Changes in the Levels of Carbohydrate as a Function of Environmental Variabilities in Hybrids and Tall Coconut Palms

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Abstract

Considerable differences were observed in the leaf contents of carbohydrate fractions in three-year old seedlings of the cultivars West Coast Tall×Gangabondam, West Coast Tall×Chawghat Dwarf Orange, Chawghat Dwarf Orange×West Coast Tall, and West Coast Tall palms. The trend of changes in the different months of the year were similar in all of them. The hybrids, however, were superior to WCT in their efficiency in the mobilization of carbohydrates. These changes observed between the months were influenced by the mean number of hours of sunshine per day during this period. The daily mean temperatures did not seem to influence these changes. The active mobilization of the carbohydrates took place during the period when the rainfall also was high.

Introduction

Palms possess a unique characteristic feature of vegetative and reproductive phases of growth interlinked during the entire span of their life. This implies that, unlike in many dicot trees, where the partitioning of photosynthates for vegetative and reproductive phases of growth follows a definite seasonal cycle, in the coconut palm, such partitioning is a continuous process. Being a tree crop of long life and continuous productivity, the palm is influenced considerably by the environmental variables in its productive features (Marar and Pandalai, 1957 ; Ziller, 1960). The nature of metabolic cycles as influenced by the environmental changes that have a direct role on the growth and productivity have not, however, been reported so far. The seasonal changes in the carbohydrate fractions in coconut palms in relation to solar radiation, temperature, and rainfall were the subject for the present study.

Materials and Methods

Three year old seedlings of West Coast Tall×Gangabondam, West

Coast Tall × Chawghat Dwarf, Chawghat Dwarf × West Coast Tall, and West Coast Tall palms growing under rainfed conditions were used in the study. Ten palms from each of the category were selected. Leaf samples were drawn from the yougest fully opened leaf once every month for 12 months. Each time, two leaflets from the middle of the leaf were collected between 10 A.M. and 11 A.M. and they were dried immediately at 95°C in a hot air oven. The finely powdered samples were analysed for carbohydrate fractions.

Total carbohydrates were extracted according to the method of Hagedon and Jenson (1933). Total sugars and starch were extracted according to the method of Highkin and Frankel (1962). For sugar estimation, the method of Somogyi (1952) was employed.

The mean temperatures were recorded using maximum/minimum thermometer housed in a Stevenson's screen. Hours of bright sunshine were recorded using a Campbell Stokes type sunshine recorder.

