RELEASE OF NITROGEN AND POTASSIUM FROM ROOT CONTACT PACKETS OF UREA AND MURIATE OF POTASH AND THEIR CROP RESPONSES

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By

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THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF HORTICULTURE
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1992

To My Appa & Mummy

DECLARATION

I hereby declare that the thesis entitled 'Release of nitrogen and potassium from root contact packets of urea and muriate of potash and their crop responses' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or any other similar title, of any other University or Society.

Vellanikkara,
13-7-1992.

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CERTIFICATE

Certified that the thesis entitled **'Release of nitrogen and potassium from root contact packets of urea and muriate of potash and their crop responses'** is a bonafide record of research work done by Miss. JOMOL P. MATHEW, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Miss. JOMOL P. MATHEW, a candidate for the degree of Master of Science in Agriculture with specialisation in Agronomy, agree that the thesis entitled 'Release of nitrogen and potassium from root contact packets of urea and muriate of potash and their crop responses' may be submitted by Miss. JOMOL P. MATHEW, in partial fulfilment of the requirement for the degree.

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(JOMOL P. MATHEW)

CONTENTS

LIST OF TABLES

List of Tables (contd...)

List of Tables (contd...)

LIST OF FIGURES

LIST OF PLATES

Introduction

INTRODUCTION

Fertilisers have played an undisputed dominant role in the burgeoning of India's food grain production. Efficient use of plant nutrients results in higher profits for farmers and also reduces the risk of environmental pollution which all the sources of plant nutrients are capable of creating if they are misused.

Although nitrogen and potassium fertilisation has been profitable in most crops, their efficiency of utilisation has been rather low especially in the Kharif season. This is due to the heavy losses of fertiliser nitrogen and potassium applied to crops grown during rainy season when heavy monsoon showers are experienced. Being highly soluble and mobile in soil, leaching losses of nitrogen and potassium applied in soil are high. This form of loss assumes importance especially in coarse textured soils. Fertiliser manufacture is very energy intensive and in order to save on the energy it would be prudent to evolve energy efficient production methods and reduce the field nutrient losses.

The efficiency of fertilisation or nutrient supply in wider perspective depends on matching the supply rates in the root zone to the needs of the plant in its various growth phases as defined and related to climate. As soil interferes to a large extent with the availability and the movement of nutrient ions by its physico-chemical and fixation properties, there is a need for both accelerating and retarding the nutrient release in the soils for matching it to plant's requirements. Slow rate of availability of fertiliser nutrients is important in plantation crops also, as they require year round availability of fertiliser nutrients. The high solubility of nitrogen and potassic fertilisers may lead to luxury consumption in early part of the growing season and inadequate supply of the elements for subsequent growth.

A multitude of ways have been suggested by various workers to reduce the losses of nitrogen and potassium from agricultural soils. Eventhough measures such as split application, placement etc. are well recognised and practised, use of coated fertilisers and other slow release fertilisers is restricted at present because of cost factor. Eventhough indigenous materials like neem cake are reported to improve the efficiency of nitrogenous fertilisers by inhibiting the nitrification rate, difficulties arise in their practical application due to local non-availability.

Studies by Asokan et al. (1985) revealed that there was substantial retention and slow release of urea and muriate of potash when packed in perforated polybags, the release rates being dependent on the number of perforations provided. These root contact packets are useful in plantation crops in order to provide adequate supply of nutrients throughout the year, as relatively large quantities of fertilisers are applied for a plant at a time. There is also scope for large-scale factory production of root contact packets without much additional cost. Hence the present study was envisaged to assess the dissolution rates of urea and muriate of potash placed in root contact packets and their crop responses.

The objectives of the study are:

1. Assessment of dissolution rates of urea and

muriate of potash applied as root contact packets of varying sizes and porosities.

2. Assessment of the advantage of applying urea and muriate of potash as root contact packets on crop growth.

Review of Literature

REVIEW OF LITERATURE

Being highly mobile in soil the efficiency of the applied nitrogen and potassium fertilisers is very low especially in the tropical situations where the heavy monsoon showers cause leaching losses of these nutrients. A multitude of ways have been suggested by several workers to reduce these losses and to improve the fertiliser use efficiency. A brief review of the recent and important contributions made on this line are presented here.

A. Nitrogen fertilisers

A number of nitrogenous fertilisers are being produced by the industry. These include, ammonium phosphates, calcium ammonium nitrate, ammonium sulphate, ammonium chloride and ammonia forming fertilisers like urea. Urea is the main source of nitrogen in the country contributing to 80 per cent of the total nitrogen produced (Kumar and Misra, 1985). The high nutrient content and low handling and distribution costs of urea compared to other straight nitrogen fertiliser sources, give it an advantageous position.

1. Mineralisation of urea

Upon application to soil, urea is acted on by the enzyme urease, which hydrolyses it to unstable ammonium carbamate which is immediately broken down to ammonia and carbon dioxide.

Urease, which catalyzes the hydrolysis of urea occurs universally and is abundant in soils. Large numbers of bacteria, fungi and actinomycetes in soils produce urease. A small group of bacteria known as urea bacteria have the exceptional ability to decompose urea. Urease activity in soils is known to vary with location, depth, season and forms of nitrogenous fertilisers used (Bhavanandan and Fernando, 1970).

Sankhayan and Shukla (1978) reported that about 57 to 82 per cent of added urea nitrogen was mineralised within one day of incubation in fine soils. More and Varade (1982) observed that 65 per cent of applied urea nitrogen was hydrolysed within two or four days at various moisture potentials. Yadav and Shrivastava (1987) noticed that applied urea nitrogen was hydrolysed completely within one week in a sandy loam soil.

2. Recovery of applied nitrogen

The available information shows that the fertiliser use efficiency of nitrogen fertiliser is low, often less than 30 per cent for low land rice and 50-60 per cent for irrigated upland crops (Chauhan and Misra, 1985).

3. Causes of low recoveries

The shortfall in recovery of applied nitrogen may be due to the various mechanisms by which nitrogen is lost from the soil.

The amount of rainfall immediately after fertiliser application has been shown to be an important factor affecting urea efficiency (Burg _et al_., 1982; Harper _et al_., 1983; Bouwmeester _et al_., 1985; Black _et al_., 1987; Herlihy and O'Keefe, 1987; Hoult and Mc Garity, 1987).

Almeida (1965) reported that substantial quantities of nitrogen was lost by way of leaching from ammonium sulphate. Work by Weise in 1966-70 revealed that annual leaching losses from sandy soils in Germany averaged to about 15 kg Nha^{-1} (Weise,1972). Terman and Allen (1970) observed an increase in leaching losses of nitrogen from applied ammonium nitrate and urea with increasing fertiliser rate. Pande and Adak (1971) reported that leaching loss of NO_3^- particularly in rice fields was as high as 70 per cent. Haunold (1986) found that leaching loss is on an average 10 per cent of the fertiliser applied, but can amount to more than 60 per cent.

Moe et al. (1967) observed that losses of nitrogen can occur when conditions produce high rates of run off. Padmaja and Koshy (1978) reported that on draining the surface water on the same day of fertiliser application, upto 70 per cent of the applied nitrogen is lost in run off water.

Meyer et al. (1961) found that substantial losses of nitrogen as ammonia occur from urea and urea containing fertilisers than from fertilisers containing nitrate and ammonium ions. They also found that the losses were high when the fertilisers were applied to alkaline soils of limited moisture content. Heavy losses of nitrogen through ammonia volatilization from surface applied fertilisers have been reported by several workers (Basdeo and Gangwar, 1976; Aulakh et al., 1984; Pedrazzini and Tarsitano, 1986; Singh and Bajwa, 1987 and Rao, 1987). In experiments conducted by Zhu et al. (1989) 63 per cent of the total nitrogen from urea was lost when it was broadcast and incorporated into soil before transplanting rice, 30 per cent of the total nitrogen lost being in ammoniacal form. Ammonia volatilization was the dominant mechanism of gaseous nitrogen loss from broadcast urea when applied to rice (Datta et al., 1991).

Significant losses of nitrogen by denitrification in submerged soils have been reported by Akhundov (1967) and Mac Rae et al. (1968). The soils and areas worst affected by this process are those subject to alternate submergence and drying (Rajale, 1970). Haunold (1986) observed that denitrification losses are on an average 10-30 per cent of the fertiliser applied, but in several cases may exceed 40 per cent.

Loss of nitrogen through biological and chemical immobilisation was studied by Craswell and Vlek (1979).

The above cited references clearly indicate that ammonia volatilization, nitrate leaching and denitrification may be attributed to be the main causes of the low recovery of applied nitrogen. The extent of loss by each mechanism and their relative significance is highly dependent on the form of applied nitrogen, soil and climatic conditions.

4. Improving efficiency of urea

Gould et al. (1986) reported that urea efficiency could be altered by the use of slow release systems, urease inhibitors, chemical additives, by altering the physical form or by placement.

a. Incorporation and placement

Tamhane et al. (1966) reported that under rainfed conditions, placement of fertiliser below the seed gave higher response than broadcasting. Higher yields were obtained in barley when 86 per cent of the nitrogen was placed 10 cm deep in soil and 25 per cent was applied as foliar spray (Varshney and Singh, 1976). Rao and Das (1982) observed that the post-rainy season wheat and barley responded significantly to drilling of nitrogen over broadcasting. In a trial conducted by Chavan *et al.* (1988), fertiliser placement 3-4 cm below and 3-4 cm by the side of the seed showed better production of sorghum in dry land. Incorporation of top dressed urea into soil was found effective in minimising volatilization losses of surface applied urea (Tisdale *et al.*, 1990).

b. Modification of physical form

Application of ball type fertilisers made by mixing ammonium sulphate and clay soil into the reduced layer of paddy soil increased grain number and uptake of nitrogen by rice plants (Shiga *et al.*, 1977). Rao *et al.* (1984) reported that application of urea super granule (USG) significantly increased herb and essential oil yields of citronella over prilled urea (PU).

Monreal *et al.* (1986) reported that localizing urea in a nest reduced both its rate of hydrolysis and subsequent nitrification, thereby increasing the recovery of added nitrogen.

The apparent nitrogen recovery and nitrogen use efficiency were higher for large granule urea (LGU) than those for prilled urea (PU) in lowland rice (Sahu and Mitra, 1989). In rice, grain yield was significantly greater for urea briquettes (UB) than split application of PU (Singh et al., 1989).

Root-zone placement (5-6 cm deep) of USG significantly increased yield and yield attributes of rice and nitrogen recovery in upland alluvial soils compared to PU (Agarwal et al., 1990). In field experiments to compare the relative efficiency of prilled urea and modified urea fertilisers on rainfed lowland rice, urea super granule was found significantly superior to prilled urea in respect of grain yield and nitrogen use efficiency (Thakur, 1991).

c. Split application

Split application of nitrogen fertilisers was found to be effective for reducing nitrogen losses and regulating nitrogen supply in vegetable crops (Heilman et al., 1966). Substantial increase in grain yield was obtained due to split application of nitrogen in rainfed hybrid sorghum (Lingegowda et al., 1971). Alexander et al. (1976) observed an increased uptake of nitrogen by sweet potato when the fertiliser was applied in two splits compared to full basal dressing. Kuizenga (1977) reported that split dressings of nitrogen delayed lodging in winter barley but could not increase yields. Cartee et al. (1986) indicated that split application of nitrogen fertiliser could increase profits in dryland wheat.

Split application of urea gave maximum grain yield compared to full basal application in rice (Datta et al., 1990 and Moletti et al., 1990).

Sud et al. (1991) reported that split application of urea increased the nitrogen recovery by 11 per cent in potato compared to its full basal application.

d. Modifications to reduce rate of release

The objective in developing slow release fertilisers is to release nitrogen at a rate that tends to match the nutrient requirements at different stages of the crop plants.

(i) Substances of low water solubility

Atanasiu (1955) reported that slowly available nitrogen forms (ureaform) could be applied to crops at very high rates without adverse effects.

Granular oxamide was found to exhibit slow release properties when applied to bermuda grass (Allen et al., 1971).

Maynard and Lorenz (1979) reported that ureaform and isobutylidenediurea (IBDU) could be effectively used for turf grass fertilisation.

Application of IBDU was found to be as effective as 3-4 splits of urea in cranberries (Shawa, 1979). Kavanagh et al. (1980) and Sartain (1982) observed that IBDU was an effective slow release fertiliser capable of maintaining quality and growth of turf grass.

Kissel and Cabrera (1988) reported that volatilization losses from IBDU was negligible compared to that from urea.

(ii) Sparingly soluble minerals

Mag-Amp was reported to be a suitable slow release fertiliser for the production of container nursery stock, flower crops, landscape installations and turf grass (Lunt and Kofranek, 1962; Lunt et al., 1962, 1964). Nitrogen from these metal ammonium phosphates was reported to become available at a rate greater than would be expected from the solubility of the compounds and it was proved that nitrifiability rather than solubility is the main factor controlling the availability of nitrogen to plants (Prasad et al., 1971). Maynard and Lorenz (1979) reported that Mag-Amp could be used in the production of potted plants and container grown woody ornamental plants.

(iii) Soluble substances that gradually decompose

Experiments conducted in Japan revealed that guanyl urea was capable of increasing the yield of flooded rice (Hamamoto, 1966; International Rice Commission, 1966). Uptake of nitrogen by rice was slightly greater with guanyl urea sulphate (GUS) than with PU (IRRI, 1985).

(iv) Nitrification inhibitors

Patil (1972) reported that neem oil could be advantageously used for reducing nitrogen loss and increasing the efficiency of nitrogenous fertilisers.

