

PREDICTION OF OUT-TURN MADE TEA TO GREEN LEAF USING SIMPLE AGROCLIMATIC FACTORS

A. Thevathasan and T. Thevadasan

(Tea Research Institute of Sri Lanka, Talawakele, Sri Lanka)

The variation of monthly average out-turn made tea to green leaf is explained by a fitted regression model. A table is constructed using the multi-factor model which could be used to determine the 95% confidence limits of OT. MT/GL. Of several agroclimatic factors tested it is shown that the only input information required are monthly rainy days and the pan evaporation rate (mm). Pan evaporation rate is not measured at present on estates but the device for its measurement could be easily made at estate level.

INTRODUCTION

Out-turn made tea to green leaf (OT.MT/GL) is generally defined as the ratio of the weight of bulk made tea or sifted made tea to the weight of green leaf expressed as a percentage. The bulk and sifted OT.MT/GL differ considerably, mainly due to the refuse tea which is not taken into account for sifted out-turn (OT). In this study reference is made only to bulk made tea which has a direct relationship with green leaf, with the out-turn varying appreciably from day to day. This variation is considered to be influenced by weather factors such as rainfall, sunshine, evaporation, rainy days, etc. Attempts have also been made to relate the out-turn of made tea to green leaf with the composition of shoot age from pruning (Keegal, 1955). However, the variation in OT has not as yet been quantified in terms of the above factors. This variation creates problems for management in terms of accountability of made tea and payments made for bought leaf. At present, bought leaf suppliers are paid on the basis of a fixed rate of 1 kg of made tea from 4.5 kg of green leaf (i.e. 22.2% OT. MT/GL) as stipulated by the Tea Commissioner. Occasionally *ad hoc* reduction in green leaf weight is made to maintain OT higher than 22.2%. In view of the stipulated fixed rate for payment, suppliers are invariably over paid or under paid. The main objective of our study was to find a relationship between the variation of OT with agroclimatic factors.

MATERIALS AND METHODS

Generally tea factories in Sri Lanka maintain meteorological records to help manipulate the processes of tea manufacture. For the purpose of this study, only data relating to monthly rainfall and number of rainy days were collected from 1982 to 1984 from a factory located in each elevational category, viz, low, mid and high grown. In addition, records of pan evaporation were collected only from the up-country factory as this was not available for the other two locations. The OT. MT/GL on the basis of bulk made tea were extracted from the records in the three factories. The Meteorological Department defines a rainy day as one with a rainfall

of more than 0.3 mm. As leaf moisture including surface wetness was taken into consideration for this study, a day even with a rainfall of less than 0.3 mm was taken as a rainy day for this investigation.

The first step in this study is to determine a suitable statistical model which fits these data adequately. To start with a simple linear model of the form $Y = A + BX + E$ was tested where Y represents OT.MT/GL, X refers to a single weather factor, A and B represent the regression coefficients to be estimated while E refers to the random variation. The correlation for OT.MT/GL vs number of rainy days gave a better value than that obtained with total rainfall. However, this correlation was not sufficient enough to fit a model for prediction. Figure 1 a, b and c show a scatter diagram of monthly average OT vs rainy days for the three locations. It is observed that there are wide fluctuations of points for rainy days with low values but with points closer to the line for rainy days with higher values. It is therefore apparent that there is some other factor accounting for the high variabilities around the rainy days with low values. To resolve this other parameters such as wind speed, sunshine and relative humidity were included. But all the above parameters could be represented in a single factor, pan evaporation (Doorenbos and Pruitt, 1977) for this study. Since this data was readily available in the up-country factory, this parameter was incorporated into the following model and tested.

$$Y = A + BX_1 + CX_2 + E$$

where Y = Outturn GL/MT
 X_1 = No. of rainy days/month
 X_2 = Pan evapotranspiration/month (mm)
 E = Random error associated with the OT. GL/MT

This represents a multiple regression model with two variables having the constants A , B and C to be estimated using the least square method. When fitting the above model using the reciprocal value of OT.MT/GL (i.e. OT.GL/MT) a multiple correlation coefficient value of $R = 0.94$ was obtained.