Results and Discussion

The results are presented in Figs. 1 and 2 and Tables 1 to 3. Considera-

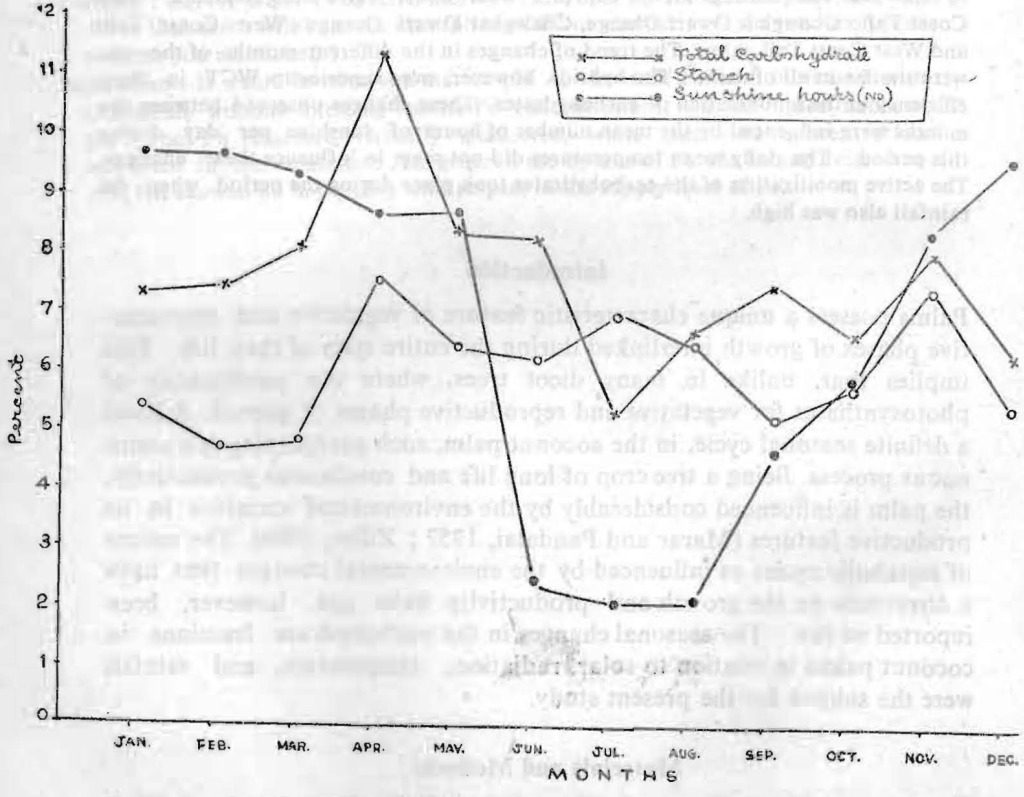

Fig. 1. Seasonal changes in total carbohydrates, starch and sunshine hours in the hybrid WCT × G.

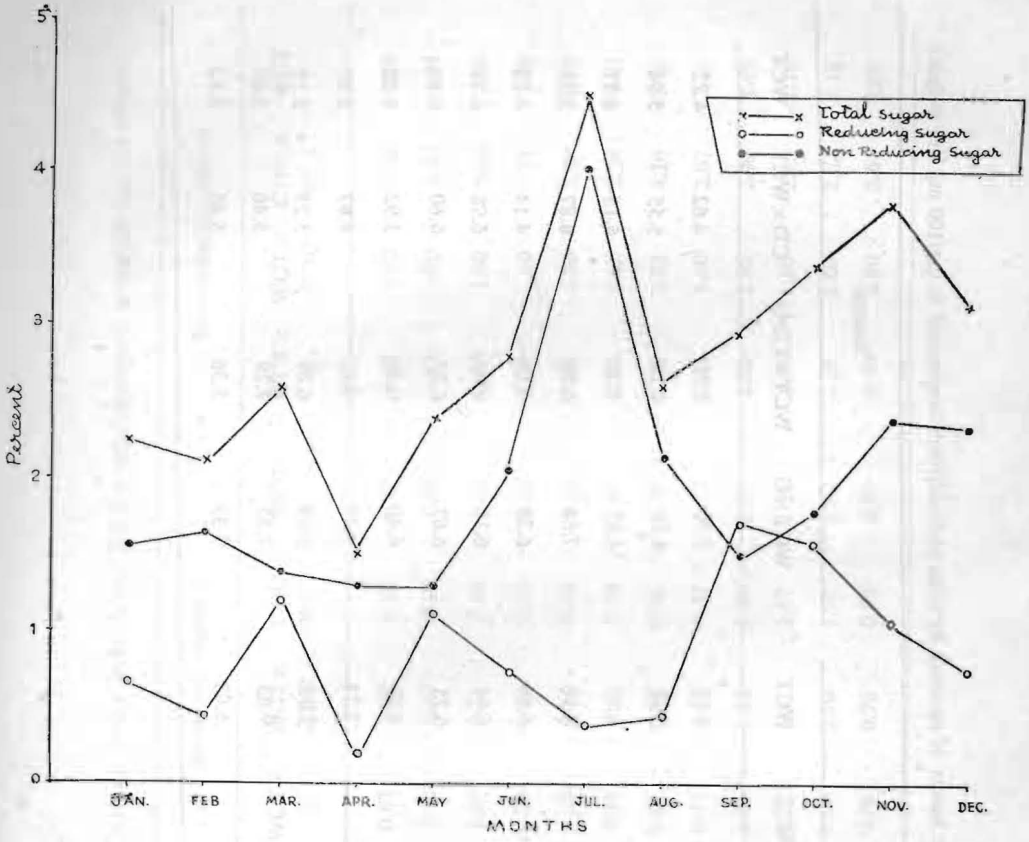

Fig. 2. Seasonal changes in sugar levels in the hybrid WCT×G hybrid.

