RESPONSES TO MANURING IN VARIOUS LOW-COUNTRY CONDITIONS

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Introduction

The yield of tea under estate conditions will depend on a number of factors, *e.g.* the yield potential of the seed and jât of tea grown, the density of planting, the amount and distribution of rainfall, the system of pruning, the method of plucking and manuring, the incidence of pests and diseases, *etc.* The optimum response to some of these factors is dependent on others; for example, manuring will give the best results if the rainfall is adequate and well distributed, if there is a sufficient stand of bushes to utilise the manure applied, if the bushes are pruned in the proper way, and if pests or diseases do not upset the normal functioning of the bushes. In short, yield is the integrated effect of a number of factors operating together, any one of which may become the limiting factor in any one year. Hence, even on the best-managed estates, where the general trend of yields over a period is rising, there can be an occasional shortfall of crop.

In order to investigate the effect of one of the major agronomic factors on tea yields, namely manuring, which has contributed greatly to the phenomenal increase of the low-country average during the past five years, typical estates in each of the planting districts of the zone were asked for information on the acreages cultivated, manurial applications given, yields obtained and rainfall conditions during the past 12 years. In all, 31 estates were addressed and I am very grateful to the 26 estates who have furnished some or all of the information requested. I now propose briefly to survey the main conclusions derived from the statistical examination of the data and to relate these to the findings from our own limited experimental work.

Survey Facts

The estates covered in this survey were at elevations ranging from 200 to 2,000 feet, and had annual rainfalls varying from 50 to 230 inches. The low rainfall-averages occur in the Balangoda area, which experiences severe droughts and wind in the South-West monsoon; and the high rainfalls occur in the Kelani Valley and parts of the Ratnapura district. The pruning cycle is of two years duration, but some estates adopt the 18th-month cycle, especially where Shot-hole Borer is a problem, and a few the 3-year cycle. The manure mixture used is mainly T. 521, which is the standard T. 500 with a higher proportion of potash, and variants thereof. In earlier years, potash levels, in accordance with the views held then, were appreciably lower than in recent times. The amounts of nitrogen applied over the period varied from 45 to 150 lb. per acre per annum generally, but for the past 8 years or so, rarely has the annual application fallen below 80 lb. per acre. Magnesium in the form of dolomite has been sporadically used on some estates, but one estate has systematically incorporated magnesium sulphate in its standard mixture for the past 5 years.

Statistical Terminology

Before discussing the results of the examination of the data, I should like to explain briefly a few statistical terms which will be referred to in the course of my paper. The term *correlation coefficient* is used to denote the degree of association between two variables, *e.g.*, yield and nitrogen. This coefficient varies between plus 1 and minus 1; a positive value indicates that an increase in one factor is associated with an increase in the other, while a negative value indicates that when one factor increases the other tends to decrease. A statistic calculated from the correlation coefficient and termed the *predictability* or *precision index* measures the precise contribution of any one of a number of factors to the whole result. It is appreciably lower than the correlation coefficient. The *regression coefficient* measures the rate of increase or decrease of one variable per unit increase of the other. The relationship between the two is expressed as a simple linear equation: $y = a + bx$, where a is a constant, b the regression coefficient, x the independent variable, and y the dependent variable. These statistics are illustrated in Fig. 1 (p. 137) where y is the yield of tea per acre, x the amount of nitrogen applied in the fertiliser mixture, b the regression coefficient, and a the constant.

A *multiple regression* equation is one expressing the relationship between three or more variables *e.g.* yield, nitrogen and rainfall. The term *partial correlation* is used to indicate the correlation between two variables when the third is held constant. It is derived from the total correlations between the factors.

