USE OF POTASH FERTILIZER IN AGRICULTURE IN SRI LANKA

A REPORT
BASED ON STUDIES UNDER A
CIDA - FUNDED RESEARCH PROGRAMME
1984 - 1992

Prepared for NARESA by Dr U. Pethiyagoda

Natural Resources, Enegy & Science Authority of Sri Lanka

CONTENTS

FOREWORD

This report summarises the results of the studies carried out under a CIDA - funded research programme on the use of potash fertilizer initiated in 1983. I wish to record our thanks to the Canadian International Development Agency (CIDA) for the assistance provided under this programme. The research facilities in several institutions and laboratories have been enhanced through the provision of equipment under this grant. The grant also supported one scientist for post-graduate training to Ph.D. level at the University of Manitoba.

The programme was coordinated and administered by NARESA under the guidance of its Working Committee on Agriculture and Animal Husbandry. This report was prepared by Dr U. Pethiyagoda, Consultant, Mahaweli Authority of Sri Lanka.

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BACKGROUND

In 1978, the German Agency for Technical Co-operation (GTZ) in association with the Ceylon Fertilizer Corporation prepared a very comprehensive report on promotion of fertilizer distribution and consumption in Sri Lanka. In this study, for the first time, a survey on fertilizer consumption practices of small farmers of paddy, tea, rubber and coconut were made. The study revealed that the proportion of small farmers who had never used fertilizers were 24 percent in rice, 47 percent in tea, 58 percent in rubber and 83 percent in coconut. Only 33 percent of tea cultivators, 30 percent of rice cultivators, 15 percent of rubber growers and 3 percent of coconut growers used fertilizers on a regular basis. About 51 percent of paddy cultivators, 57 percent of tea, 65 percent of coconut and 73 percent of rubber growers were unaware of the dosages of fertilizers recommended by the authorities. These were a few of the dismal observations made in the report.

Subsequently, in 1980, the Canadian International Development Agency (CIDA) engaged a team of consultants to study the distribution and utilization of muriate of potash in Sri Lanka. This mission concluded that the overall fertilizer distribution and marketing procedures in the country were efficient. However, in the long term more information would be required to encourage greater use and optimum application of muriate of potash, and through field trials to pinpoint the responsiveness of various crops to the fertilizer under different conditions. Such information will enable agronomists to refine their general recommendations into more precise prescriptions for adoption in specific circumstances. These were some of the considerations which stimulated CIDA to initiate a research co-operation programme on the use of muriate of potash.

Since 1978 Canada has been the sole supplier of muriate of potash fertilizer to Sri Lanka. CIDA which channels this commodity under the aid agreement signed between the Governments of Canada and Sri Lanka, not only supplies the fertilizer to meet the needs of the agriculture sector, but also provides a component for research in the optimum utilization of the fertilizer. The Memorandum of Understanding signed in 1983 between Canada and Sri Lanka for implementing this Agreement, allocated a sum of C$ 350,000/= for a research and extension programme for an initial 3 - year period. Since the research co-ordination programme covers a variety of crops including food, horticultural and plantation crops, the Natural Resources Energy and Science Authority of Sri Lanka (NARESA) was appointed as the national co-ordinator of the programme, and Prof. R.J. Soper of the University of Manitoba was named as the CIDA Research Monitor.

Goal

The broader objectives to which this project would contribute are increased agricultural productivity for paddy and tree crops grown in Sri Lanka and balance of payments support.

In more specific terms the goals stated in the CIDA Plan of Operations envisaged the following results:-

(a) to increase agricultural production by the use of potash
(b) to improve the information base on potash use, and
(c) to identify the optimum use of fertilizer, with emphasis on potash, for various types of crops and various types of soils.

Specific objectives

The research studies are intended,

(i) through field studies and back-up analysis to obtain more precise information on the response of different crops under different conditions to muriate of potash.

(ii) to determine the best methods of application

(iii) to obtain information about the amount of potassium in drainage water, and

(iv) to find the long term effects of the use of this fertilizer.

Implementation Strategy:

In terms of the Memorandum of Understanding the following activities were identified.

Scope of Canadian Work

(a) Provision of a research grant to cover incremental expenses associated with carrying out research to determine optimum utilization of muriate of potash.

(b) Provision of research consultant to liaise with NARESA in implementing the research programme.

(c) Provision of assistance to cover the expenses of a part-time consultant to advise CIDA on the proper allocation of the research grant.

Scope of Sri Lanka Work

(a) Provision of adequately trained research personnel to carry out the necessary scientific work.

(b) Reviewing and commenting on the plan of work proposed by the Research Consultant to ensure its consistency with the agricultural research objectives of the Government of Sri Lanka.

(c) Preventing duplication of research effort

(d) Validating field test findings and dissemination of these to extension workers

(e) Arranging with CIDA for the approval and financial control of the research grant

(f) Reviewing research proposals and recommending appropriate proposals through the Research Consultant to CIDA for approval.

The Natural Resources, Energy and Science Authority which took over the responsibility of co-ordinating and administering the research programme, implemented the programme in accordance with its own time-tested procedure, and using its statutory working committee on Agriculture and Animal Husbandry as the supervisory consultative arm.

Operation of the Project

With an initial allocation of Canadian dollars 350,000/= for 3 years, the programme got off the mark in early 1984, with 14 research projects. One of these projects comprised entirely of a postgraduate training programme in which one scientist was trained for a PhD degree at the University of Manitoba. In 1985, three new projects were approved and in 1986, five more projects were added. In 1987, 5 new projects were included and finally in 1989 two more were added, making in all 29 research projects. The programme which was to be concluded in March 1991 was subsequently given time till March 1992. The total amount of funds allocated by CIDA between 1983 and 1990 for this programme was C$ 1,300,000 (approximately equal to Sri Lanka Rs. 32,907,300 which included the cost of postgraduate training for one scientist, 3 review seminars on the programme, and the cost of publication summarising the achievements in the programme. A final progress analysis seminar held in May 1992, brought the research programme to a conclusion.

