

CHANGES IN CARBOHYDRATE LEVELS AND STARCH/ SUGAR RATIO IN THREE TURMERIC (*CURCUMA DOMESTICA* VAL.) CULTIVARS GROWN IN MONOCULTURE AND AS AN INTERCROP IN COCONUT GARDEN*

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ABSTRACT

Seasonal changes in the carbohydrate fractions like starch and total sugars as well as starch/sugar ratio in three turmeric cultivars *viz.*, Cls. No. 24 (C₁), Cll. 328 Sugandham (C₂) and Duggirala (C₃) grown in monoculture and as an intercrop in coconut garden were determined. Cultivar Cls. No. 24 showed higher build up of starch in leaves as well as rhizomes when grown as a pure crop than as an intercrop, while for the cultivars Cll. 328 Sugandham and Duggirala this difference between the two cropping systems was not apparent. The stage of maximum rhizome growth rate coincided with a reduction in the starch/sugar ratio in leaves, the reduction being more pronounced in cultivar Cls. No. 24 than in cultivars Cll 328 Sugandham and Duggirala. Such a marked reduction in the starch/sugar ratio in leaves recorded by the cultivar Cls. No. 24 indicated that during rhizome bulking period, this cultivar was more efficient in the translocation of photosynthates than the other two cultivars.

INTRODUCTION

In many crop plants, the mobilisation of storage carbohydrates is a major process which may limit the economic yield. Moorby (1970) found that in potato, there was a gradual turn over of stored ethanol insoluble material in the haulm, and that this was transferred to the tubers, while Judel and Mengel (1982) noted that the mobilisation of fructosans and starch may limit grain production. In the case of turmeric since the rhizomes depend on the carbohydrate supply from the foliage, a

continued translocation of assimilates from leaves to rhizomes over a prolonged growth period is necessary to ensure maximum rhizome growth. Eventhough turmeric is presently cultivated in different agroecological conditions and under different cropping systems, the information on the changes of carbohydrate fractions as influenced by environmental factors is lacking. In the present study, the seasonal changes in starch and total sugars as well as starch/sugar ratio of three turmeric cultivars grown in monoculture and in association

* Part of the Ph. D. thesis submitted by the first author to the University of Calicut, Kerala

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with coconut were determined with a view to find out the role of carbohydrate mobilisation in determining the rhizome yield.

MATERIALS AND METHODS

The study was conducted in the experimental farm of Central plantation Crops Research Institute, Kasaragod, Kerala with three turmeric (*Curcuma domestica* Val.) cultivars viz., Cls. No. 24 (C₁), Cll. 328 Sugandham (C₂) and Duggirala (C₃) for two years 1977 and 1978. Generally, the temperature and input of photosynthetically active radiation (PAR) were lower, and precipitation was higher during the early period of crop growth (June to August) than during the latter period (September to November) (Table I). The PAR input was higher in 1977 than in 1978 during major period of the crop growth. The only environmental variable found consistently different between the two cropping systems was the solar radiation. On an average, intercropped stand received about 46 per cent of the incoming PAR.

The crop was raised in monoculture (pure stand) or in association with coconut of West Coast Tall (WCT) variety of 30 years of age (intercropped stand) adopting a completely randomized design with five replicates. Both coconut and turmeric (pure as well as intercropped stands) were manured as per the recommended package of practices. Leaf as well as rhizome samples were collected for the estimation of starch and total sugars at 4th, 6th, 8th, 11th, 14th, 18th, 22nd, 26th and 30th weeks (harvest) after planting. At each interval, eight plants *i.e.*, four plants randomly selected from each of the two inner rows were collected from each replication. The sampled plants were separated into leaves, rhizomes and roots, and dried at 70°C in a hot air oven.