Rainfall and Yield

Now to the results. In the low-country, rainfall is generally not a limiting factor of yield, the exceptions being the Balangoda district and parts of the Matara and Kegalle districts. In these and particularly in the first, it is the incidence of the rainfall in certain months, and not the total rainfall, that matters. But when the total rainfall in any one year falls appreciably below the normal, the yield is adversely affected. It is possible to calculate a multiple regression equation between rainfall (R), manuring (N), and yield (Y), which will fit in well with the data. Such an equation calculated for an estate in the Matara district was as follows: $y = 415 + 2.1\,N + 2.64\,R$. The application of this formula in years of deficient rainfall will give an indication of what yield can be expected. A statistical examination of the rainfall figures during critical periods of the year and of the yield data should result in higher correlations being obtained, and regression equations which give closer agreement between observed and calculated yields.

Manuring and Yield

A study of the yield responses to manuring has been made on data from 22 estates which supplied adequate information. The typical patterns of such responses are shown in Fig. 2 (p. 138) where yields are plotted against the nitrogen in the fertilizer mixture applied.

The regression lines show the varying trends of yields on different estates. In nearly all cases the response to manuring over the basal level is positively significant, but in one case the crop showed no significant change when over 60 lb. of nitrogen per acre was given. In the other cases the magnitude of the regression coefficient or the rate of increase of yield per unit of nitrogen, within the limits applied, varies greatly, *viz.*, from 0.8 to 9 lb. of crop per pound of nitrogen applied in the mixtures used. On estates which are high-yielding, the regression coefficient

may be high and the constant low *or* the regression coefficient may be low and the constant high. On low-yielding estates the regression coefficient is low and the constant also relatively low. Obviously, the greatest economic advantage from manuring is obtained on those estates where a high regression coefficient is noted. A low regression would indicate the operation of a limiting factor of yield. Whether this is inherent in the climate, as in the Balangoda area, or whether it is a soil factor or the tea is too old or of a jât which shows a low response to manuring under shade, or whether the stand of tea is inadequate for the manure applied, or pests and diseases limit yields, can only be ascertained after further inquiry and experiment. That pests and diseases have affected yields in some years has been indicated by some estates.

In regard to bush stand, it is clear from the literature (Visser *et al*, 1958) that planting distances do affect yield appreciably. It is not uncommon in the low-country for young-tea areas which have a stand of about 6,000 bushes to the acre to yield over 2,000 lb. when about 10 years of age, when the old fields give less than 1,000 lb. per acre. It is doubtful if the old tea in the greater part of the low country has an average stand of more than 2,500 bushes per acre. Fig. 3 (p. 139) shows how yield can be affected by bush number; the data are from our manurial trial at Endane over the past five years, where applications of nitrogen higher than the basal dressing of 80 lb. per acre per annum have not increased yields. The correlation coefficient between these two factors was found for the first cycle to be 0.74, with a precision index of 0.33. In simple terms, about one-third of the variability of yield of the plots is, in this instance, determined by bush number.

The statistical examination of the data shows that yield, in nearly all cases where a significant response has been obtained, is closely related to the quantity of nitrogen applied. The increase is linear up to about 145 lb. per acre, after which there is generally a tendency for yields to level off. In this connection, reference may be made to Eden (1958) where he indicates from experiments carried out in Assam and Nyasaland on the use of high levels of nitrogen, that in practice the law of diminishing returns begins to operate at levels of nitrogen greater than about 200 lb. per acre, though the theoretical dosage is about 240 lb. per acre. The yields obtained were in the region of 1,700 to 1,800 lb. per acre. Experience in the low country of Ceylon is different; yields over 2,400 lb. per acre have been obtained with dressings of less than 150 lb. per acre of nitrogen.

With regard to potash, it has been difficult to assess the effect of this nutrient on yield independent of nitrogen, as there has been a fair degree of consistency in the use of standard mixtures with constant ratios of N, P and K on most estates and thus inadequate random variation of the data. In the relatively few cases where there has been some variation in the potash/nitrogen ratio, the partial regression coefficients and partial correlations calculated between potash and yield when nitrogen is kept constant, appear to indicate that in these instances the use of potash in higher than standard amounts has not been of advantage. It is notable, for instance, that in our Endane manurial trial, potash applied in excess of the basal level of 60 lb. per acre per annum has not increased yields over the average of 1,600 lb. per acre. This statement should not, however, be considered to be generally applicable in the low country since potash deficiency does exist on some estates in the zone.