LIST OF PROJECTS

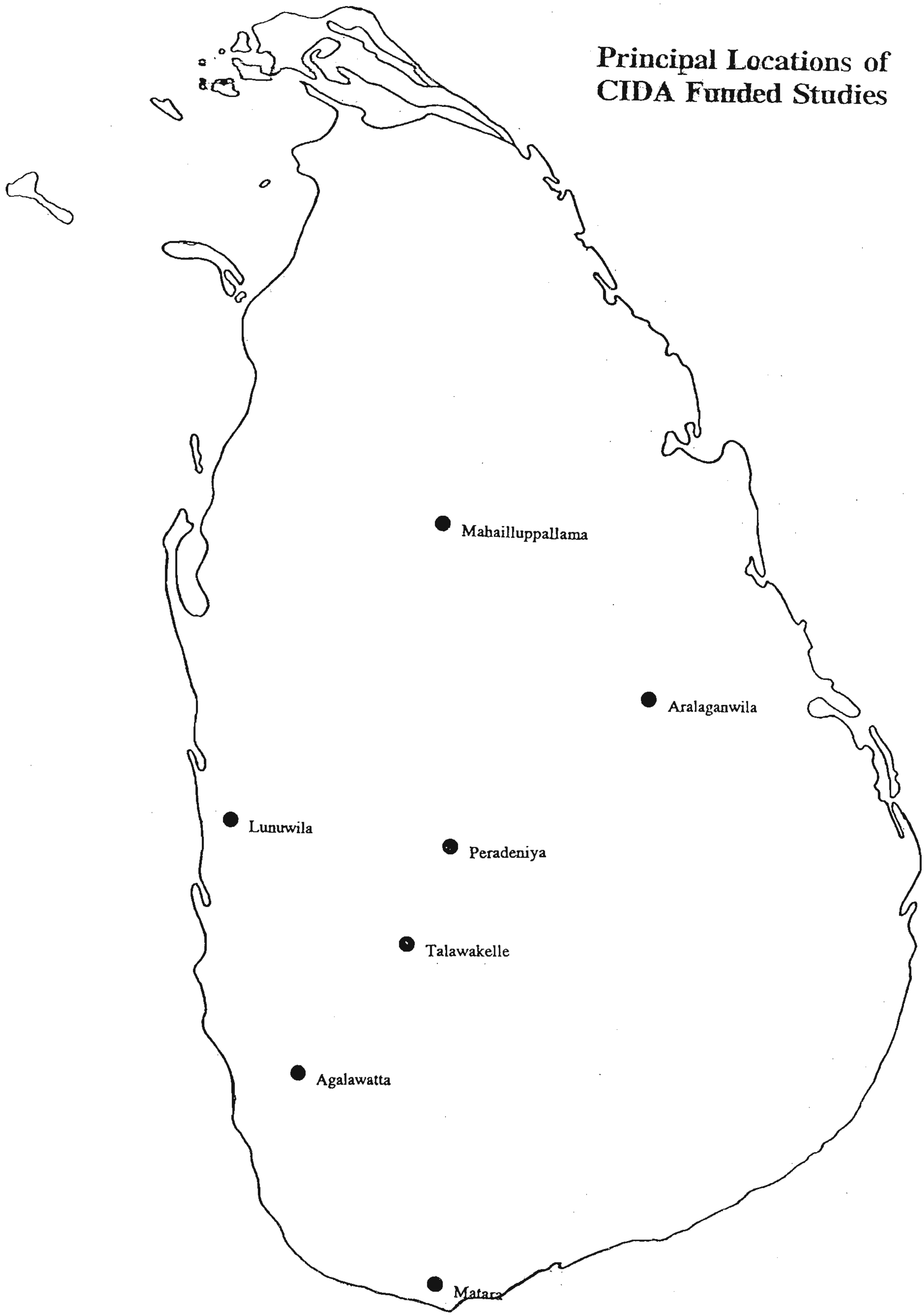
Code No.	Researcher	Title	Year of Start
CIDA/83/01	-	-	-
CIDA/83/02	Dr S.L. Amarasiri (1984-1989) Mrs I.S. Padmasiri (1984-1992) Mr D.M. Jinadasa (1984-1992)	Evaluation of the potassium requirements of banana in the mid-country wet zone of Sri Lanka.	1984
CIDA/83/03	Mr N.A. Nandasena (1984-1987) Dr G. Keerthisinghe(1984-1989) Prof. M.W. Thenabadu (1984-1992) Dr A.N. Jayakody (1988-1991) Mr P. Weerasinghe* (1984-1985) Mrs K.A.Anula Senaratna* (1986-1987) Mr N.J. Liyanage* (1987-1991)	The effect of potassium buffer capacity and mobility of non-exchangeable potassium on availability of potassium in some of the important rice soils of Sri Lanka.	1984
CIDA/83/4	Mr M. Jeganathan (1983-1992) Miss M.N. Dias (1983-1987)	Studies of potassium, magnesium interaction in coconut	1984
CIDA/83/5	Mr M. Jayasundara(1983-1989) Mr H.Wijewardena (1983-1991) Dr S.P.R. Weerasinghe (1984-1986) Dr S.L. Amarasiri (1986-1988) Dr V. Yogaratnam (1988-1991) Mrs M. Samarasinghe (1992-1992)	Some fertilizer studies on selected vegetable crops in the up-country intermediate zone of Sri Lanka	1984
CIDA/83/6	Dr K.N. Wickramasinghe (1983-1987) Dr S. Krishnapillai (1983-1992) Dr D.K. Weerasinghe (1983-1984)	To evaluate the efficiency of uptake and utilization of potash fertilizers by mature tea in Sri Lanka with special reference to soil fertility, crop production, drought resistance and recovery from pruning.	1984
CIDA/83/7	Mr M. Watson (1984-1986) Mr G. Wadasinghe 1984-1988) Dr S. Krishnapillai (1988-1992) Miss J.D.N.A.G. Nanayakkara* (1987-1989)	Role of potassium in relation to drought hardiness in young tea.	1984
CIDA/83/8	Dr M.K.S.A. Samaraweera (1983-1990)	Study of potassium and magnesium deficiency in young rubber.	1984
CIDA/83/9	Dr N. Yogaratnam (1984-1991) Mr M. Weerasuriya* (1984-1987) Mr S.M.M.Iqbal* (1987-1991)	Potassium and Magnesium Nutrition on *H. Brasiliensis* and associated covers: (1) Soil and leaf as a guide to potassium nutrition of *H. brasiliensis* (2) Effects of different levels of K on Mg uptake by immature rubber. (3) K nutrition of Hevea in relation to stimulation. (4) The influence of K on N status of leguminous covers and its effect on the N status and growth of *Hevea* during the immature phase.	1984

Code No.	Researcher	Title	Year of Start
CIDA/83/10	Mrs L.V.K. Liyanage	Effect of nitrogen, phosphorus, potassium and magnesium on the establishment and early growth of *Pueraria phaseoloides* grown under coconut.	1984
CIDA/83/11	Dr K.P. Premaratne (1984-1990) Prof. H.P.M. Gunasena (1984-1990) Dr U.R. Sangakkara (1984-1990)	Fertilizer potassium effects on yield and quality of pineapple.	1984
CIDA/83/12	Prof. M.A. Pemadasa (1984-1991) Mr V.B. Chandrasena* (1985-1988)	Studies on the ~~particular~~ fertility status of soils in Matara District with special emphasis on K.	1984
CIDA/83/13	Mr P.J. Wickramasinghe (1984-1988) Mr H.A. Sumanasena (1986-1992) Mr H.A.S. Perera 1984-1987) Mr R. Siritharan (1984-1986) Mr M. Dharmadasa (1987-1992) Mr W.D.L. Gunaratne (1988-1992)	Investigation on Cardamom under CIDA fertilizer project.	1984
CIDA/83/14	Dr S. Kathirgamathiah (1984-1992)	Demonstration of the effect of fertilizers on minor export crops in cultivators fields.	1984
CIDA/85/15	Dr N. Yogaratnam (1985-1992) Miss L. Samarappuli (1985-1992)	Some aspects of moisture stress in *Hevea brasiliensis* grown under Sri Lankan conditions	1985
CIDA/85/16	Mrs L.V.K. Liyanage (1985-1992) Mr K.B. Dasanayake (1987-1992) Mr H.A.J. Gunathilaka (1985-1987)	Effect of N and K on the growth and yield of Cocoa grown under coconut as mixed crop in the wet zone of Sri Lanka	1985
CIDA/85/17	Dr L.G.G. Yapa (1985-1991) Dr K.A. Nandasena (1991-1992) Mr B.V.R. Punyawardena* (1985-1988) Mr W.M.U.N. Wanasundara* 1988-1990) Mr G.K.K. Priyantha Kumara* (1991-1992)	Effects of soil moisture and soil strength/bulk density on the availability of potassium in some of the important soils in the dry zone of Sri Lanka.	1985
CIDA/86/18	Dr U.R. Sangakkara (1986-1992) Miss B.S.Thrikawala* (1987-1988) Mr M.M. Keerthi* (1898-1990) Mr H.S.K. Fernando* (1990-1992)	Effect of potassium fertilizer on growth and yield of tropical tubers.	1986
CIDA/86/19	Dr(Mrs) Sujatha Premaratne (1986-1992)	To investigate the effect of potassium application on the establishment, management and persistence of legume based pastures in the mid country of Sri Lanka.	1987
CIDA/86/20	Dr P.A.J. Yapa (1986-1989) Dr N. Yogaratnam (1986-1991) Mr D.J.S.J. de Zoysa* (1987-1991)	Use of rubber factory effluents as a fertilizer with special reference to nitrogen, potassium and phosphorus.	1987

Code No.	Researcher	Title	Year of Start
CIDA/86/21	Dr U.R. Sangakkara (1987-1992) Mr N.J.H. Gamage* (1987-1992)	Effect of potassium on nodulation and growth of tropical legumes	1987
CIDA/86/22	Dr J. Handawela (1986-1992) Mr W.A. Karunatillaka (1986-1988) Mr Y. Sarathchandra* (1986-1989)	Study the role of potassium fertilizer for stabilizing upland rainfed farming in the dry zone of Sri Lanka.	1986
CIDA/87/23	Mr Nihal Welikala (1987-1992) Dr H. Somapala (1987-1989) Miss Y. Jayasooriya (1987-1989)	Relationship between soil potassium and response of sweet potato grown under coconut to added potassium fertilizers.	1987
CIDA/87/24	Dr R. Senaratne(1987-1992) Mrs S.F.B.N. Gunawardene (1987-1990) Miss N.D.L. Liyanage (1987-1990) Miss D.S. Ratnasinghe (1990-1992)	Competitive ability, growth and yield of some grain legumes in intercropping system as affected by the level of K and N and their interaction.	1987
CIDA/87/25	Dr R. Seneviratne (1987-1992)	Potassium needs of rice crop grown on some major soil types of the central region.	1987
CIDA/87/26	Mrs S.N. Harischandra (1987-1992)	Effect of potassium on growth and yield of sweet potato, Innala and Colocasia under different land classes.	1987
CIDA/87/27	Mrs C. Jayasekera (1987-1992)	Effect of N,K,Cl and Abscisic acid on drought tolerant characteristic of major varieties of coconut.	1987
CIDA/89/28	Dr(Mrs) D.C. Bandara (1989-1992)	The effect of potassium application on the growth and yield of rice *(Orysa sativa)* varieties subjected to moisture stress.	1989
CIDA/89/29	Dr R.B. Mapa (1989-1992) Dr G. Wadasinghe (1989-1992)	Effect of potassium on drought tolerance of maize, mung bean, ground nut and chilies in Mahaweli System B	1989

* Research Assistants.

