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THE USE OF LEAF APPEARANCE RATES ESTIMATED FROM MEASUREMENTS OF AIR TEMPERATURE TO DETERMINE HARVEST INTERVALS FOR TEA

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SUMMARY

The effects of temperature (13–20 °C) and potential soil water deficit (0–350 mm on the leaf appearance rates of six contrasting clones of tea (*Camellia sinensis*) were studied over twenty-five months to provide guidance to tea growers in southern Tanzania on the choice of harvest intervals. Within the fully irrigated treatments (potential soil water deficit < 65 mm) the mean time period between a shoot unfurling its second and third true leaf (a phyllochron) ranged from 5.8–7.9 d during the warm–wet season to 11–19 d during the cool-dry season. Between 61 and 79% of the weekly variation in the mean leaf appearance rate (1/phyllochron) for each clone could be explained by an asymptotic relation with the mean air temperature. Building on research in India which has suggested that appropriate harvest intervals for tea can be derived from measurements of leaf appearance rates, a simple procedure is described for determining harvest intervals from the daily mean air temperature. Corrections to account for the effects of drought and clonal differences in responses to temperature are also explained.

INTRODUCTION

Tea (*Camellia sinensis* L.) is an evergreen shrub from which tender shoots are normally harvested at intervals of one to three weeks to produce a marketable beverage. In most tea growing regions, growers will specify a 'target' type of shoot that represents the most profitable compromise between the value and the quantity of the harvested leaf. The finest quality and the highest value teas are usually produced by harvesting only the apical buds or 'tips' of the shoots (Owuor *et al*., 1990). However the yield from harvesting such shoots is small, as a shoot with one unfurled leaf can have a mass which is only a third of that for a shoot with three unfurled leaves (Stephens and Carr, 1994). The target type of shoot can be quantified in terms of the number of leaves or the size, weight or length of the shoot (Palmer-Jones, 1977).

In southern Tanzania many growers aim to maximize the proportion of harvested shoots that have three unfurled leaves. Traditionally this has been achieved largely by the skill of the people (known as pluckers) harvesting the tea.

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Shoots with more than three leaves are minimized by 'breaking-back', a process where the pluckers harvest shoots with three leaves and then break and discard the lower, older leaves in order to maintain a level plucking surface or 'table'. Shoots with less than three leaves remain unharvested. With increasing financial pressure to raise labour productivity, however, there is less opportunity for the pluckers to be selective and it is now common in Tanzania for all of the easily-harvestable shoots that emerge above the artificial flat surface of the bush to be removed at each harvest. Mechanical harvesting systems now being introduced in eastern and central Africa are also inherently non-selective.

With the decline in selective harvesting, the choice of the harvest interval has become the main management tool for controlling the quality of the harvested leaf. Historically tea has been harvested at intervals which depend on the season and the availability of labour. Judgements of when to change these intervals have largely been based on the visual appearance of the crop and often on the height of the shoots above the 'table'. However research in Malawi has shown that it is possible to maximize the proportion of harvested shoots with three unfurled leaves by programming the harvest interval in relation to the period of time, termed the shoot replacement cycle (SRC), that it takes for an axillary bud released from apical dominance to unfurl the third 'true' leaf (Grice, 1982; Clowes, 1986). By selecting an interval that is one-quarter of the SRC, four successive generations of shoots can be established on each bush and the 'mean' shoot of each generation can be harvested on the date when it has just unfurled its third leaf. In southern Malawi, where the shoot replacement cycle during the main growing season is 42 d, the recommended harvest interval is therefore 10–11 d. Stephens and Carr (1993) and Burgess and Carr (1997) have shown how the length of the shoot replacement cycle varies with clone, and is sensitive to the air temperature, the soil water deficit and nutrient availability.

