172212

SOIL TEST CROP RESPONSE STUDIES ON COLEUS (*Solenostemon rotundifolius* Poir J. K. Morton) IN THE LATERITE SOILS OF KERALA

By

M. NAGARAJAN

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Soil Science and Agricultural Chemistry

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR-680 656

KERALA, INDIA

2003

DECLARATION

I hereby declare that the thesis entitled **"Soil test crop response studies on coleus (*Solenostemon rotundifolius* Poir J.K. Morton) in the laterite soils of Kerala."** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara

M. Nagarajan

Date: 30.12.03

CERTIFICATE

We, the undersigned members of the advisory committee of **Mr.M.Nagarajan** a candidate for the degree of **Master of Science in Agriculture**, with major field in Soil Science and Agricultural Chemistry, agree that the thesis entitled **"Soil test crop response studies on coleus (*Solenostemon rotundifolius* Poir J.K Morton) in the laterite soils of Kerala."** may be submitted by **Mr.M.Nagarajan** in partial fulfillment of the requirement for the degree.

30/12/03

Dr. M.A. Hassan
(Chairman, Advisory Committee)
Associate Professor
Department of Soil Science and Agricultural Chemistry
College of Horticulture
Vellanikkara.

31/12/03

Dr. K.C. Marykutty

Associate Professor and Head
Department of Soil Science
and Agricultural Chemistry
College of Horticulture
Vellanikkara.

30.12.03

Dr. P. Suresh kumar

Assistant Professor,
Radio Tracer Laboratory
College of Horticulture
Vellanikkara.

30/12/03

Dr.V.V. Radhakrishnan

Associate Professor
Department of Plant breeding and Genetics
College of Horticulture
Vellanikkara.

30/12/03

EXTERNAL EXAMINER

Dr. M. BALAGOPALAN
HEAD, DIVISION OF SOIL SCIENCE
KFRI, PEECHI

ACKNOWLEDGEMENT

I first thank the God Almighty, for enabling me to complete this endeavour successfully.

I have great pleasure to place on record my profound sense of gratitude and indebtedness to **Dr. M. A. Hassan**, *Associate Professor, Department of Soil Science and Agricultural Chemistry and Chairperson of my advisory committee for his kind concern, expert advice, utmost sense of patience and constant encouragement, throughout the course of the study and preparation of the thesis. It is my privilege and great fortune to work under his guidance.*

I place my thanks with special gratitude and deep respect to **Dr. K.C. Marykutty,** *Associate Professor and Head, Department of Soil Science and Agricultural Chemistry and Member of my advisory committee for her constructive critisism and valuable suggestions during the course of this study.*

I am respectfully thankful to **Dr. P. Suresh Kumar,** *Assistant Professor, RTL, Department of Soil Science and Agricultural Chemistry and member of my advisory committee for his valuable suggestions and critical evaluation of the manuscript.*

I sincerely thank **Dr. V.V. Radhakrishnan**, *Associate professor, Department of Plant breeding and Genetics and member of my advisory committee for his timely suggestions and help rendered during preparation of the manuscript.*

I extend my esteem regards to **Dr. G.S.L.H.V. Prasada Rao,** *Associate Dean, College of Horticulture, Vellanikkara for providing necessary facilities for this study.*

The good support and care extended to me from the teaching staffs especially Dr.Mariam, Dr. Sam, Dr. Sushama, Dr.Jacob John, Dr. Mini, Dr. Betty Bastin, Dr. Saifudeen, Dr. Durgadevi, Gopi Sir and also non teaching staffs Mr. P.R. Sathyan, *Mr. M. Anantha Krishnan, Mrs. Kamalakshi, Madhumathi and Mr. Ratheesh of the Department of SS & AC is thankfully acknowledged.*

I gratefully acknowledge my friends Sambu, Dr. K. Dhinesh Babu, Muthu, Ponns, Bhavani, Venkatesh, Ganapathi, Sankar, Ramesh, Kamal, Jinnappa, Gopi, Chandrahasan, Mani and Dr. Rajmams.

I am deeply indebted to my classmates Priya, Preetha and Lakshmisree, and other department mates Suresh, Rajesh, Sinish, Resmi, Deepa and Vidhu.

I am thankful especially to Ambili. S. Nair for her timely help in doing Path Analysis, and my friends Sridhar, Suresh, Murugesh, Pandiyaraja, Muthu, Venkatesh and Murugadoss support and encouragement.

I take this opportunity to thank my senior friends Vezha, Boopathi, Arul, Karthik and department junior friends for their help during the period of my study.

The award of KAU JuniorResearch Fellowship is deeply acknowledged.

I am in dearth of words to express my gratitude and indebtedness to my beloved father, mother, sister and relatives for their eternal boundless affection, moral support and encouragement in all endeavours.

M. Nagarajan

Dedicated to

THE MEMORIES OF MY SISTER

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS

AICRP	-	All India Coordinated Research Project
ANOVA	-	Analysis of variance
CD	-	Critical difference
FGE	-	Fertility Gradient Experiment
ha	-	hectare
IARI	-	Indian Agricultural Research Institute
Kg	-	Kilogram
KAU	-	Kerala Agricultural University
K	-	Potassium
N	-	Nitrogen
OC	-	Organic Carbon
P	-	Phosphorus
RBD	-	Randomized Block Design
STCR	-	Soil Test Crop Response
STVs	-	Soil Test Values
T	-	Targeted yield
t	-	tonne
TNAU	-	Tamil Nadu Agricultural University

Introduction

1. INTRODUCTION

Soil is the most valuable resource, but it is finite and non-renewable. In agriculture, soil is a basic medium for growing plants. The prime objective of an intensive agricultural system is to achieve the highest yield per unit area. The crop production has to be increased through the efficient and economic use of fertilizers apart from the use of high yielding varieties. So, the fertilizers play a major role in agriculture. There is a strong relationship between fertilizer consumption and production of the crops. Hence, there is a need to application of fertilizers, based on the requirement of crops.

An efficient fertilization means optimization of soils nutrient replenishment with the minimization of nutrient losses to the environment (Maene, 2001). High level of fertilizer use efficiency is of interest not only to the individual farmer, but also to the country's agriculture. This is achievable when supplies from soil and fertilizers to the plant are well balanced. The continued use of unbalanced fertilizers results in depletion of soil supplies of nutrients provided through the fertilizers and consequent decline in fertilizer response.

As the cost of the fertilizers goes on increasing, their demand by the farmers, which depends on their ability to purchase them, gets reduced. Therefore, 'Economic rationality', dictates a more comprehensive approach to fertilizer utilization incorporating soil tests, field experimentation and economic evaluation of results.

The fertilization programmes are to be based on soil properties, especially on its inherent capacity to supply nutrients to the crops in a balanced proportion and crop uptake. The real balance for maximum yield is "not that between the applied nutrients but that after taking into account the relative contribution from soil and fertilizer" (Ramamoorthy, 1993). The emphasis on soil test based balanced fertilization has become much more relevant in the present scenario of high fertilizer costs and yield maximization programmes.

In this contest, a Soil Test Crop Response study arises in soil fertility evaluation programme due to great diversity of soils, climate, crops and management practices. The Soil Test Crop Response (STCR) approach is the study of quantitative relationship between soil test values, applied nutrients and the resultant crop yield. This will enable us to prescribe the nutrient requirements of the crop to obtain a desired yield.

A well established soil test calibration helps to apply fertilizers in precise amounts to obtain high use efficiency and maximum possible yield in an ecosystem. In this part, there are several mathematical models developed for soil test calibrations. The formulation of fertilizer recommendation must take into account, the soil nutrient status and the crop needs. This has emphasized the use of soil test for fertilizer prescriptions.

Soil testing is a chemical method for estimating the nutrient supplying power of a soil. It involves series of steps including collection of soil samples, extraction of available nutrients, interpretation of the data and formulation of fertilizer prescriptions. Different soils differ in their capacity to supply the nutrients to crops and the crops also differ in their nutrient requirements. Hence the soil test data should be correlated with nutrient uptake by crops for making efficient fertilizer recommendation.

Soil test crop response correlation studies fulfill the above needs. In this approach, required variations in soil fertility are created in one and the same field. The available nutrient status of the soil is determined in the laboratories and correlated with the crop response to the applied nutrients in the field. From the data, fertilizer prescription equations are derived for the particular crop in a particular soil type. Then these equations are test verified in farmer's fields before large scale adoption. Such soil test based fertilizer recommendation avoids the wastage or under usage of fertilizers.

Soil test crop response experiments are conducted for a crop or cropping sequence on a soil type which represents a larger area in a particular region. The results of the experiments can be extrapolated to other areas of similar soils to avoid the laborious and expensive process of conducting STCR experiment in each piece of land.

Higher rate of fertilizer consumption can be optimized by, judicious application of organic manures. The combined use of organics and inorganics enhance the nutrient use efficiency in sustainable agriculture. Hence, the soil test crop response correlation studies are conducted under integrated plant nutrient systems (IPNS) with different crops in different situations.

Among the minor tuber crops, the coleus (*Solenostemon rotundifolius* Poir J.K.Morton.) is popularly known as 'Chinese potato' or 'poor man's potato. It is an important crop grown extensively as a vegetable in South Indian states. The crop is being cultivated in Kerala in the uplands in the monsoon season and in rice fallows during summer. Locally it is grown in our homesteads and as well as in kitchen gardens. This aromatic vegetable-cum-tuber possesses an elite flavour and taste and it enjoys a covetable consumer preference. The nutritive status of this crop compares favourably with many of the major tuber crops. Coleus tuber contains 20.1 to 30.0 per cent dry matter, 14.7 to 20.8 per cent starch, 0.04 to 0.31 per cent protein and 0.57 to 0.96 per cent sugar (Sreekumari and Abraham, 1985).

It is grown for its small edible tubers, which can be used as a substitute for potato. In order to meet the increasing demand, the soil management practices and mineral nutrition studies of coleus demands much attention. The studies on mineral nutrition of coleus are restricted and due to necessity of alternate soil test based recommendations for Kerala instead of the already prevalent (Hassan *et al.*, 2001). Hence the soil test crop response studies are conducted in coleus to develop an efficient prescription equation.

In Kerala 65 per cent of land area is covered by laterite soil (KAU, 1989). Hence, the study is conducted in laterite soil with inclusion of organic manure to exploit the yield potential of coleus. The soil test crop response studies were undertaken in coleus in laterite soils of Kerala with the following objectives.

- To establish the relationship between soil available and applied nutrients with tuber yield of coleus through a response surface model.
- To provide a basis for fertilizer recommendation for maximum and economic tuber yield at varying soil test values.
- To develop soil test based balanced fertilizer recommendation for specific yield targets of coleus.
- To evaluate the conjoint use of organic manure and fertilizer in relation to the soil test values in coleus cultivation.

Review of Literature

2. REVIEW OF LITERATURE

The present investigation was undertaken with a view to develop rationalized fertilizer prescriptions for coleus in laterite soils of Kerala. Literature on various approaches for predicting yield of crops, soil test calibrations and fertilizer recommendations for an individual crop (coleus) based on various experiments are reviewed in this chapter.

2.1 FERTILIZER RECOMMENDATIONS BASED ON SOIL TEST APPROACHES

The yield of crop is influenced to a very great extent by the application of chemical fertilizers when all other production factors are kept at optimum level. It is necessary to quantify the functional relationships between different inputs and crop yield, to know the crop yield for various fertilizer levels and to optimise fertilizer doses for attaining either maximum yield or economic yield. Hence, statistical models are developed in agriculture for making any logical production system (Sankar, 1992). Efficient prediction models are quite imperative for the prediction of crop yield as well as optimisation of chemical fertilizers (Sankar, 1986).

In earlier stages, many mathematical models were used for soil test calibrations, yield prediction and optimisation of fertilizer doses. Liebig's linear model emerged in the 18^{th} century, states that a proportionate increase in yield will be obtained for each incremental addition of nutrients to soil. Liebig's law of minimum is applicable only to mobile nutrients like nitrate nitrogen.

The quadratic model was developed by Heady and Ray (1971) for calculating the fertilizer requirements of crops by using two different economic situations and found that for achieving desired result, biological and economic variables are to be combined in a function.

For calibrating yield fertilizer trend, Colwell (1968) proposed orthogonal polynomial model to accommodate different fertilizer interaction effects. It is possible to fit linear, quadratic, cubic and quadratic of any n^{th} order polynomial depending on the significance of the variables.

Mitscherlich (1909) developed a model for expression of the growth rate for different levels of an essential immobile nutrient in the soil. It stated that the increase in yield per unit of added nutrient was proportional to the difference between the maximum attainable and the actual yield. It was modified by Bray (1948) by introducing efficiency coefficients to soil test and applied forms of nutrients and hence it was called as Mitscherlich-Bray model.

Nutrient Index approach was developed by Parker *et al.* (1952) based on the soil test values of different nutrients. According to the values of soil tests samples are classified into low, medium and high categories.

The critical nutrient level concept was established based on the fact that if the soil nutrient content is below the critical level, the possibility of response is greater and vice versa. Three different techniques are adopted to find the critical limits of available nutrients viz., the graphical procedure (Cate and Nelson, 1965), mathematical procedure using two mean square discontinuous model (Cate and Nelson, 1971) and linear response plateau (LRP) model (Anderson and Nelson, 1975). This approach helps to determine the soil test value beyond which application of fertilizer is not required. But it does not tell anything about how much fertilizer is to be applied in quantitative terms with different soil test values.

In Kerala, Nambiar *et al.* (1977) proposed the ten-class system to prescribe the fertilizer recommendation. They have categorized the lower fertility level to 3 classes, medium fertility level to 4 classes and higher fertility level to 3 classes. Totally the fertility status of the soil is grouped into 10 classes. For each fertility class, recommendations are given based on the package of practices for each crop.

The above mentioned models are not satisfied with balanced fertilization and high level of fertilizer use efficiency. A well established soil test calibration help to apply fertilizers in precise amounts to obtain high use efficiency of applied nutrients and maximum possible yield in an ecosystem.

Soil test calibration is intended to establish a relationship between the levels of soil nutrient as determined in the laboratory and the crop response to fertilizer observed in the field. Such a relationship helps to develop calibration charts and permits balanced fertilization of crops. Complexity in soil test crop response studies (STCR) arises due to great diversity of soils, climate, crops and management practice (IISS, 1999). The STCR studies focus attention mainly on the following aspects

1) Targeted yield concept
2) Multiple regression model
3) Soil test based prescriptions under Integrated Plant Nutrient Supply System (IPNS)

2.1.1 Targeted yield concept

Ramamoorthy *et al.* (1967) have refined the procedure of fertilizer prescription is given by Troug (1960) and later extended to different crops in different soils (Ramamoorthy *et al.*, 1975, Randhawa and Velayutham, 1982). They established the theoretical basis and experimental proof for the fact that the Liebig's 'law of minimum' operates equally well for N, P and K.This implies that for obtaining a given yield, a definite quantity of nutrients must be taken up by the plant (Reddy and Ahmed 1999). This forms the basis for fertilizer recommendation for targeted yield of a crop

$$FD = \frac{NR}{CF} \times 100 \times T - \frac{CS}{CF} \times STV$$

Where,

FD = Fertilizer dose (kg ha^{-1})

NR = Nutrient requirement of crop (kg t^{-1})

CS = Contribution of nutrient from soil (%)

CF = Contribution of nutrient from fertilizer (%)

STV = Soil Test Values (kg ha^{-1})

T = Targeted yield (t ha^{-1})

This model is useful for computing fertilizer doses for varying soil test values for obtaining different yield targets. The derived doses are then tested under farmer's field conditions for their reproducibility before they are generalized for large scale adoption (Sankar *et al.*, 1989).

The fertilizer prescriptions based on this concept are more quantitative, precise and meaningful because of the combined use of soil and plant analysis data for computation. The uptake of nutrients from the soil and fertilizer together should be in a ratio, which is actually needed by the specific variety of the crop. This is possible only by fertilizer application based on targeted yield model and not by any other method of fertilizer prescription (Ramamoorthy, 1993). This approach forms the basis for the National Programme on All India Co-ordinated Research Programme on Soil Test Crop Response Correlation Studies of ICAR in India. Experiments based on this approach are being conducted in seventeen centres in the country and fertilizer adjustment equations have been developed mostly for field crops. (Rao and Srivastava, 2001).