ble variation in the carbohydrate fractions were noted during different months in all the types studied. The seasonal variation also showed the same trend in all of them. These seasonal changes as obtained in T×G hybrids are shown in Figs. 1 and 2. The total carbohydrate and starch content showed a rapid increase during the months of April and November (Fig. 1). In both the fractions, the concentration was reduced by 30-50% during July-October. The number of sunshine hours was maximum, ranging 8-10 hr/day during January to May and again in November and December, whereas during June-September, the number of sunshine hours was lowest ranging from 2-4 hr/day only.

The total sugar content as well as the non-reducing fractions showed an increase during July, and again later in November (Fig. 2).

The hybrids and Tall palms showed considerable variation between them in the total carbohydrate, starch, and sugar fractions. The magnitude of changes in the levels of carbohydrate fractions in different months was more in the hybrids. The mean temperature recorded during this period of study also ranged from 27°C to 31°C. The data on the rainfall recorded during the study are represented in Table 3.

TABLE 1. Total carbohydrate and starch contents in the leaves of coconut hybrids and cultivars (expressed in mg/100 mg dry weight)

Month	Total carbohydrate				Starch			
	WCT×G	WCT×CDO	CDO×WCT	WCT	WCT×G	WCT×CDO	CD×WCT	WCT
January	7.39	6.98	7.15	8.68	5.38	5.21	4.62	4.22
February	7.48	8.25	7.53	6.08	4.79	4.19	5.55	5.94
March	8.10	7.98	7.10	8.73	4.85	5.20	5.15	6.11
April	11.55	10.39	9.98	9.23	7.64	6.91	6.87	7.18
May	8.55	9.78	9.08	6.64	6.28	6.03	4.14	4.12
June	8.28	9.03	8.90	6.64	6.18	6.01	6.98	6.21
July	5.28	4.78	6.63	6.75	6.67	6.27	6.60	6.30
August	6.68	6.34	4.15	6.05	6.40	6.30	5.92	6.02
September	7.53	5.18	6.33	7.73	5.17	4.82	4.67	4.97
October	6.63	8.25	6.00	7.63	5.69	6.09	5.25	5.17
November	8.03	8.03	7.95	9.63	7.53	7.29	5.46	5.07
December	6.25	5.53	5.94	6.03	5.39	5.36	5.45	5.12

TABLE 2. Total sugar, reducing and non-reducing sugar fractions in the hybrids and WCT palms (expressed in mg/100 mg dry weight)

Month	Total sugars				Reducing sugars				Non-reducing sugars			
	WCT × G	WCT × CDO	CDO × WCT	WCT	WCT × G	WCT × CDO	CDO × WCT	WCT	WCT × G	WCT × CDO	CDO × WCT	WCT
January	2.20	2.50	1.7	1.8	0.63	0.70	0.32	0.71	1.57	1.80	1.38	1.09
February	2.10	1.90	2.3	2.2	0.45	0.47	0.47	0.86	1.65	1.40	1.83	1.34
March	2.60	2.20	1.2	1.7	1.20	0.71	0.36	0.82	1.40	1.50	0.84	0.88
April	1.50	1.70	1.5	1.3	0.20	0.30	0.32	0.21	1.30	1 40	1.18	1.09
May	2.40	1.50	1.9	1.4	1.10	0.46	0.40	0.61	1.30	1.10	1.50	0.79
June	2.80	2.80	3.2	3.1	0.75	0.61	0.88	1.69	2.05	1.20	2.34	1.41
July	4.50	4.20	4.5	3.4	0.44	0.77	0.34	0.39	4.06	3.43	4.16	3.01
August	2.60	2.10	2.6	1.8	0.46	0.50	0.53	0.75	2.14	1.60	2.07	1.05
September	3.20	3.60	3.4	3.4	1.70	1.62	1.50	1.75	1.50	1.98	2.90	1.65
October	3.40	2.50	3.8	3.3	1.57	1.31	1.67	1.54	1.83	1.20	2.13	1.76
November	3.80	4.70	4.6	4.3	1.41	2.10	1.98	2.12	2.39	2.60	2.62	2.18
December	3.12	3.60	3.6	3.8	0.78	0.76	0.93	0.83	2.34	2.80	2.67	2.97