Abraham et al. (1975) observed that neemcake could be profitably used to increase the efficiency of urea applied to wetland rice. They found that application of 40 kg N ha^{-1} as neem coated urea was equivalent to 80 kg N ha^{-1} as urea. Urea treated with neem cake 20 per cent by weight increased grain yield of paddy (Kulkarni et al., 1975; Shanker et al., 1976; Oommen et al., 1977b; Reddy and Shinde, 1981; Singh et al., 1982).

When thiourea was pelletted with urea in a ratio of two parts urea and one part thiourea, the rate of hydrolysis was halved (Malhi and Nyborg, 1979).

Field experiments with sugarcane indicated that the treatment of urea with nitrapyrin (N-serve) or neem cake increased its efficiency resulting in significantly higher cane yields (Parashar et al., 1980).

The combination of neemcake with urea economised the dose of urea by 25 per cent for potato (Sharma et al., 1980).

The results of field trials on Varalexmi hybrid cotton revealed that the efficiency of applied nitrogen could be improved by the use of neemcake treated urea and N-serve treated urea (Seshadri, 1985).

Neem coated urea was found superior to PU for flooded rice (Patil et al., 1987 and Singh and Mishra, 1987). The laboratory experiments in lateritic and black soils indicated significantly lower levels of nitrification at least upto a period of one month with Nimin Coated Urea treated soils in comparison to those treated with uncoated urea (Vyas and Mistry, 1991).

(v) Urease inhibitors

Baird and Ngueguim (1991) reported that N-(n-butyl) thiophosphoric triamide (NBPT) amended urea performed more effectively than urea alone with respect to grain yield, grain nitrogen uptake and total above ground dry matter uptake of nitrogen in maize.

Urease inhibitors [hydro quinone (HQ), phenyl phosphorodiamidate (PPDA) and N-(n-butyl) thiophosphoric triamide (NBPT)] could reduce ammonia volatilization following the application of urea under aerobic and water logged conditions (Zhengping et al., 1991).

Vidyasagar et al. (1992) noticed substantial reduction of ammonia volatilization with incorporation of urea dithiocarbamate pellets compared to urea alone.

(vi) Conventional water-soluble products treated to impede dissolution

a. Continuous impermeable coatings

Patrick et al. (1964) reported that plastic coated urea was superior in increasing rice yield as compared to uncoated materials when applied subsurface before planting.

In leaching studies, 94 per cent of the uncoated urea was recovered in one day compared to 49 per cent recovery of nitrogen from coated urea (13.2 per cent resin) in four weeks of intermittent leaching (Brown et al., 1966).

Rindt et al. (1968) observed that the dissolution rate of urea could be reduced by coating with sulphur.

Rice grain yield and protein content were improved and recovery of applied N by the rice plant was increased upto 50 per cent or higher with sulphur coated urea (Hong, 1976).

In trials conducted by Maples et al. (1976), sulphur coated urea (SCU) was found to be capable of increasing nitrogen efficiency for cotton under conditions that favour denitrification or leaching.

Matocha (1976) noticed that losses of ammoniacal nitrogen by volatilization from SCU was much less compared to conventional ammoniacal fertilisers regardless of the application method.

Lian et al. (1977) reported that rice yields from sandy loam soils were 4.4 per cent higher with SCU than with ammonium sulphate. Studies by Nair and Tomy (1978) revealed that sulphur coated urea could be effectively used for increasing nitrogen use efficiency in lowland rice. Oommen _et al_. (1977a) observed that crude protein content of paddy grains was 8.35 per cent when shellac coated urea was applied as against 7.44 per cent when uncoated urea was applied.

Salonius (1978) reported that plastic coated urea was more efficient in white spruce plantations in Canada as compared to prilied urea. He also observed that coated urea was released slowly and to a smaller volume of soil and that less of it was immobilised by microbial and chemical actions.

Experiments at Pattambi, Kerala, showed that sulphur coated urea increased nitrogen response and grain yield in rice (Anon, 1979).

Abbruscato and Axley (1979) noticed a reduction in ammonia loss from urea when it was coated with iron sulphate.

In field experiments conducted by Pokharna (1981), 75 kg N ha^{-1} of gypsum coated urea gave almost the same yield of bajra as 100 kg N ha^{-1} applied in the form of urea granules.

In a trial to assess the efficiency of different modified urea fertilisers viz. SCU, LCU, urea briquettes and USG, SCU and LCU were found to be most effective for rice (Bandyopadhyay and Biswas, 1982).

Nitrogen uptake, nitrogen recovery percentage and grain yield per unit input of nitrogen were increased in rice by application of gypsum or rock phosphate coated urea (Moorthy, 1982). Balasubramanian and Davood (1986) observed that SCU when broadcast and incorporated increased the plant height, number of panicles m^{-2} and grain yield of rice compared to PU applied in splits.

Lac coated urea was found to be superior to prilled urea for flooded rice (Patil et al., 1987; Singh and Mishra, 1987).

In a trial to assess the relative efficiency of slow release nitrogen sources on lowland rice and their residual effect on succeeding wheat, there was no significant difference in yield between the nitrogen sources for rice, but SCU, LCU and NCU increased the yields of the succeeding wheat crop as compared to untreated urea (Srivasthava and Tripathi, 1989).

In a ryegrass field trial over 24 weeks, urea rubber matrix gave higher dry matter yields than prilled urea through efficient matching of nitrogen supply and crop demand (Hassan et al., 1990).

In studies by Smith and Harrison (1991), three polymers (polyacrylate, vinyl alcohol, starch-based) were evaluated for controlled release properties when expanded in urea. The expansion capacity of each polymer varied depnding on the type of fertiliser solution.

Sharma and Patel (1991) reported that gypsum coated urea and rock phosphate coated urea resulted in significantly higher yield of potato tuber than urea applied alone or in combination with calcium carbonate.

b. Semipermeable coating

Osmocote was identified as a slow release fertiliser for date palm by Doughty et al. (1985). Champs (1988) observed positive effect with osmocote on conifers. Williams et al. (1990) reported that osmocote was effective in limiting nitrogen leaching loss when applied to potted plants.

c. Impermeable coatings with tiny pores

Dahnke et al. (1963) reported that placement of fertilisers in perforated polyethylene capsules effectively controlled the rate of release of the fertiliser constituents for corn in the field but did not significantly increase yield or recovery of the constituents.

Studies by Asokan et al. (1985) under cropped field and simulated conditions showed substantial retention and slow release of urea when packed in perforated polyethylene packets.

A variety of strategies thus have potential for improving the efficiency of urea, the choice of which should be according to crop, soil and climate.

B. Potassic fertilisers

Losses from potassic fertilisers

In trials conducted by Jung and Dressel (1969) on oats, potassium leaching was less on loamy than on sandy soil, irrespective of the time of fertiliser application to the former.

Substantial losses of potassium by leaching have been reported by Bouat (1971), Weise (1972) and Oliveira and Oliveira (1976).

Loss of added potassium by runoff has been reported by Dunigan *et al*. (1976).

Split application and placement

Das *et al*. (1970) reported that split application of potassic fertiliser as significantly superior to its application only as a basal dose, the former giving a significant eight per cent higher grain yield over the latter.

Deep placement of potassium fertilisers as opposed to surface applications significantly increased growth and yield of apricot trees (Abadia _et_ _al_., 1971).

Split or localised application of potassium was found to minimise leaching losses from irrigated grape vines and fruit trees in sandy soils (Bouat, 1971).

Kim and Park (1971) observed that split application of potassium to rice increased the grain yield, reduced occurrence of disease and increased potassium uptake. Similar increase in grain yield of paddy by split application over single basal dressing was reported by Su (1976) and Velayutham and Velayudham (1991).

Oliveira and Oliveira (1976) reported that losses of potassium from soils could be minimised by split application.

Split application of potassium was found to be effective for maintaining a desired release pattern in the root zone to meet the crop requirement (Ranganathan, 1981).

Split application of potassium to rice was reported to minimise losses due to luxury consumption and leaching (Braun and Roy, 1983).

In sandy loam soils of Uttar Pradesh, split application of potassium increased wheat yields by 440-490 kg ha^{-1} as compared to a single basal application (Singh and Mahatim, 1987).

Slow release potassic fertilisers

Potassium frit was succssfully used to supply potassium for prolonged periods to chrysanthemums, poinsettias, hydrangeas, cyclamen and cotton grown in pots (Lunt and Kwate, 1956).

Lunt and Oertli (1962) observed that potassium release from osmocote was strongly affected by temperature but not by medium water content, pH or microbial activity.

In pot experiments with rice, coated NPK fertilisers were significantly better than uncoated fertilisers with respect to plant height, number of tillers, number of panicles, dry matter and grain yield (Mohanty and Kibe, 1967).

Locascio and Fiskell (1970) reported that water melon yields were higher with sulphur coated potassium chloride (KCl) than those with a single uncoated fertiliser application, but not significantly different from those with split applications of uncoated fertiliser.

Terman and Allen (1970) noticed that sulphur coating of KCl reduced leaching losses.

Sulphur coated KCl was superior to spring applied uncoated KCl, and equal to split applications of uncoated KCl for alfalfa production (Mays, 1977).

Encapsulated NK fertilisers were found to be useful in tea in maintaining higher level of potassium for 13 days more than that obtained with physical mixture with an associated yield increase of 5 to 6 per cent (Ranganathan, 1978).

The effectiveness of resin and sulphur coated fertilisers in tobacco was investigated by Valentine et al. (1978) and they observed that coated potassium fertilisers were more effective especially in the years of heavy rainfall.

Maynard and Lorenz (1979) noticed that the potassium release from potassium frits was affected by particle size.

In a study of potassium release from selected slow release fertilisers, osmocote had relatively linear release rates while the release rate from Mag-Amp was rapid initially and decreased over time (Holcomb, 1981).

Asokan et al. (1985) reported that packing of fertiliser in perforated polythene bags could effectively reduce the rate of release of muriate of potash when applied to rubber.

As in the case of nitrogen, the effectiveness of the above proposed strategies for increasing the efficiency of potassic fertilisers will vary considerably depending upon situations.

Materials and Methods

MATERIALS AND METHODS

The present study was aimed at assessing the dissolution rates of urea and muriate of potash applied as 'root contact packets' of varying sizes and porosities and their crop responses.

The study consisted of two parts,

I Assessment of dissolution rates

II Assessment of advantage of root contact packets

Location

The trials were carried out at the College of Horticulture, Vellanikkara, Thrissur, situated at 10° 32'N latitude and 76° 10'E longitude and at an altitude of 22.25 m above mean sea level.

I Assessment of dissolution rates

Root contact packets of varying sizes and porosities were prepared by perforating polythene bags of 250 gauge (23 cm x 15 cm size) using pin presses and sealing them at different levels using a heat sealer after filling the fertiliser. For this, pin presses were fabricated by fixing nails (having diameter 1.08 mm) on wooden boards at different spacings. The polythene bags were then pressed against these pin presses in a screw press.

A. Dissolution rate of urea

Experiment No.1

This experiment was done to assess the rate of dissolution of urea from packets of different porosities and quantities. It was carried out in a coconut plantation about 12 years old with the fertiliser packets placed in the basins.

Soil

The soil of the experimental area was deep, well drained sandy clay loam.

Table 1. Physico-chemical properties of the soil

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1. Mechanical composition (Hydrometer method, Bouyoucos, 1962)

Sand : 52.3 per cent

Silt : 22.5 per cent

Clay : 25.2 per cent

Texture : Sandy clay loam

2. Chemical composition

Constituent	Content	Rating	Method used for estimation
Total N	0.126 per cent	Medium (Class 6)	Micro Kjeldahal method (Jackson, 1958)
Available phosphorus (Bray-1 extract)	7.4 ppm	Medium (Class 4)	Chlorostannous reduced molybdo phosphoric blue colour method (Jackson, 1958)
Available potassium (Neutral normal ammonium acetate extract)	159.8 ppm	High (Class 8)	Flame photometry (Jackson,1958)
pH(1:2.5 soil : water)	5.3	Acid-Medium (Class 3)	pH meter method (Jackson,1958)

Season and climate

The experiment was conducted during the period from

June 1991 to November 1991. The meteorological data for the period from June 1991 to November 1991 are presented in Appendix 1.

Layout and design (Fig.1)

Design : Completely Randomised Design

Treatments : The following 20 factorial combinations of five packet sizes (50, 100, 150, 200 and 250 g) and four porosities (1, 2, 3 and 4 perforations cm^{-2}) constituted the treatments.