Prescription equations are derived for desired yield targets by using targeted yield approach at TNAU, Coimbatore for different varieties of different crops like rice, maize, sorghum, ragi, groundnut, black gram, soybean, sugarcane, cotton, tapioca, sunflower and chilli in different soil series (Raniperumal *et al.*, 1982, 1984, 1986, 1987 and 1988; TNAU, 1994; Baskaran *et al.*, 1994 and Loganathan *et al.*, 1995). Santhi *et al.* (2002) have developed the fertilizer dose equation for onion by using the targeted yield approach. The State Department of Agriculture, Maharashtra, used the targeted yield approach for giving fertilizer recommendation for field crops (Velayutham and Reddy, 1990).

In Kerala, fertilizer prescription equations have worked out for rice variety Bharathi (Swadija *et al.*1993), Cassava variety M4 (Swadija, 1997) and Ginger variety Maran (Jayalakshmi, 2001). The prescription equations also developed for desired yield targets of rice in low land acid laterite soils of Kerala (KAU, 1996a) and for different crops like Nendran Banana, turmeric, rice in the laterite soils of Kerala (KAU, 2003).

In Hisar (Haryana), Singh *et al.* (2000) formulated the targeted yield equations for barley, cotton and wheat. Tamboli and Sonar (1999) have worked out fertilizer prescription equations for sonar wheat and chickpea in vertisols of Maharastra. Reddy and Ahmed (1999) revealed that the fertilizer recommendation based on targeted yield approach is very effective and quantitative one for groundnut grown in rice fallows (Inceptisol) in Andhra Pradesh.

Ahmed *et al.* (2000) worked out soil test based fertilizer requirements for different yield targets of castor in dry land Alfisols. Soil test based targeted yield equation have been developed for Bhendi, Potato and Sugarcane in Karnataka (GKVK, 2002).The superiority of fertilizer recommendations based on targeted yield approach over the general/blanket doses has indicated by several scientists. Fertilizer application based on targeted yield approach would be the most economical (Ramamoorthy and Pathak, 1969).

2.1.2 Multiple Regression model

The functional relationship between more than two variables is known as mutiple regression. So here the yield parameter 'Y'is regressed with soil nutrients, fertilizer nutrients, their quadratic terms and the interaction between soil and fertilizer nutrients. This approach was suggested by Ramamoorthy *et al.* (1967) for prescribing fertilizer doses based on soil test values to attain either maximum yield or maximum profit. This model is more realistic and practical and it is also based on the creation of artificial fertility gradients.

In this approach, Ramamoorthy (1974) established a significant relationship between soil test values, fertilizer dose and crop yield by fitting a multiple regression of the quadratic form taking linear terms of soil and fertilizer nutrients. By conducting gradient experiment a range in soil test values in one and the same field is created for minimizing interference of other factors affecting yield and relate them through multiple regression with quadratic response function.

The relationship is established by fitting a regression of the quadratic form can be expressed as,

$$\mathbf{Y = A \pm b_1SN \pm b_2SN^2 \pm b_3SP \pm b_4SP^2 \pm b_5SK \pm b_6SK^2 \pm b_7FN \pm b_8FN^2 \pm b9FP \pm b_{10}FP^2 \pm b_{11}FK \pm b_{12}FK^2 \pm b_{13}FNSN \pm b_{14}FPSP \pm b_{15}FKSK}$$

Where

Y - Crop yield (kg ha^{-1})

A - Intercept

b_1 to b_{15} - Regression coefficients

SN, SP and SK - Soil available N, P and K (kg ha^{-1})

FN, FP, FK - Fertilizer N, P and K (kg ha^{-1})

There are eight different response types signified by the signs for the linear and quadratic forms of the added fertilizer and the interaction term between the fertilizer and soil test values (Ramamoorthy *et al.*, 1967).

The following eight response types are recognized, but except the last, first seven types are non-ideal for derivation of soil test based fertilizer recommendation.

(i) - - +	(ii) - - -	(iii) + + +	(iv) + + -
(v) - + +	(vi) - + -	(vii) + - +	(viii) + - -

The interactions among the nutrients available in the soil and added through external sources like fertilizer are due to variation in nutrients availability in the soil and application of fertilizers in varying proportions. Regression analysis has been used to establish meaningful relationships between fertilizer use, soil test values and yield of the crops. The significant value of coefficient of determination (R^2) with high order of predictability (66%) indicates the suitability of the fertilizer calibration for varying soil test values for obtaining maximum profit per ha have been derived where the response to added nutrient followings the law of diminishing returns as illustrated by Ramamoorthy and Velayutham (1974).

If the predictability is more than 66 per cent the soil test values are calibrated to obtain fertilizer doses for economic and maximum yield per hectare and maximum profit per rupee spent on fertilizer. From the regression analysis, the dose of fertilizer for maximum and economic response can be computed by partial regression technique

$$\mathbf{F\,(maximum)} = \frac{\mathbf{b - d.s}}{\mathbf{-2c}}$$

$$F\,(\text{economic}) = \frac{b - d.s - r}{-2c}$$

Where,

b, c and d = linear, quadratic and interaction coefficients

S = soil test values

r = ratio of nutrient to produce unit quantity of yield

The multiple regression models are more efficient and useful for studying fertilizer responses under varying levels for soil and fertilizer contribution for different crops on different soils. When compared to other models there is high percentage of yield predictability with minimum of experimental error. In addition, based on R^2 adequacy and also the Residual Mean Square Ratio (RMSR) test, the model was found to be more efficient than other models studied.

Ramamoorthy and Velayutham (1971) recommended multiple regression analysis for STCR work in India. Hanway (1971) suggested multiple regressions for relating field response of crop with laboratory results to study the crop response principles for the system containing several uncontrollable variables.

Multiple regression analysis accurately evaluates the effects of soil and fertilizer nutrients on both the plant uptake of nutrients and yield (Reddy *et al.*, 1985). This analysis enables the study of number of factors simultaneously at a time (Ahmed, 1985). This approach suffers from the limitation that fertilizer doses worked out for getting maximum profits would usually give yields lower than the potential yields. This may lead to lower levels of crop production (Dev, 1997). However, fertilizer requirements have been computed for maximum yield of cereal crops (Sharma *et al.*, 1990), vegetable crops such as bhendi, tomato, brinjal, cabbage, cauliflower and green chillies raised in Alfisols of southern India (Rao and Subramanian, 1994) and rice and pulse crops (Boopathi, 1995 and Santhi, 1995) in inceptisols of Tamil Nadu.

Fertilizer adjustment equations for varying soil test values for maximum yield and profit per hectare have been calibrated using multiple regression model for different crops like rice (Raniperumal *et al.*, 1982 and 1984), sorghum (Raniperumal *et al.*, 1982), maize (Sumam, 1988), ragi (Mercykutty, 1989) and groundnut (Raniperumal *et al.*, 1986) at Tamil Nadu in different soil types.

Sankar *et al.* (1987) have computed the optimization of fertilizer N, P and K nutrients and prediction of yield at varying soil test values based on regression models. The soil test based fertilizer prescriptions were calibrated only for N and P nutrients for rabi sorghum in the black soils of Maharastra (Sankar *et al.*, 1985).

Based on this approach, the fertilizer doses were optimized for different crops in different centres viz., Pusa for sugarcane (1994-95), Hisar for wheat (1995-96), Hyderabad for sunflower (1995-96) and rice (1995), Ludhiana for wheat (1995-96) with R^2 value of more than 0.67 (IISS, 1999).

2.1.3 Soil test based prescriptions under integrated plant nutrient supply system (IPNS)

Integrated Plant Nutrient Supply System (IPNS) includes fertilizer (macro and micronutrients) additions along with available organic manures like farmyard manure, compost, green manure, bio fertilizers etc. to soil to enhance the soil fertility. All these will be possible only if the amounts and kinds of fertilizer required can be calculated for different pre-determined levels of production as well as the effect of these on soil fertility. The principle of fertilizer application for targeted yields of crops based on soil test values has been developed for this purpose (Ramamoorthy, 1994).

As in the regular STCR studies, the field experiment consisted of two parts,

a). Creating artificially a large variation in fertility status by applying four graded dose of N, P and K fertilizers to four strips and by growing a gradient crop to stabilize the treatments. The 'P' and 'K' levels were fixed based on P and K fixing capacities of soil.

b). Test crops were grown with treatments combination of different levels of N, P, K and two to three levels of organic manures and absolute controls.

The test crops were grown up to maturity and harvested. The yields of economic produce were recorded. The available NPK status of the before and after the STCR experiment, and the concentrations of NPK in the plant samples collected at harvested were chemically analyzed. Using the concentrations and yield data, the total uptake of NPK by the test crops were calculated (Selvakumari *et al.*, 1998).

2.1.3.1 Integrated plant Nutrient supply system and optimising fertilizer doses for targeted yields of crops

The basic data viz., nutrient requirement, soil and fertilizer nutrient efficiencies reveal the inherent differences among crops/varieties which can more efficiently utilize ether the soil or fertilizers sources o the nutrient, commonly crops gave distinctly varying capacity to rice nutrients available in the soils, planning of higher yield targets on the crop which has a greater ability to utilize the fertilizer nutrient will increase the use efficiency of the applied fertilizers (Organics and inorganics).

Reddy *et al.* (1987) reported that the fertilizer use efficiency was atleast 30 per cent more in targeted yield approach, based on soil tests than the general recommendation as revealed by the response ratio.

Under IPNS, positive interactions among the nutrient elements are expected. This synergistic effects, has lead to accentrate the fertilizer use efficiency. The fertilizer prescription equation can be expressed as in IPNS are given below,

$$\mathbf{FD} = \frac{\mathbf{NR}}{\mathbf{CF}} \times 100 \times \mathbf{T} - \frac{\mathbf{CS}}{\mathbf{CF}} \times \mathbf{STV} - \mathbf{Co}$$

where,

FD = Fertilizer dose (kg ha^{-1})

NR = Nutrient requirement of crop (kg t^{-1})

CS = Contribution of nutrient from soil (%)

CF = Contribution of nutrient from fertilizer (%)

STV = Soil Test Values (kg ha^{-1})

T = Targeted yield (t ha^{-1})

Co = Contribution from organics

This targeted yield approach with IPNS is also effectively used for appropriate fertilizer recommendation with organics. Based on the level of application of organic manures, the dose of chemical fertilizers adjusted through soil test calibration (Raniperumal *et al.*, 1984). Prescription equations involving the conjoint use of organics and inorganics have been reported by Santhi (1995) in rice with FYM and phosphobacteria, Baskaran *et al.* (1994) in tapioca with composted coirpith, Duraisamy *et al.* (1989) in ragi with FYM, Mercykutty (1989) in ragi with Azospirillum and Raniperumal *et al.* (1988) in ragi with FYM.

Prasad and Prasad (1993) reported that the conjoint use of chemical fertilizers and organic manures lead to efficient use of fertilizer and considerable saving in fertilizers. The magnitude of contribution by the organic and biological sources of plant nutrients complementing fertilizers in meeting nutrient requirement of crops (Tandon, 1994).

In STCR correlation studies organic/biofertilizer treatments were also included under integrated plant nutrition system for optimising the fertilizer doses (Raniperumal *et al.*, 1984; Murugappan, 1985; Sumam, 1988; Maragatham, 1995; Santhi, 1995 and Andi, 1998).

In Kerala, Swadija (1997) and Jayalakshmi (2001) computed the targeted yield equations under IPNS for cassava and ginger. They have taken farm yard manure as organic source.

By using targeted yield equation with IPNS the fertilizer doses were worked out for different crops like turmeric and rice (Kharif and Rabi) during 2001 and for Nendran banana during 2000-2001 in laterite soils of Kerala (KAU, 2003).

The AICRP on STCR conducted large number of experiments all over the country in different soil agroclimatic regions. The Palampur (Himachal Pradesh) centre has generated integrated nutrient adjustment equations for targeted yields of maize, wheat, raya and Soyabean crops during 1994-98. In Rajasthan, Bikaner centre has developed fertilizer prescription equation under integrated use of fertilizer and manures for groundnut crop during 1999.

In Madhya Pradesh, Jabalpur centre has generated integrated nutrient adjustment equations for sunflower crop during 2000. In Hyderabad, Andhra Pradesh during 1999-2000, fertilizer prescriptions involving IPNS equations were worked out for onion and groundnut with Farmyard manure as organic source. In Tamil Nadu, Coimbatore centre has developed fertilizer adjustment equations under IPNS for onion during 1998-99 with Azospirillum and FYM. (IISS,2001)

In Karnataka, the fertilizer prescription equations involving IPNS have been developed for Cabbage, Ragi and Groundnut during 1998. (GKVK, 2001)

2.2 NUTRITIONAL REQUIREMENTS OF TUBER CROPS WITH REFERENCE TO COLEUS

Coleus requires optimum level of fertilization for higher yield. It shows good response on applied nutrients as fertilizer, so that the nutrient requirement of coleus varies with the cultivars, cropping system, management practices etc. For maximization of yield and quality of the tubers, it needs adequate amount of N and K.

2.2.1 Response of coleus to nitrogen

An experiment with coleus crop laid out by Singh and Maini (1969) with six levels of nitrogen 10, 20, 40, 60, 80 and 100 kg ha^{-1} showed that the tuber yield increased significantly with increase in nitrogen from 0 to 60 kg/ha and beyond that there was no positive response.

Mandal *et al.* (1971) observed that, the maximum tuber yield was obtained at 100 kg of N ha^{-1}, which was not significantly superior to 75 kg of N ha^{-1} for sweet potato in the red loam soils of Kerala. Nambiar *et al.* (1976) reported that increasing rate of applied nitrogen significantly increased the number of tubers per plant in sweet potato.

An experiment conducted at Nileswar (KAU, 1978) on coleus, it was found that raising the nitrogen level from 40 to 80 kg gave an additional yield, which was significantly superior to 40 kg N ha^{-1}. Krishnappa and Shivashankara (1981) also observed significant increase in potato tuber yield with increased nitrogen application.

Grewal *et al.* (1979) reported that applied nitrogen increased tuber size in potato. A positive correlation between nutrient contents of sweet potato tubers and vegetative parts during the growth period was observed by Mica (1969). Rao and Arora (1979) observed that increase in nitrogen rates increased the total nitrogen uptake and tuber nitrogen contents.

Coleus dry matter content was increased by increasing with nitrogen fertilization (Singh and Maini, 1969). The split application of nitrogen once at planting and again 30 days after planting, which is the tuber forming period and enhancing top growth during tuber development period has been reported by Morita (1967).

2.2.2 Response of coleus to potassium

Potassium acts as a corrective element for the harmful effects of nitrogen, and the adequate supply of potassium will increase the photosynthetic efficiency of leaves (Russel, 1973).

Coleus was found to respond to potassium applications. Over pooled analysis, application of potassium at the rate of 120 kg ha^{-1} increased the yield over potassium applied at 40 kg ha^{-1} (KAU, 1978). Applied potassium increased potassium contents and uptake in potato (Sharma *et al.*, 1976) and the split doses of K application at sowing, earthing up and bulking stages were given higher yield (Shukla and Rao, 1974).

Potassium has been identified as being necessary for rapid translocation of nutrients at the later stage of tuberization and bulking. Split application of potash is associated with efficient absorption and translocation of nutrients from soil to plant (Shukla and Singh, 1975).

2.2.3 Effect of combined application of N, P and K

N, P and K in various combinations increased the yield, while PK combinations decreased the yield in sweet potato (Yong, 1970).

The response of *Dioscorea alata* to four levels of nitrogen and five levels of potash was tested with a factorial experiment by Singh *et al.* (1973). The data revealed that the tuber yield increased progressively with the increase in nitrogen application to 80 kg of K_2O ha^{-1} and 120 kg of K_2O ha^{-1} but declined with further application of nitrogen and potassium.

Varis (1973) revealed that nitrogen fertilization to potatoes increased the uptake of N, P, K, Ca and Mg. Phosphorus application increased the uptake of N, K, Ca and Mg. Gupta and Saxena (1975) reported that nitrogen increased tuber protein contents, and decreased the starch and dry matter contents.

Loue (1979) reported that nitrogen and potash removal increased with increasing application of nitrogen and potash fertilizers respectively. Geetha (1983) reported that a fertilizer dose of 60 kg N, 30 kg P_2O_5 and 120 kg K_2O ha^{-1} applied in split doses gave an economic cultivation of coleus.