Although the shoot replacement cycle system has allowed growers to determine an appropriate harvest interval for a given season, it can be too cumbersome to provide week to week guidance when there are rapid changes in growing conditions (Burgess and Carr, 1997). Previously Das (1984) in Assam, and Murty and Sharma (1989) in south India have proposed that harvest intervals could be based on the time that it takes a shoot to unfurl two successive leaves. Although this time period has been called the 'leaf expansion time', it is more correctly defined as a phyllochron (Bond, 1945). This paper describes the effects of temperature and soil water deficit on the phyllochron of six contrasting tea clones in southern Tanzania with the aim of developing a methodology for planning harvest intervals that can be used, with confidence, by the tea industry.

METHODOLOGY

Site and climate

The experiment took place at the Ngwazi Tea Research Unit (lat 8°32′S, long 35°10′E, altitude 1840 m) in the Mufindi District of the Southern Highlands of

Tanzania. The site lies 20 km north-west of the traditional tea-growing area that currently produces approximately 11 000 t made tea each year. Full details of the site are given by Burgess and Carr (1996).

The year can be divided into three main seasons on the basis of rainfall and temperature. Over 95% of the annual rainfall of 800–1100 mm occurs during the warm–wet season from the end of November to May, when the monthly mean air temperature is 16–19 °C. The dry season can be divided into two: cool (13–16 °C) from June to August and warm (16–19 °C) from September to November. The annual short-wave radiation varies from 5950 to 6400 MJ m^{-2}, with a mean daily value of 17 MJ m^{-2}. The highest mean monthly mid-afternoon vapour pressure deficit, which occurs in October, is only 1.5 kPa. As this is below the level at which the shoot growth of well-water tea is reduced (Tanton, 1982), the yields of tea during the warm–dry season in Mufindi are influenced principally by the soil water deficit.

Clones and irrigation treatments

In August 1988 six clones, of scientific and/or commercial importance in East Africa, were planted in four replicate blocks at spacings of 1.2 × 0.8 m within a clone × drought experiment described fully by Burgess and Carr (1996). There were two small-leaved clones from Tanzania (1 and 207), an intermediate-sized-leaved clone (6/8) and two large-leaved clones (S15/10 and K35) from Kenya and a large-leaved clone (SFS150) from Malawi. In order to bring the tea into production as early as possible, young branches were 'pegged' horizontally between April and October 1989; the tea was not pruned until May 1994. The first commercial harvest took place in December 1989, and the tea received annual applications of 300 kg N ha^{-1} as 20 N: 10 P_2O_5: 10 K_2O fertilizer in 1990, 1991 and 1992.

For the purposes of irrigation scheduling, the soil water deficit on day i (SWD_i, mm) was calculated daily using a simple water balance (Equation 1):

$$SWD_i = SWD_{i-1} - R_i - I_i + D_i + ET_i \qquad (1)$$

where R_i is the rainfall, I_i is the irrigation, D_i is the instantaneous drainage and ET_i is the crop evapotranspiration all calculated daily in mm. The value of ET_i was taken to equal the daily evaporation from a screened 1.85-m square × 0.6-m deep evaporation pan (Burgess and Carr, 1996). During the initial periods of the dry seasons in 1991 and 1992, the experimental area was uniformly irrigated to field capacity whenever the potential soil water deficit reached 45 mm. Differential drought treatments were then applied for 13 weeks between 18 July and 20 October in 1991, and between 19 August and 16 November in 1992. During this time, the sub-plots closest to a centrally-placed sprinkler lateral, labelled I_5, were returned to field capacity after each irrigation (potential SWD < 65 mm), whereas those furthest from the lateral, labelled I_0, received no water and the potential SWD reached 355 and 415 mm in 1991 and 1992 respectively. In an intermediate treatment, labelled I_3, the potential SWD reached 170 mm in 1991 and 150 mm in 1992.

Phyllochron measurements

Each week between December 1990 and December 1992, ten shoots were selected within a fully irrigated sub-plot of each clone. Between March 1991 and December 1992, ten shoots were also selected within partially irrigated (I_3) and unirrigated (I_0) sub-plots of the same block. Daily values of the mean air temperature (T_{mean}, °C) were calculated from the average of the daily maximum and minimum temperatures measured within a Stevenson screen approximately 700 m from the experimental site.