RESULTS AND DISCUSSION

The least square estimate of A , B and C and their significant levels are given in the following table.

TABLE 1—*Estimated Regression coefficients and t-values*

Coefficient	Estimated value	t-value	
A	0.044581000	22.70	***
B	0.000196270	-4.99	***
C	-0.000064688	3.62	**

** — Significant at 99% level

*** — „ „ 99.9% level

OT.MT/GL(%) Vs RAINY DAYS

Mid Country

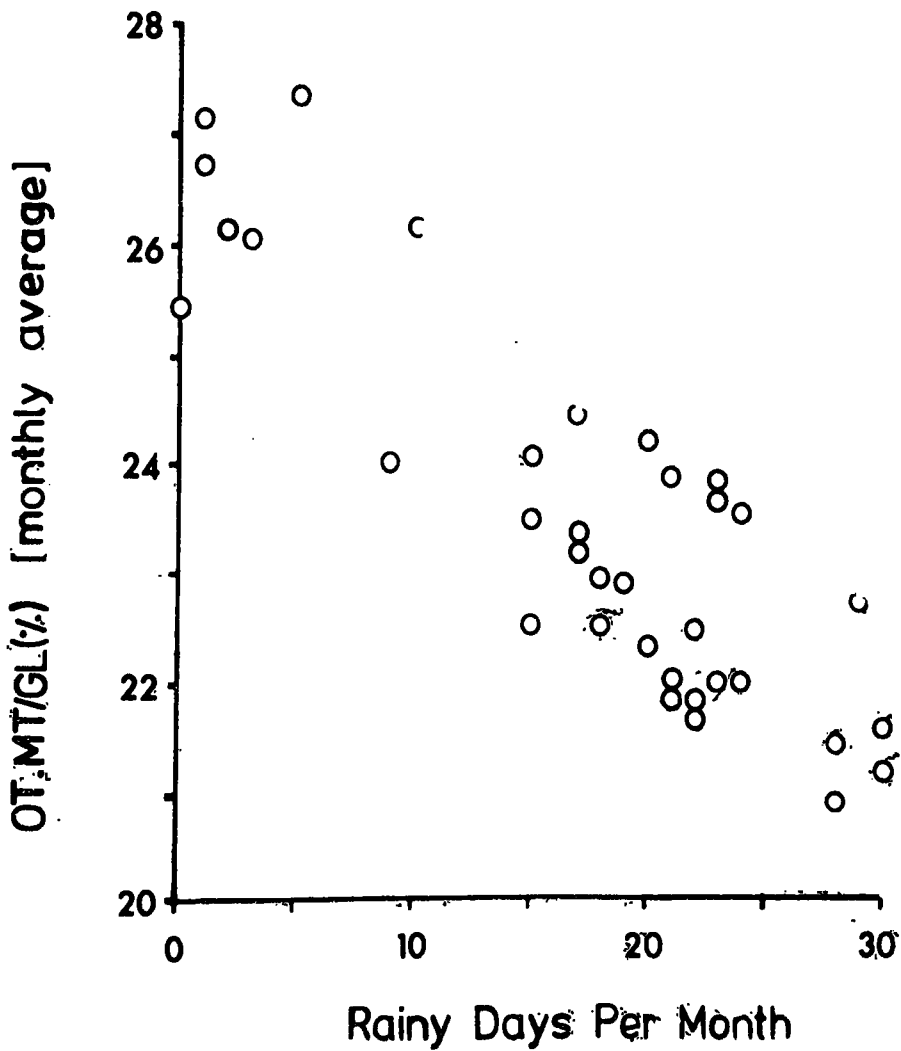


Fig. 1 b — Relationship between monthly average outturn (%) and rainy days for the mid country.