TABLE 3. Mean sunshine hours per day and total rainfall in different months

Month	Average daily sunshine hours	Total monthly rainfall (mm)
January	9.9	—
February	9.8	—
March	9.5	13.5
April	9.0	19.4
May	9.0	160.0
June	2.8	1332.3
July	2.3	954.2
August	2.3	986.1
September	4.9	545.1
October	5.6	254.1
November	8.6	67.0
December	9.7	—

The seasonal changes in the carbohydrate fractions were found to be related to the changes in the number of sunshine hours per day. The number of sunshine hours are highest during January-May, when a rapid increase in the total carbohydrate and starch contents is noted. The period of sunshine falls sharply to very low levels of 2-3 hr/day during June-August, when a rapid decline in total carbohydrate and starch content also observed. A slight increase in these fractions noted in November again corresponds with an increase in sunshine hours.

The alcohol soluble sugar content recorded a peak during July which coincides with low total carbohydrate and starch contents and low sunshine period. As much as 80% of soluble sugar content was found in the non-reducing fraction during the month of July. Thus, higher contents of carbohydrate and starch in the leaves are the result of higher sunshine hours per day while the increased soluble sugar content, especially the non-reducing fraction is due to low sunshine hours per day. The period of high rainfall also appears to have some association with rapid changes in the soluble fractions of the carbohydrates. Since the temperature did not record much variability during the period of study, the observed changes could not be related to this factor.

The rate of production of leaves in WCT palms is higher during June-November (Marar and Pandalai, 1957). The period of active mobilization of carbohydrates observed during the present study coincides with the period of active leaf production. The leaf production during the period of study was higher (about 8 leaves) in the hybrids than that in the WCT (about 6 leaves). The magnitude of changes in carbohydrate fractions appears to influence the growth. The increase in carbohydrate content in April ranges from 30-42% in the hybrids, as against about 6% in the WCT. The increase in the concentration of alcohol soluble sugars in July was 42-54% in the hybrids, while it was only about 8% in the WCT.

These results indicate that the hybrids are more efficient than WCT in mobilization of carbohydrates. The period of active synthesis on the other hand seems to follow the period of high sunshine hours.

In coconut palm, the development and growth of inflorescence are intimately associated with the development and growth of leaves (Patel, 1938). The present study indicates that the synthesis and mobilization of carbohydrates in the leaves follow a definite pattern and it is influenced by the seasonal changes in solar radiation and precipitation. The period of increase in dry matter is associated with the rapid increase in the starch content in the leaves. More intensive studies at the subcellular, cellular and organ level in association with detailed studies on the sequences of morphogenesis in the developing bud in young palms would be helpful to understand the critical phases, if any, in the growth and development of inflorescence in coconut palm. Information on this aspect of physiology would be helpful for determining the best period for application of inputs that would ensure maximum productivity.

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Discussions

Pethiyagoda : Did you also study any diurnal fluctuation of leaf carbohydrate levels ? Any comments on export of carbohydrates out of the leaf ?

Kasturi Bai : Yes. On the first questions that we studied was the changes in starch and sugar concentrations in the leaf tissue from 6.00 AM to 9.00 AM. The changes in starch content were considerable

On the second question, I have no comments to make.

Venkateswaran : What is the relationship between the variations in carbohydrate etc. to the variations in yield ?

Kasturi Bai : This was not investigated in the present study as the material is yet to commence bearing.