts (mainly in the stems). On the contrary, Cock[3] reported that MCol 113, a profuse branching type,

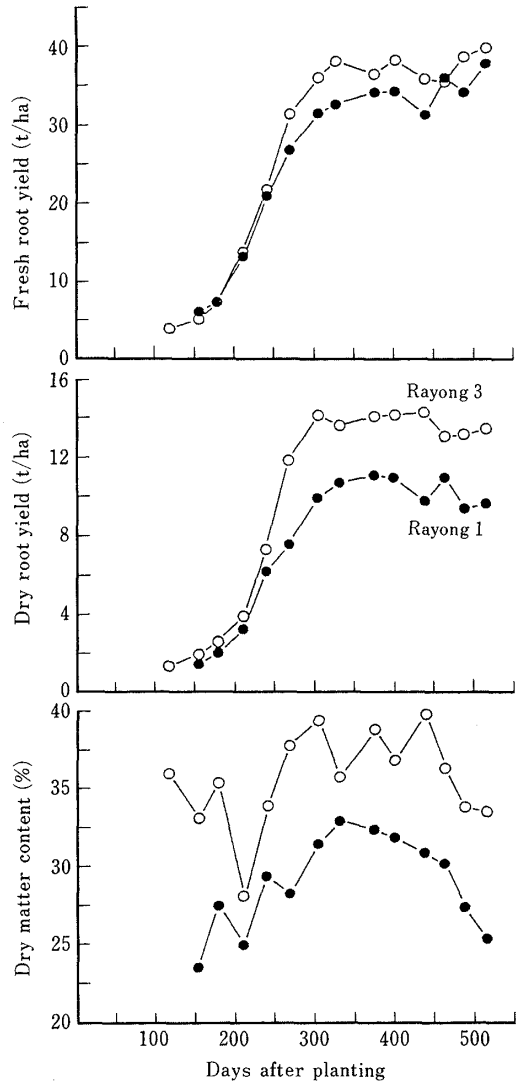

Fig. 2. Changes in fresh and dry root yields, and dry matter content of root.

produced the highest yield among 40 clones in Colombia and suggested that a high yielding cultivar should have a large LAI and a high harvest index, but the distribution of dry matter to the root should not be so great that leaf production is curtailed. In our present study, Rayong 3 did not show such a profuse branching habit but produced significantly more branches than Rayong 1. A recommended cultivar, Rayong 3, has certain advantages related to the storage root production when compared with a traditional cultivar, Rayong 1 ; i) it maintained a high dry matter productivity which was associated with a high LAI throughout the growth stages during the rainy season, ii) it had a high distribution efficiency of dry matter to roots reflecting in a high harvest index and iii)

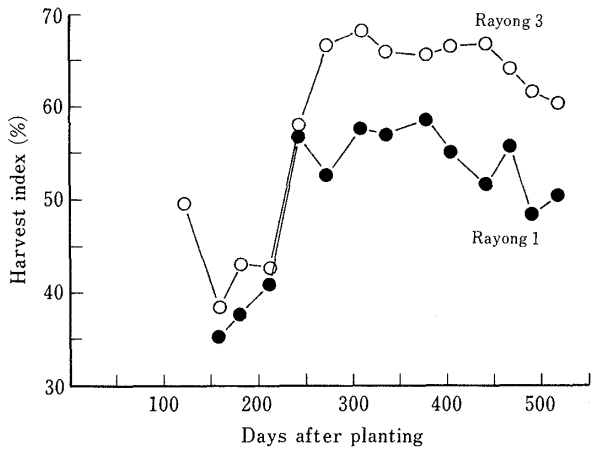

Fig. 3. Change in harvest index during a 17-month growth cycle of Rayong 1 and Rayong 3.

quite high dry matter and starch contents of roots. It must be emphasized that a sparse branching type, like Rayong 3, maintained a high harvest index though the dry matter production increased more than that of a non-branching type, Rayong 1.

However, Rayong 3 has the shortcomings related to the tolerance of water shortage and germination ability of stems compared with Rayong 1[8,9]. Moreover, Rayong 3 remains a problem of yield stability on infertile soils and with extensive cultivation. Using more cultivars and clones with various growth characteristics and plant types, further investigations should be conducted to define the physiological characteristics which minimize the shortcomings of Rayong 3.

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