OT.MT/GL(%) Vs RAINY DAYS

UP Country

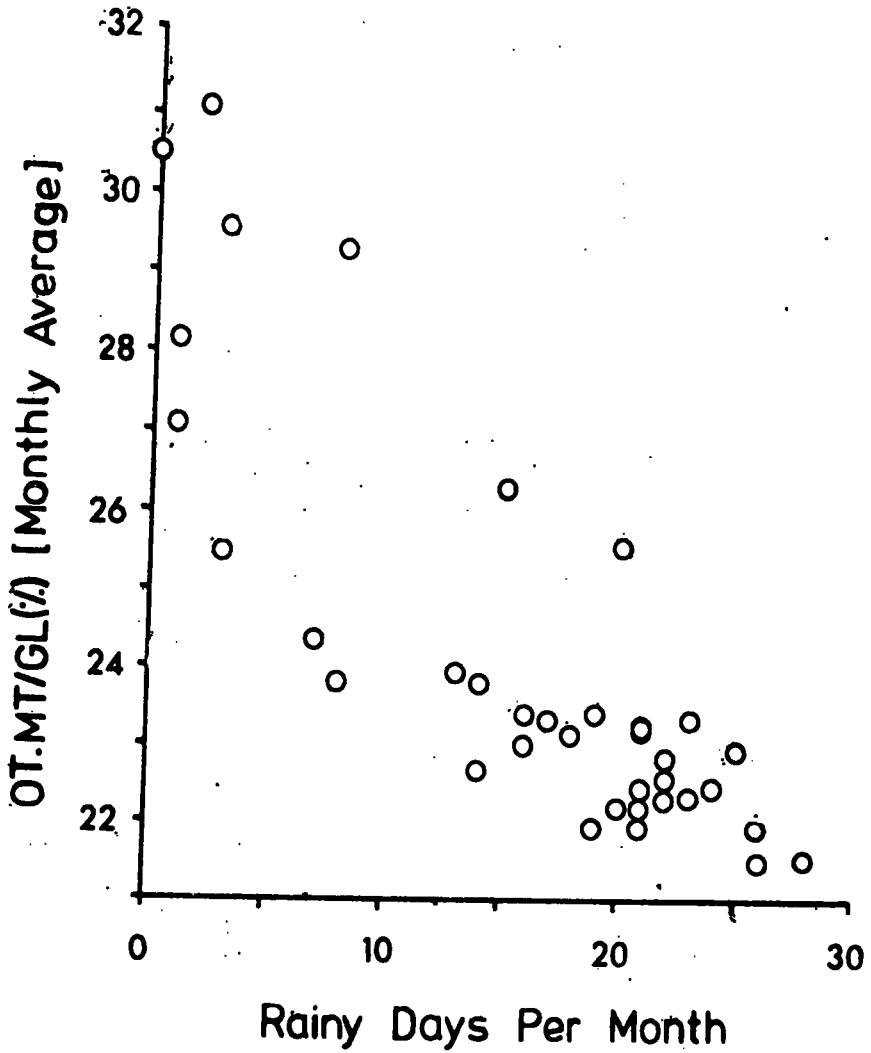


Fig. 1 c — Relationship between monthly average outturn (%) and rainy days for the up country.

TABLE 2—Upper and Lower limits of OT.MT/GL (%) (OT Table)