Materials and Methods

3. MATERIALS AND METHODS

The research programme with the aim of investigating the soil test crop response relationship of coleus in laterite soils of Kerala was undertaken at the College of Horticulture, Vellanikkara. For this study the technique of inductive methodology developed by Ramamoorthy (1968) as followed in AICRP for investigations on STCR correlation (Reddy *et al.*, 1985) was adopted. The field experiments consisted of fertility gradient experiment with the crop maize and STCR experiment with the crop coleus, using fertilizers and organic manures. The details of the field experiments conducted methods of analysis of soil and plant samples, and the statistical methods followed are presented in this chapter.

3.1 DETAILS OF THE EXPERIMENTAL SITE

3.1.1 Location

The fertility gradient experiment (FGE) and the STCR experiment were conducted in the farm attached to the College of Horticulture, Vellanikkara during May-November, 2002. The field is located at 10°31'N latitude and 76°13'N longitude at an altitude of 25 m above mean sea level.

3.1.2 Climate

The experimental area enjoys a typical humid tropical climate with the mean annual rainfall of 191.95mm and the maximum, minimum temperatures of 32.1 and 23.29°C respectively. The relative humidity ranges from 71 to 87 per cent. The evaporation rate ranges from 92.5 to 198.8mm. During the cropping period a mean rainfall of 420.95 mm (May-June) and 278.92 mm (July-November) were received for the stand of gradient crop and the test crop respectively. The mean maximum and minimum temperature for the gradient crop was 31.3 and 23.9°C, while for the test crop it was 30.48 and 3.12°C. The mean evaporation (mm) prevailed during two cropping seasons were 108.5 and 106.2 mm respectively. The mean relative humidity was 81.5 and 80.2 per cent relatively for the gradient and the test crop respectively.

3.1.3 Soil type

The soil type of the experimental site was laterite, which comes under the order of Ultisol. The soil was sandy loam in texture with low water holding capacity. It was acidic with a pH of 5.1 having high P fixing capacity (80%) and low K fixing capacity (7%). The initial physical and chemical properties of the soil are given in following table.

Table 3.1 Physical and chemical properties of initial soil sample of the experiment

S.No	Property	Unit	Value
1.	Mechanical composition		
	i). Sand	%	46.5
	ii). Silt	%	22.6
	iii). Clay	%	30.9
2.	Texture	-	Sandy clay loam
3.	pH	-	5.10
4.	EC	dSm^{-1}	0.11
5.	CEC	$cmol(p^+)kg^{-1}$	4.53
6.	P fixing capacity	%	80
7.	K fixing capacity	%	7
8.	Organic carbon	%	0.615
9.	Available N	kg ha^{-1}	257.53
10.	Available P	kg ha^{-1}	15.19
11.	Available K	kg ha^{-1}	120.62

3.2 FIELD EXPERIMENTS

3.2.1 Fertility gradient experiment

The main objective of this experiment was to create variations in soil fertility in one and the same field, so as to generate the values for each controllable variable (fertilizer) dose at different levels of uncontrollable variable (soil fertility). It is necessary to create such variations in soil fertility to ensure better correlations between soil test values and response to fertilizers.

3.2.2 Layout of the experiment

The selected field was divided into four equal strips and each strip into four equal plots. Totally 16 soil samples were collected from 0-15 cm depth and another 16 soil samples from 0-30 cm depth.

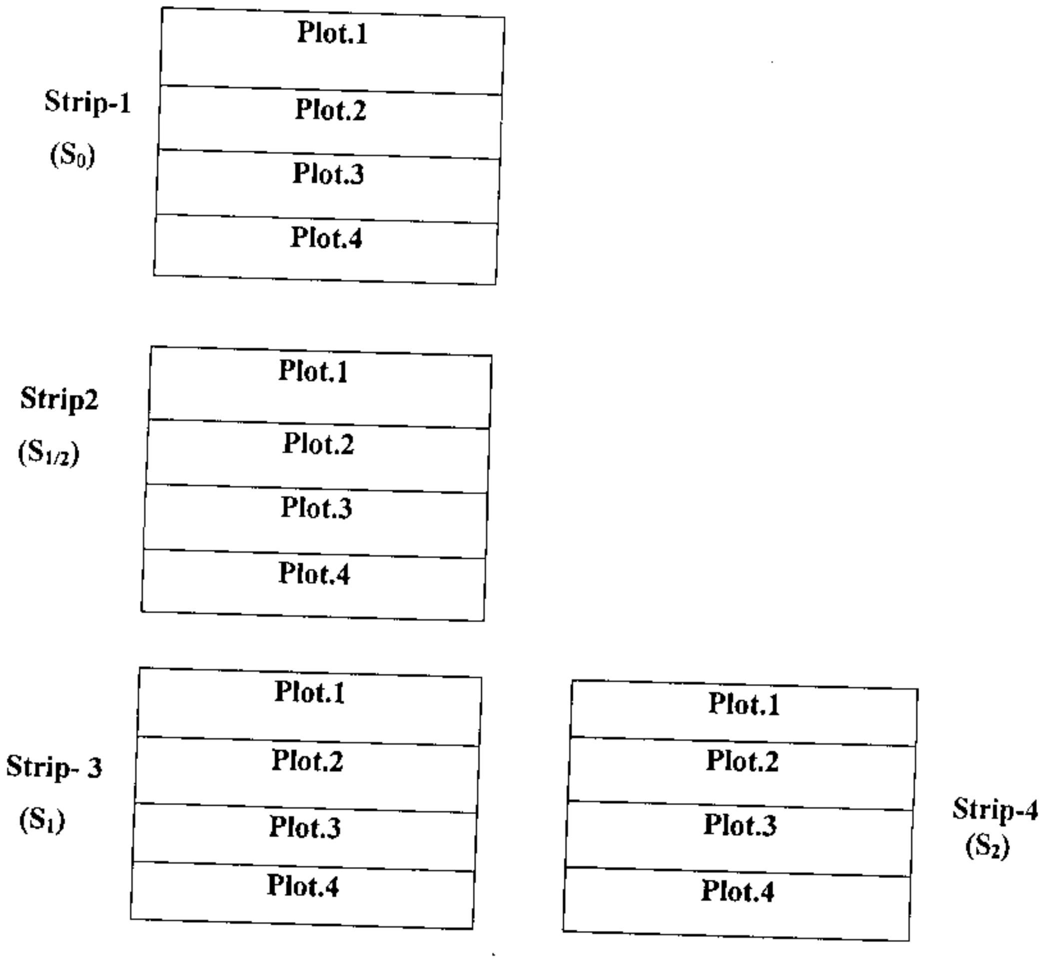
3.2.3 Treatments

Graded doses of N as Urea (46% N), P as Rajphos (16% P_2O_5) and K as muriate of potash (60% K_2O) were applied in four strips. This formed the treatments for FGE. The doses of NPK were fixed as mentioned in the instruction manual for STCR studies (Reddy *et al.*, 1985).

Table 3.2. Treatment Structure for FGE

Strip	**Treatment**	**Fertilizer dose (kg ha^{-1})**		
		N	**P_2O_5**	**K_2O**
I	$N_0 P_0 K_0$	0	0	0
II	$N_{1/2} P_{1/2} K_{1/2}$	75	50	90
III	$N_1 P_1 K_1$	150	100	180
IV	$N_2 P_2 K_2$	300	200	360

Fig. 3.1. Fertility gradient experiment (field layout)



Strip I	- $N_0 P_0 K_0$	-No fertilizers
Strip II	- $N_{1/2} P_{1/2} K_{1/2}$	-Half the standard dose
Strip III	- $N_1 P_1 K_1$	-Standard dose
Strip IV	- $N_2 P_2 K_2$	-Double the standard dose

Plate No. 1 General view of gradient crop experiment

Plate No. 2 General view of gradient crop maize in Strip I (N_0 P_0 K_0)

Plate No. 3 General view of gradient crop maize in Strip II ($N_{1/2}$ $P_{1/2}$ $K_{1/2}$)

Plate No. 4 General view of gradient crop maize in Strip III (N_1 P_1 K_1)

Plate No. 5 General view of gradient crop maize in Strip IV (N_2 P_2 K_2)

3.2.4 Gradient crop

A gradient crop of fodder maize (*Zea mays* L.) variety CO-1 was raised following the usual agronomic practices (KAU, 1996b) except the treatments. The seeds were obtained from TNAU, Coimbatore. The seeds were dibbled at a spacing of 30 x 15 cm on 7.05.2002 and the crop was harvested on 11.07.2002

3.2.5 Observations recorded

3.2.5.1 Green fodder yield

At harvest, strip wise green fodder yield was recorded leaving one border row all around in each strip and expressed in t ha^{-1}.

3.2.5.2 Dry fodder yield

Four plant samples were collected from each strip prior to general harvest. After recording fresh weight the plant samples were dried in an oven at 60±5°C to constant dry weight. The dry fodder yield was computed strip wise from these observations.

3.2.6 Uptake of nutrients

The sixteen composite plant samples (one from each plot) were analysed for N, P and K contents. The analytical methods adopted are represented in the table 3.6 the uptake of nutrients was calculated using the plant dry weight and their nutrient contents and expressed in kg ha^{-1}

3.2.7 Soil analysis

Soil samples were collected from two different depths (0-15 cm and 0-30 cm) prior to fertilizer application and after harvest. The methods of soil analysis adopted are given in table 3.6.

Apart from that a composite soil sample was collected from whole field and analysed for mechanical composition, pH, soluble salts, cation exchange capacity, organic carbon and available N, P and K contents and P and K fixing capacities.

3.2.8 Statistical analysis

The data related to gradient crop experiment viz., fodder yield, nutrient uptake, crop and soil analysis after harvest were subjected to statistical analysis adopting the technique of analysis of variance (ANOVA) for Randomised Block Design (RBD) as described by Snedecor and Cochran (1968). Critical difference is provided wherever F test is significant.

3.3 STCR EXPERIMENT

The principle methodology adopted in the STCR experiment is to establish quantitative relationship between soil test values, applied nutrients and the resultant crop yield. Hence field experiments were conducted with measured levels of fertilizer nutrients viz., N, P_2O_5 and K_2O with the test crop. This investigation was superimposed in the four fertility gradients created as mentioned in the instructional manual for STCR experiment (Reddy *et al.*, 1985).

3.3.1 Test crop

The test crop for the STCR experiment was coleus and the variety used was Nidhi, which is a popular high yielding variety in Kerala. This variety yields on an average 10-20 tonnes of tuber with 14.7 to 20.8 percent starch. Disease free planting materials were obtained from RARS, Pattambi. The nursery has been raised for transplanting on 25-5-2002.

3.3.2 Treatments

Treatment structure comprises of factorial combinations of four levels of N, three levels of P and five levels of K along with three levels of FYM. The treatment levels and doses of nutrients applied are given in Table 3.3.

Table 3.3 Treatment levels of STCR experiment

Nutrient levels	Fertilizer dose (kg ha^{-1})			FYM t ha^{-1}
	N	P_2O_5	K_2O	
1	0	0	0	0
2	20	45	25	7.5
3	40	90	50	15.0
4	80	-	100	-
5	-	-	200	-

3.3.3 Design and layout of the experiment

Each strip was divided into 24 plots of 2 x 1.5 m size. These 24 plots are allotted with 22 treatment combinations and 2 control plots in each strip.

Design	: Response surface design
Treatments	: 24
Number of strips	: 4
No. of plots	: 24 x 4
Spacing	: 30 x 15 cm
Plot size	:2x1.5m
No. of plants per plot	: 33
System of planting	: Raised bed system

Fig.3.2 STCR experiment (Field layout)

Strip I (S_0)

T1	T18	T2	T20	T21	T22
T8	T3	T5	T7	T6	T9
T10	T11	T12	T13	T14	T17
T15	T16	T4	T19	T23	T24

Strip II ($S_{1/2}$)

T1	T18	T2	T20	T21	T22
T8	T3	T5	T7	T6	T9
T10	T11	T12	T13	T14	T17
T15	T16	T4	T19	T23	T24

Strip III (S_1)

T1	T18	T2	T20	T21	T22
T8	T3	T5	T7	T6	T9
T10	T11	T12	T13	T14	T17
T15	T16	T4	T19	T23	T24

Strip IV (S_2)

T1	T18	T2	T20	T21	T22
T8	T3	T5	T7	T6	T9
T10	T11	T12	T13	T14	T17
T15	T16	T4	T19	T23	T24

Table 3.4 Treatment structure of STCR experiment

T.No	Fertilizer doses (kg ha^{-1})			FYM (t ha^{-1})
	N	P_2O_5	K_2O	
T1	0	0	0	0
T2	0	0	0	0
T3	0	0	0	7.5
T4	0	0	0	15
T5	0	0	25	7.5
T6	20	0	25	7.5
T7	20	45	25	7.5
T8	0	0	50	7.5
T9	0	45	50	7.5
T10	20	0	50	0
T11	20	45	50	0
T12	40	0	50	0
T13	40	45	50	0
T14	40	90	50	0
T15	0	0	100	15
T16	20	45	100	15
T17	40	90	100	0
T18	80	0	100	0
T19	80	45	100	15
T20	80	90	100	0
T21	40	45	200	0
T22	40	90	200	0
T23	80	45	200	15
T24	80	90	200	15

Plate No. 6 General field view of STCR experiment

Plate No. 7 General view of test crop coleus in Strip I (N_0 P_0 K_0)

Plate No. 8 General view of test crop coleus in Strip II ($N_{1/2}$ $P_{1/2}$ $K_{1/2}$)

Plate No. 9 General view of test crop coleus in Strip III (N_1 P_1 K_1)

3.3.4 Manures and fertilizers

The organic manure as per treatments was applied after the raised bed formation. Full dose of P and half dose of N and K were applied at 30 days after transplanting, then remaining half dose of N and K fertilizers were top dressed at 20 days after first application (50 DAS).

Table 3.5.Nutrient contents of organic manure and fertilizers

Fertilizers/organic manures	Nutrient content
Urea	46% N
Rajphos	16% P_2O_5
Muriate of potash	60% K_2O
FYM	0.51% N, 0.3% P_2O_5, 0.47% K_2O

Management practices were carried out as per package of practices recommendation without treatments

3.3.5 Observations recorded

3.3.5.1 Tuber yield

The plants are carefully pulled out from the plot, the tubers were separated, cleaned and the fresh weight was recorded and expressed in t ha^{-1}.

3.3.5.2 Root and leaf yield

The leaf with stem and the roots from the tuber were carefully separated and fresh weight, dry weight were recorded.

3.3.5.3 Uptake of nutrients

It was computed separately for haulms and for tuber. After the harvest, pooled samples (100 g) were collected from each plot in all the strips. The samples were dried uniformly in hot air oven at the temperature range of 60±5°C. The samples were analysed separately for the contents of N, P and K at harvest using the methods given in table 3.6. The total uptake of N, P and K was computed from the nutrient contents and dry weights of plant parts and expressed as kg ha^{-1}.

3.3.6 Soil analysis

Soil samples were collected from 0-15 cm soil depth after land preparation but before fertilizer application, and after the harvest of the test crop. The soil samples were analysed for organic carbon and available N, P and K contents adopting the analytical methods given in table 3.6.

Table 3.6. Methods of soil and plant analysis

Parameter	Method	Reference
Soil Analysis		
Mechanical composition	International pipette method	Piper (1966)
pH	Potentiometry	Jackson (1973)
Electrical conductivity	Conductometry	Jackson (1973)
Cation exchange capacity	Neutral normal ammonium acetate methods	Scholenberger and Dreibelbis (1930)
P fixing capacity	Equilibrium with potassium dihydrogen phosphate	Waugh and Fitts (1966)
K fixing capacity	Equilibrium with Potassium chloride	Waugh and Fitts(1966)
Organic carbon	Wet oxidation method	Walkely and Black (1934)
Available N	Alkaline permanganate method	Subbiah and Asija (1956)
Available P	Bray No.1 extract method	Watanabe and Olsen (1965)
Available K	Neutral normal ammonium acetate method	Hanway and Heidal (1952)
Plant analysis:		
Total N	Modified micro kjeldahl method	Jackson (1973)
Total P	Vanado-molybdo phosphoric acid yellow colour method	Jackson (1973)
Total K	Flame photometry	Piper (1966)

3.4 FERTILIZER PRESCRIPTION FOR SPECIFIC YIELD TARGET - TARGETED YIELD MODEL

In targeted yield concept fertilizer prescription equations were developed from the data on soil test values, tuber yield, and the nutrient uptake by coleus. From the equations, fertilizer recommendations are made for specific yield targets of coleus with and without FYM.

