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THE IMPLICATIONS OF WEATHER/CROP RELATIONSHIP IN TEA CULTIVATION

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Yield variation in tea was found to be associated with cambial activity in stem and root, and level of root reserves. Hence, the weather parameter, $f_t R_w S_p$ used for prediction of yield, can also be used to follow the growth potential of stem and root, and variation of root reserves. The physiological implications of this relationship are examined in relation to some cultural operations.

INTRODUCTION

In the management of tea plantations weather constitutes the major uncontrollable factor that influences plant growth and thereby determines management efficiency. Kandiah and Thevadasan (1980) derived a weather term $f_tR_wS_p$, from daily recordings of air temperature, rainfall and sunshine hours, that was found to quantify the effect of weather on crop from April to December in the wet zone hill country of Sri Lanka. Yield response to $f_tR_wS_p$ lags by a month, so that monthly yield is predictable at the beginning of the month. The overall effect of weather on the growth of tea will be on its gross increase in dry weight of which crop is a fraction. Thus, crop variation will be related to growth variation in the rest of the plant. Some aspects of this relationship are reported in this study, where crop was assessed along with secondary growth of stem and root, and root reserves. The physiological implications of weather/crop relationship in tea cultivation, are examined in the light of the results.

MATERIALS AND METHODS

Assessment of yield, growth of stem and root

A plot of tea of clone TRI 2024 was used for obtaining yield and growth data. Cultural operations adopted are described elsewhere (Kandiah ahd Thevadasan, 1980). Crop was harvested on 44 occasions over a period of 12 months from March, 1974 to April, 1975. Growth of stem and root was assessed by diameter increments on 15 randomly selected bushes, using a Vernier Caliper. Repeated measurements were made at the same point on marked branches and proximal end of roots 1—1.5 cm diameter, exposed at the time of assessment only.

Estimation of reserves

In the tea bush, root wood tissues serve as suitable material for determining the status of reserves in the bush (Kandiah, 1975). Reserves in the root wood of random samples from the experimental plots were estimated periodically by the method normally used for routine analysis in our laboratories (Kandiah, 1971; 1975).

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Meteorological data

The meteorological data were obtained from the Tea Research Institute Meteorological Station (Kandiah and Thevadasan, 1980).

RESULTS

Weather/yield correlation

The yield in a month was predicted from the weather term, $f_tR_wS_p$, of the previous month, from April to December, during which period 75 per cent of the crop was harvested, (Kandiah and Thevadasan, 1980).

Growth pattern of the tea bush

Fig. 1 shows how growth varies in the shoot (b) and the root (c) of the bush, along with fluctuations in the level of root reserves (d). Monthly crop, from April to February, is plotted along with the weather term for the preceding month (a). Growth in diameter of the stem and root during six consecutive periods are shown by histograms. Their areas are proportional to increases in the corresponding periods, the total area of the histograms is equivalent to the total increase which is taken to be 100 in each case. This provides a common basis for comparison of crop with stem and root growth. The heights of the histograms represent rate of growth.

The distribution of rainfall (f) and the variation in '*transpiration index*' (e) which gives a measure of water availability for transpiration (Kandiah and Thevadasan, 1980), are also shown. The year could be divided into a wet and a dry season depending on water availability. The period from April to December is the wet season, characterised by a transpiration index of unity or near unity, when the plant hardly experiences water stress. The period from January to March is the dry season, characterised by transpiration index often below unity, when the plant experiences water stress. Crop prediction is possible, using the weather term $f_tR_wS_p$, in the wet season from April to December.

Growth results plotted in Fig. 1 indicate that variation in monthly yield from April to December closely corresponds to that of the weather term of the preceding month. Cambial activity in stem and root was found to be seasonal showing peaks that could be related to the first cropping peak in the season. Active stem growth corresponds approximately to the rush crop period and it is followed by active root growth. Growth activation, with the onset of rains in April, seems to progress from shoot to root. Consequently, when cropping has slackened, there is active root growth.

Root reserves (polysaccharides) fluctuate with two major peaks — one at the beginning of the rainy season in April and the other at the beginning of the dry season around December. Accumulation of reserves is not appreciable during the period of active root growth from June to October. Unlike the crop, the level of reserves in the root, in any month, was noted to be more related to the weather term of the same month ($r = 0.80$) than to that of the previous month ($r = 0.02$). Thus, root reserve peaks are followed by cropping peaks.