		Monthly Pan Evaporation (mm)													
		35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	..	25.35	25.49	25.63	25.78	25.92	26.08	26.24	26.40	26.57	26.75	26.94	27.13	27.34	27.55
		21.94	22.15	22.36	22.58	22.80	23.02	23.24	23.46	23.69	23.91	24.13	24.36	24.58	24.80
2	..	25.16	25.30	25.44	25.58	25.73	25.88	26.04	26.20	26.37	26.55	26.74	26.93	27.13	27.35
		21.89	22.10	22.31	22.53	22.75	22.96	23.18	23.40	23.63	23.85	24.07	24.29	24.51	24.72
3	..	24.98	25.11	25.25	25.39	25.54	25.69	25.84	26.01	26.18	26.35	26.54	26.73	26.94	27.15
		21.85	22.06	22.27	22.48	22.69	22.91	23.13	23.35	23.57	23.79	24.03	24.22	24.43	24.65
4	..	24.79	24.93	25.06	25.20	25.35	25.50	25.65	25.81	25.98	26.16	26.35	26.54	26.75	26.96
		21.80	22.01	22.22	22.43	22.64	22.86	23.07	23.29	23.51	23.72	23.94	24.15	24.36	24.57
5	..	24.61	24.74	24.88	25.02	25.16	25.31	25.46	25.63	25.79	25.97	26.16	26.35	26.56	26.78
		21.75	21.96	22.17	22.38	22.59	22.80	23.02	23.23	23.44	23.66	23.87	24.03	24.28	24.48
6	..	24.44	24.56	24.70	24.84	24.98	25.13	25.28	25.44	25.61	25.79	25.98	26.17	26.38	26.60
		21.71	21.91	22.12	22.33	22.54	22.75	22.96	23.17	23.38	23.59	23.80	24.03	24.20	24.40
7	..	24.26	24.39	24.52	24.66	24.80	24.95	25.10	25.26	25.43	25.61	25.80	26.00	26.21	26.43
		21.66	21.87	22.07	22.28	22.49	22.70	22.90	23.11	23.32	23.52	23.72	23.92	24.12	24.31
8	..	24.09	24.22	24.35	24.48	24.62	24.77	24.93	25.09	25.26	25.44	25.63	25.83	26.04	26.27
		21.62	21.82	22.02	22.23	22.43	22.64	22.85	23.05	23.25	23.45	23.65	23.84	24.03	24.22
9	..	23.92	24.05	24.18	24.31	24.45	24.60	24.75	24.92	25.09	25.27	25.46	25.66	25.88	26.11
		21.57	21.77	21.97	22.18	22.38	22.58	22.79	22.99	23.19	23.38	23.57	23.76	23.95	24.12
10	..	23.76	23.88	24.01	24.15	24.29	24.43	24.59	24.75	24.92	25.10	25.30	25.50	25.72	25.95
		21.52	21.72	21.92	22.12	22.32	22.52	22.72	22.92	23.12	23.31	23.50	23.68	23.85	24.03
11	..	23.59	23.72	23.85	23.98	24.12	24.27	24.42	24.59	24.76	24.95	25.14	25.35	25.57	25.81
		21.47	21.67	21.87	22.07	22.27	22.47	22.66	22.86	23.05	23.23	23.41	23.59	23.76	23.93
12	..	23.43	23.56	23.69	23.82	23.96	24.11	24.27	24.43	24.61	24.79	24.99	25.21	25.43	25.67
		21.43	21.62	21.82	22.01	22.21	22.41	22.60	22.79	22.97	23.15	23.33	23.50	23.66	23.82
13	..	23.28	23.40	23.53	23.66	23.81	23.95	24.11	24.28	24.46	24.65	24.85	25.07	25.30	25.54
		21.38	21.57	21.77	21.96	22.15	22.34	22.53	22.72	22.90	23.07	23.24	23.40	23.56	23.71
14	..	23.13	23.25	23.38	23.51	23.65	23.80	23.96	24.13	24.32	24.51	24.72	24.93	25.17	25.41
		21.33	21.52	21.71	21.90	22.09	22.28	22.46	22.64	22.82	22.99	23.15	23.31	23.46	23.60
15	..	22.98	23.10	23.23	23.36	23.51	23.66	23.82	23.99	24.18	24.38	24.59	24.81	25.04	25.29
		21.28	21.47	21.66	21.84	22.03	22.21	22.39	22.57	22.73	22.90	23.05	23.20	23.35	23.49