A shoot, derived from an axillary bud, will normally produce a 'fish' leaf (a small leaf with an unserrated margin) followed by a series of 'flush' or true leaves (Bond, 1942). In order to obtain reproducible measurements, each shoot was selected when the actively growing terminal bud could be exposed by touching the tip of the *second* true leaf with a single finger (Fig. 1). A phyllochron was then defined as the number of days from this starting point until it was possible to 'flick'

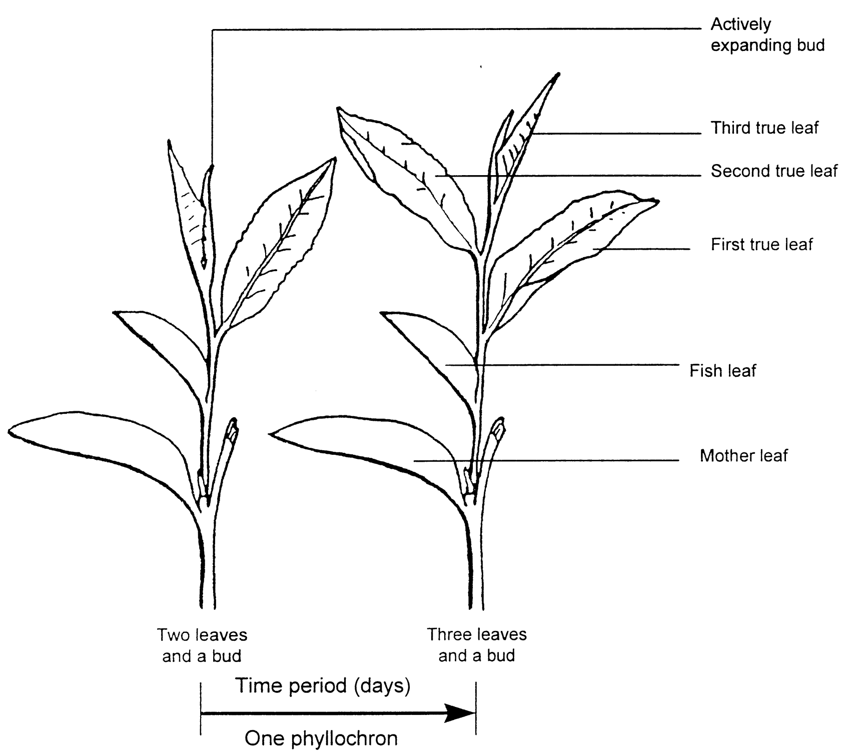

Fig. 1. Sketch showing the changes in development during one phyllochron from the unfurling of the second to the third true leaf.

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out the terminal bud by touching the tip of the *third* true leaf in the same way (Burgess and Myinga, 1992).

RESULTS

Seasonal changes in phyllochron

Within the fully irrigated sub-plots, there were both clonal and seasonal ($p \leqslant 0.001$) differences in phyllochron. Between December and May, when the mean weekly air temperatures were 15 to 20 °C, the mean phyllochron ranged from 5.8 d for Clone 1 to 7.7–7.9 d for Clones 6/8 and S15/10. The values for the other three clones were intermediate (6.5–6.9 d). During the cool–dry season from June to August, when the mean weekly air temperatures were 13 to 16 °C, the mean phyllochrons for the fully irrigated plants increased to 11 d for Clone SFS150, and to 19 d for Clones 1 and S15/10.

The reciprocal of the phyllochron can be termed the leaf appearance rate (LAR, leaf d^{-1}). Linear relations between leaf appearance rate and the mean air temperature were able to explain between 58 and 73% of the weekly variation in the rate of leaf appearance of each fully irrigated clone (Table 1), and the values for the apparent base temperature of leaf appearance rate ranged from 6.5 °C for Clone SFS150 to 10.1 °C for Clone S15/10, with a mean value for all six clones of 9.0 °C.