1. T_1 : 1/50 : 50g packet, 1 hole cm^{-2}
2. T_2 : 1/100 : 100g packet, 1 hole cm^{-2}
3. T_3 : 1/150 : 150g packet, 1 hole cm^{-2}
4. T_4 : 1/200 : 200g packet, 1 hole cm^{-2}
5. T_5 : 1/250 : 250g packet, 1 hole cm^{-2}
6. T_6 : 2/50 : 50g packet, 2 holes cm^{-2}
7. T_7 : 2/100 : 100g packet, 2 holes cm^{-2}
8. T_8 : 2/150 : 150g packet, 2 holes cm^{-2}
9. T_9 : 2/200 : 200g packet, 2 holes cm^{-2}
10. T_{10} : 2/250 : 250g packet, 2 holes cm^{-2}
11. T_{11} : 3/50 : 50g packet, 3 holes cm^{-2}
12. T_{12} : 3/100 : 100g packet, 3 holes cm^{-2}
13. T_{13} : 3/150 : 150g packet, 3 holes cm^{-2}

14. T_{14} : 3/200 : 200g packet, 3 holes cm^{-2}
15. T_{15} : 3/250 : 250g packet, 3 holes cm^{-2}
16. T_{16} : 4/50 : 50g packet, 4 holes cm^{-2}
17. T_{17} : 4/100 : 100g packet, 4 holes cm^{-2}
18. T_{18} : 4/150 : 150g packet, 4 holes cm^{-2}
19. T_{19} : 4/200 : 200g packet, 4 holes cm^{-2}
20. T_{20} : 4/250 : 250g packet, 4 holes cm^{-2}

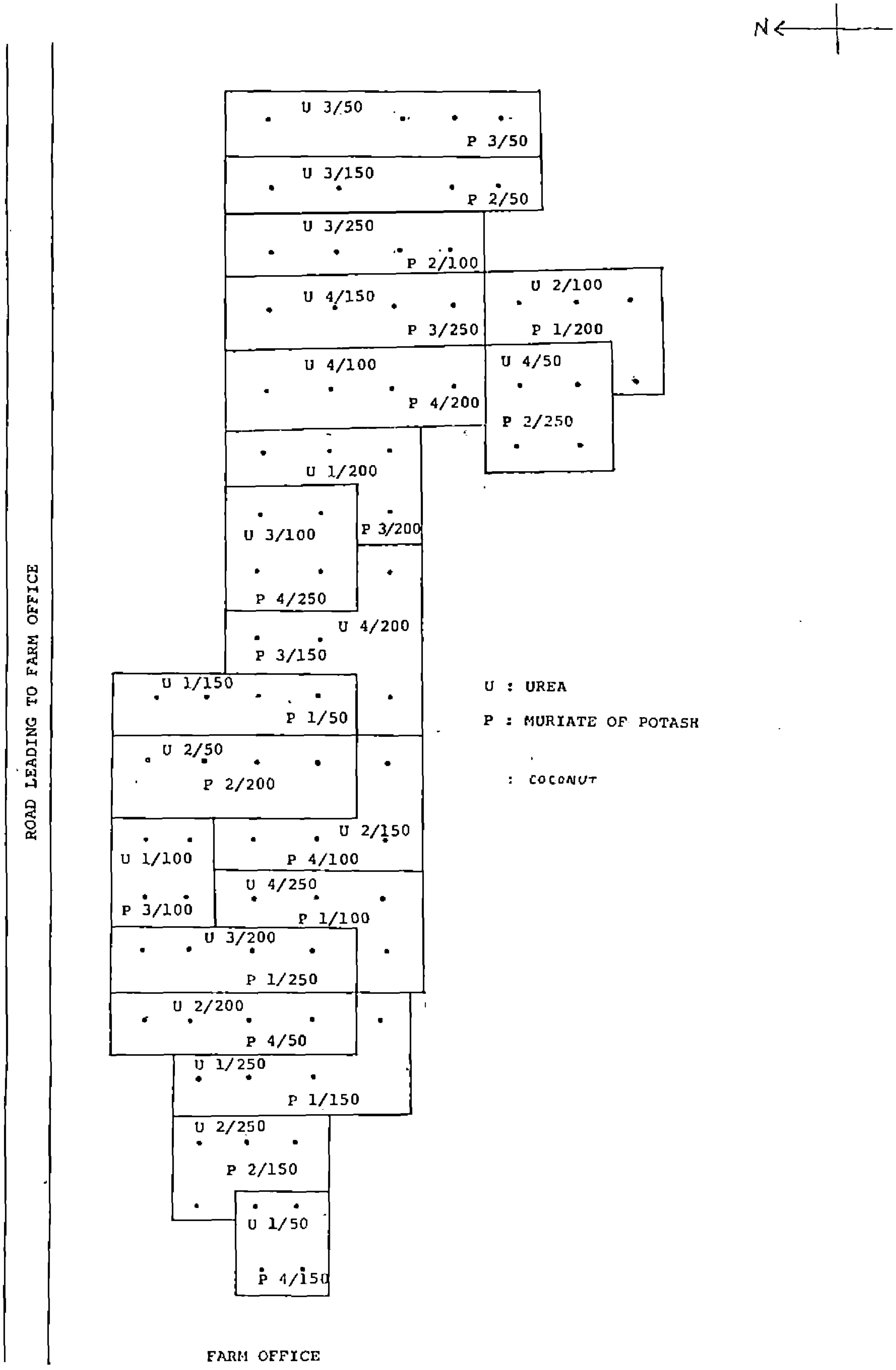
Number of replications : 5

These packets were placed in coconut basins at a distance of 1.8 m from the base of the palm, at a depth of about 15 cm.

Observations

Fertiliser packets were excavated at intervals of 15 days and the quantities of urea left in the packets were assessed. Assessment was to be made by both weighing of residual fertiliser and also through estimating the nitrogen content of fertiliser extract. Since there was no fertiliser left in practically any of the packets at any stage of excavation, extraction and estimation could not be done.

FIG.1 LAYOUT OF THE EXPERIMENT ON ASSESSMENT OF DISSOLUTION RATES OF UREA AND MURIATE OF POTASH



Experiment No.2

As it was noticed that there was no fertiliser left in any of the packets in the previous experiment, assuming the reason to be water stagnation in the basins, this experiment was conducted in a different situation, providing conditions without standing water. The site selected was an open area previously occupied by legumes. The soil of the experimental site was similar to that in the first experiment.

Season and climate

This experiment was conducted during the period from September 1991 to December 1991. The meteorological data for the period are given in Appendix 1.

Design : Completely Randomised Design

Treatments : The following 10 factorial combinations of five packet sizes (50, 100, 150, 200 and 250 g) and two porosities (1 and 2 holes cm $^{-2}$) constituted the treatments.

1. T_1 : 1/50 : 50g packet, 1 hole cm^{-2}
2. T_2 : 1/100 : 100g packet, 1 hole cm^{-2}
3. T_3 : 1/150 : 150g packet, 1 hole cm^{-2}
4. T_4 : 1/200 : 200g packet, 1 hole cm^{-2}
5. T_5 : 1/250 : 250g packet, 1 hole cm^{-2}
6. T_6 : 2/50 : 50g packet, 2 holes cm^{-2}
7. T_7 : 2/100 : 100g packet, 2 holes cm^{-2}
8. T_8 : 2/150 : 150g packet, 2 holes cm^{-2}
9. T_9 : 2/200 : 200g packet, 2 holes cm^{-2}
10. T_{10} : 2/250 : 250g packet, 2 holes cm^{-2}

Number of replications : 3

Raised beds of 90 cm x 90 cm x 15 cm were taken and the fertiliser packets were placed at a depth of 20cm.

Observations

Fertiliser packets were excavated at monthly intervals and the quantities of urea left in the packets were estimated by weighing the residual fertiliser after air drying. From this the percentage of residual fertiliser was calculated.

Experiment No.3

This experiment to study the dissolution rate of urea was done in the dry season under rainfall simulated conditions. As the dissolution rates were faster than the expected levels in experiment No.2, to extend the period of dissolution the porosities were brought down in this experiment. This experiment was carried out in the soil and location where the previous experiment was conducted.

Based on the rainfall data for the last 30 years of Vellanikkara station, the mean daily rainfall for June and July was worked out to be 2 cm and water equivalent to this was given daily for the experimental period.

Season and climate

This experiment was conducted during the period from January 1992 to March 1992. This period was rain-free. The meteorological data for the period is given in Appendix 1.

Design : Completely Randomised Design

Treatments : The following 25 factorial combinations of five packet sizes (50, 100, 150, 200 and 250 g) and five porosities (0.25, 0.5, 0.75, and 1 nail hole cm^{-2} and 1 needle hole cm^{-2})constituted the treatments.

1. T_1 : 0.25/50 : 50g packet, 0.25 hole cm^{-2}
2. T_2 : 0.25/100 : 100g packet, 0.25 holes cm^{-2}
3. T_3 : 0.25/150 : 150g packet, 0.25 holes cm^{-2}
4. T_4 : 0.25/200 : 200g packet, 0.25 holes cm^{-2}
5. T_5 : 0.25/250 : 250g packet, 0.25 holes cm^{-2}
6. T_6 : 0.5/50 : 50g packet, 0.5 holes cm^{-2}
7. T_7 : 0.5/100 : 100g packet, 0.5 holes cm^{-2}
8. T_8 : 0.5/150 : 150g packet, 0.5 holes cm^{-2}
9. T_9 : 0.5/200 : 200g packet, 0.5 holes cm^{-2}
10. T_{10} : 0.5/250 : 250g packet, 0.5 holes cm^{-2}
11. T_{11} : 0.75/50 : 50g packet, 0.75 holes cm^{-2}
12. T_{12} : 0.75/100 : 100g packet, 0.75 holes cm^{-2}
13. T_{13} : 0.75/150 : 150g packet, 0.75 holes cm^{-2}
14. T_{14} : 0.75/200 : 200g packet, 0.75 holes cm^{-2}
15. T_{15} : 0.75/250 : 250g packet, 0.75 holes cm^{-2}
16. T_{16} : 1/50 : 50g packet, 1 hole cm^{-2}
17. T_{17} : 1/100 : 100g packet, 1 hole cm^{-2}
18. T_{18} : 1/150 : 150g packet, 1 hole cm^{-2}
19. T_{19} : 1/200 : 200g packet, 1 hole cm^{-2}

20. T_{20} : 1/250 : 250g packet, 1 hole cm^{-2}

21. T_{21} : 1N/50 : 50g packet, 1 needle hole cm^{-2}

22. T_{22} : 1N/100 : 100g packet, 1 needle hole cm^{-2}

23. T_{23} : 1N/150 : 150g packet, 1 needle hole cm^{-2}

24. T_{24} : 1N/200 : 200g packet, 1 needle hole cm^{-2}

25. T_{25} : 1N/250 : 250g packet, 1 needle hole cm^{-2}

Number of replications : 2

Beds of 90cm x 90cm x 15cm were taken and the fertiliser packets were placed at a depth of 20 cm.

Observations

Fertiliser packets were excavated at intervals of 30 days. The quantities of urea left in these packets were to be assessed. Since there was no fertiliser left in practically any of the packets, extraction and estimation were not done.

Experiment No.4

As there was no fertiliser left in any of the packets in experiment no.3, this experiment was conducted in the same location, reducing the porosities further.

Season and Climate

This experiment was conducted during the period from March 1992 to June 1992 under rainfall simulated conditions. The meteorological data are presented in Appendix 1.

Design : Completely Randomised Design

Treatments : The following 25 factorial combinations of five packet sizes (50, 100, 150, 200 and 250g) and five porosities (0.0625, 0.125, 0.25, 0.5 and 1 hole cm^{-2}) constituted the treatments. In this experiment, perforations were made on the polythene bags using sewing needles of diameter 1.0 mm.

1. T_1 : 0.0625/50 : 50g packet, 0.0625 holes cm^{-2}
2. T_2 : 0.0625/100 : 100g packet, 0.0625 holes cm^{-2}
3. T_3 : 0.0625/150 : 150g packet, 0.0625 holes cm^{-2}
4. T_4 : 0.0625/200 : 200g packet, 0.0625 holes cm^{-2}
5. T_5 : 0.0625/250 : 250g packet, 0.0625 holes cm^{-2}
6. T_6 : 0.125/50 : 50g packet, 0.125 holes cm^{-2}

7. T_7 : 0.125/100 : 100g packet, 0.125 holes cm^{-2}
8. T_8 : 0.125/150 : 150g packet, 0.125 holes cm^{-2}
9. T_9 : 0.125/200 : 200g packet, 0.125 holes cm^{-2}
10. T_{10} : 0.125/250 : 250g packet, 0.125 holes cm^{-2}
11. T_{11} : 0.25/50 : 50g packet, 0.25 holes cm^{-2}
12. T_{12} : 0.25/100 : 100g packet, 0.25 holes cm^{-2}
13. T_{13} : 0.25/150 : 150g packet, 0.25 holes cm^{-2}
14. T_{14} : 0.25/200 : 200g packet, 0.25 holes cm^{-2}
15. T_{15} : 0.25/250 : 250g packet, 0.25 holes cm^{-2}
16. T_{16} : 0.5/50 : 50g packet, 0.5 holes cm^{-2}
17. T_{17} : 0.5/100 : 100g packet, 0.5 holes cm^{-2}
18. T_{18} : 0.5/150 : 150g packet, 0.5 holes cm^{-2}
19. T_{19} : 0.5/200 : 200g packet, 0.5 holes cm^{-2}
20. T_{20} : 0.5/250 : 250g packet, 0.5 holes cm^{-2}
21. T_{21} : 1/50 : 50g packet, 1 hole cm^{-2}
22. T_{22} : 1/100 : 100g packet, 1 hole cm^{-2}
23. T_{23} ; 1/150 : 150g packet, 1 hole cm^{-2}
24. T_{24} : 1/200 : 200g packet, 1 hole cm^{-2}
25. T_{25} : 1/250 : 250g packet, 1hole cm^{-2}

Number of replications : 2

Beds of size 90cm x 90cm x 20cm were taken and the packets were placed at a depth of 30 cm.

Observations

Packets were excavated at intervals of 30 days. Fresh weight and dry weight of the fertiliser left in the packets were taken. Then it was dissolved in uniform quantity of water. Nitrogen content of this solution and thus the quantity of nitrogen left in the packet was determined by Micro Kjeldahl digestion and distillation method. From this the percentage of residual urea in the packets was determined.