Total sugars and starch were extracted according to the method of Highkin and Frankel (1962). Hundred mg of dried and powdered samples were extracted in 80% ethyl alcohol. The total sugar content was then estimated

Table I. *Monthly mean values of temperature, photosynthetically active radiation (PAR) and rainfall from June to December (turmeric growing season) during the years 1977 and 1978*

Months	Temperature (°C)				PAR (E m ⁻² d ⁻¹)		Rainfall (mm)	
	Maximum		Minimum		1977	1978	1977	1978
	1977	1978	1977	1978				
June	29.8	28.1	23.2	22.5	27.3	18.2	915	1337
July	28.5	27.6	22.5	22.5	22.1	19.8	1577	1178
August	29.1	27.9	23.1	23.1	32.2	24.7	354	914
September	29.7	28.6	23.2	22.8	38.4	34.9	165	285
October	31.5	30.6	22.6	23.0	37.1	40.6	252	119
November	30.8	31.5	22.6	22.3	34.9	39.6	218	48
December	32.8	32.9	19.6	22.0	48.0	40.9	2	7

following the phenol-sulphuric acid method (Dubois et al., 1956). The residue from the alcoholic extract was used for starch estimation. The residue was kept suspended in 52% perchloric acid for 30 min with intermittent shaking. Five ml aliquots of the filtrate were digested with 2.5 N HCl at 100°C for 30 min and neutralised with 30% NaOH. Two ml of the hydrolysate were taken for the estimation of starch content by the phenol-sulphuric acid method. The starch and sugar contents in the leaves and rhizomes were then calculated, and expressed as percentages on dry weight basis.

RESULTS AND DISCUSSION

Seasonal changes (June to December) in the concentration of starch in the leaves as well as rhizomes of the cultivars showed similar patterns in both the years (Fig. 1). In the case of cultivar Cls No. 24 the maximum starch content in the leaves was attained by 18th and 22nd weeks under pure and intercropped stands respectively, while in the case of cultivars Cl. 328 Sugandham and Duggirala this was attained by 14th week under both the cropping systems. These periods had coincided with the respective stages of attainment of maximum leaf area of the cultivars. There was a marked build up of starch in the rhizomes beyond 14th week in all the cultivars followed by the rapid bulking of the rhizome.

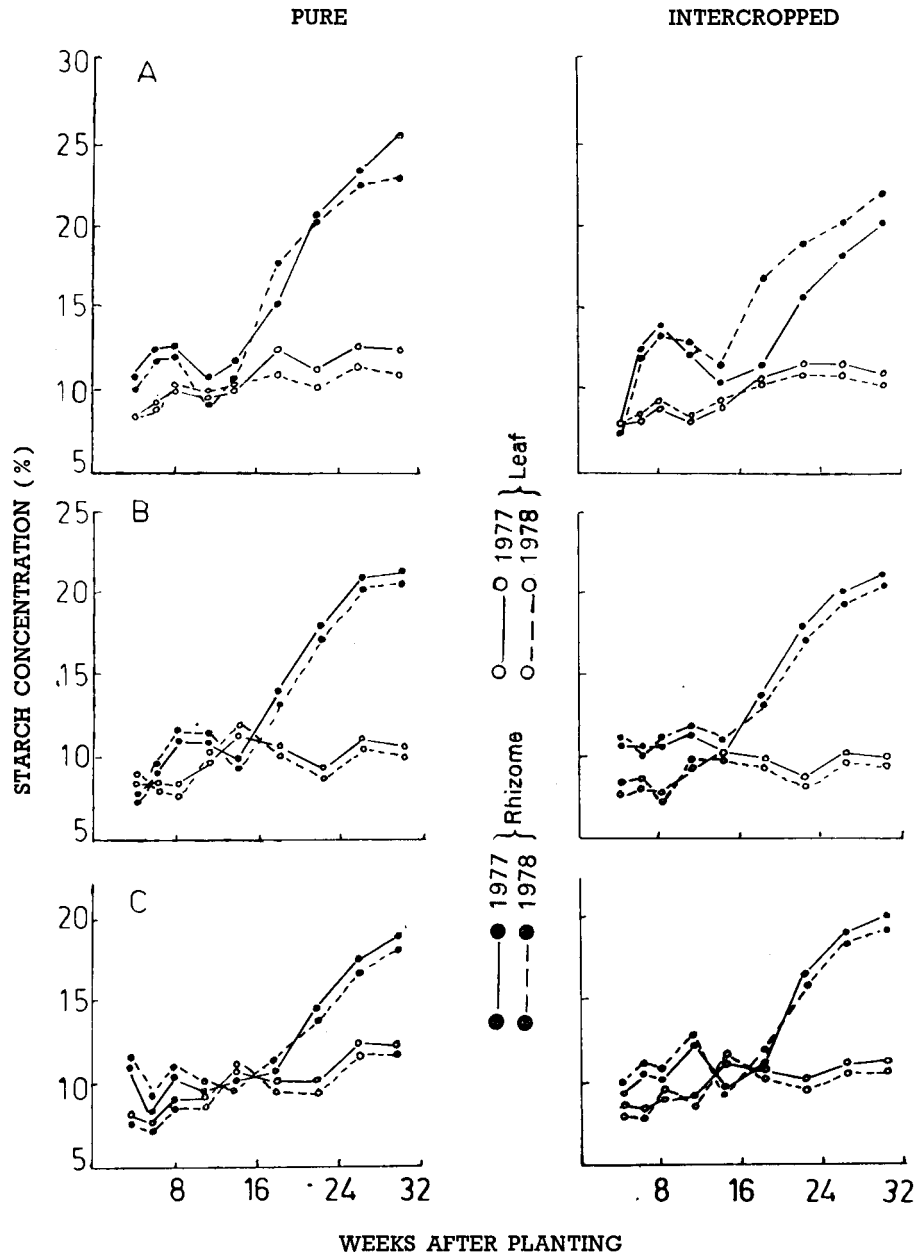
During the year 1978, when the solar energy input was less as compared to 1977, all the cultivars registered lower build up of leaf starch content, the reduction being more pronounced