However a detailed analysis of the same data showed that a higher ($p \leqslant 0.01$) proportion of the variation (61–79%) could be explained by assuming an asymptotic, rather than a linear, relation between LAR and T_{mean} (Fig. 2). The form of the relation was:

$$\mathrm{LAR} = \mathrm{LAR}_{max} - \mathrm{b} \times \mathrm{R}^{\mathrm{Tmean}} \qquad (2)$$

Table 1. Linear model: the slope (ρ, $\times 10^{-3}$ leaf d^{-1} °C^{-1}) and the y-axis intercept (a, leaf d^{-1}) with standard errors, the degrees of freedom (d.f.), and correlation coefficient (r^2, %) for the best fit linear relations between the leaf appearance rate (LAR, leaf d^{-1}) and the mean air temperature (T_{mean}, °C) for each of six fully irrigated clones between December 1990 and December 1992. The relations are of the form: LAR = $\rho \times T_{mean} + a$. The corresponding base temperatures (T_{b1}, °C) with the 95% confidence intervals are also shown.

Clone	d.f.	Slope(ρ)	Y-axis intercept (a)	r^2	Base temperature (T_{b1})
S15/10	98	16.6 ± 1.0	−0.17 ± 0.02	61	10.1 (9.0–10.9)
207	102	18.5 ± 1.1	−0.19 ± 0.02	73	10.1 (9.0–10.9)
1	99	21.5 ± 1.7	−0.21 ± 0.03	61	10.0 (8.5–11.0)
K35	99	15.2 ± 1.3	−0.13 ± 0.02	58	8.5 (6.5–9.8)
6/8	103	12.4 ± 0.9	−0.09 ± 0.02	63	7.6 (5.9–8.9)
SFS150	103	13.6 ± 1.1	−0.09 ± 0.02	59	6.5 (4.2–8.1)
Mean	614	16.2 ± 0.6	−0.15 ± 0.01	55	9.0 (8.3–9.5)