With regard to magnesium, the results obtained on an estate in the Kelani Valley where crude Epsom salts was used with the standard mixture at the rate of 2 cwt. per acre per annum over a period of five years, reveal a significant average increase in yield of 235 lb. per acre per annum during this period over that of the previous five years when magnesium was not used. This increase is not due to the slightly higher doses of nitrogen given in the later period, but it is due partly to the

increasing acreages of new tea coming into bearing during the period. Statistical analyses show that there is generally a high positive correlation between yield and the acreages of new tea coming into bearing. There is, however, little doubt that on the estate in question magnesium applied as sulphate has contributed to the increased yield obtained since 1955. As regards the effect of dolomite, the data are insufficient to estimate its precise effect on yield, but there are indications of a beneficial effect where the treatment has been carried out systematically.

As regards manuring in general, there is evidence in a number of instances that where, for say reasons of economy, the amounts of fertilizer on a normally well-manured estate, with an average stand of green-manure trees, was reduced in quantity in any year, the yield did not fall appreciably in that year provided other factors, *e.g.*, rainfall, were satisfactory. In some cases where the yield trend was rising, *e.g.*, in young tea, the yield even increased. A case in point is shown below from an estate in the Morawak Korale.

TABLE 1.—*Reduction of manuring and yield*

(Area of field 20 acres—planted 1948/49)

YEAR	NITROGEN lb. per acre	YIELD lb. per acre
1955–56	125	1,454
1956–57	112	1,104 Pruning year
1957–58	111	1,182
1958–59	46	1,421 Pruning year
1959–60	200	2,398

Conclusion

In conclusion, I have to express the hope that this article will serve the purpose, if nothing else, of showing that if accurate data on yields in relation to manuring are maintained on estates over a sufficiently long period and the data are statistically examined from time to time, valuable information can be obtained on yield trends, and the effectiveness or otherwise of any particular treatment and its economic implications. The advantages of keeping such records are, therefore, obvious.

References

EDEN, T. (1958). The maintenance of high yields of tea. *Tea & Rubb. Mail*, December 23: 5, 8.

VISSER, T. & TILLEKERATNE, L. M. DE WAAS (1958). Factors affecting the planting distance of tea. *Tea Quart.* **29**: 36–44.