3.4.1 Calculations of basic parameters

3.4.1.1 Nutrient requirement (NR)

Nutrient requirements were calculated for each and every treatment in all the four strips in terms of N, P_2O_5 and K_2O in Kg per tonne of tubers production by using the following formulae.

$$\text{Kg N required per tonne of Tubers production} = \frac{\text{Total uptake of N (kg ha}^{-1}\text{)}}{\text{Tuber yield (t ha}^{-1}\text{)}}$$

$$\text{Kg } P_2O_5 \text{ required per tonne of Tubers production} = \frac{\text{Total uptake of } P_2O_5 \text{ (kgha}^{-1}\text{)}}{\text{Tuber yield (t ha}^{-1}\text{)}}$$

$$\text{Kg } K_2O \text{ required per tonne of Tubers production} = \frac{\text{Total uptake of } K_2O \text{ (kg ha}^{-1}\text{)}}{\text{Tuber yield (t ha}^{-1}\text{)}}$$

3.4.1.2 Per cent contribution of nutrients from soil (Cs)

The nutrient contributions from the soil were calculated utilizing the data from absolute control plots.

$$\text{Per cent Contribution of N from soil} = \frac{\text{Total uptake of N in control plot (kg ha}^{-1}\text{)}}{\text{STV for available N in control plot}} \times 100$$

$$\text{Per cent Contribution of } P_2O_5 \text{ from soil} = \frac{\text{Total uptake of } P_2O_5 \text{ in control plot (kg ha}^{-1}\text{)}}{\text{STV for available } P_2O_5 \text{ in control plot}} \times 100$$

$$\text{Per cent Contribution of } K_2O \text{ from soil} = \frac{\text{Total uptake of } K_2O \text{ in control plot (kg ha}^{-1}\text{)}}{\text{STV for available } K_2O \text{ in control plot}} \times 100$$

3.4.1.3 Per cent contribution of nutrients from fertilizer (CF)

The per cent contribution of nutrients from fertilizer was calculated utilizing the data obtained from plots treated with fertilizers only and no FYM was applied, by using the given formulae.

$$\text{Contribution of N from fertilizer (\%)} = \frac{\text{Total uptake of N in fertilizer treated plot (kg ha}^{-1}\text{)} - \text{STV for available N in treated plot} \times \frac{\text{Average Cs}}{100}}{\text{Fertilizer N applied (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of } P_2O_5 \text{ from fertilizer (\%)} = \frac{\left(\text{Total uptake of } P_2O_5 \text{ in fertilizer treated plot (kg ha}^{-1}\text{)}\right) - \left(\text{STV for available } P_2O_5 \text{ in treated plot} \times \frac{\text{Average Cs}}{100}\right)}{\text{Fertilizer } P_2O_5 \text{ applied (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of } K_2O \text{ from fertilizer (\%)} = \frac{\left(\text{Total uptake of } K_2O \text{ in fertilizer treated plot (kg ha}^{-1}\text{)}\right) - \left(\text{STV for available } K_2O \text{ in treated plot} \times \frac{\text{Average Cs}}{100}\right)}{\text{Fertilizer } K_2O \text{ applied (kg ha}^{-1}\text{)}} \times 100$$

3.4.1.4 Per cent contribution of nutrients from FYM (COM)

The data from FYM applied plots but treated with no fertilizers were utilized to calculate the per cent contribution of nutrients from FYM by using the given formulae.

$$\text{Contribution of N from FYM (\%)} = \frac{\left(\text{Total uptake of N in FYM treated plot}\right) - \left(\text{STV for available N in treated plot} \times \frac{\text{Average Cs}}{100}\right)}{\text{N applied through FYM (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of } P_2O_5 \text{ from FYM (\%)} = \frac{\text{Total uptake of } P_2O_5 \text{ in FYM treated plot} - \text{STV for available } P_2O_5 \text{ in treated plot} \times \frac{\text{Average Cs}}{100}}{P_2O_5 \text{ applied through FYM (kgha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of } K_2O \text{ from FYM (\%)} = \frac{\text{Total uptake of } K_2O \text{ in FYM treated plot} - \text{STV for available } K_2O \text{ in treated plot} \times \frac{\text{Average Cs}}{100}}{K_2O \text{ applied through FYM (kg ha}^{-1}\text{)}} \times 100$$

After computation of data utilizing the above formulas, average were taken out to obtain NR, CS, CF and COM in terms of N, P_2O_5 and K_2O

3.4.1.5 Targeted yield equation

The basic parameters calculated were substituted into targeted yield equations for prescribing fertilizers dose for any yield target, based on soil tests as given below

<u>Without FYM</u>

$$FN = \frac{NR}{CF/100} T - \frac{CS}{CF} SN$$

$$FP_2O_5 = \frac{NR}{CF/100} T - \frac{CS}{CF} SP \times 2.29$$

$$FK_2O = \frac{NR}{CF/100} T - \frac{CS}{CF} SK \times 1.21$$

With FYM

$$FN = \frac{NR}{CF/100} T - \frac{CS}{CF} SN - \frac{COM}{CF} \times ON$$

$$FP_2O_5 = \frac{NR}{CF/100} T - \frac{CS}{CF} SP \times 2.29 - \frac{COM}{CF} \times OP \times 2.29$$

$$FK_2O = \frac{NR}{CF/100} T - \frac{CS}{CF} SK \times 1.21 - \frac{COM}{CF} \times OK \times 1.21$$

Where,

FN = Fertilizer N in kg ha^{-1}

FP_2O_5 = Fertilizer P_2O_5 in kg ha^{-1}

FK_2O = Fertilizer K_2O in kg ha^{-1}

NR = Nutrient requirement of N or P_2O_5 or K_2O in kg t^{-1}

CS = % Nutrient contribution from soil

CF = % Nutrient contribution from fertilizer

COM = % Nutrient contribution from FYM

SN = STV for available N in kg ha^{-1}

SP = STV for available P in kg ha^{-1}

SK = STV for available K in kg ha^{-1}

ON = N applied through FYM in kg ha^{-1}

OP = P applied through FYM in kg ha^{-1}

OK = K applied through FYM in kg ha^{-1}

T = Yield target in t ha^{-1}

3.5 MULTIPLE REGRESSION ANALYSIS

The technique of multiple regression is the proper statistical tool to assess the contribution of nutrients from the soil to yield. This approach was suggested by Ramamoorthy *et al.* (1967) for prescribing fertilizer doses based on soil test values to attain either maximum yield or maximum profit. This model is more realistic and practical approach based on the creation of artificial fertility gradients. In this approach, Ramamoorthy (1974) established a significant relationship between soil test values, fertilizer dose and crop yield by fitting a multiple regression of the quadratic form taking linear terms of soil and fertilizer nutrients. By conducting gradient experiment a range in soil test values in one and the same field is created for minimizing interference of other factors affecting yield and relate them through multiple regression with quadratic response function.

The regression equation obtained using quadratic function can be expressed as,

$$Y = A \pm b_1SN \pm b_2SN^2 \pm b_3SP \pm b_4SP^2 \pm b_5SK \pm b_6SK^2 \pm b_7FN \pm b_8FN^2 \pm b_9FP \pm b_{10}FP^2 \pm b_{11}FK \pm b_{12}FK^2 \pm b_{13}FNSN \pm b_{14}FPSP \pm b_{15}FKSK$$

where

Y - Crop yield (kg ha^{-1})

A - Intercept

b_1 to b_{15} - Regression coefficients

SN, SP and SK - Soil available N, P and K (kg ha^{-1})

FN, FP, FK - Fertilizer N, P and K (kg ha^{-1})

If the equation has a high and significant R^2 value and, if the response type of N is say +, - and -, i.e., linear, fertilizer nutrient N is positive, quadrative fertilizer N (FN^2) is negative and interaction of fertilizer and soil N (FNSN) is negative, and further the terms are also significant then the equation can be used for optimization analysis. The optimum dose of N for maximum yield is

$$FN = \frac{b_7}{2b_8} - \frac{b_{13}}{2b_8} \times SN$$

For maximum profit is

$$FN = \frac{b_7}{2b_8} - \frac{b_{13}}{2b_8} \times SN \frac{1}{2b_8} R$$

Where

FN = Fertilizer nitrogen

SN = Soil available nitrogen

R = Ratio of unit cost of fertilizer (one kg of fertilizer nutrient) and value of crop (value of one kg of tuber)

b_7, b_8 and b_{13} = Coefficients of linear, quadratic and interaction terms of fertilizer

3.6 STATISTICAL ANALYSIS

3.6.1 Correlation

Correlation is a statistical device, which helped to analyse the covariation of two or more variables. Correlation co-efficients were obtained using the analytical data, tuber yield and with the basic soil characters.

3.6.2 Correlation of soil major nutrient content with yield

The data on analysis of major nutrient contents of soil as such correlated with the yield, without considering the any treatments and strip levels

3.6.3 Correlation of plant major nutrient content with yield

The data on analysis of plant major nutrient contents of all treatments as such correlated with yield to know the influence of these elements on yield.

3.6.4 Path analysis

The correlations co-efficients of soil and plant nutrient contents with yield were subjected to path analysis to know the direct and indirect effects.

3.7 BIO-CHEMICAL ANALYSIS

The starch and protein content of the coleus tubers were analysed for 96 exprimental plots.

Results

4. RESULTS

Soil tests help in quantifying the nutrients that are expected to be available to the crop plants throughout its life cycle and in identifying the possible nutrients that might limit the crop growth and its yield. To obtain significant correlation between soil test values and crop response to fertilizers, the soil test calibration and fertilizer recommendation must be based on local field experiments. Hence the present study was undertaken to establish soil test based balanced fertilizer prescription for coleus variety Nidhi in the laterite soils of Kerala. The field experiments consisted of fertility gradient and test crop experiment. The results of the experiments are presented in this chapter.

4.1 FERTILITY GRADIENT EXPERIMENT

The fertility gradient experiment is a preparatory experiment where in the soil test crop response experiment is conducted in the subsequent season. In this study, all the needed variation in soil fertility was created in one and the same field in order to ensure homogeneity in the soil studied, management practices adopted, and climatic conditions prevailing.

The experiment area was divided into four equal strips and each strip into four equal blocks for developing a fertility gradient among the strips. The graded doses of N, P and K fertilizers were applied to create a gradient in soil fertility from strip I to strip IV. A preparatory crop of fodder maize variety Co-1 was raised in all the strips. The soil test values before and after the experiment was computed for checking the response of the gradient crop in all the four strips, whether sufficient fertility gradient has been created or not. The data were also analysed statistically to confirm the build up of fertility gradient.

Table 4.1 Soil fertility status before and after the FGE

Strip	Fertilizer dose(kg ha^{-1})			Before fertility gradient experiment				After fertility gradient experiment			
	N	P_2O_5	K_2O	Organic Carbon %	Available Nutrients (kg ha^{-1})			Organic Carbon %	Available Nutrients (kg ha^{-1})		
					N	P	K		N	P	K
I	0	0	0	0.63	256.37	15.11	117.65	0.52	224.28	11.55	106.45
II	75	50	90	0.62	258.71	15.20	120.5	0.58	238.34	14.68	173.60
III	150	100	180	0.60	254.79	15.20	123.3	0.57	250.87	20.17	237.90
IV	300	200	360	0.61	260.28	15.25	120.4	0.56	273.61	22.97	299.60
			Mean	0.615	257.47	15.19	120.4	0.55	246.72	17.57	204.28
							CD	0.026	9.812	2.28	19.29

4.1.1 Soil fertility status before and after FGE

The soil fertility gradient created from strip I to IV was confirmed by assessing the soil nutrient contents after the harvest of fodder maize (gradient crop). The data on soil analysis are furnished in table 4.1. The initial soil nutrient status before the fertility gradient experiment ranged from 0.60 to 0.63 per cent of organic carbon, 254.79 to 260.28 kg ha^{-1} of available N, 15.11 to 15.25 kg ha^{-1} of available P and 117.65 to 123.3 kg ha^{-1} of available K respectively.

The analysis of soil samples collected after the harvest of the fodder maize revealed that the ranges were 0.52 per cent to 0.58 per cent for organic carbon, 224.28 to 273.61 kg ha^{-1} for available N, 11.55 to 22.97 kg ha^{-1} for available P and 106.45 to 299.6 kg ha^{-1} for available K contents respectively.

4.1.2 Yield and uptake of nutrients by gradient crop

The green and dry fodder yield of the gradient crop (fodder maize) as well as the nutrient uptake was computed for strip wise with increase in the nutrient levels of N, P and K. The results on yield and uptake of nutrients by gradient crop were furnished in table 4.2. The maximum green and dry fodder yield were observed in strip III (S_1), which is 38.88 and 9.33 t ha^{-1} respectively, where as minimum green and dry fodder yield were recorded in strip I (S_0), which is 21.11 and 4.33 t ha^{-1} respectively.

The nutrient uptake is calculated from the nutrient content of maize and dry fodder yield. The highest nutrient uptake of N, P and K were obtained from strip-III (S_1), which were 418.97, 44.78 and 410.57 kg ha^{-1} respectively, where as, the lowest uptake was recorded in strip-I (S_0) with the values of 161.80, 15.07 and 141.85 kg ha^{-1} respectively. The statistical analysis of the data showed that fodder yield and nutrient uptake by the gradient crop differed significantly in the strips. (Table 4.2)

Table.4.2 Fodder yield and nutrient uptake of fodder maize after FGE

Strip	Fertilizer dose (kg ha^{-1})			Fodder yield (t ha^{-1})		Nutrient uptake (kg ha^{-1})		
	N	P_2O_5	K_20	Green	Dry	N	P	K
I	0	0	0	21.11	4.433	161.80	15.07	141.85
II	75	50	90	23.4	5.148	202.83	20.07	185.32
III	150	100	180	38.88	9.330	418.97	44.78	410.57
IV	300	200	360	26.18	5.759	299.50	29.94	299.4
	CD			5.92	0.819	10.42	4.35	9.62

4.2 STCR EXPERIMENT

The STCR experiment was conducted in the same field after the creation of fertility gradient with the test crop of coleus var. Nidhi. For STCR experiment each strip was divided into 24 plots of equal size (2 x 1.5 m). Judicious combinations of organic and inorganic sources of nutrient were used to obtain economic fertilize use and enhanced nutrient use efficiency. In the test crop experiment, three levels of FYM were applied as a treatment along with inorganic fertilizer treatments as mentioned in the table 3.3. The organic manure was applied across the strips in four blocks (Reddy *et al.*, 1985).

The treatment structure was in such a way that each strip as well as each FYM blocks received all the treatment combinations. In that way, each strip contained two control plots, those plots that received no FYM or fertilizer for coleus. The remaining plots (22 per strip) received either FYM or fertilizer or a combination of both organics and inorganics.

4.2.1 Pre-planting soil analysis

Soil samples were collected prior to application of fertilizers and transplanting of coleus to estimate the contribution of nutrients from the soil. The soil samples were analysed for organic carbon, available N, P and K, and the data are given in the table 4.4 to 4.7. In each strip the mean values of soil nutrient content is calculated and furnished in the table 4.3.

Organic carbon content in the soil varied from 0.53 to 0.61, 0.53 to 0.64, 0.55 to 0.65 and 0.52 to 0.64 per cent in strip I, II, III and IV respectively and the corresponding mean values were 0.57, 0.58, 0.60 and 0.59. Soil available N recorded a range in values from 219.52 to 244.60, 232.06 to 247.74, 250.88 to 263.42 and 269.69 to 288.51 kg ha^{-1} in strip I, II, III and IV with the mean values of 224.60, 239.64, 257.27, 277.53 kg ha^{-1}.

Available P status ranged from 11.17 to 13.07, 13.07 to 17.05, 18.00 to 21.41 and 21.22 to 24.25 kg ha^{-1} in strip I, II, III and IV respectively. The average mean values in the respective strips were 11.77, 15.07, 19.81 and 23.01 kg ha^{-1}.

Available K ranged from 100.8 to 156.8, 145.6 to 224.0, 201.6 to 280.0 and 280.0 to 347.2 kg ha^{-1} in strip I, II, III and IV respectively. The average K contents in each strip were 128.33, 185.26, 241.73 and 315.48 kg ha^{-1}.