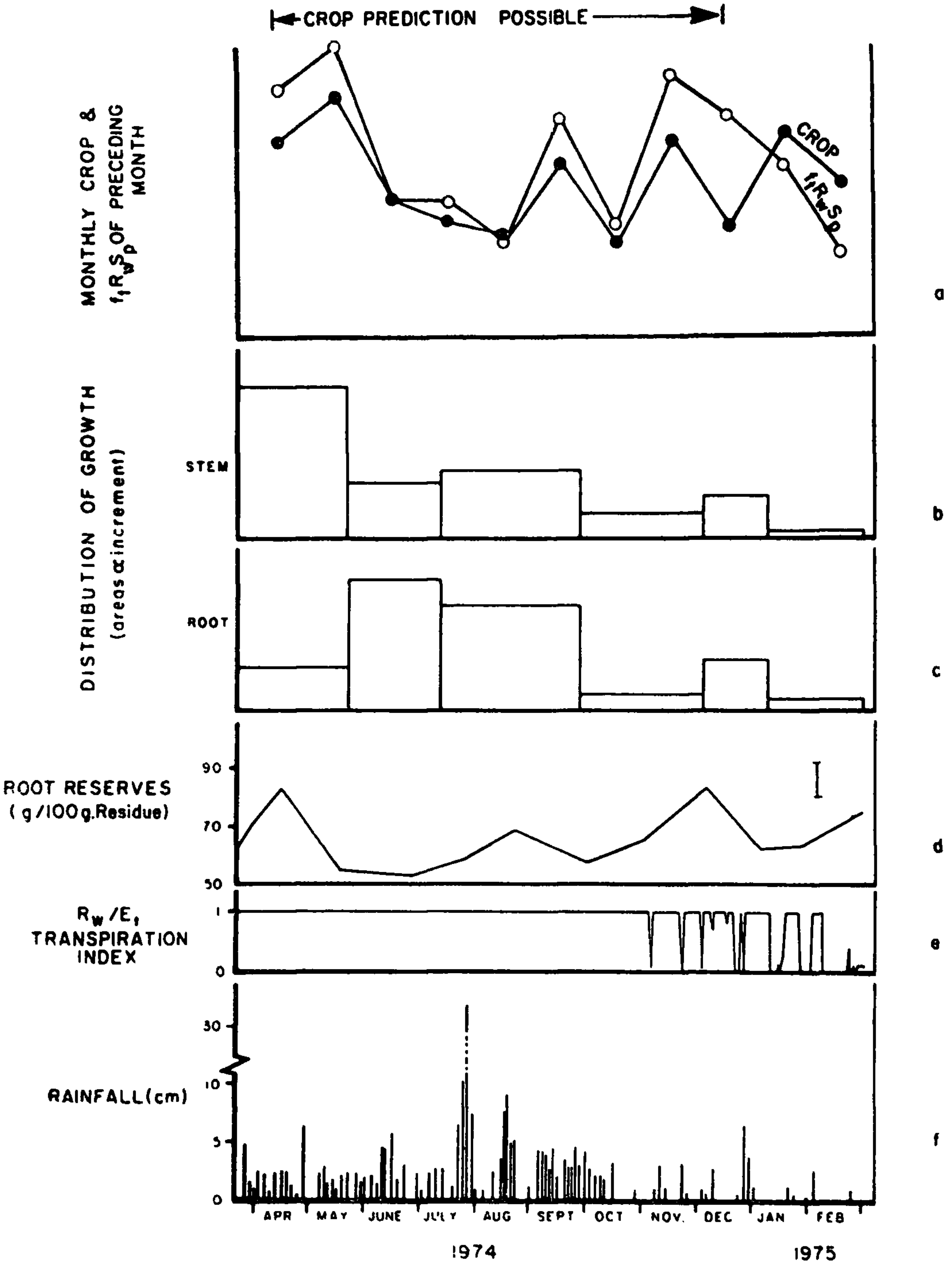

Fig. 1 — Variation of (a) monthly yield and weather term ($f_tR_wS_p$) for the preceding month; (b) distribution of growth (diameter increment) in stem (c) in root, (d) variation in root reserves; (e) transpiration index, and (f) rainfall. Bar=LSD ($P = 0.05$).

DISCUSSION

The time-lag for yield response to weather, noted in this study, has also been reported by earlier workers (Laycock, 1964; Carr, 1970; Devanathan, 1975). However, a physiological explanation for this was not given. The mode of initiation and expansion of primordia at the apical meristem of tea shoots is elucidated by the work of Bond (1945), Portsmouth and Rajiah (1957) and Goodchild (1968). These studies indicate a phase of active primordial initiation and a phase of primordial expansion, in the development of flush shoots. The former is completed eight weeks before the flush is due to be harvested. Hence, the weather, as quantified by $f_tR_wS_p$. is unlikely to influence yield four weeks later by affecting the plastochron or rate or primordia initiation. A bud emerging from its bud-scales and fish leaf (a small sized leaf) is harvested four weeks later. Therefore, it is likely for the weather term to be directly related to the stimulus that induces bud emergence, end perhaps its influence on subsequent growth is indirect. Bud emergence in turn leads to the production of auxin that triggers cambial activity (Larson, 1962). Hence, secondary growth in stem and root too is associated with cropping pattern.