Principal Locations of CIDA Funded Studies



SOILS OF SRI LANKA

The more important great soil groups recognised in Sri Lanka are Reddish Brown Earths, Low Humic Gley Soils, Solodized Solonetz, Non-Calcic Brown Soils, Immature Brown Loams, Soils on Old Alluvium, Alluvial Soils, Red Yellow Latosols, Calcic Red Yellow Latosols, Grumusols, Regosols, Red Yellow Podzolic Soils, Reddish Brown Latosolic Soils, Bog and Half Bog Soils.

Soil studies received special attention after Independence as a result of various land development schemes, particularly those initiated in the Dry Zone of Sri Lanka. Such surveys were generally undertaken by the Department of Agriculture and emphasized the chemical and physical properties of soil with very little attention paid to their spatial distribution.

The first systematic study and classification of the Soils of Sri Lanka were by Joachim and others during the decade 1935 - 1945. Subsequent soil surveys by Hunting Survey Corporation (1959-1962) and the Land Use Division of the Irrigation Department (1959 onwards) have resulted in a rapid increase in information concerning the nature and characteristics of the soils. In 1961, Moorman and Panabokke presented a new classification of the soils of Sri Lanka into great soil groups and sub groups.

The nature of the great soil groups and their areal distribution are described below.

Reddish Brown Earths

Well to imperfectly drained moderately fine-textured, reddish brown soils occupy the crests, upper and midslopes of the undulating landscape. These soils are suitable for subsidiary food crops with irrigation in the dry season and with or without supplemented irrigation in the wet season.

Low Humic Gley Soils

Poorly drained, moderately fine to fine textured soils that occur on the lower parts of the slopes and valley bottoms. These soils are well suited for rice cultivation with or without irrigation.

Solodized Solonetz

Moderately coarse textured, brown to dark brown, slightly acid, topsoil overlying moderately fine to fine textured grey alkaline subsoil and occur in the nearly flat bottom land. Unsuitable for any crops due to alkalinity but suitable for rice or pasture after reclamation.

Non-Calcic Brown Soils

Well to imperfectly drained, medium textured, brownish to yellowish soils that occur in association with Reddish Brown Earths on the crests, upper and mid slopes of the undulating landscape. Suitable for crops similar to those on Reddish Brown Earths but require more irrigation and fertilizer application.

Immature Brown Loams

Rather shallow well drained, dark brown to yellowish brown, moderately fine textured, slightly acid soils occupying the steeper eroded slopes of the rolling to hilly landscape. Suitable for forestry. Vegetables may be grown under irrigation.

Soils on Old Alluvium

Coarse-textured, well to imperfectly drained, brownish to yellowish soils occurring in association with Non-Calcic Brown Soils on the mid slopes of the gently undulating landscape. Suitable for subsidiary food crops with irrigation in the dry season and rice in the wet season.

Red-Yellow Latosols

Very deep, generally 6m, excessively drained moderately fine textured soils that occupy the crests and mid slopes of the very gently undulating landscape. Yellow Latosols are similar soils but are imperfectly or poorly drained and occupy the lower slopes. These soils are excellent for intensive cultivation of irrigated subsidiary food crops and are neutral to medium acid in reaction.

Calcic Red-Yellow Latosols

Very similar to Red-Yellow Latosols but are underlain by limestone at depths varying from a few centimetres to several metres.. Suitable for irrigated subsidiary food crops.

Grumusols

Imperfectly to poorly drained dark grey brown to black clayey soils occurring on flat landscape. Sticky when wet and very hard when dry. Wide cracks appear on drying. Suitable for irrigated rice.

Alluvial Soils

Soils of widely varying drainage (well to poorly drained), texture (sand to clay) and colour (white, reddish brown, grey, black). They occur adjacent to rivers and streams and in flood plains. The poorly drained clayey soils are suitable for rice and the lighter textured soils are suitable for subsidiary crops.

Regosols

Very deep, generally over 3m, structureless, single grain, whitish, excessively drained sands. Occur along coastline as beaches and dunes. On flat lands, regosols are suitable for coconut in the wet zone and cashew in the dry zone. Neutral to slightly acid in reaction.

Red Yellow Podzolic Soils

Well drained reddish to yellowish moderately fine textured strongly acid soils on less steep slopes of mountainous terrain suitable for tea and plantation forestry with adequate erosion control measures.

Reddish-Brown Latosolic Soils

Well to moderately well drained, reddish brown, moderately fine textured, medium acid soils, occurring in all but valley bottom positions of the rolling to hilly landscape. Wide variety of crops as grown presently are well suited for these soils.

Bog and Half-Bog Soils

These are very poorly drained soils with a surface layer rich in dark brown to black organic matter. They occur in the lowest, poorly drained positions of the flat coastal landscape. These soils are suitable for rice and reeds.

(From the National Atlas of Sri lanka - Survey Department of Sri Lanka, 1988).

POTASSIUM WITHIN THE PLANT

Potassium is a fascinating element in many ways. It is taken up by plants in large amounts - justifying its position among the three major plant nutrients, along with nitrogen and phosphorus.

All life forms appear to need this element yet it is not known to enter into the composition of any identified organic compound. It is therefore easily extractable and very mobile within the plant. More than 60 plant enzymes are known to need K ions as an activator. Some of them are critical to carbohydrate, fat and protein synthesis and to the function of ribosomes. Hence, probably the pivotal role of potassium in metabolism.

The smallness of the potassium ion probably relates to its high mobility and easy penetration through protoplasmic membranes. Therefore the participation of potassium in stomatal guard cell regulation and in osmoregulation generally. Both processes are basic to tolerance to drought, salinity and frost. Thus possibly, the beneficial effect of potassium applications in helping plants meet the effects of drought stress.

Further, the free mobility of potassium ions through membranes bestows on this element a central role in the generation and transfer of metabolic energy. Thus, plant functions that revolve around energy transactions - photosynthesis, respiration, phloem transport and elaboration of complex structural and storage materials are profoundly influenced by cellular K status.

The literature abounds with examples of potassium effects on a multitude and wide variety of plant functions. These include -

Activation of enzymes
Transport through biological membranes
Energy synthesis and energy transfer
Photosynthesis and respiration
Translocation and storage of assimilates
Osmoregulation and stomatal movement
Amino acid and protein metabolism, and
Quality and colour of fruits

All of these and other reported effects have a bearing on performance and ultimate yield of crops. Hence the importance of potassium fertilizer in agriculture.

POTASSIUM IN THE SOIL

As with all other soil nutrients, potassium moves into plant roots from the soil solution and in ionic form. The dynamics of potassium behaviour in the soil are recognised as revolving around three forms. These are commonly described as "soluble potassium", "exchangeable potassium" and "non-exchangeable potassium". It is apparent that these categories are not clear cut nor unambiguous but serve usefully to provide some understanding of fertilizer - soil - plant interactions.

The three categories are generally recognised by their extractability by solutions of different extractive ability. To stimulate the nutrient extraction pattern of roots, several empirical methods have been developed, but none of them have proved to be universally acceptable. More complicated methods employ physio-chemical approaches for determining the K - supplying power of soils. The dynamic equilibrium between different forms of potassium in soils is controlled by a complex of factors including clay mineralogy, rates of weathering, exchange properties of the soil and crop physiological features.

In conventional soil analysis, weak extraction agents (water, .025 M $CaCl_2$ etc.) are considered to yield approximate estimates of K concentration in the soil solution. These figures however change by K removal during crop growth. If stronger extraction solutions are used (e.g. lactate or ammonium acetate etc.,) large K reserves are extractable but their effective availability remains unknown. This fraction is assumed to be "exchangeable K". Even stronger acid extractants (e.g. 1 N HCl) are deemed to extract the "non-exchangeable" fraction.