Table 4.3 Strip wise mean values of soil nutrient content prior to STCR experiment

Particulars	Mean values to strips			
	I	II	III	IV
Organic carbon (%)	0.57	0.58	0.60	0.59
Available N (kg ha^{-1})	224.6	239.64	257.27	277.53
Available P (kg ha^{-1})	11.77	15.07	19.81	23.01
Available K (kg ha^{-1})	128.33	185.26	241.73	315.48

Considering the STV of all plots, the soil fertility status prior to STCR experiment ranged from 0.57 to 0.64 per cent of organic carbon and 224.60 to 277.53 kg ha^{-1}, 11.17 to 23.01 kg ha^{-1} and 128.33 to 315.48 kg ha^{-1} of available N, P and K respectively. From the data, it is obvious that the necessary gradient in soil fertility was created in the field for conducting the STCR experiment.

Table 4.4 Nutrient status of the soil prior to STCR experiment in Strip-I (So)

T.No.	pH	EC (dSm^{-1})	OC (%)	Available nutrients ($kg\ ha^{-1}$)		
				N	P	K
1	5.1	0.120	0.55	222.65	12.12	112
2	4.9	0.115	0.61	219.52	12.31	100.8
3	5.0	0.114	0.57	225.79	11.93	123.2
4	4.8	0.115	0.53	222.65	11.17	134.4
5	5.2	0.110	0.59	222.65	11.74	112.0
6	5.1	0.112	0.58	232.06	11.17	123.2
7	5.0	0.113	0.58	228.92	12.50	100.8
8	4.9	0.114	0.55	222.65	11.37	156.8
9	4.8	0.116	0.53	225.79	11.55	145.6
10	5.0	0.118	0.61	219.52	11.93	145.6
11	5.1	0.119	0.57	228.65	11.74	156.8
12	5.0	0.115	0.55	222.65	13.07	134.4
13	5.2	0.114	0.53	219.52	11.93	123.2
14	5.3	0.120	0.59	232.06	12.12	112.0
15	5.0	0.116	0.57	225.79	11.93	112.0
16	4.9	0.117	0.58	219.52	11.55	123.2
17	5.1	0.110	0.59	228.92	11.55	100.8
18	5.0	0.120	0.58	219.52	11.37	123.2
19	5.2	0.116	0.55	228.92	11.55	156.8
20	5.1	0.118	0.57	228.92	11.55	134.4
21	5.0	0.116	0.53	225.79	11.74	145.6
22	4.9	0.118	0.59	219.52	11.17	112.0
23	5.2	0.115	0.61	225.79	11.93	156.8
24	5.1	0.118	0.57	222.65	11.55	134.4
Mean			0.57	224.60	11.77	128.33

Table 4.5 Nutrient status of the soil prior to STCR experiment in Strip II ($S_{1/2}$)

T.No.	pH	EC (dSm^{-1})	OC (%)	Available nutrients (kg ha^{-1})		
				N	P	K
1	5.0	0.120	0.61	241.47	13.45	201.6
2	4.9	0.116	0.57	235.22	14.21	168.0
3	5.2	0.115	0.64	232.06	14.21	212.8
4	5.1	0.118	0.61	241.41	16.48	179.2
5	5.3	0.113	0.58	247.74	14.97	201.6
6	4.8	0.099	0.53	235.20	15.34	190.4
7	5.1	0.110	0.55	238.36	14.78	179.2
8	5.0	0.112	0.61	244.60	13.83	168.0
9	5.2	0.114	0.58	241.47	16.10	168.0
10	5.0	0.116	0.59	238.36	15.53	156.8
11	4.9	0.113	0.55	244.60	14.78	179.2
12	5.1	0.115	0.61	235.20	14.97	190.4
13	5.0	0.120	0.64	235.20	16.10	201.6
14	5.0	0.118	0.53	241.47	15.91	168.0
15	5.2	0.116	0.58	238.36	15.72	224.0
16	5.1	0.114	0.53	235.20	17.05	168.0
17	4.9	0.120	0.54	238.36	14.78	212.8
18	5.2	0.116	0.63	244.60	13.07	190.4
19	5.1	0.115	0.59	244.60	15.53	190.4
20	5.0	0.120	0.58	238.36	14.78	156.8
21	5.1	0.118	0.58	235.20	15.34	145.6
22	5.1	0.115	0.59	241.47	15.16	179.2
23	5.0	0.114	0.58	244.60	14.97	201.6
24	5.2	0.116	0.55	238.36	14.78	212.8
Mean			0.58	239.64	15.07	185.26

Table 4.6 Nutrient status of the soil prior to STCR experiment in Strip-III (S_I)

T.No.	pH	EC (dSm^{-1})	OC (%)	Available nutrients (kg ha^{-1})		
				N	P	K
1	5.1	0.112	0.64	257.15	18.00	235.2
2	5.0	0.122	0.63	250.88	19.13	246.4
3	4.9	0.114	0.58	257.15	20.65	280.0
4	4.8	0.115	0.64	257.15	19.89	257.6
5	5.3	0.118	0.57	260.28	21.22	235.2
6	5.1	0.117	0.59	263.42	20.27	201.6
7	5.0	0.115	0.55	257.12	19.89	257.6
8	5.2	0.116	0.65	250.88	20.27	257.6
9	5.0	0.120	0.63	250.88	19.13	246.4
10	5.1	0.121	0.58	254.01	18.95	224.0
11	4.9	0.123	0.55	257.15	19.51	257.6
12	5.1	0.115	0.61	257.15	20.08	235.2
13	5.0	0.116	0.58	260.28	20.65	224.0
14	4.9	0.118	0.57	263.42	20.46	246.4
15	4.8	0.119	0.59	254.01	19.51	224.0
16	5.3	0.120	0.65	254.01	19.31	235.2
17	5.2	0.122	0.57	250.88	20.27	212.8
18	5.0	0.113	0.61	254.01	19.32	224.0
19	5.1	0.118	0.59	260.28	20.08	268.8
20	5.0	0.116	0.58	260.28	18.76	268.8
21	5.0	0.120	0.59	257.15	19.51	280.0
22	5.2	0.118	0.61	263.42	19.89	235.2
23	5.1	0.120	0.57	260.28	20.27	212.8
24	5.0	0.121	0.63	263.42	20.46	235.2
Mean			0.60	257.27	19.81	241.73

Table 4.7 Nutrient status of the soil prior to STCR experiment in Strip-IV (S_2)

T.No.	pH	EC (dSm^{-1})	OC (%)	Available nutrients ($kg\ ha^{-1}$)		
				N	P	K
1	4.9	0.116	0.53	275.96	21.60	291.2
2	5.2	0.115	0.58	279.10	21.41	302.4
3	5.1	0.118	0.58	285.37	23.49	336.0
4	5.0	0.120	0.63	272.83	24.06	291.2
5	5.1	0.121	0.61	282.24	22.92	347.2
6	5.0	0.122	0.57	275.96	24.06	291.2
7	5.2	0.122	0.55	269.69	23.68	291.2
8	5.0	0.124	0.61	275.96	22.92	324.8
9	5.1	0.120	0.59	279.10	23.68	324.8
10	5.1	0.118	0.61	272.83	22.55	313.6
11	5.2	0.117	0.64	282.24	22.74	302.8
12	5.2	0.115	0.63	269.69	23.87	324.8
13	4.9	0.120	0.64	275.96	22.92	336.0
14	4.9	0.121	0.59	272.83	23.30	347.2
15	5.1	0.120	0.55	285.37	22.92	324.8
16	5.1	0.118	0.61	288.51	22.74	302.4
17	5.0	0.119	0.52	282.24	23.11	313.6
18	4.9	0.117	0.58	285.37	21.41	280.0
19	5.0	0.120	0.61	279.10	24.25	313.6
20	5.1	0.118	0.59	282.24	24.06	336.0
21	5.2	0.119	0.55	269.69	21.98	313.6
22	5.0	0.120	0.57	272.83	22.74	302.4
23	5.1	0.116	0.58	269.69	22.92	324.8
24	5.2	0.115	0.59	275.96	23.11	336.0
Mean			0.59	277.53	23.01	315.48

4.2.2 Post harvest soil analysis

Soil samples were collected after the harvest of coleus from all plots (96) and analysed for organic carbon and available N, P and K. The data are given in the table 4.8 to 4.11.

Organic carbon content in the soil varied from 0.53 to 0.94, 0.53 to 0.92, 0.53 to 1.02 and 0.53 to 1.03 per cent in strip I, II, III and IV respectively (Table 4.8 to 4.11) and the corresponding mean values were 0.67, 0.67, 0.70 and 0.69 respectively.

Available N content ranges from 188.16 to 238.66, 200.70 to 260.28, 228.72 to 285.37 and 254.01 to 304.19 kg ha^{-1} in strip I, II, III and IV respectively (Table 4.8 to 4.11) and the respective mean values were 215.32, 234.42, 253.10 and 273.67 kg ha^{-1}.

Available P status varied from 9.47 to 14.30, 11.27 to 17.05, 14.30 to 20.93 and 17.14 to 23.68 kg ha^{-1} in strip I, II, III and IV respectively and the corresponding mean values were 12.03, 13.82, 17.76 and 21.01 kg ha^{-1} respectively (Table 4.8 to 4.11).

Available K status of the soil after STCR experiment was varied from 78.4 to 190.4, 145.6 to 235.2, 190.4 to 280.8 and 224.0 to 358.4 kg ha^{-1} in strip I, II, III and IV respectively and the respective mean values were 128.8, 175.93, 229.13 and 297.73 kg ha^{-1}.

Table 4.8 Nutrient status of the soil after STCR experiment in Strip-I (So)

T.No	Fertilizer doses (kg ha^{-1})			FYM	Soil available nutrients (kg ha^{-1})			OC (%)
	N	P_2O_5	K_2O	(t ha^{-1})	N	P	K	
1	0	0	0	0	191.29	9.47	89.6	0.53
2	0	0	0	0	188.16	11.46	78.4	0.63
3	0	0	0	7.5	194.43	11.27	100.8	0.77
4	0	0	0	15	197.56	12.31	123.2	0.79
5	0	0	25	7.5	197.56	10.61	100.8	0.70
6	20	0	25	7.5	222.65	11.18	112.0	0.79
7	20	45	25	7.5	222.65	12.69	89.6	0.67
8	0	0	50	7.5	203.84	11.46	145.6	0.79
9	0	45	50	7.5	197.56	11.74	134.4	0.76
10	20	0	50	0	200.70	10.80	145.6	0.58
11	20	45	50	0	197.56	12.41	145.6	0.55
12	40	0	50	0	225.79	11.46	123.2	0.50
13	40	45	50	0	216.38	12.41	123.2	0.49
14	40	90	50	0	228.92	14.11	112.0	0.57
15	0	0	100	15	213.24	11.46	123.2	0.82
16	20	45	100	15	219.52	11.93	134.4	0.89
17	40	90	100	0	225.79	13.83	100.8	0.55
18	80	0	100	0	228.92	10.61	134.4	0.55
19	80	45	100	15	235.20	11.46	179.2	0.94
20	80	90	100	0	232.06	12.60	134.4	0.57
21	40	45	200	0	228.92	14.21	156.8	0.50
22	40	90	200	0	225.79	13.83	123.2	0.53
23	80	45	200	15	238.66	11.27	190.4	0.92
24	80	90	200	15	235.20	14.30	190.4	0.91
Mean					215.34	12.30	128.8	0.67

Table 4.9 Nutrient status of the soil after STCR experiment in Strip-II ($S_{1/2}$)

T.No	Fertilizer doses (kg ha^{-1})			FYM	Soil available nutrients (kg ha^{-1})			OC
	N	P_2O_5	K_2O	(t ha^{-1})	N	P	K	(%)
1	0	0	0	0	203.84	11.37	168.0	0.55
2	0	0	0	0	200.70	11.74	145.6	0.53
3	0	0	0	7.5	203.84	12.69	179.2	0.67
4	0	0	0	15	225.71	13.35	156.8	0.91
5	0	0	25	7.5	225.79	13.35	168.0	0.68
6	20	0	25	7.5	228.92	12.41	168.0	0.76
7	20	45	25	7.5	235.20	14.02	179.2	0.70
8	0	0	50	7.5	228.92	12.50	156.8	0.77
9	0	45	50	7.5	225.79	13.26	156.8	0.70
10	20	0	50	0	232.06	12.03	145.6	0.55
11	20	45	50	0	222.65	13.54	168.0	0.57
12	40	0	50	0	238.36	12.41	179.2	0.53
13	40	45	50	0	238.36	15.72	190.4	0.58
14	40	90	50	0	241.47	16.29	156.8	0.50
15	0	0	100	15	238.36	13.17	212.8	0.89
16	20	45	100	15	235.20	16.48	168.0	0.82
17	40	90	100	0	238.36	15.63	201.6	0.53
18	80	0	100	0	254.01	11.27	190.4	0.58
19	80	45	100	15	254.01	14.02	201.6	0.88
20	80	90	100	0	250.88	14.49	156.8	0.55
21	40	45	200	0	241.47	15.16	145.6	0.55
22	40	90	200	0	247.74	15.63	168.0	0.58
23	80	45	200	15	257.05	14.28	224.0	0.92
24	80	90	200	15	260.28	17.05	235.2	0.87
Mean					234.42	13.82	175.93	0.67

Table 4.10 Nutrient status of the soil after STCR experiment in Strip-III (S_I)

T.No	Fertilizer doses (kg ha^{-1})			FYM ($t\ ha^{-1}$)	Soil available nutrients (kg ha^{-1})			OC (%)
	N	P_2O_5	K_2O		N	P	K	
1	0	0	0	0	235.20	15.06	190.4	0.53
2	0	0	0	0	228.72	14.30	201.6	0.59
3	0	0	0	7.5	235.20	17.24	246.4	0.77
4	0	0	0	15	238.26	16.10	224.0	0.82
5	0	0	25	7.5	238.26	18.19	212.8	0.75
6	20	0	25	7.5	257.15	17.05	179.2	0.74
7	20	45	25	7.5	250.88	18.09	224.0	0.79
8	0	0	50	7.5	238.36	16.21	235.2	0.77
9	0	45	50	7.5	235.20	18.76	235.2	0.80
10	20	0	50	0	241.47	16.58	212.8	0.58
11	20	45	50	0	244.60	18.38	224.0	0.61
12	40	0	50	0	257.15	17.24	235.2	0.56
13	40	45	50	0	260.80	18.95	212.8	0.58
14	40	90	50	0	263.42	20.93	246.4	0.59
15	0	0	100	15	235.20	16.29	235.2	0.80
16	20	45	100	15	250.88	18.19	235.2	0.77
17	40	90	100	0	250.88	20.65	212.8	0.55
18	80	0	100	0	266.56	16.10	212.8	0.58
19	80	45	100	15	275.96	17.43	246.4	1.014
20	80	90	100	0	272.83	18.00	257.6	0.58
21	40	45	200	0	263.42	18.09	280.0	0.61
22	40	90	200	0	269.69	19.89	246.4	0.57
23	80	45	200	15	279.10	18.38	224.0	0.94
24	80	90	200	15	285.37	20.18	268.8	1.014
Mean					253.10	17.76	229.13	0.70

Table 4.11 Nutrient status of the soil after STCR experiment in Strip-IV (S_2)

T.No	Fertilizer doses (kg ha^{-1})			FYM (t ha^{-1})	Soil available nutrients (kg ha^{-1})			OC (%)
	N	P_2O_5	K_2O		N	P	K	
1	0	0	0	0	254.01	17.43	224.0	0.58
2	0	0	0	0	254.01	17.14	257.6	0.55
3	0	0	0	7.5	260.80	20.84	257.6	0.70
4	0	0	0	15	257.14	22.17	257.6	0.76
5	0	0	25	7.5	260.80	22.17	291.2	0.75
6	20	0	25	7.5	269.69	22.54	246.4	0.66
7	20	45	25	7.5	263.42	21.22	268.8	0.77
8	0	0	50	7.5	263.42	20.75	302.4	0.76
9	0	45	50	7.5	260.80	21.03	313.6	0.74
10	20	0	50	0	263.42	22.08	302.4	0.57
11	20	45	50	0	272.83	20.93	291.2	0.61
12	40	0	50	0	269.69	22.64	302.4	0.51
13	40	45	50	0	275.96	23.30	324.8	0.55
14	40	90	50	0	272.83	23.59	336.0	0.58
15	0	0	100	15	269.69	18.95	324.8	0.79
16	20	45	100	15	279.10	21.22	313.6	0.77
17	40	90	100	0	285.37	21.03	302.4	0.57
18	80	0	100	0	294.78	17.62	268.8	0.55
19	80	45	100	15	297.92	23.68	324.8	0.89
20	80	90	100	0	297.92	21.88	302.4	0.57
21	40	45	200	0	272.83	20.93	324.8	0.53
22	40	90	200	0	272.83	22.64	313.6	0.57
23	80	45	200	15	294.78	17.62	336.0	1.014
24	80	90	200	15	304.19	20.93	358.4	1.029
Mean					273.69	21.01	297.73	0.69

4.2.3 Yield parameter

The strip wise mean values of tubes yield are presented in table 4.12. The data on tuber yield of coleus, recorded in the experiment as influenced by treatments are given in table 4.14 to 4.17.