B. Dissolution rate of muriate of potash

Experiment No.1

This experiment was carried out to assess the rate of dissolution of muriate of potash from polyethylene packets of different porosities and with different quantities of the fertiliser. It was conducted in the same soil and location in which the first experiment on dissolution rate of urea was conducted.

Season and climate

This experiment was carried out during the period from June 1991 to November 1991.

Layout (Fig.1)

Design : Completely Randomised Design

Treatments : The following 20 factorial combinations of five packet sizes (50, 100, 150, 200 and 250g) and four porosities (1, 2, 3 and 4 perforations cm^{-2}) constituted the treatments.

1. T_1 : 1/50 : 50g packet, 1 hole cm^{-2}
2. T_2 : 1/100 : 100g packet, 1 hole cm^{-2}
3. T_3 : 1/150 : 150g packet, 1 hole cm^{-2}
4. T_4 : 1/200 : 200g packet, 1 hole cm^{-2}
5. T_5 : 1/250 : 250g packet, 1 hole cm^{-2}
6. T_6 : 2/ 50 : 50g packet, 2 holes cm^{-2}
7. T_7 : 2/100 : 100g packet,2 holes cm^{-2}.
8. T_8 : 2/150 : 150g packet, 2 holes cm^{-2}
9. T_9 : 2/200 : 200g packet, 2 holes cm^{-2}
10. T_{10} : 2/250 : 250g packet, 2 holes cm^{-2}
11. T_{11} : 3/50 : 50g packet, 3 holes cm^{-2}
12. T_{12} : 3/100 : 100g packet, 3holes cm^{-2}
13. T_{13} : 3/150 : 150g packet, 3 holes cm^{-2}
14. T_{14} : 3/200 : 200g packet, 3 holes cm^{-2}
15. T_{15} : 3/250 : 250g packet, 3 holes cm^{-2}
16. T_{16} : 4/50 : 50g packet, 4 holes cm^{-2}
17. T_{17} : 4/100 : 100g packet, 4 holes cm^{-2}

18. T_{18} : 4/150 : 150g packet, 4 holes cm^{-2}
19. T_{19} : 4/200 : 200g packet, 4 holes cm^{-2}
20. T_{20} : 4/250 : 250g packet, 4 holes cm^{-2}

Number of replications : 5

These packets were placed in coconut basins at a distance of 1.8 m from the base of the palm at a depth of 15 cm.

Observations

Packets were excavated at intervals of 15 days and the quantities of fertiliser left in the packets were estimated. Assessment was to be made by both weighing the residual fertiliser and also through estimating the potassium content of the fertiliser extract. Since there was no fertiliser left in practically any of the packets at any stage of excavation, extraction and estimation were not done.

Experiment No.2

This experiment was conducted to assess the dissolution rate of muriate of potash providing conditions without standing water since there was no fertiliser left in any of the packets in the previous experiment.

Season and climate

This experiment was carried out during the period from September 1991 to December 1991 (north-east monsoon period).

Design : Completely Randomised Design

Treatments : The following 10 factorial combinations of five packet sizes (50, 100, 150, 200 and 250 g) and two porosities (1 and 2 holes cm^{-2}) constituted the treatments.

1. T_1 : 1/50 : 50g packet, 1 hole cm^{-2}
2. T_2 : 1/100 : 100g packet, 1 hole cm^{-2}
3. T_3 : 1/150 : 150g packet, 1 hole cm^{-2}
4. T_4 : 1/200 : 200g packet, 1 hole cm^{-2}
5. T_5 : 1/250 : 250g packet, 1 hole cm^{-2}
6. T_6 : 2/50 : 50g packet, 2 holes cm^{-2}

7. T_7 : 2/100 : 100g packet, 2 holes cm^{-2}
8. T_8 : 2/150 : 150g packet, 2 holes cm^{-2}
9. T_9 : 2/200 : 200g packet, 2 holes cm^{-2}
10. T_{10} : 2/250 : 250g packet, 2 holes cm^{-2}

Number of replications : 3

Beds of size 90cm x 90cm x 15cm were taken and the fertiliser packets were placed at a depth of 20 cm.

Observations

Fertiliser packets were excavated at intervals of 30 days. Fresh weight and dry weight of muriate of potash left in the packets were taken. Then it was dissolved in uniform quantity of water. Potassium content of this solution and thus the quantity of nutrient left in the packet was determined by flame photometer method. The percentages of residual fertiliser in the packets were then calculated.

II Assessment of the advantage of root contact packets

Two separate experiments were conducted to assess the advantage of placing urea and muriate of potash in perforated polyethylene bags over application of these fertilisers in two splits. This was done using six month old cocoa seedlings as indicators. There were controls of no supply of these nutrients through fertilisers also.

A. Root contact packets of urea

This trial was done to assess the comparative advantage of root contact packets of urea and urea split application on cocoa seedlings. This experiment was carried out in the site where the first experiment on assessment of dissolution rates of urea and muriate of potash was done.

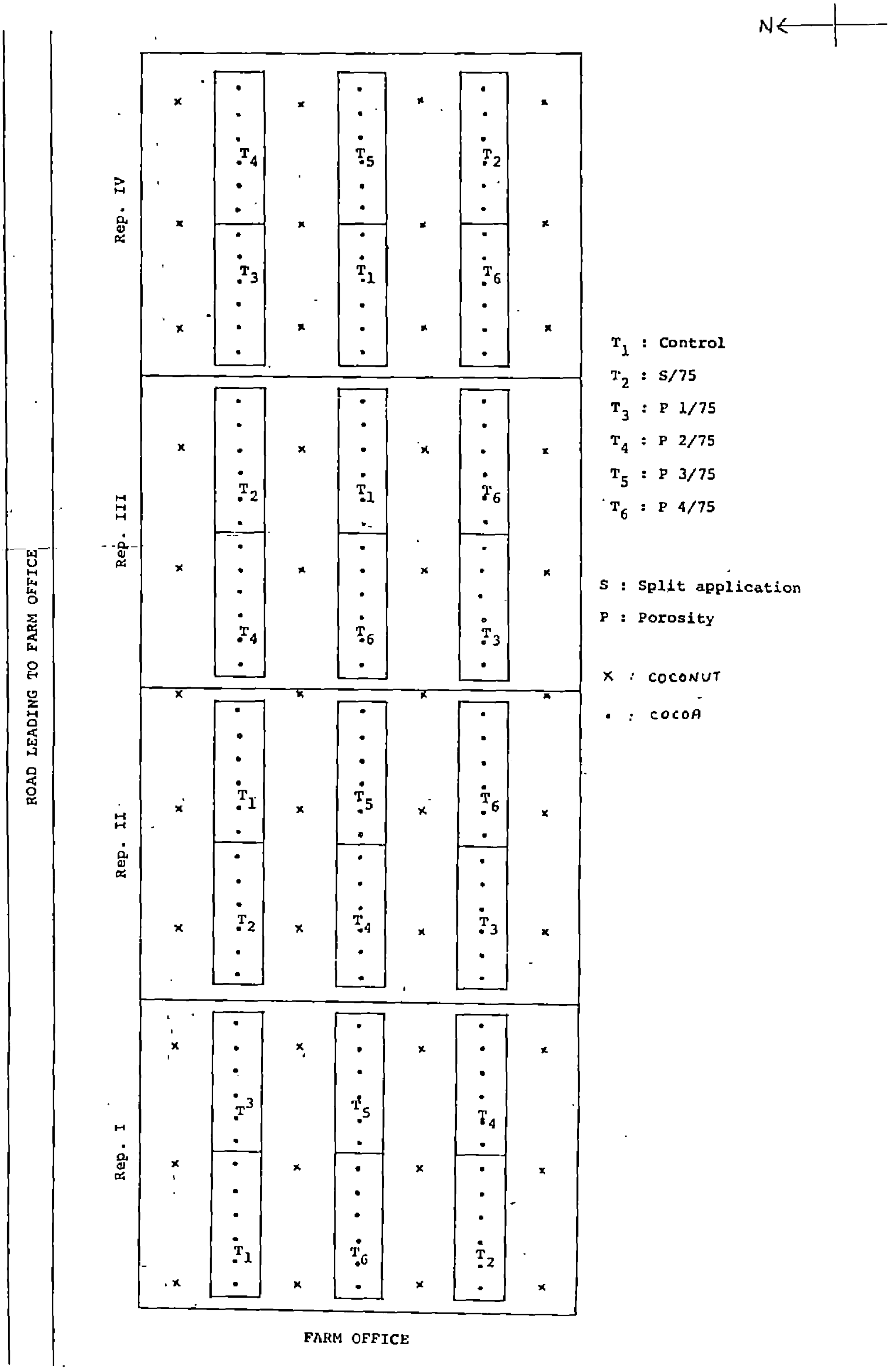
Season and climate

This experiment was conducted during the period from June 1991 to November 1991.

Layout (Fig.2)

Design : Randomised Block Design

FIG.2 LAYOUT OF THE EXPERIMENT ON ASSESSMENT OF THE ADVANTAGE OF ROOT CONTACT PACKETS OF UREA ON COCOA SEEDLINGS



Treatments:

T_1 : Control of no nitrogen supply

T_2 : 75g urea in two equal splits in June and October

T_3 : 75g urea as root contact packet with 1 needle hole cm^{-2},

T_4 : 75g urea as root contact packet with 2 needle holes cm^{-2}

T_5 : 75g urea as root contact packet with 3 needle holes cm^{-2}

T_6 : 75g urea as root contact packet with 4 needle holes cm^{-2}

Number of cocoa seedlings $plot^{-1}$: 6

Number of replications : 4

Cocoa seedlings of six months were planted in the inter-spaces of coconut. Fertiliser packets were placed on one side of the seedlings at a distance of about 4 cm from the base of the seedlings at a depth of 5 cm. In the case of split application, the fertiliser was applied around the seedlings within a radius of 4 cm.

a. Biometric observations

(i) Plant height

Height of plants was measured from the base of the plant to the tip of the stem and plot wise average was worked out.

(ii) Girth

Girth of plants was measured at a height of 15 cm and plotwise average was worked out.

(iii) Number of leaves

Number of hardened leaves was taken and the mean was worked out for the six plants in each plot.

(iv) Dry matter production

The plants were cut at the base in November and leaves and stems were separated and dried to constant weight in hot air oven (70-80°C). From the dry weight of the component parts for the six plants in a plot, the dry matter production plant^{-1} was worked out.

b. Chemical studies

ogen

The nitrogen content of leaves and stems was determined by micro Kjeldahl digestion and distillation method.

(ii) Uptake of nitrogen

The total uptake of nitrogen by the plant was calculated from the nitrogen content and dry matter production of component plant parts and expressed as g plant^{-1}.

B. Root contact packets of muriate of potash

This experiment was done to assess the relative advantage of placing muriate of potash in perforated polyethylene bags and split application. This was carried out in the same location and soil where the experiment on urea was conducted. The season and climatic conditions were also the same as that in the previous experiment.

Layout (Fig. 3)

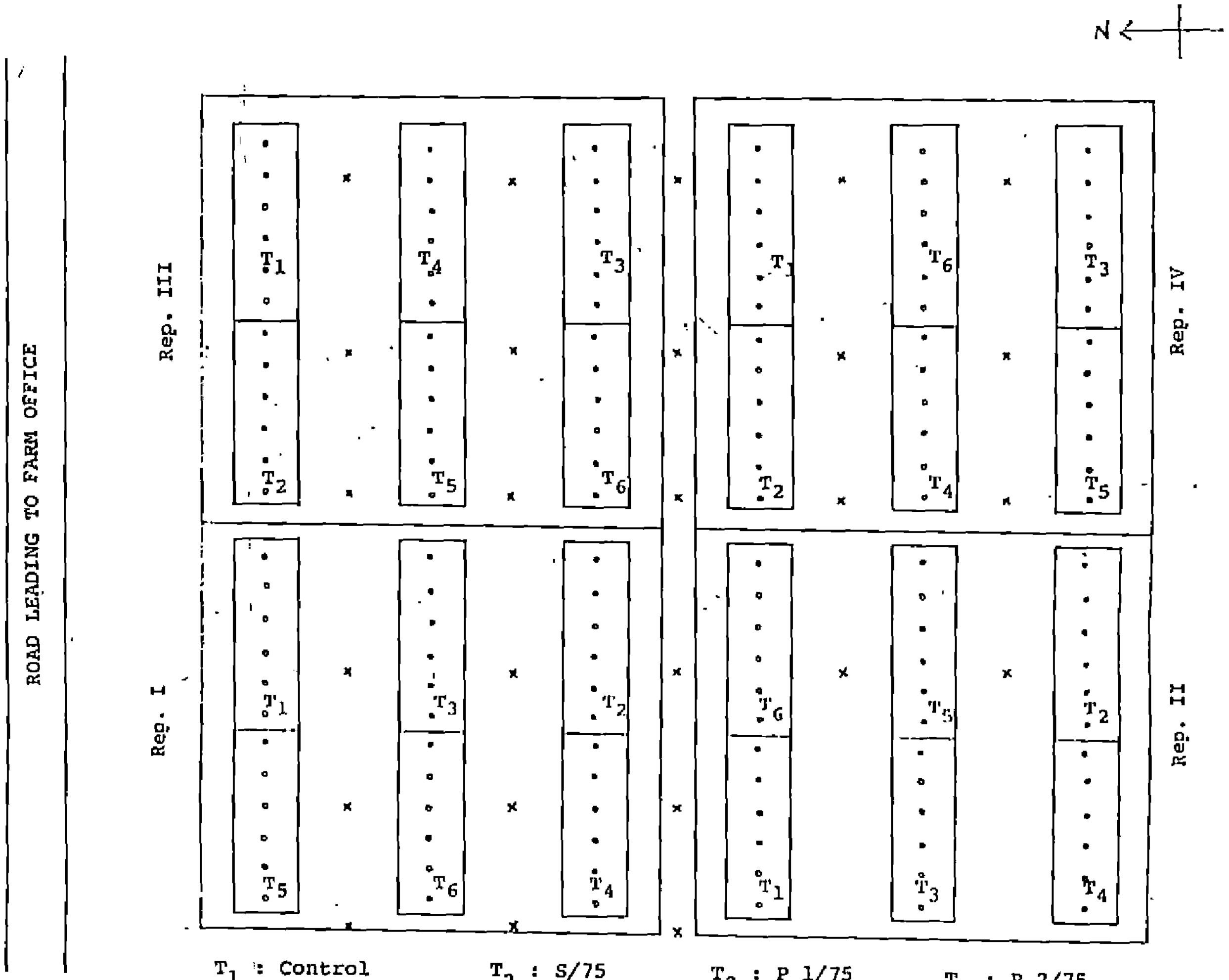
Design : Randomised Block Design

Treatments :

T_1 : Control of no potassium supply

T_2 : 75g muriate of potash in two equal splits in June and October

FIG.3 LAYOUT OF THE EXPERIMENT ON ASSESSMENT OF THE ADVANTAGE OF ROOT CONTACT PACKETS OF MURIATE OF POTASH ON COCOA SEEDLINGS



T_1 : Control

T_2 : S/75

T_3 : P 1/75

T_4 : P 2/75

T_5 : P 3/375

T_6 : P 4/75

S : Split application

P : Porosity

× : COCONUT

o : COCOA

(Jackson, 1958).

b. Uptake of potassium

The total uptake of potassium by the plant was calculated from the potassium content and dry matter production.