16	..	22.83	22.95	23.08	23.22	23.36	23.52	23.68	23.86	24.05	24.25	24.46	24.69	24.93	25.18
		21.22	21.41	21.60	21.78	21.97	22.14	22.32	22.48	22.65	22.80	22.95	23.10	23.24	23.37
17	..	22.69	22.81	22.94	23.08	23.23	23.38	23.55	23.73	23.92	24.13	24.35	24.58	24.82	25.07
		21.17	21.36	21.54	21.72	21.90	22.07	22.24	22.40	22.56	22.71	22.85	22.99	23.12	23.25
18	..	22.55	22.67	22.81	22.95	23.09	23.25	23.43	23.61	23.81	24.02	24.24	24.47	24.71	24.97
		21.12	21.30	21.48	21.66	21.83	22.00	22.16	22.31	22.46	22.61	22.74	22.88	23.00	23.13
19	..	22.42	22.54	22.67	22.82	22.97	23.13	23.31	23.49	23.70	23.91	24.13	24.37	24.61	24.87
		21.06	21.24	21.42	21.59	21.75	21.92	22.07	22.22	22.36	22.50	22.63	22.76	22.88	23.00
20	..	22.28	22.41	22.55	22.69	22.85	23.02	23.19	23.39	23.59	23.81	24.03	24.27	24.52	24.78
		21.00	21.18	21.35	21.52	21.68	21.83	21.98	22.13	22.26	22.39	22.52	22.64	22.76	22.88
21	..	22.16	22.29	22.43	22.57	22.73	22.90	23.09	23.28	23.49	23.71	23.94	24.18	24.43	24.69
		20.94	21.11	21.28	21.44	21.60	21.75	21.89	22.03	22.16	22.28	22.40	22.52	22.63	22.75
22	..	22.04	22.17	22.31	22.46	22.63	22.80	22.99	23.19	23.40	23.62	23.85	24.09	24.34	24.60
		20.88	21.05	21.21	21.36	21.51	21.66	21.79	21.92	22.05	22.17	22.28	22.40	22.51	22.62
23	..	21.92	22.06	22.20	22.36	22.52	22.70	22.89	23.10	23.31	23.53	23.77	24.01	24.26	24.52
		20.81	20.98	21.13	21.28	21.42	21.56	21.69	21.82	21.94	22.05	22.16	22.27	22.38	22.49
24	..	21.81	21.95	22.10	22.26	22.43	22.61	22.81	23.01	23.23	23.45	23.69	23.93	24.18	24.44
		20.75	20.90	21.05	21.19	21.33	21.46	21.59	21.71	21.82	21.93	22.04	22.15	22.25	22.35
25	..	21.70	21.85	22.00	22.16	22.34	22.52	22.72	22.93	23.15	23.38	23.61	23.86	24.11	24.37
		20.67	20.82	20.97	21.10	21.23	21.36	21.48	21.59	21.70	21.81	21.92	22.02	22.12	22.22
26	..	21.60	21.75	21.91	22.07	22.25	22.44	22.64	22.86	23.07	23.30	23.54	23.78	24.04	24.29
		20.60	20.74	20.88	21.01	21.13	21.25	21.37	21.48	21.59	21.69	21.79	21.89	21.99	22.09
27	..	21.51	21.66	21.82	21.99	22.17	22.37	22.57	22.78	23.00	23.23	23.47	23.71	23.96	24.22
		20.52	20.65	20.79	20.91	21.03	21.15	21.26	21.36	21.47	21.57	21.67	21.76	21.86	21.96
28	..	21.42	21.57	21.74	21.91	22.10	22.30	22.50	22.71	22.94	23.16	23.40	23.65	23.90	24.15
		20.43	20.57	20.69	20.81	20.93	21.04	21.14	21.24	21.35	21.44	21.54	21.64	21.73	21.83
29	..	21.34	21.49	21.66	21.84	22.03	22.23	22.43	22.65	22.87	23.10	23.34	23.58	23.83	24.09
		20.35	20.47	20.59	20.71	20.82	20.92	21.03	21.13	21.22	21.32	21.42	21.51	21.60	21.69
30	..	21.26	21.42	21.59	21.77	21.96	22.16	22.37	22.58	22.81	23.04	23.27	23.52	23.77	24.02
		20.25	20.38	20.49	20.60	20.71	20.81	20.91	21.01	21.10	21.20	21.29	21.38	21.47	21.56
31	..	21.19	21.35	21.52	21.71	21.90	22.10	22.31	22.52	22.75	22.97	23.21	23.45	23.70	23.96
		20.16	20.28	20.39	20.49	20.60	20.70	20.79	20.89	20.98	21.07	21.16	21.25	21.34	21.43