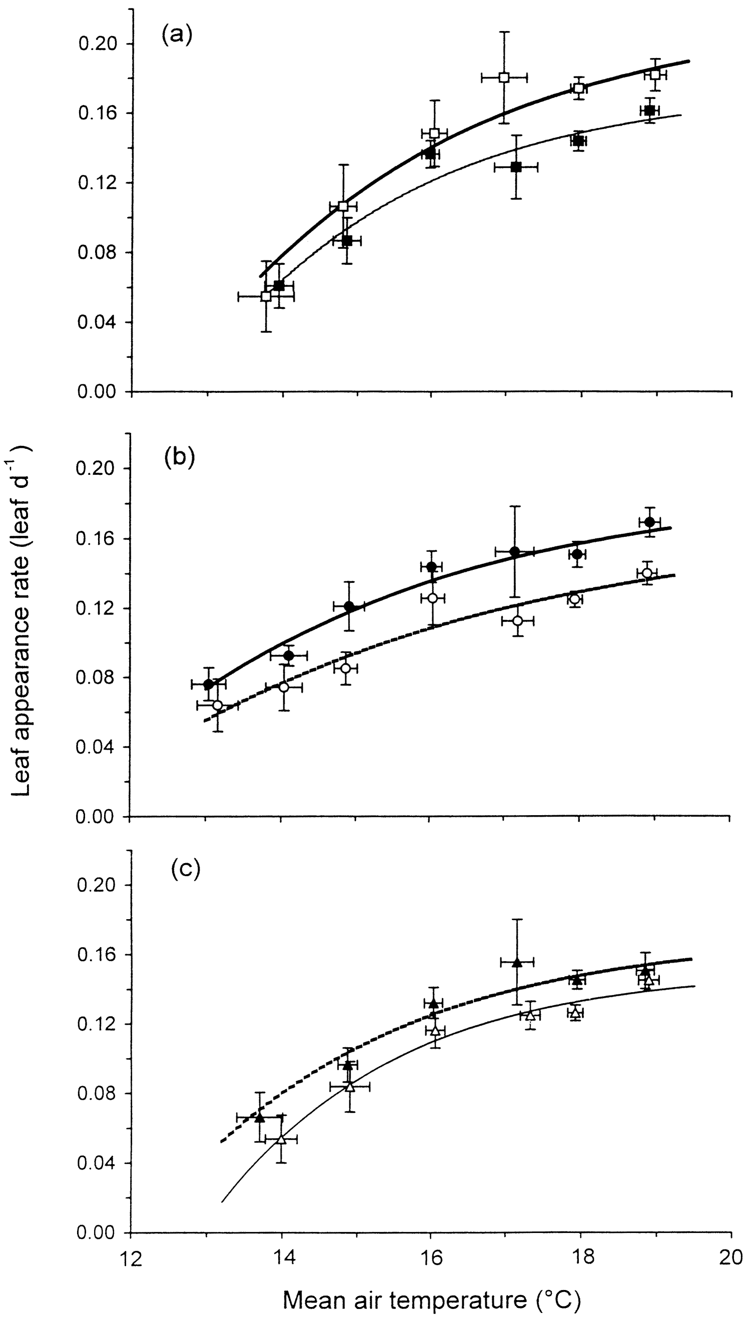

Fig. 2. Effects of mean air temperature on the leaf appearance rate of fully irrigated tea plants: (a) Clones 1 (□——□) and 207 (■——■) (b) Clones SFS150 (●——●) and 6/8 (○——○) and (c) Clones K35 (▲——▲) and S15/10 (△——△). The vertical and horizontal bars show the 95% confidence intervals.

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Table 2. Asymptotic model: the maximum leaf appearance rate (LAR_{max}, leaf d^{-1}) and the constants b and R with standard errors, the degrees of freedom (d.f.) and the correlation coefficient (r^2, %) for the best fit asymptotic relations between the leaf appearance rate (LAR, leaf d^{-1}) and the mean air temperature (T_{mean}, °C) for each of six fully irrigated clones between December 1990 and December 1992. The relations are of the form: $LAR = LAR_{max} - b \times R^{Tmean}$. The corresponding base temperatures (T_{b1}, °C) are also shown.

Clone	d.f.	LAR_{max}	b	R	r^2	T_{b1}
S15/10	97	0.152 ± 0.008	30.3 ± 32.9	0.663 ± 0.055	79	12.9
207	101	0.176 ± 0.012	15.2 ± 15.4	0.704 ± 0.056	77	12.7
1	98	0.220 ± 0.024	7.6 ± 8.2	0.753 ± 0.067	65	12.4
K35	98	0.172 ± 0.014	9.6 ± 11.7	0.718 ± 0.069	63	12.1
6/8	102	0.172 ± 0.028	1.6 ± 1.6	0.817 ± 0.076	64	11.1
SFS150	102	0.191 ± 0.021	3.0 ± 3.3	0.780 ± 0.075	61	11.0
Mean	613	0.186 ± 0.010	4.6 ± 2.5	0.765 ± 0.034	59	12.0

where LAR_{max} is the estimated maximum rate of leaf appearance (leaf d^{-1}), and b and R are constants. Values of LAR_{max} ranged from 0.152 leaf d^{-1} for Clone S15/10 to 0.220 leaf d^{-1} for Clone 1 (Table 2). The apparent base temperatures for leaf appearance rate (T_{b1}, °C) predicted by the asymptotic relations were derived from:

$$T_{b1} = \ln (LAR_{max}/b)/\ln (R) \quad (3)$$

The T_{b1} values so obtained were 2.4–4.5 °C higher than those estimated from the linear functions, ranging from 11.0 °C for Clone SFS150 to 12.9 °C for Clone S15/10. The mean value for all six clones was 12.0 °C.

Effects of drought

Within 12 d of imposing the drought treatments in 1991 and 1992, the phyllochrons for shoots within the I_0 sub-plots were greater ($p \leqslant 0.05$) than those in the fully irrigated treatments. As the drought stress in the I_0 sub-plots increased, so it became increasingly difficult to find suitable shoots for tagging. In 1991 actively growing shoots could be selected until 67 d after the imposition of drought when the potential SWD had reached 270 mm. In 1992 shoots could be selected until 70 d, when the potential SWD was 340 mm.