Statistical analysis

The data on dissolution rate and crop responses of root contact packets of urea and muriate of potash were analysed by applying the analysis of variance techniique (Panse and Sukhatme,1967).

T_3 : 75 g muriate of potash as root contact packet with 1 needle hole cm^{-2}

T_4 : 75 g muriate of potash as root contact packet with 2 needle holes cm^{-2}

T_5 : 75 g muriate of potash as root contact packet with 3 needle holes cm^{-2}

T_6 : 75 g muriate of potash as root contact packet with 4 needle holes cm^{-2}

Number of plants per $plot^{-1}$	:	6
Number of replications	:	4

Cocoa seedlings of six months were planted in the interspaces of coconut and fertiliser packets were placed as in the case of urea.

Observations

Biometric observations were taken as in the case of urea.

Chemical studies

a. Content of potassium

The potassium content of leaves and stems were determined using flame photometer method after triacid digestion

(Jackson, 1958).

b. Uptake of potassium

The total uptake of potassium by the plant was calculated from the potassium content and dry matter production.

Statistical analysis

The data on dissolution rate and crop responses of root contact packets of urea and muriate of potash were analysed by applying the analysis of variance technique (Panse and Sukhatme,1967).

Results and Discussion

RESULTS AND DISCUSSION

The data obtained from the experiments on dissolution rates of urea and muriate of potash are presented first and these are followed by the results of the experiments conducted to assess the advantage of root contact packets of urea and muriate of potash.

I Assessment of dissolution rates

A. Dissolution rate of urea

Experiment no.1

This experiment was done to assess the rate of dissolution of urea from packets of different porosities and quantities. The porosities and quantities tried were 1, 2, 3 and 4 nail holes cm^{-2} and 50, 100, 150, 200 and 250 g, respectively. Samples were excavated at intervals of 15 days. There was no fertiliser left in practically any of the packets at any stage of excavation. The reason for this was assumed to be water stagnation in the coconut basins in which these packets were placed.

Experiment No.2

This experiment to assess the dissolution rate of urea packed in perforated polyethylene bags was conducted providing conditions without standing water. The data on the percentage of residual fertiliser 30 days after application on dry weight basis are given in Table 2 and the analysis of variance in Appendix 2.

Significant difference could be noticed between the two porosities tried with respect to percentage of residual urea in the packets, there being decrease with increasing porosity.

Between the different quantities compared, percentage residue was found to increase with increasing quqntities of fertiliser. The highest percentage of residual fertiliser was observed with 250 g packets which was followed by 200 g packets. The percentage of residual fertiliser in 100 g and 150 g packets were on par and 50 g packets showed the lowest percentage of residual fertiliser.

The interaction effect of porosity and quantity was significant with regard to percentage of residual fertiliser. The data are given in Table 3.

Table 2. Effects of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Treatment	Percentage of residue 30 days after application on dry weight basis
Porosities (holes cm^{-2})	
1	20.3
2	1.9
SEm±	0.86
CD(0.05)	2.5
Quantities (g packet^{-1})	
50	2.3
100	10.8
150	9.2
200	15.3
250	18.0
SEm±	1.4
CD(0.05)	4.0

Table 3. Combined effect of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Porosities holes cm^{-2}	Percentage residue				
	Quantities, g $packet^{-1}$				
	50	100	150	200	250
1	4.7	18.0	18.4	28.2	32.3
2	0	3.7	0	2.3	3.7

SEm± = 1.9 CD(0.05) = 5.6

The results of this study thus indicated that the percentage of residual fertiliser increased or in other words rate of release decreased with decrease in porosity and increase in packet size. The dissolution rates were also very high and there was no fertiliser left in practically any of the packets when excavation was done on the 60th day after application. It was concluded that there was necessity for reducing the porosities still further if there were to be extended availability for a reasonable period.

Experiment No.3

The objective of this experiment was to standardise porosities and it was done by reducing the porosities still further. It was conducted in the dry season under simulated rainfall conditions and the daily rate of application of water was equivalent to 2 cm. An additional treatment providing holes made with sewing needle was also included in this. The porosity for this was 1 hole cm^{-2}.

Here also the dissolution rates were very high and there was no fertiliser left in any of the packets even at the first stage of sampling.

The previous experiment (Expt.No.2) was conducted in the north-east monsoon season when the total rainfall during the experimental period of one month was 203.1 cm. This corresponds to a daily rate of 0.68 cm only. In this experiment rainfall simulation was done at a rate of 2 cm day^{-1} which corresponds to rainfall intensity of the peak period of June-July. This high intensity might have resulted in the complete loss of urea in the packets eventhough the porosities tried were lesser in this compared to the previous experiment. It was then concluded that there was necessity for reducing the porosities still further if there were to be extended availability for a reasonable period in the south-west monsoon season.

Experiment No.4

This experiment was conducted to standardise porosities by reducing the porosities still further. Like the previous experiment, this was also carried out in the dry season under simulated rainfall conditions.

Here also the daily rate of application of water was equivalent to 2 cm. Perforations on packets were made with sewing needles in all the treatments. The depth of placement was also increased to 30 cm instead of 20 cm as was followed in the previous experiments.

The data on the percentage of residual fertiliser on dry weight basis and on the basis of chemical analysis are given in Table 4 and the analysis of variance in Appendix 3. There was significant difference between the porosities with regard to percentage of residual fertiliser on dry weight basis and on the basis of chemical analysis 30 days after application. The percentage of residual urea decreased with increase in porosity. Packets with 0.0625 holes cm^{-2} recorded the highest value with respect to the percentage of residual fertiliser in both the cases. On the basis of chemical analysis, this treatment was significantly superior to other treatments but on dry weight basis this was on par with the packets with 0.125 holes cm^{-2}. The packet with one hole cm^{-2} showed the lowest percentage of residual fertiliser.

Table 4. Effects of porosity and quantity of fertiliser on the dissolution rates of urea from root contact packets

Treatment	Percentage residue					
	Days after application					
	30		60		90	
	D	A	D	A	D	A
Porosities (holes cm^{-2})						
0.0625	98.7	91.1	90.4	83.8	89.2	80.8
0.125	95.1	85.4	79.4	72.9	77.8	67.8
0.25	87.2	70.6	70.7	66.0	50.0	42.1
0.5	73.4	62.7	30.8	27.9	21.9	18.5
1.0	49.2	44.1	12.3	10.5	0.0	0.0
SEm±	1.7	1.7	1.9	1.6	2.9	2.6
CD(0.05)	5.0	5.0	5.5	4.8	8.6	7.5
Quantities (g packet^{-1})						
50	76.8	73.6	58.6	54.4	49.8	41.8
100	81.3	72.5	56.1	50.4	55.1	48.8
150	84.8	70.8	59.8	53.2	44.7	38.1
200	79.8	69.6	57.7	54.5	43.4	39.7
250	80.9	67.4	51.5	48.5	46.0	40.6
SEm±	1.7	1.7	1.9	1.6	2.9	2.6
CD(0.05)	5.0	NS	5.5	NS	NS	NS

D : Values on dry weight basis

A : Values on the basis of chemical analysis

The data on dry weight basis showed significant difference between the quantities of fertiliser in the packets but the effect was not significant when the quantity of residual fertiliser was calculated on the basis of chemical analysis. On dry weight basis, 150g packet recorded the highest value and was on par with 100 g, 250 g and 200 g packets which in turn were on par with 50 g packets.

The interaction effect of porosity and quantity was significant with respect to percentage of residual fertiliser on the basis of chemical analysis but no significant difference could be noticed when calculations were made on dry weight basis. The data are presented in Table 5.

At the time of second observation 60 days after application, the effect of porosity was found similar to that 30 days after application, there being a significant decrease in the quantity of residual fertiliser with increase in porosities. Packets with 0.0625 holes cm^{-2} recorded the highest values and those with one hole cm^{-2} registered the lowest values with respect

Table 5. Combined effect of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Porosities holes cm^{-2}	Percentage residue Quantities, g $packet^{-1}$ 50	100	150	200	250
0.0625	94.7	90.4	89.1	92.6	88.5
0.125	91.9	90.4	81.0	82.4	81.5
0.25	82.1	65.0	61.7	80.3	64.2
0.5	68.5	65.1	68.4	48.1	63.6
1.0	30.9	51.5	54.0	44.9	39.3

SEm± 3.8 CD(0.05) 11.2

to the percentage of residual fertiliser both on dry weight basis and on the basis of chemical analysis.

The effect of quantity of fertiliser in packets was significant when percentage of residual fertiliser was calculated on dry weight basis but not when calculated on the basis of chemical analysis. On dry weight basis the highest percentage of residual fertiliser was observed with 150 g which was on par with all other quantities except 250 g which recorded significantly lower value.

The interaction effect of porosity and quantity was significant when calculations were made both on dry weight basis and on the basis of chemical analysis. The data are presented in Tables 6 and 7, respectively.

At the time of third observation 90 days after application also, a decreasing trend in the quantity of residual fertiliser with increase in porosity could be observed. Here also packets with 0.0625 holes cm^{-2} recorded the highest and those with one hole cm^{-2} recorded the lowest values with respect to percentage of residual

Table 6. Combined effect of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Porosities holes cm^{-2}	Percentage residue on dry weight basis				
	Quantities, g $packet^{-1}$				
	50	100	150	200	250
0.0625	82.0	90.0	91.7	93.3	95.0
0.125	81.0	82.5	73.0	85.0	75.6
0.25	78.0	73.0	69.3	72.0	61.4
0.5	30.0	21.5	45.7	38.0	19.0
1.0	22.0	13.5	19.3	0.0	6.6

SEm± 4.2 CD(0.05) 12.2

Table 7. Combined effect of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Porosities holes cm^{-2}	Percentage residue on the basis of chemical analysis				
	Quantities, g packet^{-1}				
	50	100	150	200	250
0.0625	78.9	83.0	81.8	85.2	90.0
0.125	74.0	72.9	65.0	80.1	72.7
0.25	72.9	65.7	61.6	71.5	58.3
0.5	27.5	20.5	40.0	35.8	15.6
1.0	18.7	10.0	17.9	0.0	6.0

SEm± 3.7 CD(0.05) 10.7

fertiliser both on dry weight basis and on the basis of chemical analysis.

The effect of quantity of fertiliser in the packets was not significant both on dry weight basis and on the basis of chemical analysis.

The interaction effect of porosity and quantity was significant with respect to percentage of residual fertiliser on the basis of chemical analysis but the effect was not significant when calculations were made based on dry weight. The data are presented in Table 8.

As in experiment No.2, it was noticed that the dissolution rate was influenced by the number of perforations and quantities of fertiliser packed. When perforations were closer, the release was faster in both these experiments.

From the above experiments it is concluded that there is substantial retention and slow release of urea when packed in perforated polybags. Root contact packets with 0.5 needle holes cm^{-2} appear to be better

Table 8. Combined effect of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Porosities holes cm^{-2}	Percentage residue Quantities, g packet^{-1} 50	100	150	200	250
0.0625	77.9	82.3	82.3	82.3	79.1
0.125	70.7	75.1	61.6	74.4	57.2
0.25	40.4	64.3	32.7	20.6	52.5
0.5	20.2	22.4	14.0	21.3	14.4
1.0	0.0	0.0	0.0	0.0	0.0

SEm± 5.7 CD(0.05) 16.7

as some quantity of fertiliser is left even after three months of application. At the same time they ensure substantial release of the fertiliser compared to the packets with fewer perforations. The fertiliser contained in packets with one needle hole cm^{-2} was completely exhausted by the third observation 90 days after application. Perforations made with needles appear to be better compared to those made with nails as needle holes provide extended availability for reasonable periods as evidenced from the experiments. To suit availability upto varying periods and for different rainfall patterns, further standardisations of porosity of bags would be necessary especially in south-west monsoon periods.

