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A COMPUTER PROGRAMME FOR THE EFFICIENT DIRECTION OF FIELD OPERATIONS IN TEA ESTATES

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A weather term $f_t\ R_w\ S_p$ derived from daily recordings of temperature, rainfall and sunshine hours is interpreted through BASIC language for calculation on a microcomputer, such as Sinclair Spectrum. Since $f_t\ R_w\ S_p$ was found to be highly correlated to crop yield and other related aspects of plant growth, the computer can be programmed to direct many cultural operations in the field. It is shown as to how the computer could be programmed to provide generalised instructions on whether the plant response could be best, average or poor for pruning, N-fertilizer application, spraying for shot hole borer infestation and predict yield potential, recommending appropriate plucking frequency. The scope for further improving the method of computing the weather term and thereby increasing the utility of the computer in estate management is discussed.

INTRODUCTION

The principal factors controlling the growth of land plants operate through soil and climate and they determine the availability of nutrients, water and photosynthates for plant growth. Glass house culture of plants as practised extensively in temperate climates allows for control of soil and climatic factors. During recent years computers have been used for the more efficient management of glass house crops to optimise yield (Van de Vooren, 1975 ; Weaving, 1980 ; Burrage, 1981). However, in order to optimise yield in field crops, plant growth must be adjusted by cultural operations to suit the uncontrollable weather components of the environment, unlike glass house culture.

Under modern agricultural systems it is possible to select the best variety to grow in almost ideal soil conditions with pests and diseases kept under control ; yet, to obtain maximum yield a proper understanding of the effect of weather on plant growth is essential. Some work in this direction has been done in the tea crop (Devanathan, 1975 ; Kandiah, 1980 ; Kandiah and Thevadasan, 1980). This paper presents a method for developing a computer programme that would enable the tea grower to feed simple routine weather recordings into a small computer and obtain reliable guidance on the implementation of cultural operations, so as to optimise growth response from the tea plant.

Basis of developing the computer programme

Tea under cultivation has been recognised as a very suitable climate indicator crop. A constant proportion of the vegetative growth of the plant is harvested 45 to 60 times a year (Eden, 1949). The yield records of manufactured tea is a very suitable indicator of plant growth. Devanathan (1975) showed that the growth potential of the tea plant is proportional to a term 'f_t RS' derived from temperature, rainfall and sunshine hour recordings. Subsequently, Kandiah and Thevadasan (1980) introduced refinements in the use of rainfall and sunshine data which markedly improved growth correlation of the weather term. Kandiah (1980) showed how the weather term which could be considered to indicate the agroclimatic potential for growth of the plant, could be used to guide cultural operations in tea estates. The method of deriving the weather term, unfortunately, is rather involved and cumbersome to compute and hence had discouraged its adoption by tea growers. The computer programme presented here is essentially meant to overcome this drawback.

The calculation of the agroclimatic potential at any time of the year now involves only the tapping in of daily recordings of maximum and minimum temperatures (°C), rainfall (mm) and sunshine hours. The rest of the calculations could be left to a small computer which would provide daily values of the weather term, $f_t\ R_w\ S_p$ where f_t=temperature coefficient, R_w=rainfall term and S_p=sunshine hours term. Basing on the magnitude of these values for a specific period, the computer can be programmed to provide advice on many cultural operations in the tea plantation (Fig. 1).