for the pure stand of cultivar Cls No. 24. Cls No. 24 also showed higher starch content in the leaves as well as rhizomes when grown as a pure crop than as an intercrop, while for the cultivars Cl. 328 Sugandham and Duggirala, this difference between the cropping systems was not apparent. The starch content in the leaves and rhizomes of cultivar Cls. No. 24 was higher than those of the other two cultivars, especially under the monoculture system. These results indicated that cultivar Cls. No. 24 is reacting more to the higher solar energy input than the cultivars Cl. 328 Sugandham and Duggirala.

The seasonal variation (June to December) in the concentration of total sugars in the leaves and rhizomes of cultivars Cl. 328 Sugandham and Duggirala did not show any marked difference between the two years of study (Fig. 2). But, in the case of cultivar Cls. No. 24 the total sugar content in the rhizome was found to be considerably higher in 1978 when there was a reduction in the rhizome yield, as compared to 1977. Also, the sugar concentration in the leaves of this cultivar attained a much higher maximum value in 1978 than in 1977, under the monoculture system.

The highest build up of sugars in the leaves occurred during the period of 14th to 18th week after planting. There was marked rise in the sugar content in rhizome by 22nd week when the maximum rhizome growth rate was noted. This increase in the sugar content in both leaves and rhizomes had resulted in a reduction in their starch/sugar ratio (Fig. 3). In all the cultivars, the stage

Fig. 1. Seasonal changes in the starch concentration in three turmeric cultivars under pure and intercropped stands (A. Cls. No. 24; B. Cl. 328 Sugandham; C. Duggirala)



2. Seasonal changes in the concentration of total sugars in three turmeric cultivars under pure and intercropped stands (A. Cls. No. 24; B. Cl. 328 Sugandham; C. Duggirala)