TABLE 2 (Contd.)—Upper and Lower Limits of OT. MT/GL (%) (OT Table)

		Monthly Pan Evaporation (mm)														
		105	110	115	120	125	130	135	140	145	150	155	160	165	170	
1	..	27.78	28.01	28.26	28.53	28.80	29.10	29.40	29.72	30.06	30.41	30.78	31.17	31.57	31.98	
		25.02	25.24	25.45	25.66	25.86	26.06	26.26	26.46	26.65	26.83	27.02	27.20	27.38	27.55	
2	..	27.58	27.81	28.07	28.33	28.61	28.90	29.21	29.54	29.87	30.23	30.60	30.98	31.38	31.80	
		24.94	25.15	25.36	25.56	25.76	25.95	26.14	26.33	26.52	26.70	26.87	27.05	27.22	27.39	
3	..	27.38	27.62	27.88	28.14	28.42	28.72	29.03	29.36	29.70	30.05	30.42	30.81	31.21	31.62	
		24.85	25.06	25.26	25.46	25.65	25.84	26.02	26.20	26.38	26.56	26.73	26.90	27.07	27.23	
4	..	27.19	27.44	27.69	27.96	28.24	28.54	28.85	29.18	29.52	29.88	30.25	30.64	31.04	31.45	
		24.77	24.97	25.16	25.35	25.54	25.72	25.90	26.07	26.25	26.41	26.58	26.75	26.91	27.07	
5	..	27.01	27.26	27.51	27.79	28.07	28.37	28.69	29.01	29.36	29.71	30.09	30.47	30.87	31.29	
		24.68	24.87	25.06	25.25	25.43	25.60	25.77	25.94	26.11	26.27	26.43	26.59	26.75	26.90	
6	..	26.84	27.08	27.34	27.62	27.91	28.21	28.52	28.85	29.20	29.56	29.93	30.31	30.71	31.13	
		24.59	24.78	24.96	25.14	25.31	25.48	25.65	25.81	25.97	26.13	26.28	26.44	26.59	26.74	
7	..	26.67	26.92	27.18	27.46	27.75	28.05	28.37	28.70	29.05	29.40	29.78	30.16	30.56	30.97	
		24.49	24.68	24.85	25.02	25.19	25.35	25.51	25.67	25.83	25.98	26.13	26.28	26.43	26.57	
8	..	26.50	26.76	27.02	27.30	27.59	27.90	28.22	28.55	28.90	29.26	29.63	30.02	30.41	30.83	
		24.40	24.57	24.74	24.91	25.07	25.23	25.38	25.53	25.68	25.83	25.97	26.12	26.26	26.41	
9	..	26.35	26.60	26.87	27.15	27.45	27.76	28.08	28.41	28.76	29.12	29.49	29.87	30.27	30.68	
		24.30	24.47	24.63	24.79	24.94	25.09	25.24	25.39	25.53	25.68	25.82	25.96	26.10	26.24	
10	..	25.20	26.46	26.73	27.01	27.31	27.62	27.94	28.28	28.62	28.98	29.35	29.74	30.13	30.54	
		24.19	24.35	24.51	24.66	24.81	24.96	25.10	25.25	25.39	25.52	25.66	25.80	25.94	26.07	
11	..	26.06	26.32	26.59	26.88	27.18	27.49	27.81	28.15	28.49	28.85	29.22	29.61	30.00	30.41	
		24.09	24.24	24.39	24.54	24.68	24.82	24.96	25.10	25.24	25.37	25.51	25.64	25.77	25.90	
12	..	25.92	26.18	26.46	26.75	27.05	27.36	27.69	28.02	28.37	28.73	29.10	29.48	29.87	30.28	
		23.98	24.12	24.27	24.41	24.55	24.69	24.82	24.95	25.09	25.22	25.35	25.48	25.61	25.74	
13	..	25.79	26.06	26.34	26.63	26.93	27.24	27.57	27.90	28.25	28.61	28.97	29.36	29.75	30.15	
		23.86	24.01	24.14	24.28	24.42	24.55	24.68	24.81	24.93	25.06	25.19	25.32	25.44	25.57	
14	..	25.67	25.94	26.22	26.51	26.81	27.13	27.45	27.79	28.13	28.49	28.86	29.24	29.63	30.03	
		23.74	23.88	24.02	24.15	24.28	24.41	24.53	24.66	24.78	24.91	25.03	25.15	25.28	25.40	
15	..	25.55	25.82	26.10	26.40	26.70	27.01	27.34	27.67	28.02	28.38	28.74	29.12	29.51	29.91	
		23.62	23.76	23.89	24.01	24.14	24.26	24.39	24.51	24.63	24.75	24.87	24.99	25.11	25.24	