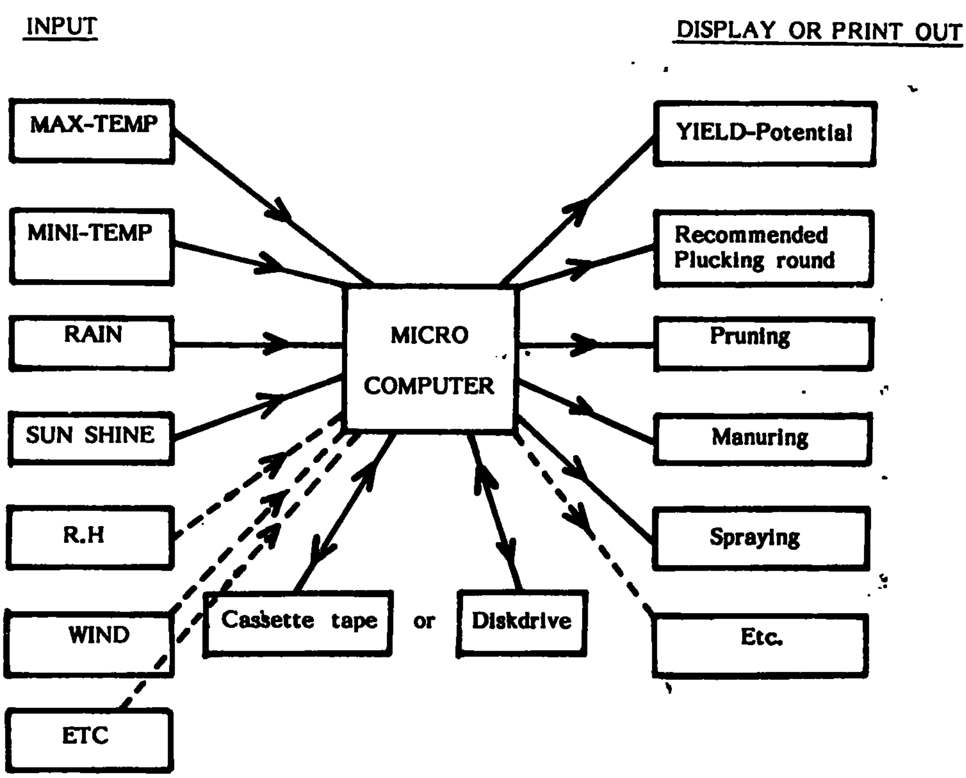

Fig. 1—Computer system for weather based direction of field operations in Tea Estates.

The instructions given to the computer would be based on integrated values of daily $f_t\ R_w\ S_p$ which had been calculated by the computer and stored in its external memory. Our experience up to now indicate that totals of $f_t\ R_w\ S_p$ for the preceding 30 days can be used to derive various instructions (Kandiah, 1980).

Considering St Coombs Estate, Talawakele of the Tea Research Institute of Sri Lanka, where previous work on this aspect was done (Kandiah, 1980; Kandiah and Thevadasan, 1980) monthly values of the weather term vary from 686 to 330 with a mean of 443 (derived from five years weather recordings) (Kandiah and Thevadasan, 1980).

Thus for St Coombs Estate the computer can be instructed to consider 30 day totals above 500 as 'High', below 400 as 'Low' and between 400 to 500 as 'Medium' agro-climatic potential. Basing on the above grading, cultural instructions could be chosen as a selection from three combinations indicated in rows A, B or C of Table-A, on any day of the year.

The valuation of 30 day – $f_t\ R_w\ S_p$ for high, medium and low agroclimatic potential could vary from estate to estate and ideally should be calculated individually for each estate or group of estates in the same agroclimatic area. The physiological basis on which these instructions could be derived from the weather term had been discussed by Kandiah (1980).

TABLE (A) — *Basing on aggregate values of the weather term, $f_t\ R_w\ S_p$, for the preceding 30 days, guidance on yield potential (1), and cultural operations (2) to (5), could be chosen by the computer as shown in rows A, B or C.*

(1)	(2)	(3)	(4)	(5)
Yield potential in the following 4 weeks	*Recommended plucking round in the following 4 weeks*	*If pruned now*	*If N-Fertilizer is applied now*	*Probable Shot-hole borer beetle population now*
(A) Heavy Crop	Short Plucking Round	Recovery Good	Efficient Assimilation of - N	Beetle Population Low
(B) Average Crop	Medium Plucking Round	Recovery Average	Reasonable Assimilation of-N	Beetle Population Medium
(C) Low Crop	Long Plucking Round	Recovery Risky	Poor Assimilation of -N	Beetle Population High

Computation of the weather term

Algorithm that should be adopted in the computation of the weather term, $f_t\ R_w\ S_p$ using a microcomputer following the method published by Kandiah and Thevadasan (1980) is summarised in the appendix (see Tables 1, 2 and – 3 Appendix). These could be provided in a tape cassette. The authors have successfully fed weather data from St Coombs Estate, of the Tea Research Institute of Sri Lanka, into a microcomputer in the computer department of the University of Jaffna and derived instructions on cultural operations as outlined in Table A.

DISCUSSION

In this paper a method for evaluating the integrated effect of three weather factors, temperature, rainfall and sunshine hours, on plant growth is presented. The calculation of the weather term $f_t R_w S_p$ could be implemented on a microcomputer such as Sinclair Spectrum with a cassette recorder or microdrive. Programme for the calculation of $f_t R_w S_p$ (appendix) could be stored in a cassette tape or in a floppy disc. By using the programme any clerical staff could operate the computer and derive information on yield potential, plucking frequency, pruning, manuring, spraying for Shot-hole Borer, etc. as categorised in Table A, at any time of the year. These instructions could be displayed on a TV screen. The present cost of this system would be between Rs. 10,000/- to Rs. 16,000/- (depending on whether cassette tape or disc drive is chosen to store the programme) which is well within the reach of many estates. It is possible to further improve the weather term by incorporating additional data such as relative humidity and wind run ; furthermore information on soil and plant features would help more meaningful interpretation of the weather term to specific agroclimatic regions, where $f_t R_w S_p$ as calculated now may not seem a very suitable indicator of the agroclimatic potential. But these developments would follow the practical application of $f_t R_w S_p$ to assess agroclimatic potential for plant growth in the regions best suited for its use now e.g. the wet zone hill country of Sri Lanka, where a third of the tea in Sri Lanka is grown. It is by practical application on a wide scale that one could identify limitations and attempt refinements.