The ability of a soil to maintain consistency in the fraction entering the soil solution is defined by its "potassium buffering capacity". A better buffered system maintains a near uniform content in the soil solution.

The literature abounds with such terms as "available K", "K pool", "fixed" or "bound K" whose identity with respect to the three categories mentioned above is not altogether clear. It is not within the scope of this presentation to attempt a reconciliation.

There is a paucity of data on the potassium status of Sri Lankan soils and some of the studies in this series attempt to address this problem.

Leaching column experiment to evaluate the changes of K-reserves in an alfisol (CIDA/83/03)

PRIORITIES FOR POTASH RESEARCH

As a major plant nutrient and a large component of the national fertilizer budget, potassium is a natural candidate for research attention. Although a number of studies on a variety of crops have been reported in the literature, the present CIDA Project is a landmark in that it focussed and concentrated attention on a single nutrient.

The ultimate objective of fertilizer research is to improve efficiencies and reduce costs. The journey towards this goal traverses several areas. An examination of these areas suggests the rationale on which the CIDA Project would have been based and dictates the selection of studies for support.

Not much is known of the potassium status of Sri Lankan soils. Even less of the behaviour of applied potassic fertilizer and the changes that occur in the various fractions within the soil (soluble, available and non-available). These fractions are in a dynamic situation and shifts between them are influenced by a number of factors, environmental and cultural. Growth of a crop brings in a further variable. Most of the studies reported have included a consideration of soil related factors and three have made this their primary focus (83/03, 85/17 and 87/25).

Soils submerged for rice cultivation can be expected to be subject to a special situation and therefore warrant study. Likewise, the special climatic conditions of a bimodal rainfall pattern with two intervening droughts justifies attention to the behaviour of the element under conditions of alternate wetting and drying.

A major factor that limits yield in tropical agriculture is the frequent occurrence of drought and moisture deficits created by high ambient temperatures and exposure to bright sun. Potassium is reported to pay a key role in regulating osmotic functions and in facilitating stomatal movement. This manifests in mitigating the ill-effects of drought and improves the capacity of the crop to cope with moisture stress.

Five studies (83/07, 85/15, 87/27, 89/28 and 89/29) have addressed the issue in such diverse crops as tea, rubber, coconut, rice, maize,mung bean and chilies.

The question of how potassium may influence nodulation of legumes and their competitive ability in crop mixes was examined in two projects (86/21 and 87/24).

It is known that potassium is antagonistic to the entry of other cations, in particular magnesium while there is a positive interaction with nitrogen. Three studies focus on these phenomena (83/04, 83/08 and 85/16). The crops concerned are coconut, rubber and the mixed cropping situation of coconut and cocoa.

Certain crops are regarded as heavy consumers of potassium. These include banana, tuber crops and certain vegetables. Four studies have therefore been directed to them (83/02, 83/05, 86/18 and 87/26). Cardamom and other minor export crops are relatively recent in their impact as systematically managed crops. Three of the studies carried out concern them (83/13, 83/14 and 85/16). Additionally the studies on potassium requirements of tea (83/06) rubber (83/08), pastures (86/19), legumes (86/21) and rice (87/25) seek to supplement and refine existing knowledge of the effects of potassium on the growth and yield of these crops.

Finally, a group of studies (83/04, 83/09, 83/12 and 86/20) are best described as inquiries into analytical methods, techniques and opportunities. Attempts to understand correlations between soil, leaf and nut water analyses in coconut, between soil and leaf analyses in rubber, an ecological approach to understanding soil potassium status by vegetational variation, effect of nutrient supplementation on growth of natural turf and the use of tomato "phytometers" and the possibility of using rubber factory effluents as fertilizer, comprise this group.

SUMMARY OF PROJECT FINDINGS

1. BEHAVIOUR OF POTASSIUM IN SOIL

1.1 Potassium in paddy soils

The study by Jayakody and Thenabadu sought to determine the dynamics of potassium behaviour in paddy soils. In a first screening of five paddy soils collected from geographically distinct areas, an incubation study showed considerable differences between them in K fixation, release and buffering capacities. Low K release was related to low non-exchangeable K and low buffering capacity. Addition of potassic fertilizer did not affect the non-exchangeable fraction as fixation capacity was low.

In the presence of the paddy crop, a sharp decrease in reserve potassium in the soil was associated with the rapid growth phase of the crop during the first month. From the second month to harvest, there was an increase in this fraction, suggested to be due to lower crop demand and replenishment from the added fertilizer and potassium carried in by irrigation water.

A leaching column experiment employing two soil types (Reddish Brown Earth and Non-Calcic Brown Soil) showed that the NCB soil leached almost twice as much K as the RBE. This was reduced by the presence of a crop but increased with application of potassic fertilizer. Consequent upon the increased leaching from the NCB soil, its reserve potassium was also shown to be depleted at the conclusion of the experiment at 32 days.

1.2 Soil Compaction and behaviour of soil potassium

Yapa and Nandasena examined the effects of soil compaction, moisture status and potassic fertilizer application on the dynamics of potassium within the soil and crop. Three soils from three locations were studied and the crop employed was maize which was intercropped with cowpea in one experiment.

Soil compaction reduces plant growth and results in a corresponding decrease in plant uptake and tissue potassium. While soil compaction affected grain yield adversely, potassium application had no effect.

There is a positive response of both tissue potassium and grain yield to soil moisture. Even with no applied potassium, yield was considerably improved by moisture alone. The response to potassium was greatly enhanced by improved moisture conditions. The maintenance of soil at 45 - 50% available moisture and with K_2O at 100 kg/ha, grain yield was enhanced more than six-fold.

In intercropped stands of maize and cowpea there was no response to potassium by either crop. In mixed stands, the yields of both maize and cowpea were inferior to those of sole stands of the crops, the depression being more marked in the case of cowpea.

However, the Land Equivalent Ratio, defined as the sum of the relative land areas required as sole crops to produce the yields achieved in the mixed stand, indicated a consistent superiority by intercropping. The improvement was however modest at about 10 -15% at one location and between 4 - 11% at the other.

Intercropping substantially reduced exchangeable potassium contents in the soil.

1.3 Soil potassium and sweet potato performance when grown under coconut

Welikala studied the influence of potassium fertilizer application on soils and on sweet potato yields grown as an intercrop under coconut. The experiment was replicated at fifteen sites in two districts - Kurunegala (IL1 agroecological region) and Gampaha (WL3 agroecological region). The soils covered a range of values for normal ammonium acetate extractable potassium. An attempt was made to relate sweet potato yields to applied potassium and the extractable fraction in each soil.

Sweet potato responded to added potassium at all sites with an optimum level being at the rather low value of 45 kg/hectare.

Correlations between surface soil test potassium and absolute yield were poor due to other complicating environmental factors. The relationship was slightly better when potassium at the 15 - 30 cm depth was considered.

"Percent relative yields" (defined as the yield without added potassium expressed as a percentage of the maximum yield obtained) correlated much better with soil test potassium.

It was noted that unfavourable conditions such as poor drainage, excessive light interception by coconut crowns and possibly magnesium deficiency impaired the correlations.

Soil potassium correlated well with leaf potassium levels which in turn influenced percent relative yields positively.

2. POTASSIUM, SOIL MOISTURE AND DROUGHT

Consistent benefits in mitigating the effects of drought are reported for the diverse crops on which studies were conducted under this project.

Reduced transpiration, better stomatal regulation and improved retention of water by plant tissues are reported. Visually, improved turgor, reduced wilting, sustained yield and lowered casualties are the favourable results of optimal use of potassic fertilizers.

2.1 Tea

Krishnapillai reports a reduction of transpiration and an increase of leaf diffusive resistance in nursery plants of a drought resistant and a drought susceptible tea clone. Growth response to potassium was however limited.

During the first three years in the field, a yield improvement of about 20% resulted from application of potassic fertilizer. Increased levels of potash however benefitted the performance during the exceptionally severe drought of 1987.

Strong indications of an antagonistic effect on magnesium absorption were obtained and increased supply of the latter in the high potash treatments resulted in a great improvement of yield. Additionally, the importance of matching increases in nitrogen supply is recognised.

2.2 Rubber

In experiments carried out on young rubber in the field and on small grafts in cement pits, Samarappuli and Yogaratnam report the superiority of mulching with paddy straw over traditional legume covers and "natural" (weed) covers. Mulching improved soil moisture retention, plant water use parameters and enhanced the effects of fertilizer applications. Potassium in excess of the recommendations was found to be detrimental to growth ("girthing").

However, when potted plants were subjected to moisture stress, supplies of potash above recommended levels ameliorated the effects of moisture shortage.