As evident from the data on tuber yield, the control plots in all the strips registered much lower yield (3970 to 12530 kg ha^{-1}) than the treated plots (3970 to 20,200 kg ha^{-1}) in the respective strips.

Table 4.12. Strip wise mean yield of coleus

Tuber yield kg ha^{-1}	Mean values to strips			
	I	II	III	IV
Control plots	4265	4910	11725	10315
Treated plots	7162	7367	13694	9863
All plots	6920	7162	13530	9901

The average tuber yield in all the plots ranged from 6920 kg ha^{-1} to 13530 kg ha^{-1} and the respective mean values of 6920, 7162, 13530 and 9901 kg ha^{-1} were recorded in strip I to strip IV respectively (Table 4.12)

Table 4.13. Maximum and minimum tuber yield obtained due to treatments

Particulars	Strip	Soil test values kg ha^{-1}			Fertilizer dose kg ha^{-1}			FYM t ha^{-1}	Tuber Yield (kg ha^{-1})
		N	P	K	N	P_2O_5	K_2O		
Maximum yield	III	260.88	18.76	268.8	80	90	100	0	20200
Minimum yield	I	222.65	12.12	112	0	0	0	0	3970

Among the treated plots, the highest tuber yield were recorded as 20,200 kg ha^{-1} in strip III (S_1T_{20}), which received 80:90:100 kg ha^{-1} of N, P_2O_5 and K_2O as fertilizers, when the STVs were 260.28, 18.76 and 268.8 kg ha^{-1} of available N, P and K respectively (Table 4.13)

The lowest yield of 3970 kg ha^{-1} was registered in strip-I (S_0T_1), which was not applied with any nutrients (organics and inorganics) and the STVs were 222.65, 12.12 and 112 kg ha^{-1} of available N, P and K respectively (Table 4.13).

4.2.4 Nutrient uptake by coleus

The nutrient uptake of coleus was calculated separately for tuber and haulm of coleus for all treatments. Total nutrient uptake of N, P and K by coleus (tuber + haulm) is represented in table 4.14 to 4.17. The mean values in each strip are given in table 4.18.

Uptake of N, P and K ranged from 22.66 to 185.10, 3.27 to 30.27 and 36.63 to 324.61 kg ha^{-1} N, P and K in all strips. The highest uptake was registered by K, followed by N and P. In the control plots (Table 4.18), uptake of N registered mean values of 23.12, 42.92, 74.65 and 68.18 kg ha^{-1} in strip I, II, III and IV respectively. The mean uptake of P in strip I to IV were 3.77, 6.52, 10.78 and 9.91 kg ha^{-1}. Uptake of K recorded mean values of 41.99, 64.7, 121.07 and 110.85 kg ha^{-1} in strip I to IV.

Table 4.14 Effect of fertilizer application on yield and uptake of nutrients in strip-I

T.No	Yield ($kg\ ha^{-1}$)	Fertilizer dose ($kg\ ha^{-1}$)			FYM ($t\ ha^{-1}$)	Uptake of nutrients ($kg\ ha^{-1}$)		
		N	P_2O_5	K_2O		N	P	K
1	3970	0	0	0	0	22.66	3.27	36.63
2	4560	0	0	0	0	23.58	4.27	47.35
3	13320	0	0	0	7.5	70.89	12.21	118.74
4	12980	0	0	0	15	77.68	12.28	100.67
5	6000	0	0	25	7.5	32.14	4.81	61.16
6	7760	20	0	25	7.5	35.82	7.68	80.38
7	5070	20	45	25	7.5	30.62	5.42	53.57
8	7620	0	0	50	7.5	56.11	8.08	103.77
9	5320	0	45	50	7.5	28.09	5.35	60.15
10	6500	20	0	50	0	78.49	10.12	141.67
11	7580	20	45	50	0	64.93	10.24	117.34
12	7530	40	0	50	0	106.65	11.86	172.81
13	7550	40	45	50	0	76.24	11.53	127.25
14	7570	40	90	50	0	55.22	9.06	96.39
15	5950	0	0	100	15	60.12	7.93	118.82
16	5540	20	45	100	15	62.46	10.38	122.46
17	8110	40	90	100	0	34.63	7.81	88.90
18	8660	80	0	100	0	55.17	10.37	107.80
19	4630	80	45	100	15	83.99	11.62	157.41
20	5260	80	90	100	0	29.57	5.44	54.28
21	4360	40	45	200	0	41.69	6.18	81.91
22	4710	40	90	200	0	33.53	6.19	69.19
23	8220	80	45	200	15	50.10	8.40	108.85
24	7330	80	90	200	15	60.47	10.95	122.65

Table 4.15 Effect of fertilizer application on yield and uptake of nutrients in Strip-II

T.No	Yield ($kg\ ha^{-1}$)	Fertilizer doses ($kg\ ha^{-1}$)			FYM ($t\ ha^{-1}$)	Uptake of nutrients ($kg\ ha^{-1}$)		
		N	P_2O_5	K_2O		N	P	K
1	4810	0	0	0	0	43.39	6.72	62.23
2	5010	0	0	0	0	42.46	6.32	67.17
3	7480	0	0	0	7.5	71.03	10.80	110.02
4	7500	0	0	0	15	75.90	10.80	113.81
5	9010	0	0	25	7.5	96.11	14.61	162.89
6	6760	20	0	25	7.5	67.60	10.18	115.14
7	6050	20	45	25	7.5	86.89	12.62	136.80
8	12330	0	0	50	7.5	95.19	15.04	177.76
9	3970	0	45	50	7.5	66.34	10.75	124.11
10	10560	20	0	50	0	108.11	15.30	203.09
11	5290	20	45	50	0	61.66	10.70	113.15
12	9550	40	0	50	0	100.58	13.95	178.35
13	8350	40	45	50	0	42.71	7.52	86.09
14	8730	40	90	50	0	70.81	13.47	128.00
15	9620	0	0	100	15	131.61	19.44	260.65
16	9590	20	45	100	15	158.24	23.97	304.78
17	5140	40	90	100	0	62.78	11.16	117.38
18	6630	80	0	100	0	66.99	9.98	133.93
19	8470	80	45	100	15	72.67	10.28	145.72
20	4860	80	90	100	0	62.21	11.01	103.68
21	5590	40	45	200	0	71.72	11.03	145.70
22	4550	40	90	200	0	69.52	11.99	141.37
23	6140	80	45	200	15	125.62	16.13	223.81
24	5910	80	90	200	15	114.59	18.14	202.96

Table 4.16 Effect of fertilizer application on yield and uptake of nutrients in strip-III

T.No	Yield (kg ha^{-1})	Fertilizer doses (kg ha^{-1})			FYM (t ha^{-1})	Uptake of nutrients (kg ha^{-1})		
		N	P_2O_5	K_2O		N	P	K
1	10920	0	0	0	0	72.10	10.55	115.1
2	12530	0	0	0	0	77.21	11.01	127.05
3	10750	0	0	0	7.5	78.72	11.09	124.36
4	9930	0	0	0	15	86.13	11.50	138.01
5	10110	0	0	25	7.5	83.20	11.43	138.52
6	12680	20	0	25	7.5	68.52	10.84	124.48
7	12240	20	45	25	7.5	90.10	14.46	158.17
8	14600	0	0	50	7.5	164.18	21.43	291.36
9	15460	0	45	50	7.5	97.04	16.14	189.50
10	13500	20	0	50	0	130.07	17.93	231.27
11	12740	20	45	50	0	92.34	14.94	170.45
12	16980	40	0	50	0	162.45	20.71	276.18
13	10540	40	45	50	0	67.12	10.62	123.85
14	7990	40	90	50	0	54.16	10.51	96.84
15	17140	0	0	100	15	136.14	18.32	279.86
16	14080	20	45	100	15	110.92	16.37	227.52
17	12560	40	90	100	0	90.56	17.71	173.23
18	19310	80	0	100	0	179.87	22.10	324.61
19	12130	80	45	100	15	111.27	15.86	217.68
20	20200	80	90	100	0	185.10	30.27	321.01
21	15780	40	45	200	0	112.73	16.02	238.17
22	15410	40	90	200	0	117.22	20.80	239.91
23	12970	80	45	200	15	103.17	14.79	201.85
24	14180	80	90	200	15	138.17	23.29	248.68

Table 4.17 Effect of fertilizer application on yield and uptake of nutrients in Strip-IV

T.No	Yield ($kg\ ha^{-1}$)	Fertilizer doses ($kg\ ha^{-1}$)			FYM ($t\ ha^{-1}$)	Uptake of nutrients ($kg\ ha^{-1}$)		
		N	P_2O_5	K_2O		N	P	K
1	11170	0	0	0	0	80.63	11.22	132.46
2	9460	0	0	0	0	55.73	8.60	89.24
3	12050	0	0	0	7.5	86.76	11.77	129.49
4	12830	0	0	0	15	85.57	12.56	131.82
5	9080	0	0	25	7.5	64.07	8.80	106.76
6	7940	20	0	25	7.5	57.57	7.77	95.07
7	9560	20	45	25	7.5	65.98	10.29	108.45
8	11370	0	0	50	7.5	72.12	10.61	135.13
9	7650	0	45	50	7.5	60.04	9.44	107.15
10	10240	20	0	50	0	67.20	9.23	120.57
11	11810	20	45	50	0	68.51	11.15	123.37
12	10440	40	0	50	0	67.79	8.13	116.21
13	8090	40	45	50	0	62.46	9.47	104.21
14	11880	40	90	50	0	84.79	16.26	141.18
15	11970	0	0	100	15	90.21	12.00	176.21
16	12080	20	45	100	15	69.92	11.04	139.55
17	12660	40	90	100	0	91.90	17.19	168.45
18	10850	80	0	100	0	86.21	10.24	153.72
19	11230	80	45	100	15	81.60	11.75	150.03
20	10090	80	90	100	0	69.22	12.99	123.00
21	7720	40	45	200	0	63.83	9.35	120.59
22	4580	40	90	200	0	92.99	14.96	158.49
23	6350	80	45	200	15	152.12	17.64	225.34
24	6530	80	90	200	15	147.79	20.31	207.12

Table 4.18. Strip wise mean uptake of N, P and K (kg ha^{-1}) at harvest

Particulars	Mean values to strips			
	I	II	III	IV
Control plots				
Uptake N	23.12	42.92	74.65	68.18
Uptake P	3.77	6.52	10.78	9.91
Uptake K	41.99	64.7	121.08	110.85
Treated plots				
Uptake N	56.1	84.86	108.05	81.83
Uptake P	8.26	12.91	17.70	13.8
Uptake K	96.5	159.69	206.72	138.58
All plots				
Uptake N	52.95	81.86	108.68	80.20
Uptake P	8.39	12.57	16.19	11.78
Uptake K	97.92	148.27	199.06	135.98

In general the mean values of N uptake were registered as 52.95, 81.86, 108.68 and 80.20 kg ha^{-1} in strip I, II, III and IV respectively. The average P uptake were 8.39, 12.57, 16.19 and 11.78 in strip I to IV. The mean values of K uptake were 97.92, 148.27, 199.06 and 135.98 in strip I to IV respectively.

The highest N, P and K uptake were registered in strip III (S_1) with the values of 108.68, 16.19 and 199.06 kg ha^{-1}, whereas the lowest N, P and K uptake were recorded in strip I (S_0) with the values of 52.95, 8.39 and 97.92 kg ha^{-1}.

4.3 SOIL TEST CALIBRATION STUDIES

The purpose of soil test crop response studies in essence is calibration of STVs for fertilizer recommendation. The main objectives of crop response model are

i) Computation Fertilizer Adjustment equation for specific yield targets at varying STVs.

ii) Optimization of fertilizer nutrients for maximum and economic yields at varying STVs.

The calibration of soil test data would be more useful for the farmer to obtain site specific fertilizer dose for the crops to get maximum and economic yield. Balanced use of soil and fertilizer nutrients can be achieved though soil test based fertilizer recommendation.

4.3.1 Optimization of fertilizer doses for different yield targets – Targeted yield model

The available nutrient status of the soil and applied nutrients through fertilizers has a linear relationship between yield of the crop and uptake of a nutrient. This implies that for obtaining a economic produce (yield), a definite quantity of nutrients must be taken up by the plant. Once this is known, the fertilizers that need to be applied can be estimated by taking into account the efficiency of contribution from soil available nutrients and the efficiency of uptake from applied fertilizer nutrients towards the total uptake of the nutrient. This forms the basis for fertilizer recommendation for targeted yield of a crop. The basic parameters needed for a given soil type in an agro-climatic condition are,

i) Nutrient requirement (NR) per unit of produces (economic part)

ii) Per cent contribution of nutrients from the soil (CS)

iii) Per cent contribution of nutrients from the fertilizer (CF)

The above values were calculated using the formulae represented in chapter 3.4.1 and are presented in table 4.19.

Table 4.19. Basic data required for computing targeted yield equations

Nutrients	NR kg t^{-1}	CS %	CF %	COM %
N	9.15	21	61.6	21.05
P_2O_5	1.38	46.85	9.57	13.59
K_2O	16.38	40.85	56.60	57.23

4.3.1.1 Nutrient requirement

The computed values showed that coleus var. Nidhi required 9.15 kg N, 1.38 kg P_2O_5 and 16.38 kg K_2O ha^{-1} to produce one tonne of tuber. This data revealed that coleus require more amounts of N and K, when compared to P.

4.3.1.2 Soil and fertilizer efficiencies

Soil and fertilizer efficiencies were worked out using the formulae given under 3.4.1. The soil efficiencies were 21, 46.85 and 40.85 per cent for N, P_2O_5 and K_2O respectively, and the fertilizer efficiencies were 61.6, 9.57 and 56.6 per cent N, P_2O_5 and K_2O respectively.

It was evident from the data contribution of fertilizer was so high compared to contribution from soil in the case of N and K_2O, whereas in the case of P_2O_5, the contribution from soil was higher than that of contribution from fertilizer.

4.3.1.3 Organic manure efficiency

The organic manure efficiency COM for N, P and K nutrients were computed using the formulae given under 3.7.1.4. The computed value for organic manure efficiency was 21.05, 13.59 and 57.23 per cent for N, P_2O_5 and K_2O.

4.3.1.4 Fertilizer prescription for targeted yield of coleus

The fertilizer prescription equations were developed for N, P_2O_5 and K_2O by substituting the corresponding NR, CS, and CF values in targeted yield equations.

The prescription equation for coleus was obtained as,

$$FN = 14.85\ T - 0.34\ SN$$
$$F\ P_2O_5 = 14.42\ T - 11.21\ SP$$
$$F\ K_2O = 28.93\ T - 0.87\ SK$$

Where,

FN, F P_2O_5, F K_2O - Fertilizer N, P_2O_5 and K_2O respectively in kg ha^{-1}

T - Target yield of tuber in t ha^{-1}

SN, SP, SK - Soil available N, P and K in kg ha^{-1} respectively.

4.3.1.5 Fertilizer prescription for targeted yield of coleus involving IPNS

By using the basic parameters like, Nutrient Requirement (NR), Per cent contribution from soil (CS), Per cent contribution from fertilizer (CF) and the per cent contribution from organic manures (COM) to yield, the prescription equations are developed under Integrated Plant Nutrient Supply System (IPNS). Where, FYM was used as organic source and which have 0.51, 0.13, 0.37 and 25.70 per cent of nitrogen, phosphorus, potassium and moisture content respectively.

