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INFLUENCE OF LEVELS OF NITROGEN AND POTASSIUM FERTILIZERS ON CHLOROPHYLL CONTENT IN MATURE CLONAL TEA LEAVES

S. Krishnapillai and V. L. Ediriweera

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

The effect of increasing levels of nitrogen and potassium fertilizers on the chlorophyll content of mature tea leaves of clone TRI 2024 recovering from pruning was investigated. The leaves for this study were collected from a long established NPK 3^3 factorial field trial from plots that received N at 112 (N_1), 224 (N_2) and 336 (N_3) kg N ha^{-1} an^{-1}; K at O (K_0), 70 (K_1) and 140 (K_2)kg K_2O ha^{-1} an^{-1} and P at O (P_0), 30 (P_1) and 60 (P_2) kg P_2O_5 kg ha^{-1} an^{-1}. The results showed that the chlorophyll content increased with increasing levels of N and K, the increase being more marked with potassium fertilizers. The significance of these findings are discussed in relation to photosynthesis and blackness of made tea.

INTRODUCTION

Potassium was one of the first elements to be recognized as essential for the growth of plants and is linked with almost all the phenomena of plant physiology. Potassium has been reported to intervene in water economy (Lacaille, 1966 ; Maurya and Gupta, 1984), pigment synthesis (Bolle-Jones and Notton, 1953), protein synthesis and enzyme activities which are all important physiological functions in a plant system.

In tea, of the mineral elements available in the mature leaf tissues, potassium comes next to nitrogen and amounts to 1.5 to 2.0% on a dry matter basis. The fact that tea leaves contain such high levels clearly emphasizes its role in the physiological functions of the plant.

In many of our field trials on nitrogen and potash, yield was the main criterion examined and no basic studies were available on their effects on other physiological functions, *viz.* water economy, resistance to desiccation, total chlorophyll content, tissue "hardiness ", etc.

Chlorophyll is the green pigment found in leaves and is undoubtedly the most important plant pigment determining the photosynthetic efficiency and productivity of plants. A greater content of chlorophyll in leaf tissues could greatly influence increased photosynthesis thereby improving yields.

Factors that increase the chlorophyll content of leaves would naturally increase their photosynthetic efficiency. In this respect, nitrogen and magnesium are important as they play a vital role in the formation of the structure of the chlorophyll molecule itself and therefore their importance need not be stressed. Other major elements, notably potassium also play an important role in the synthesis of chloiophyll by taking part in various enzyme activities necessary for such building up processes (Evans and Sorger, 1966; Jones, 1961). In this study the influence of varying levels of nitrogen and potassium fertilizers on chlorophyll content of leaves of mature clonal tea plants was investigated.

MATERIALS AND METHODS

The leaf material used in this investigation was obtained from clone TRI 2024 in a long term NPK field trial at St. Coombs Estate, Talawakele (1300 m amsl). In the original trial nitrogen, phosphorus and potassium are being tested each at three levels, in a factorial design, making 27 treatments in all, with each treatment replicated thrice. The levels of NPK were 112, 224 and 336 kg. N ha^{-1} an^{-1}; 0,70 and 140 kg. K_2O ha^{-1} an^{-1} and O, 30 and 60 kg. P_2O_5 ha^{-1} an^{-1}. The trial has now lasted almost 25 years under the different NPK fertilizer treatments, and has completed 5 cycles with the last prune being given in mid-1985, during the south west monsoon.

Sampling

The leaf samples for the chlorophyll estimation were obtained from fully expanded mature leaves on the shoots recovering from pruning. At the time of this study many of the recovering shoots had produced about 10-12 leaves each and were almost ready for tipping or levelling off. For our analysis the 5th, 6th and 7th leaves from the apex in the central upright shoots from each of 10 bushes were collected at random, and about 25 to 30 such leaves collected from each plot. Two batches of such samples from each plot were collected from replicates I and II, located about 200 m apart, in the same field. Leaves were collected only from the following treatment plots :

(1) $N_1P_1K_0$	(4) $N_2P_1K_0$	(7) $N_3P_1K_0$
(2) $N_1P_1K_1$	(5) $N_2P_1K_1$	(8) $N_3P_1K_1$
(3) $N_1P_1K_2$	(6) $N_2P_1K_2$	(9) $N_3P_1K_2$

(Where N_1 = 112, N_2 = 224 and N_3 = 336 kg N ha^{-1} an^{-1}
K_0 = O, K_1 = 70 and K_2 = 140 kg K_2O ha^{-1} an^{-1}
and P_1 = 30 kg P_2O_5 ha^{-1} an^{-1}).

Extraction Procedure

As soon as the leaves (25-30) were brought to the laboratory they were cleaned with tissues to mop off moisture and cut into small pieces using a pair of scissors. The cut pieces were mixed well and two 5 g samples drawn for the extraction of chlorophyll. Two 10 g portions from this lot were dried overnight in an oven at 80°C for subsequent dry ashing for K analyses.

The 5 g fresh leaf material was macerated in a homogenizer with 50 ml acetone (80% v/v) for 3 min., and the contents filtered through Whatman No. 4 filter paper. Five ml of the filtrate was transferred to a 25 ml standard flask and made to volume with acetone (80% v/v). This solution was used for the quantitative estimation of chlorophyll, by the method of Arnon (1949).