Knowledge of annual variation of agroclimatic potential in estates would enable the management to make a meaningful and scientific analysis of crop output and detect shortcomings presently undetected and, some times erroneously attributed to "bad" weather. It is hoped that this paper would help revive interest on the weather/crop studies published on tea and utilize the the opportunity offered by the computer for the practical implementation of these findings.

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APPENDIX

Computation of f_t R_w S_p on a microcomputer

Almost all the microcomputers have BASIC language interpreter. Calculation of the weather terms require two short tables to be stored in the memory. We could store these tables using DATA statements and read the values into the memory using READ statements. Using a one dimensional array, Table 1 could be stored into the memory. Table 2 values could be stored using a 2—D array.
1 — D array is with 36 elements with the indices ranging from 0 — 35.

2 — D array is of dimension 12 x 2, first column for the value of R_a and 2nd column for the value of N.

We could feed the values of a, b, c, d, (or n) Table 3 using INPUT statements. Given the month through the INPUT statement, the value of c (or N) could be obtained by searching the 2nd column of 2—D array. We can use integer 1 — 12 to denote the months January — December.

Derivation of f_t R_w S_p—(refer Table 3)

Calculation of f_t

Calculate $f = \frac{a+b}{2}$

Find the nearest integer less than f and the decimal part of f. Let these numbers be q and m respectively.

Search the 1 — D array for the values corresponding to q and q+1. Let these values be x and y respectively.

Then $f_t = (y - x)m + x$

Calculation of R_w

Calculate h=(.0022804 Ra)+(.0041203) Ra/N)n

Ra could be obtained by searching the 1st column of the 2 — D array. To calculate i we need the values of j and h from the calculation of the previous day. These could be fed into the computer using INPUT statement. Let these be pj and ph.

Then $i = pj - ph$ if $i < 0$ then $i=0$: if $i \geqslant 76$ then $i=76$
$j = c+i$
$k = \min(h, j) = R_w$

Calculation of Sp

Sp=d+0.3 (e−d)

Weather term W

$W = f_t R_w Sp.$

TABLE 1 — *Rates of photosynthesis at various temperatures relative to 25°C.*

0°	1°	2°	3°	4°	5°
0.034	0.045	0.059	0.076	0.099	0.123
6°	7°	8°	9°	10°	11°
0.152	0.189	0.226	0.267	0.311	0.352
12°	13°	14°	15°	16°	17°
0.398	0.443	0.484	0,530	0.575	0.662
18°	19°	20°	21°	22°	23°
0.667	0.712	0.756	0,804	0.851	0.901
24°	25°	26°	27°	28°	29°
0.949	1.000	1.050	1.101	1.155	1.209
30°	31°	32°	33°	34°	35°
1.268	1.329	1.389	1.450	1.512	1.570

(Kandiah and Thevadasan, 1980)

TABLE 2 — *Monthly values of solar radiation at the top of the atmosphere (R_a) in cal. cm^{-2} day^{-1}, maximum possible sunshine hours (N) for Sri Lanka (Latitude 7 N), and the equation for estimating Evapotranspiration of the crop ($=E_t$ mm) from hours of sunshine (n) recorded by Campbell Stokes recorder.*

		Ra*		N*	$.0022804\ R_a + (.0041203\ R_a/N)n = E_t$ mm
January	..	788	..	11.75	
February	..	841	..	11.89	
March	..	881	..	12.10	
April	..	888	..	12.24	
May	..	868	..	12.45	
June	..	850	..	12.52	
July	..	856	..	12.45	
August	..	872	..	12.38	
September	..	876	..	12.17	
October	..	850	..	11.96	
November	..	800	..	11.82	
December	..	770	..	11.75	

* From McCulloch, 1965

(Kandiah and Thevadasan, 1980)

TABLE 3— *Methods of computing the weather term $f_t R_w S_p$ from daily recordings of air temperature, rainfall and sunshine hours.*

Meteorological Data

a — Maximum temperature (°C)
b — Minimum temperature (°C)
c — Rainfall (mm)
d — Sunshine (hours from Campbell Stokes recorder)
e — Day length (N hours from Table 2)

Derivation of f_t, R_w and S_p

Temperature coefficient (f_t)

f — Mean temperature (= (a+b)/2)°C
g — f_t = value in Table 1 corresponding to temperature in f

Rainfall term (R_w)

h — Evapotranspiration(= E_t mm calculated using Table 2 and d)
i — Available water in soil carried over from previous rainfall (= j-h)* mm to a maximum of 76 mm)
j — Rainfall used for computing R_w = (c+i) mm
k — R_w = h or j whichever is less
l — S_p = d+0.3(e-d)

Weather term
= $f_t R_w S_p = g \times k \times l$

* Values of j and h refer to those of the previous day where negative values of (j-h) are considered 0.

(Kandiah and Thevadasan, 1980)