16	..	25.44	25.71	26.00	26.29	26.59	26.91	27.23	27.57	27.91	28.27	28.63	29.01	29.40	29.80	
		23.50	23.63	23.75	23.88	24.00	24.12	24.24	24.36	24.48	24.60	24.71	24.83	24.95	25.07	
17	..	25.33	25.61	25.89	26.19	26.49	26.80	27.13	27.46	27.81	28.16	28.52	28.90	29.29	29.68	
		23.38	23.50	23.62	23.74	23.86	23.98	24.09	24.21	24.32	24.44	24.56	24.67	24.79	24.91	
18	..	25.23	25.51	25.79	26.09	26.39	26.70	27.03	27.36	27.70	28.06	28.42	28.79	29.18	29.57	
		23.25	23.37	23.49	23.60	23.72	23.83	23.94	24.06	24.17	24.28	24.40	24.51	24.63	24.74	
19	..	25.14	25.41	25.70	25.99	26.30	26.61	26.93	27.26	27.60	27.96	28.32	28.69	29.07	29.45	
		23.12	23.24	23.35	23.46	23.57	23.69	23.80	23.91	24.02	24.13	24.24	24.35	24.46	24.58	
20	..	25.04	25.32	25.61	25.90	26.20	26.52	26.84	27.17	27.51	27.86	28.22	28.59	28.97	29.36	
		22.99	23.10	23.21	23.32	23.43	23.54	23.65	23.76	23.87	23.98	24.08	24.19	24.30	24.42	
21	..	24.96	25.23	25.52	25.81	26.11	26.43	26.75	27.08	27.41	27.76	28.12	28.49	28.87	29.26	
		22.86	22.97	23.07	23.18	23.29	23.39	23.50	23.61	23.71	23.82	23.93	24.04	24.14	24.25	
22	..	24.87	25.15	25.43	25.73	26.03	26.34	26.66	26.99	27.32	27.67	28.03	28.39	28.77	29.16	
		22.72	22.83	22.94	23.04	23.14	23.25	23.35	23.46	23.56	23.67	23.77	23.88	23.99	24.09	
23	..	24.79	25.07	25.35	25.64	25.94	26.25	26.57	26.90	27.23	27.58	27.93	28.30	28.67	29.06	
		22.59	22.69	22.80	22.90	23.00	23.10	23.21	23.31	23.41	23.52	23.62	23.72	23.83	23.93	
24	..	24.71	24.99	25.27	25.56	25.86	26.17	26.49	26.81	27.15	27.49	27.84	28.20	28.58	28.96	
		22.46	22.56	22.66	22.76	22.86	22.96	23.06	23.16	23.26	23.36	23.47	23.57	23.67	23.78	
25	..	24.64	24.91	25.19	25.48	25.78	26.09	26.41	26.73	27.06	27.40	27.75	28.11	28.48	28.86	
		22.32	22.42	22.52	22.62	22.72	22.82	22.92	23.01	23.11	23.21	23.32	23.42	23.52	23.62	
26	..	24.56	24.84	25.12	25.41	25.71	26.01	26.33	26.65	26.98	27.32	27.67	28.02	28.39	28.77	
		22.19	22.29	22.38	22.48	22.58	22.67	22.77	22.87	22.97	23.07	23.16	23.26	23.36	23.46	
27	..	24.49	24.76	25.04	25.33	25.63	25.93	26.25	26.57	26.90	27.23	27.58	27.94	28.30	28.68	
		22.05	22.15	22.24	22.34	22.44	22.53	22.63	22.72	22.82	22.92	23.01	23.11	23.21	23.31	
28	..	24.42	24.69	24.97	25.26	25.56	25.86	26.17	26.49	26.82	27.15	27.50	27.85	28.22	28.59	
		21.92	22.01	22.11	22.20	22.30	22.39	22.48	22.58	22.67	22.77	22.87	22.96	23.06	23.16	
29	..	24.35	24.62	24.90	25.19	25.48	25.78	26.09	26.41	26.74	27.07	27.41	27.77	28.13	28.50	
		21.79	21.88	21.97	22.06	22.16	22.25	22.34	22.44	22.53	22.62	22.72	22.81	22.91	23.01	
30	..	24.29	24.56	24.84	25.12	25.41	25.71	26.02	26.34	26.66	26.99	27.33	27.68	28.04	28.41	
		21.66	21.75	21.84	21.93	22.02	22.11	22.20	22.29	22.39	22.48	22.57	22.67	22.76	22.86	
31	..	24.22	24.49	24.77	25.05	25.34	25.64	25.95	26.26	26.58	26.91	27.25	27.60	27.96	28.33	
		21.52	21.61	21.70	21.79	21.88	21.97	22.06	22.15	22.25	22.34	22.43	22.52	22.62	22.71	