Treatment effects on growth, increase of girth, early attainment of a tappable stage and latex yield were supported by physiological parameters such as leaf nutrient contents, stomatal conductance, transpiration and leaf water potential.

Increase of potassium supply levels again suggested an antagonistic effect on uptake of magnesium.

2.3 Paddy

Cultivation of rice in the minor Monsoon Season for the Dry Zone (Yala or South West Monsoon) is constrained by lack of adequate water. Bandara addresses the question whether increased supplies of potassium to moisture stressed rice varieties in pot culture could alleviate the adverse effects.

Four popular rice varieties were studied under four irrigation regimes and three potash levels. While frequency of irrigation affected both vegetative growth and all of the yield parameters measured, the effects of potassium and the interactions were erratic. However, some positive indications were obtained that higher levels of potassium enhanced weight per panicle and number and weight of filled grains per panicle. High potassium levels also suggest a compensatory effect on the negative effects of longer irrigation intervals on yield parameters.

A special feature of this study was an evaluation of treatment effects on the accumulation of ninhydrin active compounds in leaf extracts determined by thin layer chromatography (TLC). The well documented accumulation of amio-acids under conditions of moisture stress, of proline in particular, was confirmed. At higher levels of potassium supply, proline accumulation was reduced. The effects were consistent for both vegetative and reproductive stages, for all varieties tested and for both soils used in the experiments.

2.4 Chillies and groundnut

The Non Calcic Brown (NCB) soils are of widespread occurrence in parts of the island. They have a low retentivity of water (less than 120 mm/M depth) and low nutrients, including available potassium. They therefore require high frequencies of irrigation and are responsive to fertilizer.

Mapa and Wadasinghe studied the performance of chilies and groundnuts at three levels of potassium supply and three water regimes on a representative NCB soil.

Groundnut yields were shown to be insensitive to both potassium supply and to moisture. This result is however suspect due to the reported rat damage in the experimental plots. Pod yield of chilies was not influenced by potash level but was higher in the treatment when the soil was maintained at field capacity (by irrigation at 3 day intervals) than at the 6 and 9 day frequencies.

High potassium supply increased the leaf diffusive resistance of both species in the water-stressed treatments, indicating improved stomatal control in response to drought. Shoot water potentials however showed no relation to levels of potassium.

Plant analyses at harvest time suggested that tissue potash percentages were lower in groundnut than in chilies. Uptake of potash by groundnut was more sensitive to soil moisture level than was the case for chilies. Soil potassium determinations at the commencement and conclusion of the experiments were consistent with he observations on plant uptake.

The authors conclude that currently recommended potash levels for groundnuts and chilies are adequate to enable these crops to tide over moderate droughts.

Plots of Groundnut at diffrent K and soil moisture levels (CIDA/89/29)

3. CROP RESPONSES

3.1 Banana

Banana is considered a crop with a high potassium demand. With yields of 50 tons per hectare of fruit being possible, removals of the element from the soil could be as high as 1500 kg K per annum. Although an important horticultural crop, banana in Sri Lanka is poorly managed. Neither inorganic nor organic fertilizers are applied and cultivation and field sanitation practices are often neglected. Consequently, yields are poor.

Padmasiri and Jinadasa set out to determine the requirements of major fertilizers for banana and the effects of mulching with straw and cattle manure.

There is an apparently much lower response to nitrogen and potassium than seems to be the experience in other countries. Thus, while the requirements for these elements appear to be 120 kg N/ha/year and 240 - 360 kg K_2O /ha/year, other countries routinely add quantities ranging from 280 - 600 kg/ha/yr of N and anything from 400 - 1300 kg/ha/yr of K_2O.

Possible reasons for this may be that the cultivar "ambul" used in these experiments has lower demands than commercially cultivated varieties elsewhere, that some other factor (possibly moisture deficits) limit response or that operational difficulties have distorted the results. The authors comment that disease, pests, wind damage and theft compelled the abandonment of some sites. Of 15 sites at which trials commenced, only 6 were finally considered valid for analysis.

The modest requirement for potassium in these trials is further substantiated by the reported accumulation of soil K with higher levels of supply.

Measuring girth of banana plants at flowering stage (CIDA/83/02)

3.2 Vegetables

The Intermediate Zone of Up-Country Sri Lanka is important as a vegetable growing area. In some of the lands a succession of vegetables in rotation, is the traditional farming practice.

Wijewardena and co-workers report a lack of response to applied potash, of the early crops in a sequence. High yielding crops however require about 100 kg of K_2O per hectare.

In the absence of K and Mg applications yield decline commenced with the second crop in the sequence and continued. Likewise, continued applications of K showed residual effects from the third crop onwards.

In contrast, repeated applications of magnesium did not show residual effects. This is interpreted as due to leaching losses from the acidic soil at the experimental sites.

The fertilizer response of successive crops was seen to be influenced by the particular components of the sequence.

(This account is taken from the authors' summary in the absence of the whole paper).

3.3 Tea

The potassium nutrition of tea has received fair attention and some of the major features are as follows:

The response to applied K is generally slow to appear as also the harmful effects of suspending applications of this nutrient. Although crop removed contains nearly half as much K as N, response to the former have been comparatively modest. The long term effects of K deprivation on the formation of wood in the bush frame are quite substantial. There is a strong interaction between N and K on yield and latterly, the observation that high levels of K have an antagonistic effect on magnesium uptake.

Krishnapillai examined the need to enhance levels of K supply necessitated by sharp increases in N applications to tea and the possible deleterious effects on magnesium uptake. Hitherto, at relatively modest levels of N supply up to 240 kg/ha/year, the corresponding potash requirement was about 140 kg/ha/year. When the nitrogen was increased to 360 kg/ha/year and magnesium supplied at 30 kg MgO as kieserite, the tea responded up to 180 kg of potash.

At very high levels of up to 360 kg potash, visual magnesium deficiency symptoms were manifested. Responses to potassium were consistently enhanced by concurrent application of magnesium.

3.4 Rubber

Potassium is not of particular importance as a nutrient for rubber and the soils on which it is grown appear generally to be adequately supplied with this element.

Yogaratnam and Iqbal examined the possible effect that potassium fertilizers may exert on the early growth of grafts of some commercially important clones grow in five representative soil series. Early growth parameters and girthing which is important for tappability were examined.

The results were generally negative - the potassium supplying capacity of the soils being adequate to support early growth without the need for added potassic fertilizer.

Potassium deficiency in rubber (CIDA/83/09)

Magnesium deficiency in rubber (CIDA/83/09)

Straw as source of potassium for tolerance to moisture stress (CIDA/85/15)

3.5 Coconut

That potassium is the most important major nutrient for coconut has been well established in experiments. However, in the heavily leached sandy and lateritic soils, its continued application has resulted in widespread magnesium deficiency which is now regarded as a major reason for poor yields in otherwise well fertilized coconut plantations.

Jeganathan examined the effects of differential potassium and magnesium fertilizers on mature coconut in two ecologically distinct regions. At the site in the wet zone, there was a significant improvement of yields with potash application. This was not so at the site in the intermediate zone over the five year period of the experiment. There seemed also to be an overall decline in yield in successive years, particularly at the higher K levels.

Although there was no yield response to differential Mg applications, in the sixth year, magnesium levels were doubled. This led to an improvement in magnesium status within the plant but has not caused a yield benefit in the first year following the change.

It is suggested that the effects of droughts have modified response to fertilizer treatments.

Analyses of leaf and nut water samples broadly displayed the classical antagonisms between cations.

Magnesium deficiency in coconut (CIDA/83/04)

Potassium deficiency in coconut (CIDA/83/04)

3.6 Cardamom

Apart from the major agricultural crops, information on fertilizer requirements is scanty. With the recently awakened interest in the so-called "minor export crops", Sumanasena and co-workers sought to determine the effects of NPK fertilizers on cardamom. Existing fertilizer recommendations are empirically based on experience in other countries and on reported performance on local plantations.

It would be relevant to mention that estimated local yields are inferior to those reported from other countries. The present investigations suggest that the major fertilizer nutrients are not the limiting factors. Rather it seems that moisture available (rainfall and soil depth) is the most important. It could also be that non-selected planting material and the consequent genetic mix is not particularly responsive to applied fertilizer. However, certain characteristics as number of shoots (suckers) and panicles were benefitted by fertilizer applications.