B. Dissolution rate of muriate of potash

Experiment no.1

This experiment was done to assess the rate of dissolution of muriate of potash from packets of different porosities and quantities. The porosities and quantities tried were 1, 2, 3 and 4 nail holes cm^{-2} and 50, 100, 150, 200 and 250 g, respectively. Samples were excavated at intervals of 15 days. There was no fertiliser left in any of the packets at any stage of excavation. The reason for this was assumed to be water stagnation in the coconut basins in which these packets were placed.

Experiment No.2

This experiment to assess the dissolution rate of muriate of potash packed in perforated polyethylene bags was conducted providing conditions without standing water. It was done in the north-east monsoon season and the porosities and quantities tried were 1 and 2 nail holes cm^{-2} and 50, 100, 150, 200 and 250 g, respectively. Samples were excavated at intervals of 30 days.

The data on percentage of residual fertiliser in the packets on dry weight basis and on the basis of chemical analysis are given in Table 9 and the analysis of variance in Appendix 4.

Significant difference could be noticed between the two porosities tried at all the three stages of sampling with respect to the percentage of residual

Table 9. Effects of porosity and quantity of fertiliser on the dissolution rate of muriate of potash from root contact packets

Treatment	Percentage of residue					
	Days after application					
	30		60		90	
	D	A	D	A	D	A
Porosities (holes cm^{-2})						
1	77.9	74.4	62.7	59.6	58.4	52.1
2	68.6	65.2	52.4	44.7	35.2	30.7
SEm±	0.7	0.9	2.9	1.1	1.6	1.5
CD(0.05)	2.1	2.6	8.5	3.1	4.7	4.5
Quantities (g packet^{-1})						
50	69.7	63.6	48.7	44.8	37.3	29.9
100	71.3	69.7	62.2	51.5	49.0	45.1
150	69.6	69.6	55.5	53.2	46.3	42.2
200	76.2	73.5	56.2	52.7	46.1	39.7
250	79.5	72.7	65.3	58.8	55.2	50.0
SEm±	1.1	1.4	4.5	1.7	2.5	2.4
CD(0.05)	3.3	4.2	NS	5.0	7.5	7.2

D : Values on dry weight basis

A : Values on the basis of chemical analysis muriate of potash on dry weight basis and on the basis of chemical analysis, there being decrease with increasing porosity.

The effect of packet size was significant at all the stages of sampling with respect to percentage of residual fertiliser except when the percentage of residual fertiliser was calculated on dry weight basis at the second stage of observation 60 days after application.

At the first stage of observation 30 days after application when calculations were made on dry weight basis, 250 g packets recorded the highest value which was on par with 200 g packets with respect to percentage of residual fertiliser. The lowest value was registered by 150 g packets which was on par with 50 g and 100 g packets. On the basis of chemical analysis 200 g packets registered te highest value and was on par with all other quantities except 50 g packets which recorded the lowest value.

At the second stage of observation, the highest percentage of residual fertiliser was obtained with

250 g packets when calculated on the basis of chemical analysis. This was followed by 150 g packet which was on par with 200 g packet and 100 g packet which were significantly superior to 50 g packet.

At the third stage of observation, 250 g packet recorded the highest value and 50 g packet registered the lowest value both on dry weight basis and on the basis of chemical analysis.

The interaction effect of porosity and quantity was significant only at the first stage of observation when the percentage of residual muriate of potash was calculated on dry weight basis. The data are presented in Table 10.

The results indicated that as in the case of urea, dissolution rate of muriate of potash was also influenced by the number of perforations cm^{-2} and the quantity of fertiliser. The dissolution rate increased with increase in perforations and decrease in quantities. The highest quantity combined with least number of perforations resulted in the maximum value for the residue.

Table 10. Combined effect of porosity and quantity of fertilizer on the dissolution rate of muriate of potash from root contact packets

Porosities (holes cm^{-2})	Percentage residue				
	Quantities, g packet^{-1}				
	50	100	150	200	250
1	71.3	78.7	73.6	80.5	85.6
2	68.0	64.0	65.5	71.8	73.5

SEm± 1.6 CD(0.05) 4.6

However, the values were much higher as compared to urea. Substantial quantities of muriate of potash were left in the packets even after 90 days of application but urea was completely released by the second stage of sampling 60 days after application when tried at the same level of porosity. Since this experiment was conducted in north-east monsoon season when the rainfall intensity was relatively low, the effect of porosities need to be standardised in south-west monsoon also.

II Assessment of the advantage of root contact packets

A. Root contact packets of urea

This experiment was carried out to assess the advantage of root contact packets of urea as compared to split application of this fertiliser. The test crop was cocoa and seedling growth was used as the test criterion. Rsults on these are given below.

a. Biometric observations

(i) Height of seedlings

The data on height of seedlings at different stages of observation are given in Table 11 and the analysis of variance in Appendix 5.

There was no significant difference between the treatments with respect to the height of seedlings at any of the stages of observations.

On 30th day of planting, the highest height of 36.6 cm was recorded in plots receiving 75 g urea applied in two equal splits and those receiving 75 g urea as root contact packets with four holes cm^{-2}. The lowest value was recorded in the control.

At the second stage of observation 60th day of planting 75 g urea applied as root contact packets with four holes cm^{-2} recorded the highest value while those with two holes cm^{-2} recorded the lowest value.

On 90th day of planting 75 g urea applied as root contact packets with four holes cm^{-2} recorded the highest value. It was followed by 75 g packets with three holes cm^{-2}. Packets of 75 g with one hole cm^{-2} recorded the lowest value.

Table 11. Effect of application of urea in splits and as root contact packets on height of cocoa seedlings

Treatment	Height of seedlings, cm				
	Days after planting				
	30	60	90	120	150
Control	33.5	40.1	51.7	63.6	78.1
S/75	36.6	42.1	53.0	66.3	84.5
P 1/75	35.0	40.5	51.6	66.0	81.1
P 2/75	33.9	40.0	53.5	67.5	81.8
P 3/75	34.9	41.1	54.5	68.3	85.6
P 4/75	36.6	43.7	57.8	69.4	88.1
SEm±	2.5	1.7	3.2	3.8	5.6
CD(0.05)	NS	NS	NS	NS	NS

S - Split application P - Porosity, cm^{-2}

On 120th day of planting, 75 g packets with four hols cm^{-2} reecorded the highest value. The lowest value was observed in the control.

At the last stage of observation 150th day of planting the highest height was recorded in plots receiving 75 g urea as root contact packets with four $holes^{-2}$. Here also the lowest value was registered in the control.

In general,application of 75 g urea in packets with four holes cm^{-2} gave the highest values with regard to height of seedlings at the various stages of observation. Lower values were registered in control plot and in those receiving 75 g urea packed in polyethylene bags with reduced number of perforations. These differences were however not statistically significant at any of the stages of observation. Being a nutrient rated as low in the soil (Table 1), substantial improvement in growth because of its supplementation was expected. The lack of a consistent and significant improvement in growth is perhaps due to inefficient utilisation from the applied fertiliser. Hevy rains might have resulted in the leaching losses of the nitrogen applied in splits. Better response could have perhaps been obtained with increased number of splits. The root contact packets would have been a suitable alternative but with the high porosities used which resulted in rapid dissolution, they might also have failed to ensure extended availability.

(ii) Girth of seedlings

The data on the girth of seedlings are presented in Table 12 and the analysis of variance in Appendix 6.

The treatments showed no significant difference with regard to the girth of seedlings at any of the stages of observation. The reasons for the lack of significant response on plant height must be applicable to this growth parameter also.

(iii) Number of leaves

The data on number of leves are presented in Table 13 and the analysis of variance is given in Appendix 7.

There was no significant difference between the treatments at any stage of observation.

Table 12. Effect of application of urea in splits and as root contact packets on girth of cocoa seedlings

Treatment	Girth of seedlings, cm				
	Days after planting				
	30	60	90	120	150
Control	2.4	2.9	3.4	3.8	4.6
S/75	2.6	3.0	3.4	3.7	4.4
P 1/75	2.7	3.0	3.4	3.6	4.3
P 2/75	2.6	2.9	3.3	3.8	4.5
P 3/75	2.7	2.9	3.4	3.8	4.4
P 4/75	2.6	2.8	3.3	3.7	4.6
SEm±	0.12	0.10	0.12	0.13	0.18
CD(0.05)	NS	NS	NS	NS	NS

S - Split application P - Porosity, cm^{-2}

Table 13. Effect of application of urea in splits and as root contact packets on number of leaves of cocoa seedlings

Treatment	Number of leaves				
	Days after planting				
	30	60	90	120	150
Control	15.3	14.9	22.1	29.6	31.5
S/75	14.3	14.5	21.7	28.6	33.3
P 1/75	15.7	13.9	22.6	27.6	29.0
P 2/75	15.2	12.7	21.0	28.1	32.1
P 3/75	14.5	14.5	23.0	31.2	36.9
P 4/75	16.4	13.5	23.3	27.7	30.3
SEm±	0.58	1.15	1.22	2.27	2.61
CD(0.05)	NS	NS	NS	NS	NS

S - Split application P - Porosity, cm^{-2}

At the time of first observation 30 days after planting, the highest value (16.4) was recorded in the set receiving 75 g urea as root contact packet with four holes cm^{-2}. The lowest value was registered when 75g urea was applied in two equal splits. At the next stage 60 days after planting also, the treatment differences continued to be non-significant with the control of no nitrogen supply recording the highest mean value. Ninty days after planting root contact packets with four holes cm^{-2} recorded the highest value. The lowest value was observed with root contact packets with two holes cm^{-2}. Urea applied in packets with three holes cm^{-2} recorded the maximum number of leaves while that applied in packets with one hole cm^{-2} recorded the lowest value both on 120th and 150th days after planting.

In general, higher number of leaves was obtained when urea was applied in polyethylene packets with higher number of perforations. These differences were noted in mean values only and statistical analysis of the data indicated lack of significance in this character at any stage. The reasons for such a lack of response on plant height have already been discussed. The same reasons must apply for this growth parameter also.

(iv) Dry matter production

The data on dry matter production are presented in Table 14 and the analysis of variance in Appendix 8.

No significant difference could be observed between the treatments with respect to dry matter production. Split application of urea gave the highest value and it was followed by 75 g packets with three holes cm^{-2}. The lowest value was observed in the control. The reasons for the lack of response on plant hight are applicable in this case also.

b. Chemical studies

The data on nutrient content and total nutrient uptake are given in Table 14 and the analysis of variance in Appendix 8.

There was no significant difference between the seedlings with respect to the nitrogen content of the stem. The data on nitrogen content of leaves showed significant difference between the treatments. Urea applied as splits as well as in root contact packets recorded maximum values and were significantly superior

Table 14. Effect of application of urea in splits and as root contact packets on dry matter production, nitrogen content and total nitrogen uptake of cocoa seedlings

Treatment	Drymatter production g $plant^{-1}$	N content of stem per cent	N content of leaves per cent.	Total nitrogen uptake g $plant^{-1}$
Control	39.5	1.7	2.5	0.9
S/75	59.9	2.0	2.9	1.5
P 1/75	49.9	2.0	2.8	1.2
P 2/75	49.6	2.0	2.9	1.3
P 3/75	59.2	1.8	2.9	1.5
P 4/75	55.6	1.8	2.9	1.4
SEm±	5.87	0.12	0.05	0.16
CD(0.05)	NS	NS	0.15	NS

S - Split application P - Porosity, cm^{-2}

to the control treatment which recorded the lowest value.

The treatments showed no significant difference with respect to total nitrogen uptake. The highest value (154.7 g plant^{-1}) was recorded when urea was applied in two splits and the lowest value was in the control.

The highest value for dry matter production was also obtained when urea was applied in splits. Uptake being the product of drymatter production and nutrient content, split application resulted in maximum uptake of nitrogen eventhough the effect was not significant.

The results of the study on dissolution rate of root contact packets of urea revealed that holes made with nails and porosities above one hole cm^{-2} resulted in rapid dissolution of the fertiliser and thus failed to ensure extended availability during the main rainy season. However, substantial retention and slow release of the fertiliser could be achieved with porosities below one hole cm^{-2}. But such packets could not be tested for their advantage to crops in the rainy season. In the present study to assess the advantage of the root contact packets, the packets were all having nail holes and higher porosities. With such porosities, the dissolution rates were probably so very high that these were only as useful as a single application. Severe losses of the applied nutrient by way of leaching might have resulted in the lack of response of the seedlings to the nitrogen applied in splits. However, split application as well as application of urea as root contact packets could register some advantage which attained statistical significance over the control in the case of content of the nutrient in leaves.

B. Root contact packets of muriate of potash

This experiment was carried out to assess the comparative advantage of root contact packets of muriate of potash and split applications of this fertiliser on cocoa seedlings. Results are presented and discussed below.

a. Biometric observations

(i) Height of seedlings

Data on height of plants are presented in Table 15 and analysis of variance in Appendix 9.

Table 15. Effect of application of muriate of potash in splits and as root contact packets on height of cocoa seedlings

Treatment	Height of seedlings, cm				
	Days after planting				
	30	60	90	120	150
Control	35.4	38.5	46.7	53.3	63.7
S/75	37.1	40.5	47.3	54.3	69.2
P 1/75	36.9	39.3	47.9	55.9	62.9
P 2/75	36.0	39.9	49.4	55.4	65.1
P 3/75	37.9	41.1	48.3	52.2	59.7
P 4/75	37.0	39.3	47.5	53.2	57.3
SEm±	1.2	1.0	1.7	2.6	2.4
CD(0.05)	NS	NS	NS	NS	7.3

S - Split application P - Porosity, cm^{-2}

There was no significant difference between the treatments except at the last stage of observation 150 days after planting. Even at this stage, there was no consistent trend of variation with treatments.