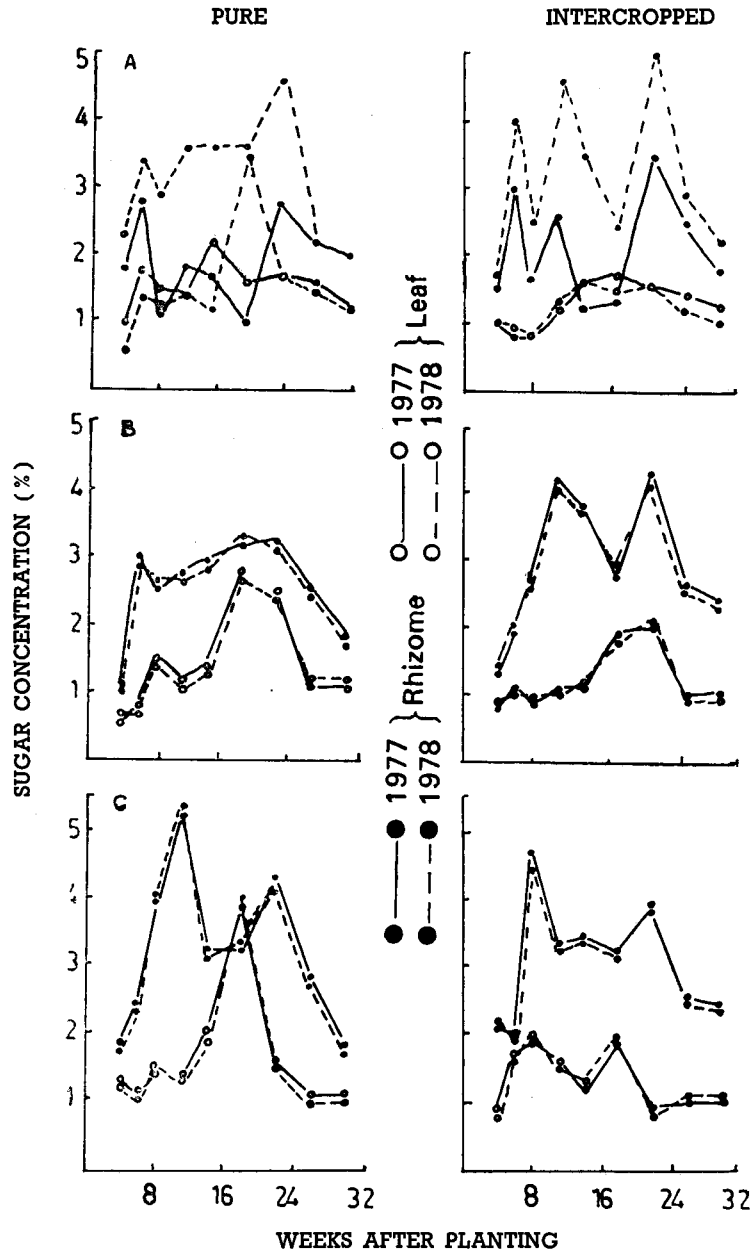
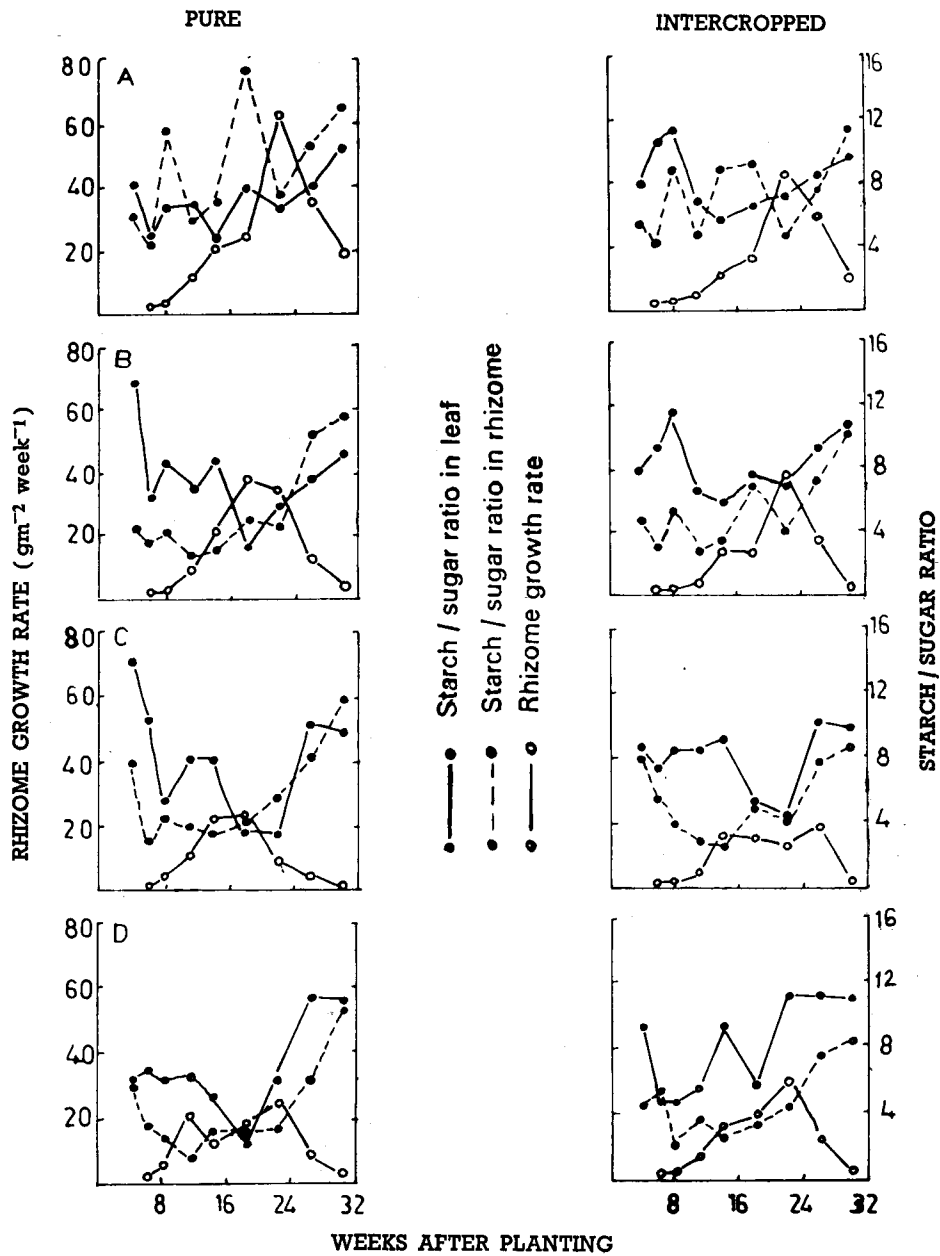