In concept, the weather term is directly related to the rate of photosynthesis (Devanathan, 1977). Hence, its influence on crop should operate through photosynthesis. The pattern of mobilisation of 'labelled' assimilates from tea leaves (Sanderson and Sivapalan, 1966; Wickremasinghe and Perera, 1972) and the nature of shoot/root interaction in tea (Kulasegaram, 1969; Kandiah and Wimaladharma, 1978) lead one to attribute the delayed influence to a fraction of the leaf assimilates undergoing a metabolic turn over in the root, before influencing shoot growth. In this context it should be noted that root reserves in this study, unlike the crop, was correlated more to the weather term of the same month than to that of the previous month.

The root factor could be hormonal (*eg* cytokinins and gibberellins) and/or nutritional in nature and is probably translocated in the xylem sap. Reduced soil water content, warm days and cool nights, characteristic of the dry season, lead to water stress in the plant. This can affect the composition and rate of translocation of the root factors and the mode of partitioning of assimilates, thereby altering cropping response. The superior quality of the crop in these months, (Wickremasinghe, 1974) may be associated with such a change. It was found possible to substantially increase crop by irrigation during this period, but irrigation checked the development of quality (Kandiah *et al.*, 1979).

Stem and root growth and variation of root reserves are associated with cropping pattern which can be predicted from April to December. Thus, the weather term would also serve to follow cambial activity in stem and root, and level of root reserves, which can be useful for correct timing of cultural operations. Pruning, manuring and spraying for pests such as shot-hole borer (*Xyleborus fornicatus Eichh*) are the more obvious examples where the weather term could be used to appropriately time these operations.

Pruning

Pruning is a critical cultural operation in the management of tea plantations which involves severe reduction of foliage in the plant. One of the factors that determines successful recovery from pruning is the level of root reserves (Kandiah, 1971). It is often observed that recovery is better when pruning is done just prior to the peak cropping period. The weather term $f_tR_wS_p$, can be used to predict the rush crop a month ahead. The reason for the successful recovery during this period is probably due to the high level of root reserves (Kandiah, 1975). In addition, cambial activity in the stem may also have a bearing, especially in relation to translocation of root factors and the healing of pruning cuts. Thus, in the wet zone hill country of Sri Lanka, for the seasons represented in Fig. 1, the appropriate time to prune will be late March or early April, into the South West Monsoon.

Manuring

Tea receives high doses of nitrogenous fertilizers which nowadays constitute the biggest component of the cost of production. Manuring practices in tea plantations in Sri Lanka are usually based on annual yield and distribution of rainfall, the former decides the dosage and the latter the times of application. The efficiency of utilisation of nitrogenous fertilizers from the soil by the tea plant is poorly understood, and the maxim of "little and often" is adopted in the absence of a better guideline, and consequently fertilizer is applied in split doses that could range from two to six applications per year.

For the efficient uptake and utilization of nitrogen from the soil, besides soil moisture, level of root reserves is also critical, for, uptake of nitrogen is known to be associated with utilization of root reserves (Selvendran and Selvendran, 1973). Thus, for both efficient uptake and maximum return in crop, in fields not due for pruning, periods prior to rush crop seem most suitable and such periods can be known using the weather term, *eg*. for the season in Fig. 1 two of these periods would be March/April and November/December. By adjusting fertilizer applications to suit plant growth in this manner it may be possible to economise on fertilizer without detriment to crop.

Spraying for Shot-hole Borer

Shot-hole Borer is the most formidable pest in tea at elevations upto 1200 m. The pest is controlled by routine application of insecticides. Recent studies have indicated that build-up of beetle population is associated with the declining phase of cropping. It was found that population peak follows the peak cropping period (Sivapalan, 1977). The low beetle population during peak cropping period could be the result of maximum cambial activity in the stem, which hinders the successful establishment of beetle galleries due to fast callusing. Using the weather term spraying programmes can be planned to suit beetle population which become predictable.

Crop prediction using weather parameters is feasible only when soil nutrients, pests, diseases and harvesting or plucking frequency do not limit yield. The importance of the latter in determining yield is often not realized. While too long plucking intervals lead to potential crop left on the plant, besides poor standard of flush, too short plucking intervals result in exhaustion of the bush and reduced crop. Crop prediction is useful to decide on appropriate plucking interval for each month in advance to suit cropping potential of the weather.

Knowing the cropping potential of the weather it is possible to assess the merits of cultural operations on a sound basis and to obtain maximum returns from inputs, since yield decline over any period, if attributable to weather, can be identified.

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