So, the prescription equation with FYM can be expressed as,

$$FN = 14.85\ T - 0.34\ SN - 0.34\ ON$$
$$F\ P_2O_5 = 14.42\ T - 11.21\ SP - 3.25\ OP$$
$$F\ K_2O = 28.93\ T - 0.87\ SK - 1.22\ OK$$

Where,

ON, OP and OK are quantities of N, P and K supplied through organic manure in kg ha^{-1}.

Based on targeted yield equations, ready reckoners can be prepared for recommending fertilizer dose either as inorganics alone or in combination with organics for specific targets of coleus at varying STVs.

Table 4.20 kg N required for different yield targets of coleus

Soil available N (Kg ha^{-1})	Fertilizer to be applied (kg ha^{-1})		
	10 t ha^{-1}	15 t ha^{-1}	20 t ha^{-1}
200	80.5	155	229
220	74	148	222
240	67	141	215
260	61	135	209
280	54	128	114

Table 4.21 kg P_2O_5 required for different yield targets of coleus

Soil available P (kg ha^{-1})	Fertilizer to be applied (kg ha^{-1})		
	10 t ha^{-1}	15 t ha^{-1}	20 t ha^{-1}
8	55	127	198
10	32	104	176
15	-	48	120
20	-	-	60

Table 4.22 kg K_2O required for different yield targets of coleus

Soil available K (kg ha^{-1})	Fertilizer to be applied (kg ha^{-1})		
	10 t ha^{-1}	15 t ha^{-1}	20 t ha^{-1}
150	159	303	447
175	137	282	427
200	115	260	404
250	71	216	361

4.3.2 Multiple regression analysis for prescription of fertilizer doses at varying soil test values

In soil test crop response correlation studies yield is computed as a function of soil and fertilizer nutrients keeping all other factors at an optimum level. The data obtained from the experiment fitted in to a quadratic response model by using the theory of regression.

The multiple regression model includes linear, quadratic and interaction terms of soil and fertilizer nutrients. The multiple regression model developed at IARI (Ramamoorthy, 1974) and mentioned in the chapter 3.6 formed the basis for this calibration. This model predicts the type of response for each nutrient for different crops (Singh and Sharma, 1978).

Among the different type of responses for working out fertilizer doses at varying soil test values, the response type of +, -, - signs respectively for coefficients of linear, quadratic and interaction terms of the nutrient was considerable to be the normal type.

By using the field experiment data, the yield prediction equation have been developed, which can be expressed as,

$$Y = -33214.88 + 220.67\ SN - 0.441\ SN^2 + 1459.75\ SP - 24.81 SP^2 + 41.33\ SK - 0.120\ SK^2 + 88.66\ FN - 0.264\ FN^2 - 88.24\ FP + 0.493\ FP^2 + 48.39\ FK - 0.183\ FK^2 - 0.037\ FNSN + 1.49\ FPSP - 0.034\ FKSK$$

$$(R = 0.674)$$

The above mentioned equation have been developed by using 15 variables comprising of linear, quadratic and interaction terms of soil available and fertilizer N, P and K nutrients had 67.4 per cent predictability which was significant also.

Among the three fertilizer nutrients, FN only showed the normal type (+, -, -) of response.

The soil test based fertilizer adjustment equation with respect to FN was worked out by using a formulae mentioned in chapter 3.6, which can be expressed as,

$$FN\ (maximum) = 168 - 0.07\ SN$$

$$FN\ (economic) = 168 - 0.13\ SN$$

This is an adjustment equation of the fertilizer N in terms of the soil test 'N'.

4.4 CORRELATION STUDIES

Simple correlation's coefficient was worked out for Nutrient uptake, soil available nutrients, applied nutrients with the tuber yield of coleus. Those correlation coefficient results are presented in this chapter.

4.4.1 Correlation coefficients between nutrient uptake at harvest and yield of coleus

Table 4.23 Correlation coefficients between nutrient uptake and tuber yield

	Uptake of N	Uptake of P	Uptake of K
Uptake of N			
Uptake of P	0.9441**		
Uptake of K	0.9687**	0.9376**	
Tuber yield	0.6357**	0.6537**	0.6613**

** Significant at 1%

Uptake of N, P, and K was positively correlated with yield and the inter correlation's between uptake of N, P and K were also significant.

4.4.2 Yield and nutrient uptake with available and applied nutrients

Uptake of nutrients showed positive correlations with available and applied N, P and K as evident from the table 4.24

Table 4.24. Correlation co-efficient of yield and nutrient uptake with available and applied nutrients

	Yield	N uptake	P uptake	K uptake
Organic carbon	0.2878**	0.1174	0.0694	0.1257
Available N	0.4566**	0.2963**	0.2804**	0.2482*
Available P	0.4994**	0.3725**	0.3476**	0.3201**
Available K	0.4265**	0.3492**	0.3185**	0.2837**
Fertilizer N	0.0156	0.2417*	0.2744**	0.2630**
Fertilizer P_2O_5	0.1430	0.0144	0.2257*	0.0559
Fertilizer K_2O	0.0706	0.2776**	0.3200**	0.3640**
FYM	0.0542	0.2459*	0.1920	0.2442*

** - Significant at 1% level

*- Significant at 5% level

From the data it is evident that higher correlation was observed between nutrient uptake and available nutrients. Whereas, in the case of applied nutrients, N and K, was highly correlated with nutrient uptake than P and FYM. Tube yield was positively correlated with organic carbon and available N, P and K contents in the soil.

4.4.3 Correlation's of plant major nutrient contents with yield

Higher positive correlations were obtained from yield with N and K contents than P content. The correlation coefficients are presented in the table 4.25.

Table 4.25. Correlations of plant major nutrient contents with yield

	Tuber N	Tuber P	Tuber K	Haulm N	Haulm P	Haulm K
Yield	0.3451**	0.1536*	0.2916*	0.4307**	0.1930*	0.3581**
Tuber N	1.0000	0.7280**	0.8115**	0.9348**	0.7638**	0.8196**
Tuber P	0.7280**	1.0000	0.6928**	0.7200**	0.9821**	0.6929**
Tuber K	0.8115**	0.6929**	1.0000	0.8162**	0.7217**	0.9821**
Haulm N	0.9348**	0.7200**	0.8162**	1.0000	0.7488**	0.8317**
Haulm P	0.7638**	0.9821**	0.7217**	0.7483**	1.0000	0.7245**
Haulm K	0.8196**	0.6928**	0.9821**	0.8317**	0.7245**	1.0000

** - Significant at 1% level

*- Significant at 5% level

4.5 RESPONSE OF COLEUS TO APPLIED NUTRIENTS

4.5.1 Response of coleus to FYM

Tuber yield data of coleus from FYM alone applied at different levels are given in Table 4.26. In each strip two absolute control plots were maintained in that neither FYM nor fertilizer was applied.

Table 4.26. Mean response of coleus to FYM

Levels of FYM t ha^{-1}	Tuber yield kg ha^{-1}				
	Strip I	Strip II	Strip III	Strip IV	Mean
Nil	3970	4810	10920	11170	7717.5
Nil	4560	5010	12530	9460	7890.0
7.5	13320	7480	10750	12050	10900.0
15	12980	7500	9930	12083	10623.0

From this data obvious that higher yield were obtained from plots that received the FYM alone.The response of coleus to FYM application was worked out and presented in table 4.27. It is showed that the response of FYM at F_2 level

(7.5 t ha^{-1}) was higher than at F_3 level (15 t ha^{-1}) and absolute control plots. The average response at F_2 level was 412.83 kg of tuber per tonne of FYM while at F_2 level it was 187.96 per tonne of FYM.

Table 4.27. Response of tuber yield to FYM

Levels of FYM t ha^{-1}	Mean response tuber yield kg ha^{-1}	Response per tonne of FYM (kg)
7.5(F_2)	3096	412.83
15(F_3)	2820	187.96

4.5.2 Response of coleus to applied nutrients N, P_2O_5, and K_2O

Tuber yield data of coleus from same treatment levels of N, P_2O_5, and K_2O applied plots and two absolute control were taken for calculating the response of coleus to applied N, P_2O_5, and K_2O (table 4.28)

Table 4.28 Mean response of coleus to applied N, P_2O_5, and K_2O

Levels of Nutrients	Tuber yield kg ha^{-1}				
	Strip I	Strip II	Strip III	Strip IV	Mean
Control-1	3970	4810	10920	11170	7717.5
Control-2	4560	5010	12530	9460	7890.0
F_2 (20,45,25)	5070	6050	12240	9560	8230
F_3 (40,90,50)	7570	8730	7990	11880	9042

The response of coleus to applied N, P_2O_5, and K_2O was worked out and that indicated the response of yield to N was 26.1 kg per kg of N, P response with respect to yield was 11.61 per kg P_2O_5 and where as, applied K_2O responded 20.91 kg tuber yield per kg of K_2O

4.6 PATH CO-EFFICIENT ANALYSIS

The path coefficient analysis was worked out for study the direct and indirect effect of the soil and plant nutrients on tuber yield.

4.6.1 Path coefficient analysis of soil nutrients with tuber yield

Path analysis was carried out by using the significant correlation co efficient of three characters namely soil available nutrients N, P, and K with tuber yield. Abstract of the results given in table 4.29.

Table 4.29 Path co- efficient's of soil available nutrients with yield

	N	P	K	r value
N	**-0.8190**	0.8499	0.2654	0.2962
P	-0.7825	**0.8895**	0.2656	0.3725
K	-0.7693	0.8359	**0.2826**	0.3492

The highest positive direct effect was exhibited for soil P (0.8895) on tuber yield. This was followed by soil K (0.2826). The negative direct effect on yield was obtained for soil N (-0.819). The highest positive indirect effect was observed for soil P (0.8499) through soil N on tuber yield. This was followed by soil K (0.2656) via soil N on tuber yield.

4.6.2 Path coefficient analysis of plant nutrients with yield

Path analysis was carried using significant correlation coefficient of six characters namely haulm N, haulm P, haulm K, tuber N, tuber P and tuber K with tuber yield. Abstract of the results given in table 4.30

Table 4.30 Path coefficient analysis of plant nutrients with yield.

	Haulm N	Haulm P	Haulm K	Tuber N	Tuber P	Tuber K	r value
Haulm N	**0.4190**	0.0397	1.1860	-0.1662	-0.2433	-0.7690	0.4661
Haulm P	0.3135	**0.0531**	1.0331	-0.1358	-0.3319	-0.6799	0.2520
Haulm K	0.3484	0.0384	**1.4260**	-0.1457	-0.2342	-0.9253	0.5077
Tuber N	0.3917	0.0405	1.1687	**-0.1778**	-0.2460	-0.7645	0.4126
Tuber P	0.3017	0.0521	0.9880	-0.1294	**-0.3380**	-0.6527	0.2217
Tuber K	0.3420	0.0383	1.4005	-0.1443	-0.2341	**-0.9421**	0.4603

The highest positive direct effect was exhibited for leaf K (1.426) on tuber yield. This was followed by leaf N (0.4190) and leaf P (0.0531). The highest negative on yield was obtained was tuber K (-0.9421) followed by tuber P (-0.3380) and tuber N (-0.1778).

The highest positive indirect effect was observed for tuber K (1.4005) through leaf K on tuber yield. This was followed by leaf N (1.1860), tuber N (1.1687) and leaf P (1.0331) via leaf K on tuber yield. The maximum negative indirect effect on tuber yield was exerted by leaf K (-0.9253) through tuber K followed by leaf N (-0.7690) and tuber N (-0.7645) via tuber K.

4.7 STARCH AND PROTEIN CONTENT OF THE COLEUS TUBERS

The starch content of the tubers were 13.08 to 20.19 per cent, where as the protein content was 0.04 to 0.30 per cent (Table 4.31 to 4.34)

Table 4.31 Effect of fertilizer application on starch and protein content of tubers in Strip I

T.No.	Fertilizer dose (kg ha^{-1})			Starch (%)	Protein (%)
	N	P_2O_5	K_2O		
1	0	0	0	13.28	0.05
2	0	0	0	13.08	0.06
3	0	0	0	13.28	0.05
4	0	0	0	14.25	0.07
5	0	0	25	15.00	0.05
6	20	0	25	15.30	0.04
7	20	45	25	15.58	0.08
8	0	0	50	16.65	0.09
9	0	45	50	14.93	0.06
10	20	0	50	16.27	0.07
11	20	45	50	16.70	0.08
12	40	0	50	18.23	0.09
13	40	45	50	19.20	0.10
14	40	90	50	18.23	0.09
15	0	0	100	15.30	0.08
16	20	45	100	16.65	0.09
17	40	90	100	18.23	0.08
18	80	0	100	19.65	0.11
19	80	45	100	18.20	0.12
20	80	90	100	19.75	0.12
21	40	45	200	17.62	0.09
22	40	90	200	17.99	0.08
23	80	45	200	19.82	0.09
24	80	90	200	19.65	0.12

Table 4.32 Effect of fertilizer application on starch and protein content of tuber in strip II

T.No.	Fertilizer dose (kg ha^{-1})			Starch (%)	Protein (%)
	N	P_2O_5	K_2O		
1	0	0	0	14.44	0.12
2	0	0	0	13.08	0.13
3	0	0	0	14.25	0.12
4	0	0	0	14.44	0.11
5	0	0	25	15.30	0.14
6	20	0	25	16.89	0.13
7	20	45	25	16.70	0.20
8	0	0	50	16.00	0.16
9	0	45	50	15.25	0.17
10	20	0	50	16.92	0.18
11	20	45	50	17.02	0.13
12	40	0	50	18.20	0.16
13	40	45	50	18.05	0.18
14	40	90	50	18.23	0.21
15	0	0	100	14.54	0.19
16	20	45	100	16.70	0.18
17	40	90	100	18.05	0.17
18	80	0	100	19.85	0.16
19	80	45	100	19.95	0.19
20	80	90	100	18.95	0.20
21	40	45	200	17.85	0.15
22	40	90	200	18.05	0.18
23	80	45	200	19.65	0.21
24	80	90	200	19.40	0.19

Table 4.33 Effect of fertilizer application on starch and protein content of tubers in Strip III

T.No.	Fertilizer dose (kg ha^{-1})			Starch (%)	Protein (%)
	N	P_2O_5	K_2O		
1	0	0	0	15.00	0.21
2	0	0	0	15.30	0.22
3	0	0	0	15.10	0.20
4	0	0	0	15.00	0.21
5	0	0	25	15.45	0.19
6	20	0	25	16.27	0.24
7	20	45	25	16.48	0.22
8	0	0	50	15.42	0.23
9	0	45	50	14.92	0.21
10	20	0	50	16.45	0.25
11	20	45	50	16.93	0.22
12	40	0	50	17.40	0.21
13	40	45	50	17.65	0.22
14	40	90	50	17.85	0.25
15	0	0	100	15.00	0.20
16	20	45	100	16.45	0.21
17	40	90	100	17.70	0.26
18	80	0	100	18.85	0.29
19	80	45	100	19.25	0.28
20	80	90	100	19.95	0.24
21	40	45	200	17.55	0.23
22	40	90	200	17.85	0.25
23	80	45	200	20.08	0.29
24	80	90	200	20.19	0.27

Table 4.34 Effect of fertilizer application on starch and protein content of tubers in strip IV

T.No.	Fertilizer dose (kg ha^{-1})			Starch (%)	Protein (%)
	N	P_2O_5	K_2O		
1	0	0	0	15.30	0.25
2	0	0	0	15.55	0.23
3	0	0	0	14.95	0.26
4	0	0	0	16.10	0.27
5	0	0	25	15.95	0.28
6	20	0	25	16.66	0.24
7	20	45	25	16.70	0.26
8	0	0	50	15.15	0.22
9	0	45	50	15.60	0.21
10	20	0	50	16.10	0.26
11	20	45	50	16.78	0.25
12	40	0	50	18.20	0.28
13	40	45	50	18.10	0.27
14	40	90	50	18.50	0.28
15	0	0	100	15.95	0.22
16	20	45	100	17.85	0.24
17	40	90	100	18.35	0.26
18	80	0	100	19.85	0.29
19	80	45	100	19.95	0.28
20	80	90	100	19.00	0.30
21	40	45	200	18.40	0.28
22	40	90	200	18.61	0.26
23	80	45	200	19.89	0.28
24	80	90	200	20.01	0.29

Discussion

5. DISCUSSION

The prime objective of an intensive agricultural system is to achieve the highest yield per unit area. The crop production has to be increased through the efficient and economic use of fertilizers apart from the use of high yielding varieties. Soils are heterogeneous in nature and their physical, chemical and biological properties affect the availability of native and added nutrients to the crops. In soil, mechanisms like nutrient fixation and release, nutrient mobility, their mineralization and immobilization are influenced by these soil properties. So, the fertilizer application is one of the most efficient means of increasing agricultural profitability. The level of yields per hectare may be increased considerably by appropriate application of fertilizers. Hence, there is an absolute need to make fertilizer production for crops based on soil properties, or in taxonomical term soils types (Goswami *et al.,* 1986).