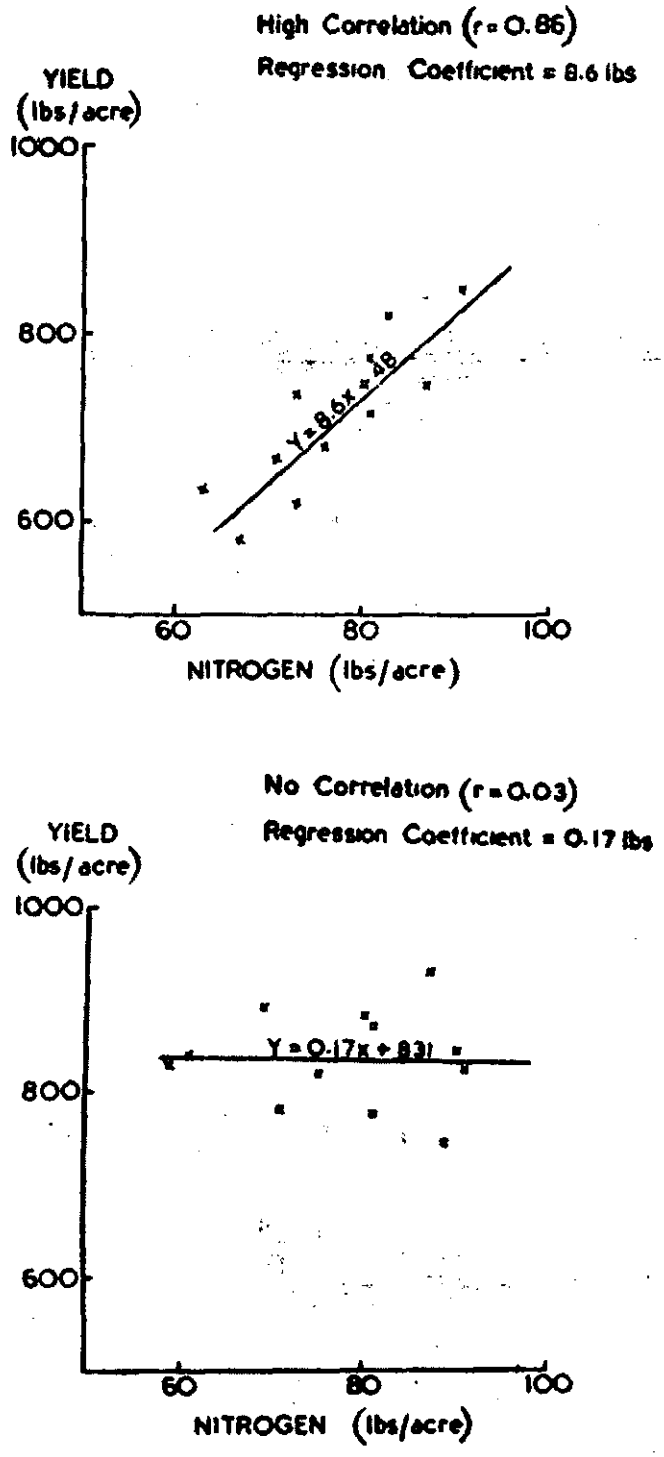

Fig. 1. The relationship between yield (y) and nitrogenous manure (x) in two instances.