Muriate of potash placed in polyethylene packets with three holes.cm^{-2} recorded maximum height and control registered lowest values both on 30th and 60th days after planting.

At the third stage of observation 90 days after planting, root contact packets with two holes cm^{-2} recorded the highest value. The lowest height was observed in the control.

Maximum height of cocoa seedlings was observed with root contact packets with one hole cm^{-2} on 120th day of observation. The lowest value was recorded in plots receiving 75 g muriate of potash as root contact packets with three holes cm^{-2}.

On 150th day after planting, there was significant difference between the treatments. Application of muriate of potash in splits gave maximum height. The lowest value was recorded in plots receiving root contact packets with four holes cm^{-2}.

Consistent and significant improvement in growth of cocoa seedlings could not be obtained with application of muriate of potash either when applied in splits or as root contact packets. The high rating of potassium in soil (Table 1) might have resulted in this lack of response. Being a nutrient highly mobile in soil, substantial losses might have occurred by way of leaching when applied in splits. The root contact packets might also have failed to provide extended availability of the nutrient due to the rapid dissolution during the peak rainy season.

(ii) Girth of seedlings

Data on girth of seedlings are presented in Table 16 and the analysis of variance in Appendix 10.

Root contact packets with one hole cm^{-2} recorded the highest values and those with four holes cm^{-2} registered the lowest values with respect to girth at all the five stages of observation (viz. 30, 60, 90, 120 and 150 days after planting) except after 90 days where control recorded the lowest value. The differences were not significant at any stage. That such a lack of crop response from

Table 16. Effect of application of muriate of potash in splits and as root contact packets on girth of cocoa seedlings

Treatment	Girth of seedlings, cm				
	Days after planting				
	30	60	90	120	150
Control	2.6	2.9	3.1	3.6	4.0
S/75	2.6	3.0	3.3	3.7	4.3
P 1/75	2.8	3.2	3.5	3.8	4.4
P 2/75	2.7	3.1	3.5	3.8	4.3
P 3/75	2.6	2.9	3.4	3.7	4.1
P 4/75	2.5	2.8	3.2	3.5	3.9
SEm±	0.10	0.13	0.12	0.12	0.15
CD(0.05)	NS	NS	NS	NS	NS

S - Split application P - Porosity, cm^{-2}

application of this nutrient is attributable primarily to the high inherent content of this nutrient has already been mentioned.

(iii) Number of leaves

Data on number of leaves are presented in Table 17 and the analysis of variance in Appendix 11.

There was no significant difference between the treatments at any stage of observation. On the 30th day of planting, root contact packets with four holes cm^{-2} recorded the highest value. The lowest value was recorded by packets with two holes cm^{-2}.

The maximum number of leaves was observed with packets with one hole cm^{-2} on 60th day after planting. The lowest value of 13.1 was recorded by split application and application as root contact packets with four holes cm^{-2}

On 90th day of planting, application of packets with four holes cm^{-2} recorded the highest value. Lowest value was recorded in the control.

Application of muriate of potash as root contact

Table 17. Effect of application of muriate of potash in splits and as root contact packets on number of leaves of cocoa seedlings

Treatment	Number of leaves				
	Days after planting				
	30	60	90	120	150
Control	14.9	14.7	19.0	21.7	22.2
S/75	15.3	13.1	19.6	24.5	27.0
P 1/75	15.9	15.2	20.2	22.1	24.5
P 2/75	14.8	13.6	20.9	23.4	22.7
P 3/75	15.7	14.4	20.2	21.7	22.7
P 4/75	16.1	13.1	21.4	26.1	22.3
SEm±	0.87	1.07	1.44	2.05	1.24
CD(0.05)	NS	NS	NS	NS	NS

S - Split application P - Porosity, cm^{-2}

packets with four holes cm^{-2} recorded the maximum value while the control plot as well as packets with three holes cm^{-2} recorded the lowest value on 120th day after planting.

On 150th day after planting, the highest value was observed with split application and the lowest value was recorded in the control.

The reasons for such a lack of significant response on plant height must be applicable to this growth parameter also.

(iv) Dry matter production

The data on dry matter production are given in Table 18 and the analysis of variance in Appendix 12.

No significant difference could be observed between the the treatments with regard to dry matter production. Highest mean value was observed with split application. Root contact packets with three holes cm^{-2} registered the lowest value. Such a lack of response may be attributed to the high inherent content of potassium in the soil.

Table 18. Effect of application of muriate of potash in splits and as root contact packets on dry matter production, potassium content and total potassium uptake of cocoa seedlings

Treatment	Drymatter production g $plant^{-1}$	Potassium content of stem per cent	Potassium content of leaves per cent	Total potassium uptake g $plant^{-1}$
Control	27.0	0.8	0.9	0.3
S/75	35.4	1.2	1.4	0.5
P 1/75	28.2	1.0	1.1	0.3
P 2/75	26.5	1.0	1.2	0.3
P 3/75	25.6	1.0	1.1	0.3
P 4/75	26.6	1.0	1.2	0.3
SEm±	2.15	0.05	0.05	0.03
CD(0.05)	NS	0.15	0.15	0.08

S - Split application P - Porosity, cm^{-2}

b. Chemical studies

Data on potassium content and total nutrient uptake are presented in Table 18 and the analysis of variance in Appendx 12.

Potassium contents of stem and leaves were both maximum with split application and lowest in control. Poor root system in early stages of growth might have failed in absorbing the potassium released from the fertiliser packets but at later stages, with an expanded root system these plants might have responded to the fertiliser applied in split.

Significant difference could be noticed between the treatments with respect to total potassium uptake. Split application recorded the highest value which was significantly superior to other treatments which were all on par. The lowest value was in the control.

Uptake being the product of dry matter production and nutrient content, higher values of dry matter and nutrient content observed with split application may be attributed to be the reason for the highest value for total potassium uptake obtained with split application.

The high inherent potassium status of the soil might have resulted in the lack of consistent and significant response in terms of growth to the fertiliser applied. The increased potassium content of leaves and uptake observed with split application can be attributed to the luxury consumption of the nutrient. The heavy south-west monsoon showers might have resulted in the rapid dissolution of muriate of potash in the polyethylene packets thus leading to an inefficient utilization by the plants.

Summary

SUMMARY

A study was conducted at the College of Horticulture, Vellanikkara, Thrissur to assess the release of nitrogen and potassium from root contact packets of urea and muriate of potash and their crop responses during the period from June 1991 to June 1992.

Separate experiments were conducted to study the efficiency of root contact packets of urea and muriate of potash. The treatments consisted of factorial combinations of four porosities (1, 2, 3 and 4 nail holes cm^{-2}) and five packet sizes (50, 100, 150, 200 and 250g) in the case of urea and four porosities (1, 2, 3 and 4 nail holes cm^{-2}) and five packet sizes (50, 100, 150, 200 and 250 g) in the case of muriate of potash. The packets were buried in the basins of coconut in south-west monsoon season and observations were taken on the percentages of residual fertilisers in the packets at intervals of 15 days.

As there was no fertiliser left in practically any of the packets in the case of both urea and muriate of potash at any stage of excavation starting from 15 days after placement, the experiments were repeated in

north-east monsoon season providing conditions without standing water.

The treatments were factorial combinations of two porosities (1 and 2 nail holes cm^{-2}) and five packet sizes (50, 100, 150, 200 and 250 g) for urea and two porosities (1 and 2 nail holes cm^{-2}) and five packet sizes (50, 100, 150, 200 and 250 g) for muriate of potash. Raised beds were prepared and the packets were placed at a depth of 20 cm. Observations were taken on the percentage of residual fertiliser at monthly intervals.

In the case of urea, significant difference could be noticed between the two porosities tried with respect to percentage of residual fertiliser in the packets, there being a decrease with increase in porosity. Between the quantities tried, the percentage of residue was found to increase with increasing quantities of fertiliser. The dissolution rates were high and there was no fertililiser left in practically any of the packets when excavated on the 60th day after application.

Unlike in the case of urea, substantial retention of the fertiliser could be noticed even upto 90 days after application in the case of muriate of potash.

Here also, a significant decrease in the percentage of residual fertiliser could be observed with increase in porosity and decrease in quantities.

As the dissolution rate of urea was very high, another experiment was conducted to standardise the porosities by reducing the porosities still further. It was conducted in the dry season under simulated rainfall conditions with the daily rate of application of water equivalent to 2 cm. Factorial combinations of five porosities (0.25, 0.5, 0.75 and 1 nail hole cm^{-2} and 1 needle hole cm^{-2}) and five packet sizes (50, 100, 150, 200 and 250 g urea) constituted the treatments. Beds were prepared and packets were placed at a depth of 20 cm. Observations were taken on the percentage of residual urea left in the packets at monthly intervals. In this experiment also, dissolution rates were high and there was no residual fertiliser in any of the packets even at the first stage of sampling 30 days after application. Hence the experiment was repeated with the porosities reduced further.

In this experiment conducted under simulated rainfall conditions, factorial combinations of five porosities

(0.0625, 0.125, 0.25, 0.5 and 1 needle hole cm^{-2}) and five packet sizes (50, 100, 150, 200, and 250 g urea) constituted the treatments. Beds were prepared and depth of placement was increased to 30 cm. Observations were made on the percentage of residual urea left in the packets at monthly intervals. Substantial retention of the fertiliser could be noticed even upto 90 days after application when porosity was upto 0.5 cm^{-2}. Significant difference could be noticed between the porosities tried with respect to the percentage of residual fertiliser. The percentage residue was found to decrease with increase in porosity at all the three stages of observation.

The advantage of applying urea and muriate of potash as root contact packets on crop growth was assessed using cocoa seedlings as indicators. The comparative advantage of urea split application and application as root contact packets was studied using six treatments. These included 75 g urea applied in two equal splits in June and October and 75 g urea applied as root contact packets with 1, 2, 3 and 4 nail holes cm^{-2}. There were controls of no nitrogen supply also. Biometric observations such as height, girth and number of leaves of cocoa seedlings were taken at monthly intervals and the dry matter production was taken 150 days after planting. Chemical studies like nitrogen content of stem and leaves and total nitrogen uptake were made 150 days after planting by distructive sampling.

There was no significant difference between the treatments with respect to height, girth and number of leaves of cocoa seedlings at any stage of observation. The data on dry matter production showed no significant difference between the treatments. There was no significant difference between the treatments with respect to the nitrogen content of stem. But split application as well as application of urea as root contact packets could register some advantage which attained statistical significance over the control in the case of nitrogen content in leaves. The data on total nitrogen uptake showed no significant difference between the treatments.

The comparative advantage of applying muriate of potash as root contact packets and split application was also studied using six treatments which included 75 g muriate of potash applied in two equal splits in June and October and 75g muriate of potash applied as root contact packets with 1, 2, 3 and 4 holes cm^{-2}. There were controls of no potassium supply also. Biometric observations were taken as in the case of urea and chemical studies such as determination of potassium content of stem and leaves and total nutrient uptake were done 150 days after planting.

Significant difference could not be observed between the treatments with regard to height of seedlings at any stage of observation except on 150th day when split application recorded the highest value.

There was no significant difference between the treatments with respect to girth and number of leaves at any stage of observation. The data on dry matter production showed no significant difference between the treatments.

Significant difference could be observed between the treatments with respect to potassium content of stem and leaves. Potassium content of stem and leaves were both maximum with split application and lowest ~~in~~ control of no potassium supply.

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Significant difference could be noticed between the treatments with respect to total potassium uptake. The highest value was obtained with split application of muriate of potash. The lowest value was in the control.

It is concluded that there can be substantial regulation and slow release of urea and muriate of potash when packed in perforated polythene bags. Polythene bags with 0.5 needle holes cm^{-2} appear to be better for urea and those with 2 holes cm^{-2} for muriate of potash as they ensure extended periods of retention with reasonable dissolution rate even upto 90 days after application. But confirmation of the advantage of the technique would require assessment based on crop responses and adoption of it at farm level would depend on the extent of savings in fertilisers and the additional cost involved in packing the fertilisers. These aspects could not be assessed with accuracy in this study and the porosities tried on cocoa seedlings were too high to ensure reasonable extension of availability both in urea and muriate of potash.

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* Original not seen.