The estimated values of A, B and C are all significant as indicated and justified in fitting the model given below.

$$\text{OT. GL/MT} = 0.044581 + 0.00019627 (\text{Rainy days/month}) \\ - 0.00064688 (\text{Pan Evaporation/month})$$

Using this multi-factor equation the predicted upper and lower limits of OT.MT/GL (Draper and Smith, 1966) for various combinations of rainy days and pan evaporation are presented in Table 2 for easy reference. For example a monthly record of 15 rainy days and a pan evaporation of 90 mm would give an upper limit of 24.81 and a lower limit of 23.20. This shows that in a month having the above number of rainy days and pan evaporation, the monthly OT.MT/GL should fall within 23.20 - 24.81 per cent with an average value of 24.05%. As it is necessary to have pan evaporation records to refer the OT Table, this should be maintained in each estate. Pan evaporation could be measured using a simple device consisting of a spherometer which costs about Rs. 500/- and an open pan containing water.

ACKNOWLEDGEMENT

We thank Dr D. S. A. Samaraweera for critical reading of the manuscript.

REFERENCES

- DRAPER, N. R. and SMITH, H. (1966). Applied Regression Analysis, John Wiley and Sons, Inc, London.
- DOORENBOS, J. and PRUITT, W. O. (1977). Crop water requirements, Irrigation and drainage. paper No. 24, FAO, Rome.
- KERDEL E. L. (1955). The out-turn of made tea to green leaf (Theoretical and Practical Considerations). *Tea.Q.* 26, 138-147.