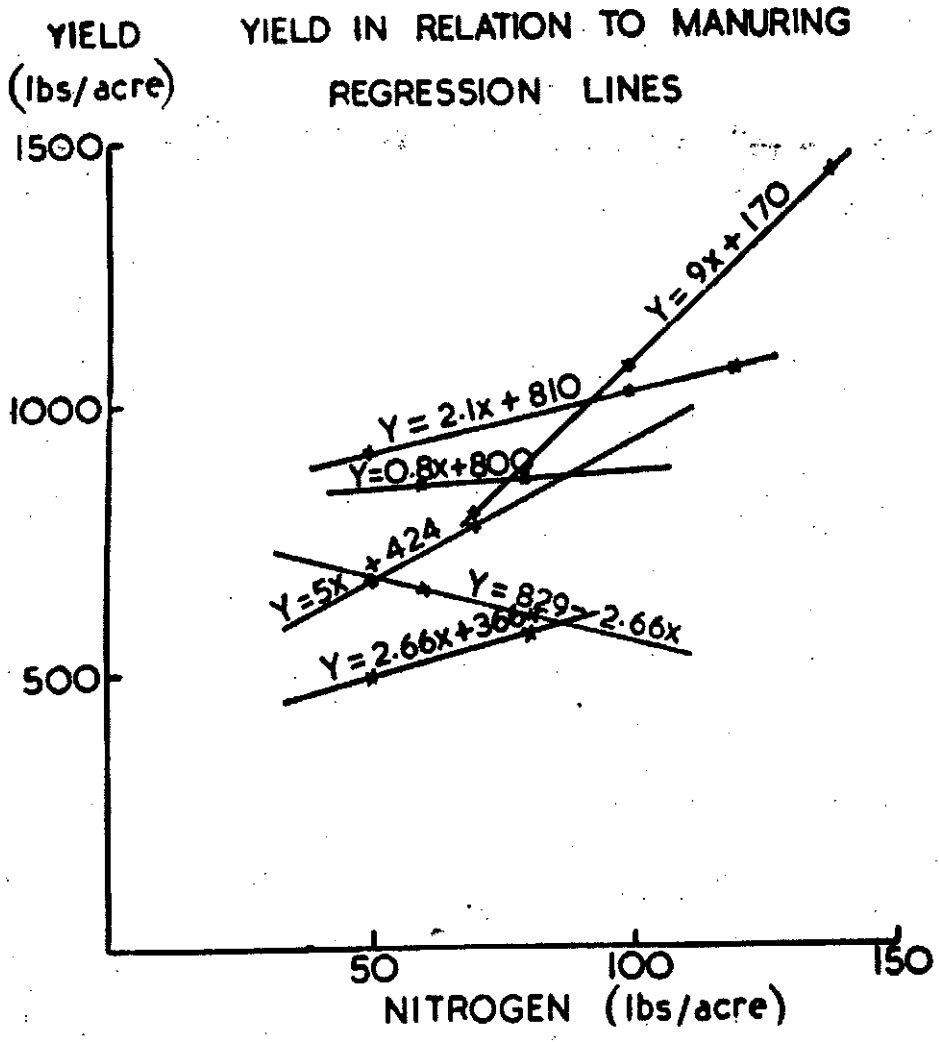

Fig. 2. The response in yield to manuring (nitrogen) on six different estates, shown as regression lines.

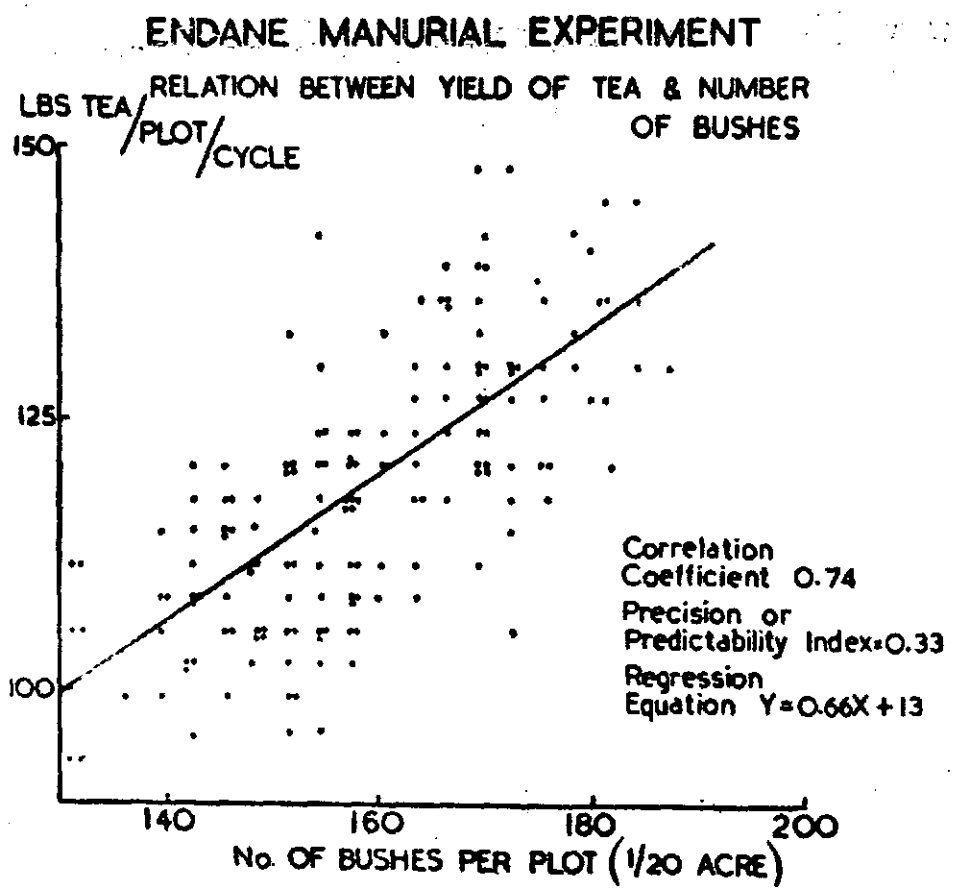

Fig. 3. The effect of bush density on yield.