To separate the effects of drought from those of temperature, the measured values of LAR for each clone, for the period from April to November in both years, were expressed as a proportion of the rate estimated from temperature alone. The best-fit asymptotic relation between this ratio and the potential SWD at the beginning of each measurement period (range: 0–350 mm) was highly significant ($p < 0.001$, $n = 843$, F ratio = 24.14). The ratio declined from 1.00 when the potential SWD was 50 mm, to zero at a SWD of 350 mm (Fig. 3).

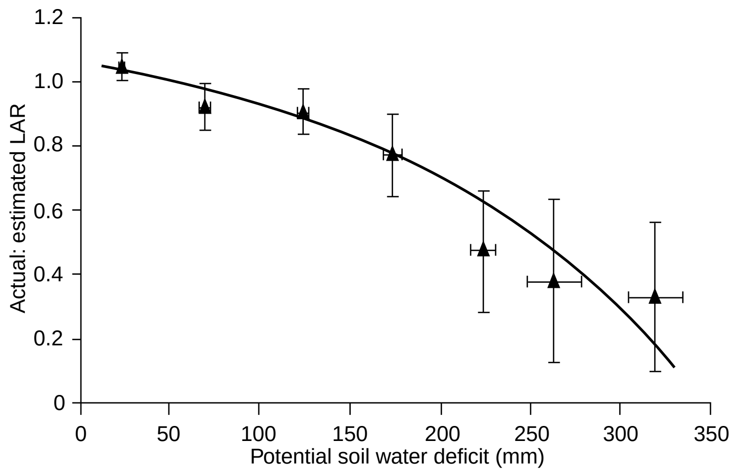

Fig. 3. Effects of the potential soil water deficit (SWD), at the start of the period, on the ratio of actual to estimated leaf appearance rate (LAR) for three- to four-year-old tea plants (mean of Clones 1, 207, SFS150, 6/8, K35 and S15/10). The vertical and horizontal bars show the 95% confidence intervals. The equation for the curve ($p = <0.001$, $n = 843$, F ratio $= 24.14$) is: ratio $= 1.218\ (\pm 0.164) - 0.161\ (\pm 0.147) \times 1.00584\ (\pm 0.00270)^{SWD}$.

DISCUSSION

Relation between leaf appearance rate and temperature

The relations between leaf appearance rate and temperature were clearly curvilinear. By contrast, earlier work at the same site suggested that the shoot development rates (from release of apical dominance to three leaves and a bud) of the same six clones were linearly related to the mean air temperature (Burgess and Carr, 1997). The principal explanation for these differences was that the shorter time-period of the leaf appearance rate measurements (typically one week instead of seven to sixteen weeks) allowed measurements to be taken over a 3 °C greater range of mean temperatures (12.7–19.7 °C) than that (14.2–18.3 °C) in the previous work.

Estimates of the mean base temperatures for the leaf appearance rate of all six clones ranged from 9.0 °C when derived from a linear equation (Table 1) to 12.0 °C when derived from an asymptotic curve (Table 2). The estimate from the asymptotic relation was also outside the 95% confidence interval (8.3–9.5 °C) indicated by linear analysis. The accuracy of the estimate of base temperature was thus heavily dependent on the assumed response function. Asymptotic functions were used in this paper because they explain significantly higher proportions of the variation in leaf appearance rates with T_{mean}, than do linear relations.

Although the range of values for T_{b1} derived using asymptotic curves (11.0–12.9 °C) was approximately half that predicted from linear relations (6.5–10.1 °C), both functions resulted in the same ranking of the clones. The low relative base temperatures for leaf appearance rate for Clones SFS150 and 6/8, and the high relative base temperatures for Clones 207 and 1 also corresponded to

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those reported for shoot development rate throughout a complete shoot replacement cycle (Burgess and Carr, 1997). By contrast, the relatively high base temperatures for Clone S15/10 were not apparent from the study by Burgess and Carr (1997). This was probably because the phyllochron measurements were taken over a wider range of mean temperatures (12.7–19.7 °C) than those for the shoot replacement cycle (14.2–18.3 °C). These differences again emphasized the potential problems of extrapolating responses from a narrow range of temperatures, even when they extend close to the base temperature.