Fig. 3. Seasonal changes in starch/sugar ratio as influenced by rhizome growth rate in three taro cultivars under pure and intercropped stands (A. Cls. No. 24 (1977); B. Cls. No. 24 (1977); C. Cl. 328 Sugandham (1977); D. Duggirala (1977))



of maximum rhizome growth rate coincided with a rapid reduction in the starch/sugar ratio in leaves. Giaquinta, Quebedeaux and Wittenbach (1980) had shown that in soybeans, a decrease in starch/sugar ratio in leaves during the pod filling stage caused an increase in the dry matter accumulation in seeds indicating that partitioning of assimilates between starch and sucrose may be an important determinant of assimilate translocation to the seeds.

Huber (1981) concluded that the rate of translocation of assimilates which is atleast partially controlled by sink demand can influence the starch accumulation in leaves. It is notable that cultivar Cls. No. 24 showed the reduction of starch/sugar ratio in leaves for a more prolonged period of 14th to 22nd week as compared to the other two cultivars where the reduction was noticed only for the period of 18th to 22nd

week after planting. Such a marked reduction in the starch/sugar ratio in leaves recorded by the cultivar Cls.No24 can be explained as due to its increased sink demand caused by high rhizome growth rate. Under such circumstances, there will be a high rate of translocation of assimilates from leaves to rhizomes thereby influencing starch accumulation in leaves. Several authors had reported that photosynthetic rates declined when starch accumulation in leaves exceeded a certain limit (Milford and Pearman, 1975; Nafziger and Koller, 1975; Mauney et al., 1979). The results suggested that during the rhizome bulking period, cultivar Cls. No. 24 was more efficient in the translocation of photosynthates than the cultivars Cl.328 Sugandham and Duggirala and this higher translocation efficiency of cultivar Cls. No. 24 can positively influence its photosynthetic rate.

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