RESULTS AND DISCUSSION

The recovery of the bushes receiving the different N, K treatments was quite satisfactory in the current pruning cycle except the plots receiving no potash, where in addition to many vacancies the recovery was very poor particularly at N_3 levels; the leaves on the recovering shoots (almost all K_0 plots) were smaller, more paler and the underside of mature leaves lower down on the shoots exhibited bronzing, a symptom associated with potash deficiency (Pethiyagoda and Krishnapillai, 1971). There were also visual differences in the leaf colour between the different potash and nitrogen plots, with the plots receiving the highest level of potash (K_2) showing comparatively dark green leaves than those from either K_0 or K_1 (Fig. 1).

The total chlorophyll content of the leaves from the different nitrogen and potash treatments are presented in Table 1.

TABLE I—*Effect of nitrogen and potash on chlorophyll content (mg g^{-1} FW) of mature leaves of clone TRI 2024*

Nitrogen levels	..	N_1	N_2	N_3
Potash levels K 0	..	0·120	0·127	0·138
K 1	..	0·133	0·140	0·144
K 2	..	0·155	0·169	0·177
LSD (P=0·01)	..		0·0024	

It is apparent that both nitrogen and potassium markedly influenced the chlorophyll content of the leaves. At each level of nitrogen, the chlorophyll content increased significantly with increasing level of potash, the highest always being at K_2 (140 kg ha^{-1} an^{-1}). Though increasing levels of nitrogen also increased the chlorophyll content the response to potash levels was more marked. The increase in chlorophyll

content was much higher when the potassium was increased from 70 to 140 kg than from O to 70 kg $K_2O\ ha^{-1}\ an^{-1}$. This could be due to the fact that at K_o and K_1 levels potassium was limiting the enzymatic process involved in the synthesis of chlorophyll. In fact, soil analyses have shown that while the K_2 plots contained potassium (exchangeable) in the region of 160-170 ppm K, the K_o and K_1 plots contained only 50 to 85 ppm K in most plots.

Since potash is found to influence the total chlorophyll content of the leaves it may also directly and/or indirectly improve crop yields through increased photosynthesis. Chlorophyll content of immature leaves (2nd leaf from the bud) of several high and low yielding clones has been reported not to be directly related to their yields (Jayanthi de Silva and Sivapalan, 1982). In their studies however, immature tissues not fully developed were used for chlorophyll estimation and such tissues might not have represented the actual amount of chlorophyll that would have otherwise formed in a fully developed leaf which is responsible for food synthesis and crop yield of the plant.

Chlorophyll estimation done on the flush from K_1 and K_2 plots (K_o excluded) showed a similar trend to that of mature leaves but the differences were comparatively small (Table 2). Here too, the chlorophyll content at K_2 level was consistently higher than that at K_1 at each level of N used.

TABLE 2—*Total chlorophyll (mg g^{-1} FW) of the flush of clone TRI 2024*

Nitogen levels		N_1	N_2	N_3
Potash levels	K_1 ..	0·0630	0·0658	0·0763
	K_2 ..	0·0688	0·0710	0·0813
LSD (P=0.05)				
	For K—0·0046 ..			
	N—0·0056 ..			

The above findings emphasize the need for increased application of potassium with increased nitrogen application for improved chlorophyll content which could possibly enhance the photosynthetic capacity of the plants. In the present fertilizer recommendation of the Institute there is always an attendant increase of potash with increased applications of nitrogen, with a definite ratio between the two elements ($N : K_2O = 2 : 1$). The results of this study lends support for this practice.

In tea, chlorophyll content of the leaves has been reported to improve the development of 'blackness' of tea which is an important criterion in the commercial evaluation of tea (Wickremasinghe and Perera, 1966). Their work has shown that with higher chlorophyll content in the flush high concentrations of phaeophytin are

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Fig. 1 – Effect of levels of potash on leaf colour of 5th to 7th leaves from apex on shoots recovering from pruning. Note colour differences.

The first two leaves on the left have received the K_2 level; the middle two leaves have received the K_1 level; the last two leaves on the right have received the K_o level.

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formed which in turn made the tea blacker. Since potash has been found to influence the total chlorophyll content of the leaf tissues, it could indirectly improve the ' blackness ' of tea and this merits further investigation.

Total potassium content of the mature leaves analysed from the 10 g samples which had received their last NPK fertilizer about 7 months prior to sampling, increased with increasing levels of potash application at each level of nitrogen (Table 3).

TABLE 3—*Total potassium (%) in mature leaves*

Nitrogen levels		N_1	N_2	N_3
Potash levels	K_0 ..	1·529	1·033	0·858
	K_1 ..	2·020	1·666	1·615
	K_2 ..	2·395	2·223	2·051

Though the potassium content of the leaves increased from K_0 to K at each level of nitrogen, it decreased with increasing nitrogen levels (*i.e.* from N_2^2 to N_3). It is possible that increased growth promoted by increasing levels of nitrogen could have brought about a dilution effect in the plant causing comparatively low values for potassium in the leaf tissues.

In this context, it is pertinent to note that this investigation was carried out at the time when the bushes had received no NPK fertilizers for about 6 to 7 months—i.e. from 3 months before and up to about 4 months after pruning (the Institute's recommendation). Despite this, the bushes still exhibited marked differences in the chlorophyll and potassium contents in the leaf tissues with respect to N and K treatments. One could infer that the applied fertilizer nutrients particularly potassium and nitrogen and possibly phosphates have long lasting effects on soil fertility either directly and/or indirectly (recycling through prunings, tea leaf litter, etc), provided regular fertilizer applications are made at the appropriate times. In fact, at the time of this investigation , both K_1 and K_2 plots contained adequate amount of mulch (tea prunings and tea leaf litter) in a well decomposed state.

The effects of potash use on water economy, resistance to desiccation (root and leaf tissues) and ' tissue hardiness ' from data obtained from the same field trial as well as from glasshouse studies and other field observations will be reported elsewhere.

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