Although mean air temperature could be used to explain most of the weekly variation in leaf appearance of well-watered clones, 20–40% of the variation remained unexplained. One possible source of this error was that leaf appearance rates were unlikely to be related to the maximum and minimum temperatures recorded within a Stevenson screen, but rather to the temperatures experienced by the growing parts of the plant (Peacock, 1975). Furthermore the assumption that the mean temperature is the average of the maximum and the minimum temperature is not strictly true. At Ngwazi recent measurements, taken every hour on an automatic weather station, suggested that actual mean daily air temperatures may be as much as 1 °C lower than those derived from simple means of the daily maximum and minimum temperatures. The seasonal changes in the daylength between 11.5 and 12.5 hours could be another source of variability, since previous studies have demonstrated that shoot extension in tea (Tanton, 1982) and leaf appearance rates in, for example, cereals (Volk and Bugbee, 1991) could be sensitive to photoperiod. The mean response within each weekly sample could also be affected by whether the selected samples were derived from inherently slow- or fast-growing shoots (Stephens and Carr, 1990).

A practical method for planning harvest intervals

Despite the above sources of error, between 61 and 79% of the weekly variation in the leaf appearance rate of six fully irrigated tea clones could be determined from daily measurements of the mean air temperature. Based on this result, simple tables were developed from the equations in Table 2 to enable growers to estimate the mean leaf appearance rate for each of the six selected clones or a combination of them all, which could also represent heterogeneous tea plants derived from seed (Table 3). 'Seedling' tea is still widely grown in Tanzania and elsewhere.

In India, Murty and Sharma (1989) proposed that the interval required for harvesting defined 'target' tea shoots could be determined from an understanding of the type of shoots that are left on the bush after the preceding harvest, and the mean leaf appearance rate. For example, if a grower aimed to harvest shoots with no more than three unfurled leaves, and the largest shoots after the preceding harvest had only one unfurled leaf, then the harvest interval should be equivalent to two phyllochrons. Table 4 illustrates how, based on measurements of the mean air temperature and the information in Table 3, it was possible to predict the accumulation of phyllochrons between harvests. Obviously, the most appropriate interval would be dependent on the harvesting policy of each individual tea

Table 3. An example of the table provided to growers to allow the calculation of the mean leaf appearance rate (LAR, leaf d^{-1}) for a mixture of Clones 1, 6/8, SFS150, S15/10, 207 and K35 from a daily measurement of the mean air temperature (T_{mean}, °C). Such a combination of clones is likely to represent a field of heterogeneous tea plants derived from seed ($LAR = 0.186 < -4.6 \times 0.765^{T_{mean}}$).

T_{mean}	LAR	T_{mean}	LAR	T_{mean}	LAR	T_{mean}	LAR
12.0	0.001	12.25	0.013	12.5	0.024	12.75	0.035
13.0	0.045	13.25	0.054	13.5	0.062	13.75	0.070
14.0	0.078	14.25	0.085	14.5	0.091	14.75	0.098
15.0	0.103	15.25	0.109	15.5	0.114	15.75	0.118
16.0	0.123	16.25	0.127	16.5	0.131	16.75	0.134
17.0	0.138	17.25	0.141	17.5	0.144	17.75	0.146
18.0	0.149	18.25	0.151	18.5	0.154	18.75	0.156
19.0	0.158	19.25	0.160	19.5	0.161	19.75	0.163
20.0	0.164	20.25	0.166	20.5	0.167	20.75	0.168

Table 4. An example showing the predicted date of harvest from estimates of the daily leaf appearance rate (LAR, leaf d^{-1}) derived from measurements of the daily mean air temperature (°C) and Table 3. The crop was initially harvested on the last day of the preceding month and was assumed to be ready for harvest when the cumulative total reached two phyllochrons.