The authors conclude that measures to mitigate the effects of drought - by proper shade management, irrigation and improvement of soil moisture storage by soil conservation measures and mulching practices, with a selection of planting material are likely to enhance production more than changes in fertilizer practices. They recommend annual applications of 120 kg of N, 75 kg of P_2O_5 and 80 kg of K_2O per hectare in two equal split applications. This represents a substantial reduction of K_2O from the currently recommended 150 kg/ha/year.

There was an indication that damage from stem and capsule borer, an important pest, was lesser at the higher levels of K_2O from the currently recommended 150 kg/ha/year.

There was an indication that damage from stem and capsule borer, an important pest, was lesser at the higher levels of K_2O tested.

3.7 Cocoa, coffee, pepper and cinnamon

Fertilizer use on these crops is generally poor and they are often merely components of a village garden crop mix.

Recognizing a need for expanding fertilizer use through demonstrations, Kathirgamathaiyah conducted a series of 26 trials distributed throughout the country. the plots were simple comparisons between unfertilized controls, those receiving the Departmental recommendations and those receiving 1 1/2 times the recommended fertilizer mixtures.

Mature cocoa showed no response to fertilizer. Coffee showed visual differences but the yield differences fell short of significance. Cinnamon and young pepper showed significant improvement at the recommended fertilizer level. Mature pepper was significantly improved beyond the recommended level and up to the highest tested.

The demonstration plots are reported to have served well for farmer training classes and also resulted in an increased use for fertilizers by cultivators of these crops.

3.8 Cocoa grown under coconut

In Malaysia, South Pacific Islands and India, cocoa is a popular and profitable intercrop with coconut. In Sri Lanka, this combination is uncommon but is encouraged because of its agronomic suitability and the favourable demand for cocoa beans.

Liyanage and Dassanayake set out to determine fertilizer requirements of cocoa grown under a mature stand of coconut in the wet zone. Four levels of nitrogen and five levels of potash in all combinations were tested and growth performance and yields followed through nine years.

In the earliest stages, neither leaf number nor plant height were affected by the fertilizer treatments. With increasing age, both fertilizers had favourable effects on girth and canopy width. There was also a positive N & K interaction. Nitrogen also advanced flowering and bearing while potassium was without consistent effect.

It was apparent that yield parameters were all benefitted by applications of fertilizer. Pod numbers, dry bean yield, beans per pod and 100 bean weight showed either quadratic or linear responses to N and K. Interactions between the two nutrients were also positive.

Leaf nutrient contents were as expected with magnesium levels showing a declining trend with increased K.

Nut yields of palms in the intercropped plots were consistently higher than those outside the experimental area.

The authors conclude that 100 g N (260 kg urea/ha) and 120 g K_2O (240 kg Muriate of potash/ha) constitute the optimum for cocoa under coconut in the wet zone from the third year onwards. In the first and second years after planting, the quantities applied were one - third and two - thirds respectively.

3.9 Tuber crops

Potassium is assigned a position of special importance in supporting the yield of tuber crops. This is believed to be due primarily to its role in favourably influencing photosynthesis, translocation of photosynthates and processes relating to their storage.

Sangakkara examined the responses of sweet potato, cassava and *Xanthosoma,* turmeric and ginger to different levels of potassium. The influence of potassium on time taken to initiate tubers in potato seedlings grown from true seed and plants arising from vegetative propagules was also determined.

The application of 225 kg of potash per hectare increased the yields of sweet potato, cassava and *Xanthosoma* about four - fold over the zero-potash control. Improvement in both bulking rate and number of storage units was recorded as being related to the increased yield.

Similar results were obtained with turmeric and ginger, although their requirements of potash were about 100 kg potash/hectare and the maximum yield was about double that of the zero - K control.

Especially where low fertilizer rates are employed, there is a benefit in splitting the allocation equally into a basal and a top dressing. When only a single application is possible, this is better done as a basal dressing. It appears that the requirement of potash by the crops studied, continues throughout all stages of their growth cycle.

Results show that increased application of potassium fertilizers advances the time to tuber initiation in potato and cormel initiation in *Xanthosoma.*

The major objective of the study by Harischandra and Kahandawela was to evaluate the performances of sweet potato, chinese potato *(Coleus rotundifolius)* and taro *(Colocasia esculenta)* on three soil classes in the low country. N,P,K and Ca applications were examined as also the application of organic matter.

Strikingly different sweet potato yields were recorded in the three different classes of soil (upland - eroded but well drained, lowland - ill drained and deniya - intermediate). These varied between experiments and were not consistent.

Responses to fertilizer effects were also somewhat erratic. Organic matter additions had a strong effect on tuber yields and on response to potassium fertilizer except in situations where the inherent organic matter levels were high.

The authors might have devoted attention to examining why sweet potato yields under lowland conditions ranged from 1.4 (Experiment 5) to 50.6 tons/hectare (Experiment 7). Somewhat similar situations are reported in respect of Chinese potato and taro as well.

Tentative fertilizer recommendations for the different tuber crops and the three types of soils are made.

3.10 Fodder

Premaratne and Premalal investigated the effects of potassium fertilizer on the fodder grass *Panicum maximum* when grown in pure stand and mixed with three common legumes *Stylosanthes hamata, Centrosema pubescens* and *Macroptilium atropurpureum.* The objective was to complement the N-fixing activity of the legumes with applied potash, and thus to benefit growth of both components of the system.

The results were largely negative, there being no worthwhile effects on growth of either grass or legumes. Legumes however improved the performance of the associated grass with the effect of *Stylosanthes* being the lowest - suggesting competition by this legume.

The levels of potash used in the experiments were low with a maximum of 90 kg/ha/year as a basal application. Literature cited in the paper suggests removals of 440 kg/ha/yr by high yielding grasses and about 200 kg/ha/yr by pasture legumes.

It is apparent from the graphs presented for yields from successive cuts, that an over-riding effect is exercised by rainfall received. Any effects of fertilizer would therefore be secondary.

3.11 Cover crops

Leguminous cover crops for coconut have found wide acceptance in several coconut growing countries. In Sri Lanka however, there is only limited observance of this practice due to a prejudice based on observations that in certain situations, ground covers have adverse effects on yield. This would suggest that balanced fertilizing of the cover crop to overcome early adverse effects would lead to the securing of long term benefits.

Liyanage examined the effects of three levels each of N,P, K and Mg on the establishment, early growth and yield of *Pueraria phaseoloides* under a mature coconut plantation. The duration of the experiment was four years.

N was without significant effect on establishment of the cover crop. The effects of K and Mg were slight while P exerted a significant beneficial effect. Similar results were obtained in regard to nodulation at six months - except that the trend was negative at the highest level of N.

Dry matter yields were improved by applications of N,P and K while Mg caused only very slight improvement above the zero level.

The expected interactions between nutrient elements were reported in respect of growth and leaf nutrient contents.

It is recommended that fertilizer at the rates of 35 kg N, 80 kg P_2O_5, 60 kg K_2O and 25 kg MgO were the most suitable levels for *Pueraria* under coconut. The yields of the main crop are unaffected by the cover crop.

3.12 Legumes

Sangakkara evaluated the influence of potassium on growth, yield, nodulation and nitrogen fixation by the important legumes bushbean, mungbean, cowpea, chickpea and groundnut.

The major conclusions are as follows:

Potassium is important for all of the selected crops in increasing growth, yield and nodulation. Bushbean, mungbean and cowpea yields are improved by more than 100% by a basal application alone.

Requirements of potash for optimum yields are 80 kg for groundnut and mungbean, 120 kg for cowpea, 150 kg for bushbean and 180 kg for chickpea.

Nodulation of all species is enhanced by potassium., This is specially pronounced in bushbean which is generally considered a poor nodulator. In the other crops, the increase in nodule number is only upto the first potash level, declining thereafter although nodule weights continue to increase.

Potassium sulphate is consistently superior to the chloride in increasing yields of bushbean, mungbean and cowpea and marginally better inducing nodulation. However, its greater cost per unit of K would not warrant its wide acceptance.

Where a single application of fertilizer is made, a basal dressing is superior to a top dressing. Optimum yields are obtained with split applications. The results suggest a nutrient requirement throughout the growth cycle. The ratios in which the two applications are allocated is suggested to be influenced by growth duration of the particular crop and the level of K supply.

Using N - 15 labelled fertilizer, potassium supply levels were shown to significantly improve nitrogen nutrition and biologcal N - fixation by mungbean and cowpea.

Using N - 15 methodology, Senaratne addressed the possibility of alleviating the growth depression of groundnut and mungbean when grown as intercrops with maize.