Appendices

Appendix-1. Weather data (weekly average) for the experimental period (from 11-6-91 to 3-6-92)

Standard week No.	Month and date	Total rainfall mm	No. of rainy days	Temperature		Relative humidity		Sun shine hours
				Maximum °C	Minimum °C	Forenoon	Afternoon	
24	Jun. 11-17	239.8	7	30.6	24.2	92	81	4.0
25	Jun. 18-24	115.6	7	29.7	23.2	94	83	3.6
26	Jun. 25-Jul.1	216.0	6	28.4	23.1	93	83	0.6
27	Jul. 2-8	161.4	7	29.3	22.8	93	78	2.8
28	Jul. 9-15	179.4	7	28.4	23.2	94	79	2.1
29	Jul. 16-22	140.9	7	29.5	22.7	94	77	2.4
30	Jul. 23-29	361.6	7	29.3	22.6	92	79	3.2
31	Jul. 30-Aug.5	160.8	7	29.0	23.3	95	84	1.9
32	Aug. 6-12	65.2	6	29.5	23.1	95	79	2.3
33	Aug. 13-19	313.9	7	27.8	22.0	95	84	1.0
34	Aug. 20-26	53.0	6	29.1	22.3	96	79	3.5
35	Aug.27-Sept.2	12.5	3	30.4	23.3	94	66	6.5
36	Sept. 3 - 9	0.0	0	31.4	23.2	90	59	9.1
37	Sept.10 -16	6.4	2	31.6	24.6	98	65	6.1
38	Sept.17 -23	18.3	4	31.5	22.4	92	59	6.8
39	Sept.24 -30	36.8	5	31.7	24.0	90	70	6.5
40	Oct. 1 - 7	11.4	3	31.2	23.5	92	77	4.1
41	Oct. 8 -14	97.3	4	30.6	23.2	91	75	4.3
42	Oct. 15-21	57.6	4	32.1	23.0	87	66	6.4
43	Oct. 22-28	40.0	5	30.8	23.1	87	72	3.9
44	Oct. 29-Nov. 4	75.4	7	29.5	23.0	96	76	3.0
45	Nov. 5-11	105.0	6	32.1	22.5	89	62	7.4
46	Nov.12-18	53.4	3	31.4	22.8	94	69	5.0
47	Nov.19-25	0.5	1	31.0	24.4	76	50	7.7
48	Nov.26-Dec.2	0.0	0	31.9	20.9	79	58	8.6
49	Dec. 3-9	0.0	0	31.3	21.4	78	45	9.7
50	Dec.10-16	0.0	0	30.9	23.5	69	56	8.0
51	Dec.17-23	0.0	0	31.9	23.2	75	49	7.9
52	Dec.24-30	0.0	0	33.2	19.9	91	45	8.6
1	Jan. 1-7	0.0	0	32.4	21.8	80	39	7.0
2	Jan. 8-14	0.0	0	32.1	20.6	66	35	9.3
3	Jan.15-21	0.0	0	32.4	22.1	72	40	9.4
4	Jan.22-28	0.0	0	33.2	19.8	60	28	9.7
5	Jan.29-Feb.4	0.0	0	33.1	20.8	80	44	9.3
6	Feb. 5-11	0.0	0	34.6	22.1	90	41	9.1
7	Feb.12-18	0.0	0	34.5	21.6	91	44	8.9
8	Feb.19-25	0.0	0	34.4	21.6	88	44	9.3
9	Feb.26-Mar.4	0.0	0	36.7	22.2	81	36	9.4
10	Mar. 5-11	0.0	0	36.3	22.3	90	37	9.3
11.	Mar.12-18	0.0	0	37.1	21.9	71	23	10.0
12.	Mar.19-25	0.0	0	37.3	23.6	85	38	59.7
13.	Mar.26-Apr.1	0.0	0	36.4	23.9	86	49	9.1
14.	Apr. 2 - 8	0.0	0	36.1	24.0	84	44	9.2
15.	Apr.9-15	0.0	0	36.1	24.8	82	45	9.1
16.	Apr.16-22	0.0	0	36.6	24.6	80	52	8.1
17.	Apr.23-29	48.6	3	36.2	24.3	80	40	8.4
18.	Apr. 30-May 6	0.0	0	35.9	25.4	80	52	9.3
19.	May 7-13	28.4	4	35.0	24.2	87	61	8.8
20.	May 14-20	58.0	3	30.9	24.1	88	73	3.7
21.	May 21-27	3.0	2	33.6	25.3	86	59	9.1
22.	May 28-June 3	11.4	3	34.0	24.9	86	59	6.3

Source: Meteorological Observatory, Vellanikkara.

Appendix 2. Analysis of variance for the effects of porosity and quantity of fertiliser on the dissolution rate of urea from root contact packets

Source	df	Mean squares
		Percentage of residual urea 30 days after application
Total	29	-
Porosities	1	2528.2**
Quantities	4	218.0**
Interaction	4	136.2**
Error	20	11.0

** Significant at 1 per cent level

Appendix 3. Analysis of variance for the effects of porosity and quantity of fertiliser on the dissolution rates of urea from root contact packets

Source	df	Mean squares					
		Percentage residue					
		Days after application					
		30		60		90	
		D	A	D	A	D	A
Total	49	–	–	–	–	–	–
Porosities	4	4048.3**	3505.0**	11226.8**	9865.4**	13942.2**	11210.9**
Quantities	4	82.9*	58.9	103.1*	69.9	225.1	171.0
Interaction	16	58.1	129.1**	121.3**	108.6**	145.2	143.7*
Error	25	29.3	29.4	35.0	27.1	86.8	65.5

D : Values on dry weight basis

A : Values on the basis of chemical analysis

* : Significant at 5 per cent level

** : Significant at 1 per cent level

Appendix 4. Analysis of variance for effects of porosity and quantity of fertiliser on the dissolution rate of muriate of potash from root contact packets

Source	df	Mean squares					
		Percentage of residue					
		Days after application					
		30		60		90	
		D	A	D	A	D	A
Total	29						
Porosities	1	658.0**	643.1**	806.0 **	1662.1**	4018.3**	3415.5**
Quantities	4	117.3**	90.2**	250.7	149.7**	248.7**	337.7**
Interaction	4	27.9*	24.9	137.0	43.3	31.6	45.4
Error	20	7.4	12.1	123.8	16.9	38.7	35.5

D : Values on dry weight basis
A : Values on the basis of chemical analysis
* : Significant at 5 per cent level
** : Significant at 1 per cent level

Appendix 5. Analysis of variance for the effect of application of urea in splits and as root contact packets on height of cocoa seedlings

Source	df	Mean squares				
		Height of seedlings, cm				
		Days after planting				
		30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	74.1	46.5*	67.1	159.0	193.9
Treatment	5	6.7	8.0	20.8	16.5	50.4
Error	15	26.9	12.0	41.9	59.2	127.0

*Significant at 5 per cent level

Appendix 6. Analysis of variance for the effect of application of urea in splits and as root contact packets on girth of cocoa seedlings

Source	df	Mean squares				
		Girth of seedlings, cm				
		Days after planting				
		30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	0.16	0.13	0.09	0.09	0.20
Treatment	5	0.07	0.02	0.01	0.03	0.06
Error	15	0.06	0.04	0.06	0.07	0.13

Appendix 7. Analysis of variance for the effect of application of urea in splits and as root contact packets on number of leaves of cocoa seedlings

Source	df	Mean squares				
		Number of leaves				
		Days after planting				
		30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	1.8	4.1	4.7	10.0	66.4
Treatment	5	2.4	2.7	2.9	7.7	30.3
Error	15	1.4	5.3	6.0	20.6	27.2

Appendix 8. Analysis of variance for the effect of application of urea in splits and as root contact packets on dry matter production, nitrogen content and total nitrogen uptake of cocoa seedlings

Source	df	Mean squares Dry matter production g plant^{-1}	N content of stem per cent	N content of leaves per cent	Total nitrogen uptake, g plant^{-1}
Total	23	-	-	-	-
Replication	3	210.75	0.01	0.01	0.1
Treatment	5	234.59	0.07	0.10**	0.2
Error	15	137.57	0.06	0.01	0.1

**Significant at 1 per cent level

Appendix 9. Analysis of variance for the effect of application of muriate of potash in splits and as root contct packets on height of ccocoa seedlings

Source	df	Mean squares				
		Height of seedlings, cm				
		Days after planting				
		30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	2.8	1.0	23.6	21.4	19.2
Treatment	5	3.0	3.6	3.3	8.2	69.7*
Error	15	6.0	4.4	11.8	27.6	23.6

*Significant at 5 per cent level

Appendix 10. Analysis of variance for the effect of application of muriate of potash in splits and as root contact packets on girth of cocoa seedlings

Source	df	Mean squares Girth of seedlings, cm Days after planting 30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	0.03	0.06	0.12	0.16	0.13
Treatment	5	0.03	0.08	0.09	0.06	0.16
Error	15	0.04	0.07	0.06	0.06	0.09

Appendix 11. Analysis of variance for the effect of application of muriate of potash in splits and as root contact packets on number of leaves of cocoa seedlings

Source	df	Mean squares				
		Number of leaves				
		Days after planting				
		30	60	90	120	150
Total	23	-	-	-	-	-
Replication	3	0.3	1.7	0.7	8.0	4.6
Treatment	5	1.2	3.1	3.1	12.6	13.9
Error	15	3.0	4.6	8.3	16.8	6.2

Appendix 12. Analysis of variance for the effect of application of muriate of potash on dry matter production, potassium content and total potassium uptake of cocoa seedlings

Source	df	Mean squares			
		Dry matter production g plant^{-1}	Potassium content of stem per cent	Potassium content of leaves per cent	Total potassium uptake g plant^{-1}
Total	23	-	-	-	-
Replication	3	58.01	0.01	0.01	0.008
Treatment	5	51.85	0.06**	0.08**	0.022**
Error	15	18.52	0.01	0.01	0.003

**Significant at 1 per cent level

Plate 1 Pin press used for making perforations on polyethylene bags

Plate 2 Root contact packets of urea

Plate 3 Root contact packets of muriate of potash


1/50
1/100
1/150
1/200
1/250

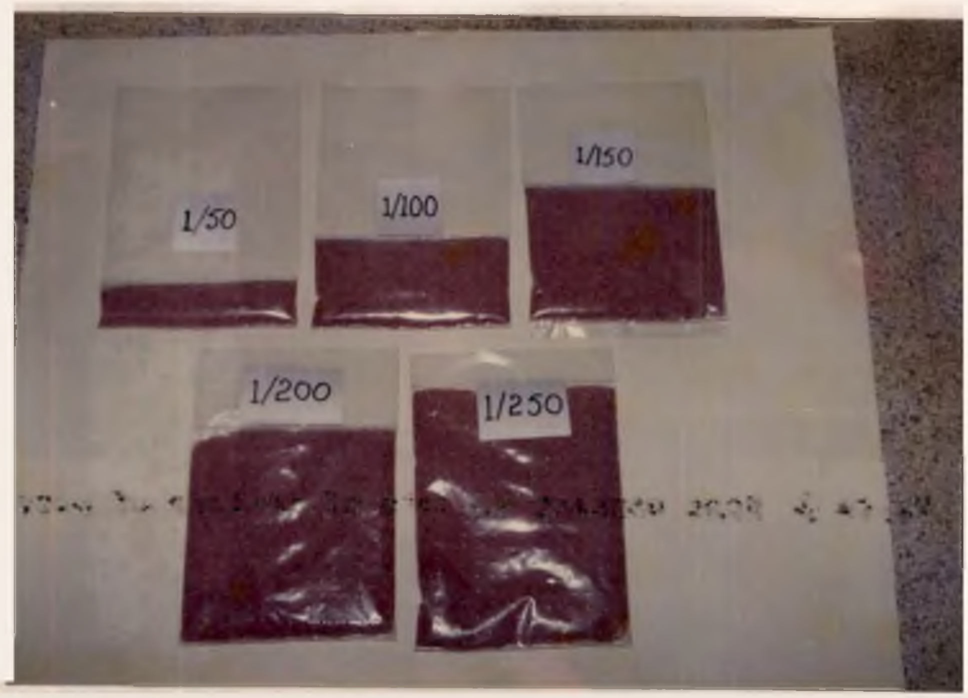
1/50
1/100
1/150
1/200
1/250

Plate 4 Root contact packets of urea placed in coconut basin

Plate 5 Root contact packets of muriate of potash placed in coconut basin

RELEASE OF NITROGEN AND POTASSIUM FROM ROOT CONTACT PACKETS OF UREA AND MURIATE OF POTASH AND THEIR CROP RESPONSES

By

JOMOL P. MATHEW

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
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Vellanikkara, Thrissur

1992

ABSTRACT

The present study 'release of nitrogen and potassium from root contact packets of urea and muriate of potash and their crop responses' was conducted during June 1991 to June 1992 at the College of Horticulture, Vellanikkara.

Root contact packets of varying porosities and quantities were prepared and separate experiments were conducted to study the efficiency of packets of urea and muriate of potash.

A series of experiments were conducted to standardise the porosities suited to provide extended retention of the fertiliser packed in polythene packets. In studies conducted in north-east monsoon season, substantial retention of muriate of potash could be observed with porosities of one and two nail holes cm^{-2} upto 90 days of application. The quantity retained was found to decrease significantly with increase in porosity. These two porosities were not suited for urea and there was no urea left in the packets 60 days after application due to the rapid dissolution at those porosities. Subsequent experiments on dissolution rate of urea conducted in simulated rain-

fall conditions with reduced porosities showed that porosities of 0.5 holes cm^{-2} and lower offer extended retention of the fertiliser even upto 90 days after application. Here also the percentage of residual urea was found to decrease with increase in porosity.

The advantage of applying urea and muriate of potash as root contact packets on crop growth was assessed using cocoa seedlings as indicators. In the case of both urea and muriate of potash, the treatments showed no significant difference with regard to the growth parameters like height, girth, number of leaves and dry matter production. Split application of urea as well as application of urea as root contact packets registered some advantage which attained statistical significance over the control in the case of nitrogen content of leaves. The data on nitrogen content of stem and total nitrogen uptake showed no significant difference between the treatments.

In the experiment on assessment of advantage of root contact packets of muriate of potash, potassium content of stem and leaves were both maximum with split application and the lowest in control. Split application was significantly superior to other treatments with respect to total potassium uptake.

It is concluded from the experiments that there can be substantial regulation and slow release of urea and muriate of potash when packed in perforated polythene bags.