	Air temperature					
Day	Maximum	Minimum	Mean	LAR	Cumulative total (phyllochron)	
					0.000	
1	19.0	9.5	14.25	0.085	0.085	
2	19.5	10.0	14.75	0.098	0.183	
3	18.0	10.0	14.00	0.078	0.261	
4	18.0	10.0	14.00	0.078	0.339	
5	17.5	9.0	13.25	0.054	0.393	
—	—	—	—	—	—	
—	—	—	—	—	1.737	
19	21.5	10.0	15.75	0.118	1.855	
20	21.5	8.5	15.00	0.103	1.958	
21	21.0	9.5	15.25	0.109	2.067	HARVEST
22	22.5	8.5	15.50	0.114	0.114	
23	24.5	11.0	17.75	0.146	0.260	

grower. Nevertheless an interval of 2 to 2.2 phyllochrons proved to be commercially acceptable in southern Tanzania where pluckers tend to remove all of the shoots with two or more unfurled leaves which are above the table.

Where tea is grown in large clonal blocks, the equations in Table 2 allow a grower to calculate harvest intervals for each individual clone. For example, at a mean air temperature of 18 °C, typical of the main growing season in Mufindi, leaf appearance rates of 0.174 leaf d^{-1} for Clone 1 and 0.130 leaf d^{-1} for Clone 6/8 were predicted. Based on these values, two phyllochrons would be equivalent to 11.5 and 15.4 d respectively. Measurements made on the same experiment during the main growing seasons in 1989 and 1990 showed that the lengths of the shoot replacement cycle (to three leaves and a bud) for Clones 1 and 6/8 were 52 and 67 d respectively (Burgess and Carr, 1997). Using the assumption, based on the work of Grice (1982), that one-quarter of the shoot replacement cycle is a suitable harvest interval, these values suggested harvest intervals of 13 d for Clone 1 and 17 d for Clone 6/8. The similarity of these intervals to those calculated from values of leaf appearance rate provided support for using 2 to 2.2 phyllochrons to determine harvest periods.

Whereas the maximum predicted difference in harvest interval between individual clones was four days at 18 °C, there were larger differences at temperatures less than this. For example, at 14 °C leaf appearance rates ranged from 0.0552 leaf d^{-1} for Clone S15/10 to 0.0992 leaf d^{-1} for Clone SFS150. Assuming a harvest period of two phyllochrons, harvest intervals of 36 and 20 d respectively were suggested, a difference of 16 d. Reassuringly, this analysis supported the field observation that Clone SFS150 required more frequent harvests than Clone S15/10 during the cool season.

In southern Tanzania, the phyllochron method of planning harvest intervals has now been used in the field for over four years. It has proved to be particularly useful between May and the end of August when there are large changes in temperature. The technique will also be useful for predicting harvest intervals at different altitudes within an extended estate. For example, some companies in Kenya have tea fields ranging in altitude from 1800 to 2200 m, with associated mean air temperatures ranging from 16.0 to 19.2 °C (Ng'etich, 1995). The equations presented in Table 2 suggest that, in the absence of drought stress, the mean leaf appearance rates for Clone 6/8 at these two locations would be 0.109 and 0.139 leaf d^{-1} respectively. Using a period of two phyllochrons, these values correspond to harvest intervals of 18 and 14 d respectively.

Although the preceding discussion has focused on well-watered tea, much of the tea in southern Tanzania and elsewhere in eastern Africa can be drought stressed for up to five months of the year. In such situations Burgess and Carr (1997) have reported how shoot growth and development rates of clonal tea, eight to twenty months after field planting, can be related to the actual soil water deficit (range: 15–90 mm). In a similar way, the relationship between leaf appearance rate and the potential soil water deficit (Fig. 3), can be used to predict the relative effect of drought stress on the mean leaf appearance rates of the selected six clones for the period 28–52 months after field planting. Once the leaf appearance rate has been estimated, the harvest interval can be related to the pre-determined number of phyllochrons.

Since the phyllochron method of planning harvest intervals has been used successfully in southern Tanzania, it now deserves to be tested in other areas of the world where tea is grown.

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