All three legumes were shown to actively fix atmospheric nitrogen when grown in association with maize, 78 - 85% of N being estimated to be derived from the atmosphere. The N derived by the maize from the associated legume ranged from 7 - 26% with groundnut being the best.

When different cultivars of groundnut were tested, significant differences in N - fixing ability were noted. Likewise, there were marked differences in the transfer of fixed N to the associated maize. The cultivar which fixed the most N grew vigorously and depressed the growth of maize. High nitrogen fixing ability therefore does not necessarily lead to high nitrogen supplying ability. The author suggests that maximum benefit from the associate legume crop could be expected in low fertility situations when moderate growth of the legume would reduce its suppressing effect on the cereal associate.

Studying the reverse situation where the cereal crop depresses legume performance, it is reported that while mung bean as a sole crop derived no significant benefit on yield parameters from K supply, there were significant benefits when it was grown as an intercrop. The optimum level of K was 80 kg/ha.

Similar results were obtained with groundnut, where in addition it was shown that N-fixation was also not affected when grown as a sole crop. When intercropped, the lack of K depressed all growth parameters and N - fixation. The effects are overcome by supplying K.

The author concludes that productivity of legume/cereal intercropping systems could be enhanced by appropriate potash fertilizer applications.

3.13 Annual crops - "slash and burn" system

The "slash-burn" (or "chena") system is a widespread system of cultivation, especially in the Dry Zone. With increasing pressure of population, fallow cycles have become shorter with consequent declines of yield and deterioration of land.

Handawela and Karunatillake set out to investigate whether upland dry farming could be stabilised by applying potassium fertilizer to counteract fertility decline due to shortened fallow cycles. As burning is a standard practice prior to growing of the crop, continuous cultivation could be expected to result in loss of potash added in the ash from burning.

There was no effect of added potassium fertilizer on yield in the first two seasons of cropping.

Where soil and moisture was conserved and biomass recycled, there was no response to potassium up to the third year from bush felling.

The experiment had to be discontinued in the third year.

4. NON CONVENTIONAL TECHNIQUES

Pemadasa and Chandrasena engaged in an exhaustive ecological/physiological study designed to evaluate the fertility of soils in the southern district of Matara.

The approach adopted was two-fold. The first comprised a detailed survey and study of floristic data collected from about 150 sites distributed throughout the district and representing different topographies, altitudes, climates, soil types and land uses. The results indicated that the vegetational composition reflected the diversity and versatility of the different environments. Overall, they were indicative of the degradation resulting from human intervention, destruction of the natural vegetation and denudation by erosion. Soil analytical data confirmed the generally low nutritional status of the major elements and the variation between and within habitats. The results of human intervention were generally adverse.

The second part of the study concentrated on five selected sites representing a range of land use systems and a wide geographical distribution. Transported blocks of turf collected from the sites and grown in pots in a uniform environment and site soils on which tomato was grown as the experimental plant were employed to obtain information on growth responses to various added nutrient solutions. The exclusion of nutrient elements singly and in combinations revealed that nitrogen and phosphorus were the principal limiting nutrients. Although the levels of potassium were low, they seemed adequate to meet the needs of the test plants.

Different levels of potassium supply endorsed the view that soil resources are adequate and supplemental additions were without advantage.

It is also concluded that levels of magnesium and calcium and of the minor nutrient elements were adequate in soils of the district.

The authors conclude that poor vegetative growth of native species was largely attributable to severe deficiencies of nitrogen and phosphorus while the supply of potassium was adequate for the best growth of plants and there was no benefit to be derived from the addition of this nutrient.

In the manufacture of rubber after removal of the latex coagulum, large quantities of serum or effluent need to be disposed. This liquid fraction contains the residue of coagulant (formic or acetic acid) and the aqueous components of latex. It is often an embarrassment as it is a pollutant of natural waterways and emits an unpleasant odour during microbial breakdown.

The literature reports that considerable efforts have been made to explore the use of latex serum as a fertilizer because of its richness in nutrients such as N(625 ppm), P(646 ppm), K(745 ppm), Mg 9140 ppm), Ca(83 ppm) and Na(366 ppm).

De Zoysa *et al.* extended work on the possible use of rubber factory effluents as a substitute or partial supplement for currently recommended inorganic fertilizer mixture for rubber and paddy. The study involved a large number of analyses of plant growth parameters, leaf and soil nutrient contents and yields of rubber and paddy.

The study confirms the potential for the use of latex serum as fertilizer.

In the case of rubber, the use of this material is found to be as good as the normally recommended fertilizer mixture. From the results it seems apparent that mature rubber is not responsive to fertilizer applications while at the young stages, fertilized treatments are superior to the zero controls.

In the case of paddy, it was found that latex effluent could substitute for half the recommended fertilizer application.

The results obtained recommend the further study of rubber factory effluents - alone or as supplements to inorganics in different environmental situations and on different crops.

Jayasekera employed amputated seedlings of coconut grown in sand culture under glasshouse conditions to study the effects of potassium, nitrogen and chlorine on growth and a number of physiological parameters. By including different degrees of moisture stress as treatments, the emphasis was on osmotic control, stomatal regulation of transpiration and changes in soluble cellular components. Nutrition was precisely controlled by the use of modified Armon and Hoagland nutrient solution.

The degree of control exercised on the experimental conditions, the instrumentation used in measuring physiological parameters and the focus on fundamental biochemical and physiological criteria prompts the inclusion of this study in the category of non-conventional techniques.

Net assimilation rates, transpiration rates and leaf water potential are enhanced by adequate supply of K and N. The beneficial effects of K on gaseous exchange and maintenance of cell turgor are suggested to be due to the capacity of this element to behave as an osmoticum. Chlorine also appears to perform a similar function although sodium is not able to replace potassium in respect of this function.

Chlorine appears to be naturally available in adequate quantities in the environment, and neither adverse effects from its absence nor benefits from its addition, could be established in these trials.

Nitrogen is shown to enhance photosynthetic activity, soluble sugars and chlorophyll production.

These experiments establish a useful technique for the study of physiological processes fundamental to growth and drought responses of coconut.

SUMMARY

The task of summarising the accomplishments of the CIDA funded research programme on potash has not been an easy one.

That a single programme devoted to a well defined area, involving 29 individual projects and at least eight institutions and sustained through nine years, is by itself a signal achievement.

The impact of the programme in upgrading scientific and technical capability and skills among the two dozen or so direct participants is no doubt a considerable though intangible benefit of the programme. When all of the peripheral participants in analytical and experimental inputs are accounted, it is probable that the beneficiaries would number around fifty. This represents a very sizeable contribution towards investment in human resources.

The programme has also provided the means and justification for augmenting facilities and instrumentation at several of the institutions. These will constitute a lasting and continuing benefit towards research and training.

At least one participant has received direct support towards obtaining a post-graduate degree. It is probable that a few more may have been able to use the work done under the CIDA Programme as part fulfillment of requirements for post-graduate research degrees.

The listed output of 19 papers and communications is an index of the value of this programme.

A major objective of the programme was to obtain precise information on the response of different crops under different conditions to muriate of potash.

About thirty different crops and cropping situations have been considered in this series of experiments. Understandably, the responses reported have ranged from negligible (fodder grass, pasture legumes, rubber) through moderate (for most of the crops studied) to high (tropical root crops and grain legumes). Considering the wide variations in the soil types and environments covered, this generalization is subject to modification in individual cases. However, it would be valid to interpret the results as indicating that no situations have emerged where the lack of potassium has by itself been identifiable as a major limitation to productivity. Sri Lankan soils are probably capable of meeting much of the need for this element by crops.

In general, the results have endorsed the practices and levels of supply recommended for potassium fertilizers for the different crops.

One of the objectives of a review such as the present one is to identify improvements that the experiences gathered suggest for incorporation into future programmes. The writer in so doing does not imply any criticism of the planning and execution of the projects. Nor does he seek to exploit the advantages of hindsight. Having personally participated in all of the three review seminars held in connection with this project, he is therefore party to any blame that could accrue on this account!

Sri Lanka has a fair record of experimentation on fertilizer and it is therefore no surprise that this series of studies has not uncovered any examples where existing recommendations are off the mark. On the other hand additional endorsements of validity have been forthcoming.

In the quest for new knowledge, it could be argued that an approach different from the classical field trial of the factorial type might have proved to be more informative. It is noted that determining the amounts of potassium removed in the drainage water was also one of the objectives of the programme. Concerns have already been expressed about the possibilities of nutrient contamination of domestic water supplies, eutrophication of reservoirs and the financial loss resulting from the fertilizer runoff. One cannot help but feel that a greater emphasis on "balance sheet" types of study may have been very rewarding. One direct study and several references to changes in the potassium within the soil suggest that a comprehensive attempt to quantify leaching and other losses would have yielded valuable information.

That several of the studies also included considerable analyses of soil potassium for changes during the experiment, indicates that the researchers were alive to the need to interpret their findings taking this factor too into account. However, there are no attempts to reconcile in quantitative terms, applied potash with crop removals, soil changes and losses by leaching. Simple phytometric studies, including the use of inert media to eliminate the complexities of soil behaviour, may have provided useful leads to complement the results of field studies.

It is commendable that most studies have included precise determination of soil characteristics, often at start and finish. The implicit relevance of soil physico-chemical parameters, suggests that one programme component might have been a comprehensive survey of the inherent potash status of representative soils over a bróader spectrum. This would have been economical in terms of effort, equipment and time. It would also have ensured uniformity and served to supplement the information available on soil chemistry. Tò my knowledge, the existing information on geo-chemistry of Sri Lankan soils does not cover potassium.

An impressive volume of data on growth parameters besides yield, is embodied in many of the study reports. It is probable that the rationale for collecting this information was its possible importance in finally interpreting main effects. As is the common dilemma in field research, the eventual differences (or their lack) are often inadequately explicable with the data gathered. Thus a great deal of painstaking work is without demonstrable reward. It would be better to first establish the magnitude of treatment differences and then to decide what particular information may be of relevance to gather in a second run, in order to understand the response. However, where a programme is of limited duration, this may be a luxury beyond practical reach.

There is the advantage that what is now seemingly unusable data would still be at the disposal of future workers by reference to the Final Reports prepared by the grantees.

A great deal of analytical data on leaf and tissue nutrients is furnished by the work under the CIDA programme. This too has value for future work although one notes that the data has followed expected patterns confirming classical observations on nutrient uptake interactions and antagonisms.

If one may point to a deficiency that may have arisen out of excessive concern and effort into such indirect performance indicators, it is that in several instances, this has deflected attention away from the main concerns of yield and quality. It is possible that this apparent obscuring of the main concerns is merely an impression created by a generous presentation and discussion of the finer points of analytical results!

Experiments most often include a "zero treatment" as control. This is the extreme at one end of the scale. It is reasonable to suggest that similarly, an extreme treatment (subject to the proviso that it should not be ridiculous!) towards the other end of the scale, may also provide useful information. It would at least eliminate the possibility that a lack of response is due to all of the treatments tested falling below a threshold minimum. A greater boldness in experimenting with upper levels well beyond current recommendations might have provided interesting observations without grossly increasing expenditure or effort. This is presented as a suggestion prompted by the fact that in many studies, treatments tested are conservatively close to existing recommendations. Finally, several of the studies concern perennial crops and some refer to an interest in "long term effects". Regrettably, programmes such as the present one must of necessity be subject to limitations of time. Nearly eight years of the present series, may seem a long time but not so where the subject is a perennial crop or the object is to study soil changes or the effects of a successive series of actions. Even with the cessation of the CIDA Project, no doubt where warranted, means will be found to continue support to research studies where it is felt that information over the long term would be of practical value.

Annex I

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Annex 2

PARTICIPATING INSTITUTIONS

1. Department of Agriculture

    1.1 Central Agricultural Research Institute, Gannoruwa, Peradeniya.

    1.2 Regional Agricultural Research Centres

        1.2.1 Angunakolapelessa
        1.2.2 Bandarawela
        1.2.2 Bombuwela

2. Department of Export Agriculture, Getambe, Kandy.

3. Coconut Research Institute, Lunuwila.

4. Rubber Research Institute, Agalawatte.

5. Tea Research Institute, Talawakelle.

6. University of Peradeniya, Peradeniya.

7. University of Ruhuna, Kamburupitiya.

8. University of Ruhuna, Matara.

Annex 3

PUBLICATIONS UNDER THE CIDA POTASIUM FERTILIZER RESEARCH PROGRAMME

Project 2: - Nil

Project 3: - Keerthisinghe, D.G., Jayakody, A.N. & Thenabadu M.W. - Potassium Release Characteristics of Six Sri Lankan Soils. *Sri Lanka J. of Agric. Sci.* **23**(2): 1-3 (1986).

- Keerthisinge D.G., Jayakody, A.N.& Thenabadu, M.W. - Effect of Soil Moisture on Availability of K in Soils. *Sri Lanka J. of Agric. Sci.* **23**(2): 70-83 (1986).

Project 4: - Jeganathan, M. - Studies on Potassium - Magnesium Interaction in *(Cocos nucifera).* In: *"Plant Nutrition - Physiology and Application"* (ed M.L. van Beusichem) pp. 611-617 (1990) Kluwer Academic Publishers.

- Jeganathan, M. - Nut Water Analysis as a Diagnostic Tool in Coconut Nutrition. Commun. *Soil Sci. Plant Anal.* **23** (17-20), 2667 - 2686 (1992).

Project 5: - Nil

Project 6: - Released new circular on *"Dolomite Application for Tea Soils"* Tea Research Institute, Talawakelle (1989).

Project 7: - Krishnapillai, S. Response to Magnesium Fertilizer in Young and Mature Tea - *Better Crop International*, **7**(2): 12-15, (1991).

Project 8: - Nil

Project 9: - Weerasuriya, S.M. and Yogaratnam, N. - Effect of Potassium and Magnesium on Growth of Young *Hevea brasiliensis. Rubber Research Institute of Sri Lanka*, **68**: 17-31 (1988).

- Weerasuriya S.M., and Yogaratnam, N. - Effects of Potassium and Magnesium on Leaf and Bark Nutrient Contents of Young *Hevea brasiliensis. Journal of the Rubber Research Institute of Sri Lanka*, **69**: 1-20 (1989).

Project 10: - Liyanage, L.V.K. Wijeratne, A.M.U. and Fernando, W.S.M.A. Effect of Nitrogen, Phosphorus, Potassium and Magnesium on the Early Establishment and Subsequent Growth and Yield of *Pueraria phoseoloides* Grass under Coconut. *Cocos* 10.

Project 11: -

Project 12: - Nil

Project 13: - Liyanaarachchige D.H. Sumanasena, H.A. Sritharan, R. Perera, H.A.S. and Wickremasinghe, P.J. - A Study on Association of Yield components in Cardomom, (*Elettaria cardomomum.* maton) found in Sri Lanka *Proc. Sri Lanka, Associ. Adv. Sci.* Part I, 49, (1991).

Project 14: - A booklet titled - "Fertilizer Use on Minor Export Crops" (1985).

Project 15: - Nil

Project 16: - Nil

Project 17: - Yapa L.G.G., Wanasundera, W.M.U.N. and Punyawardena, B.V.R. - The Role of Potassium Fertilizer in Drought Tolerance of Corn Grown in Non-Calcic Brown Soil (Haplustalfs). *J. Soil Sci. Soc. Sri Lanka*, **7**: 76-90 (1991).

- Wanasundera, W.M.U.N. and Yapa L.G.G. Influence of Soil Moisture and Potassium Application on Availability and uptake of K and Growth of Corn (Zea mays. L.) - Sri Lanka *J. Agric. Sci.* **26**: 65-73 (1989).

Project 18: -

Project 19: - Premalal, G.G.C.,Bandara, D.C. and Premaratne, S. Effect of K Applications and Growth of Legumes on Establishment and Persistence of Pastures in the Mid-country of Sri Lanka. *Proc. Sri Lanka Associ. Adv. Sec.* Part I (Abstracts), 72 (1988).

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- Premalal, G.G.C. and Premaratne, S. Effect of K and Associated Legumes on the Crude Protein Content of Pastures in the Mid-country of Sri Lanka Proc. Sri Lanka Association Adv. Sci. Part I Abstracts (1990).

- Premalal, G.G.C., Bandara, D.D.C. and Premaratne, s. Establishment and Growth of Legume Pastures Mixtures in the Mid Country of Sri Lanka. Sri Lanka J. Agric. Sci. 27: 90-97 (1990).

Project 20: - Nil

Project 21: -

Project 22: -

Project 23: - Nil

Project 24: -

Project 25: - Nil

Project 26: - Nil

Project 27: - Mudalige, R.G., Ranasinghe, C.S. and Jayasekera C. The Effect of N, K and Cl on Water Relations and Vegetative Growth of Coconut Seedlings. *Proc. Sri Lanka Assoc. Adv. Sci.* Part I (Abstracts) (1990).

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Project 28: - Nil