Since the doses of fertilizers to be applied to a crop will largely depend on the inherent soils fertility, nutrient removal and profitability. The emphasis on soil test based balanced fertilizer has become much more relevant in the present scenario of high fertilizer costs and yield maximization programmes. It is laborious and time consuming to develop prescription equations for crops in each piece of land. So experiments are conducted in a soil type, which is representative of the soil present in larger area of a particular region and the results of the experiments are extrapolated to similar soils of other areas.

The effect of N, P and K on the growth and yield of coleus has been studied in earlier times (Geetha, 1983). However, the interaction effect of all the above three nutrients and the balanced fertilizer recommendation have not been studied so far. Keeping all the above aspects in mind, the present field investigation was carried out in the laterite soils of Kerala, using coleus as test crop. The experiment was conducted at the farm attached to the College of Horticulture, Vellanikkara. The study included the fertility gradient experiment by raising the gradient crop maize variety co-1 and soil test crop response experiment with coleus variety Nidhi. It also includes the evaluation of yield response with soil test values, and development of prescription equations for coleus to obtain targeted yield. The salient findings of the experimental results are discussed in this chapter.

5.1 FERTILITY GRADIENT EXPERIMENT

Fertility gradient approach is a novel method of field experimentation for STCR studies to create desired variability in soil fertility with in the experimental area. This was done by creating fertility gradient with in the experimental field by employing the "inductive field methodology" (Ramamoorthy, 1968). The variations in soil fertility were created by dividing the whole field into four equal strips and by applying graded dose of fertilizers in each strip as furnished in table 4.1

The crop maize was used as the gradient crop due to its exhaustive removal of nutrients from the soil. A comparison of the yields and nutrient uptake by the gradient crop of maize, as well as the comparison of pre sowing and post harvest soil samples were useful for the creation of fertility in the experimental site.

5.1.1 Soil fertility status

The soil fertility status with reference to N, P and K was assessed in this experiment by analysing the pre sowing and post harvest soil samples of the gradient crop in each strip. The available nitrogen content of the soil after FGE was generally reduced from strip I to strip III because of heavy uptake of nitrogen by maize, but in strip - IV, it was slightly increased over the initial one. This is due to heavier dose of 'N' application in this strip. While considering the available 'P' after FGE, there was slight decline in strip-I, due to the crop uptake as well as due to absence of any fertilizer and no application of fertilizer. But in strip II, strip III and strip IV, the available 'P' status of the soil after FGE was slightly increased due to heavier dose of fertilizer application.

The available 'K' content of the soil was progressively increased after FGE from strip II to strip IV, where as in strip I, slight decline in available 'K' content was noticed because it was not applied with any fertilizers (control). The organic carbon content of the soil slightly declined in all the strips after FGE. This may be due to the tendency of the soil to maintain a constant C/N ratio.

The result of analysis of variance also confirmed that each strip was significantly different from the other with respect to available 'N'. The experimental soil was sandy clay loam in texture with low in organic matter content and with low cation exchange capacity. The gradient crop being maize, an exhaust crop would have taken more amount of nitrogen, resulting low nitrogen content in the soil after FGE.

Among the four fertility gradient strips, after harvest of fodder maize significant variations have been created in the status of available P. This was possible because a major portion of the applied 'P' would have been retained in the soil. Further phosphorus being an immobile nutrient, the loss through leaching was very negligible and built up of fertility gradient with regard to soil available P was well pronounced. Murugappan (1985) and Natarajan (1991) have also reported similar findings.

The fertility gradient was significantly created with respect to 'K' among all the strips. The result of analysis of variance also confirmed that each strip was significantly different from other strip with respect to available K. The fertility gradient after FGE was illustrated in fig 5.1.

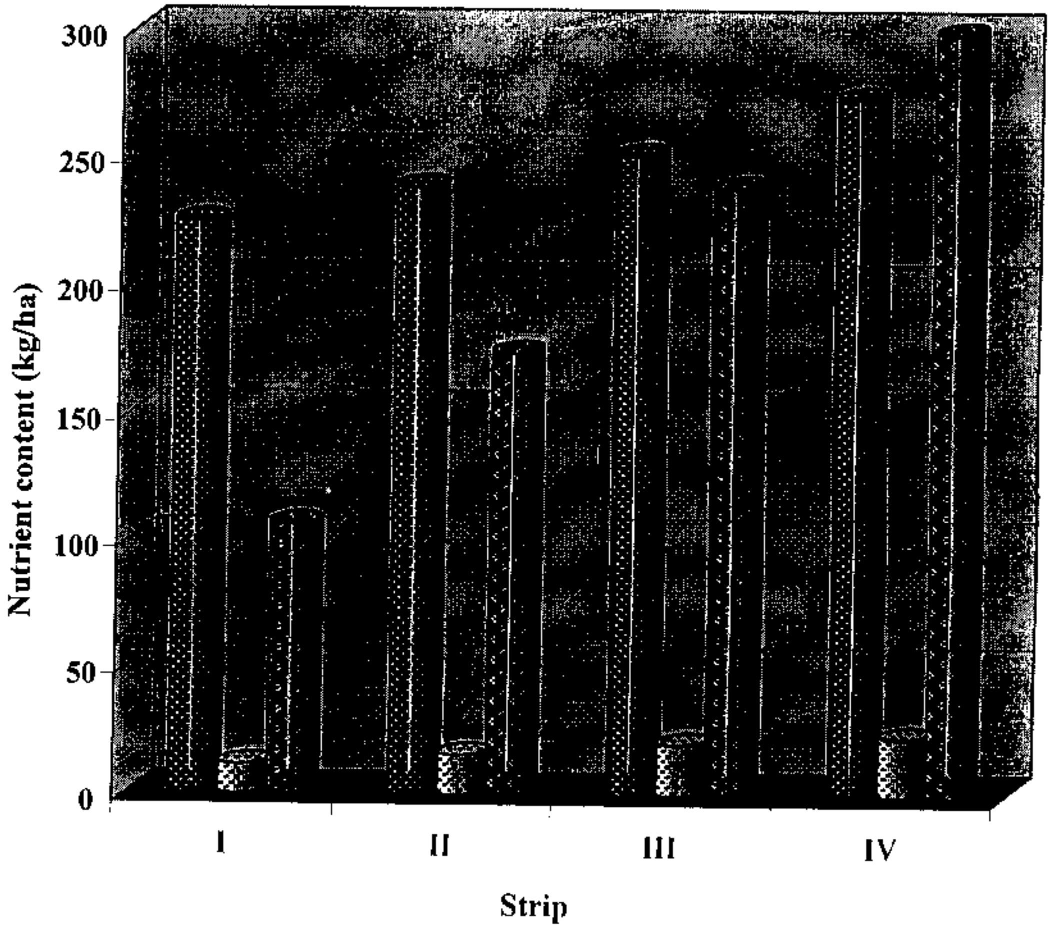


Fig 5.1 Nutrient status of the soil after the gradient crop experiment

N P K

5.1.2 Crop yield and nutrient uptake

The fodder yield of maize increased progressively from strip I (control) to strip III Reduction in yield was recorded in strip IV due to heavy doses of fertilizers, resulting in the operation of law of diminishing returns. The comparison of yield of the four strips and the significance of 'F' test clearly indicated that a variation in soil fertility was reflected on the yield. The results of variance analysis for the nutrient uptake also revealed that each strip was significantly different from other with respect to soil fertility after the harvest of fodder maize.

The comparison of soil test values before and after the gradient experiment also clearly indicated the creation of significant variations in soil fertility of the experimental field. This result was furnished in the table 4.2 and fig 5.2, 5.3.

5.2 STCR EXPERIEMNT FOR TEST CROP COLEUS

In India during the year 1967 - 68, ICAR started the All India Co-ordinated Soil Test Crop Response Correlation Project to emphasize the use of soil test for fertilizer recommendation.

In STCR Correlation Studies each plot is considered as an experimental plot in which all the variable factors influencing the crop yield are assessed. So, in this experiment each strip was divided into 24 plots of equal size before treatment allocation. Soil samples are collected from individual plots of all the strips and analyzed for pH, EC, organic carbon and available N, P and K. The treatment structure consisted of two control plots and 22 treated plots in each strip. After the treatment allocation, the crop coleus was raised following the usual agronomic practices. (KAU, 1996b)

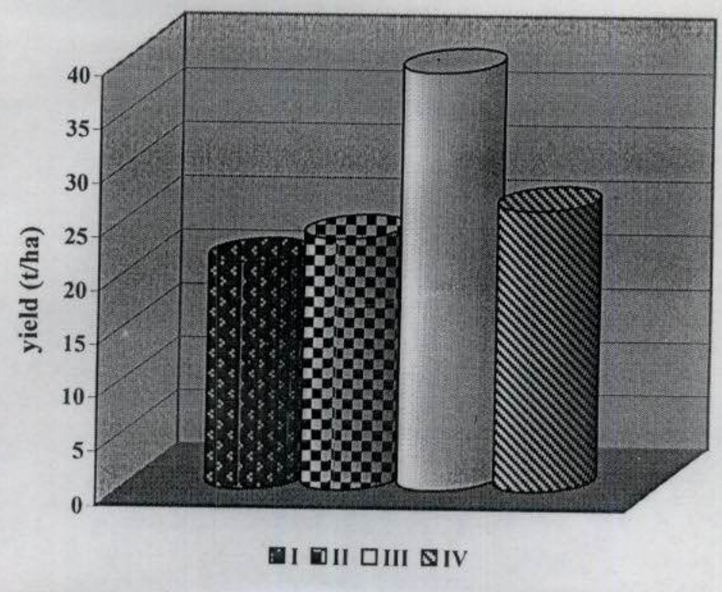


Fig.5.2 Yield of fodder maize as influenced by treatments

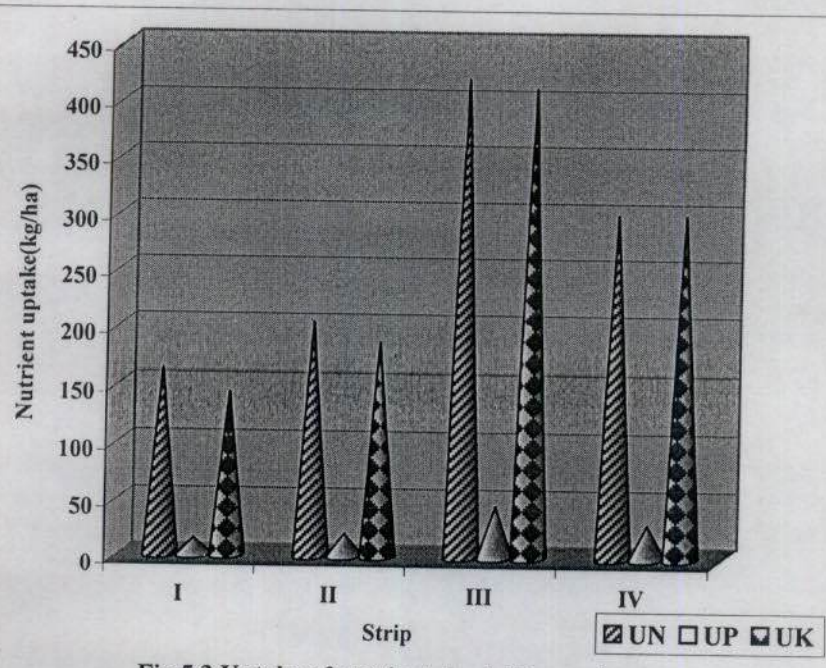


Fig 5.3 Uptake of nutrients by fodder maize

5.2.1 Post harvest soil analysis

Soil samples were collected after the harvest of coleus from all plots (96) and analysed for OC and available N, P and K. The data are furnished in the table 4.8 to 4.11. After the STCR experiment, organic content of the soil slightly increased in all the strips. This may be due to application of farmyard manure for test crop coleus. But in all the four strips available nutrients (N, P and K) declined due to uptake by the coleus crop. This proved the differences in the uptake of different nutrients and consequent influence on soil fertility status.

5.2.2 Effect of fertilizer application on yield parameter

Crop production, intensive or extensive being a complex process is controlled by a large number of exogenous and endogenous factors. In this experiment, the crop coleus was harvested at attaining maturity stage, then it was separated into halum and tuber. The yield of the plant parts was recorded separately for all the treatments. The tuber yield as influenced by treatments are in the tables 4.14 to 4.17, and the strip wise mean tuber yield of coleus are represented in the table 4.12.The tuber yield obtained from control plots are lower than obtained from treated plots. This result proved that direct effect of fertilizer application on yield of coleus.

Considering the strip wise yield, there was progressively increased from I to strip III and in strip IV it was decreased. It showed the differential response of nutrients to yield in different fertility levels. In low to medium fertile soil the response was high and consequently the yield was also high. In high fertile soil (strip IV) the response was low and it was reflected in the yield also. This may be due to the operation of the law of diminishing returns. Similar results were also obtained by Jayalakshmi (2001) and it was represented in fig 5.4.

5.2.3 Effect of fertilizer application on uptake of nutrients by coleus

The total nutrient uptake of N, P and K by coleus was calculated separately and presented in the table 4.18 and fig 5.5. Among the three major nutrients, the highest uptake was registered by K followed by N and P. Similar results were obtained by Swadija *et al.,* (1998).

The uptake of nutrients was significantly influenced by application of fertilizers. The maximum uptake of N, P and K (185.1, 30.27 and 321.01 Kg ha^{-1}) were recorded in a plot (S_1T_{20}), which have received 80:90:100 Kg $ha^{-1}$of N, P_2O_5 and K_20 respectivly. The highest yield 20, 200 Kg ha^{-1} was registered the treatment. When considering uptake of nutrients from all the plots, the control plots recorded lower nutrient uptake than the treated plots. The result proved the direct effect of fertilizer application on the uptake of nutrients and consequent influence on yield of coleus.

5.3 SOIL TEST CALIBRATION STUDIES

The calibration of soil test values would be more useful for the farmer to obtain site specific fertilizer prescription for the crops to get maximum and economic yield. The balanced use of soil and fertilizer nutrients can be achieved through soil test based fertilizer recommendation.

5.3.1 Optimization of fertilizer doses for specific yield targets

The fertilizer use in optimum amounts and proportions mainly depends on the capacity of the soil to supply the native nutrient, the efficiency of applied nutrients and the crop yields (Randhawa and Velayutham, 1982; Velayutham *et al.* 1985). The concept of fertilizer prescription for specific yield target (Troug, 1960; Ramamoorthy *et al.* 1967) is not only embraces the above aspects but also

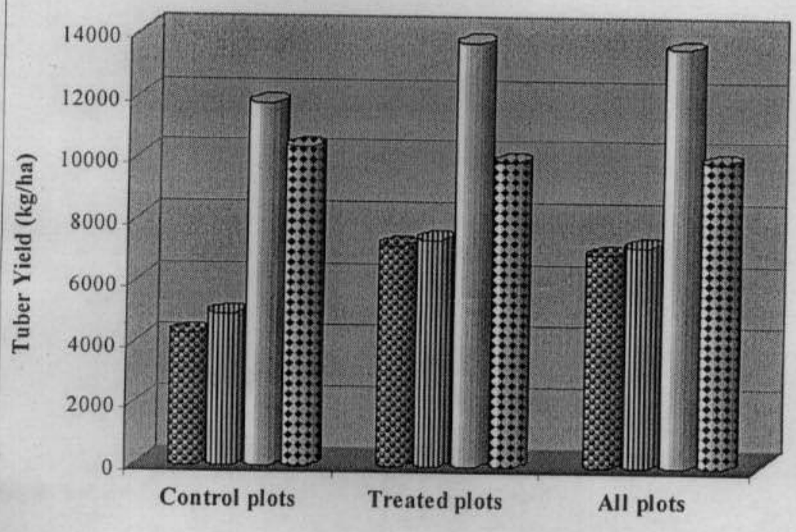


Fig. 5.4 Tuber yield of coleus as influenced by treatments

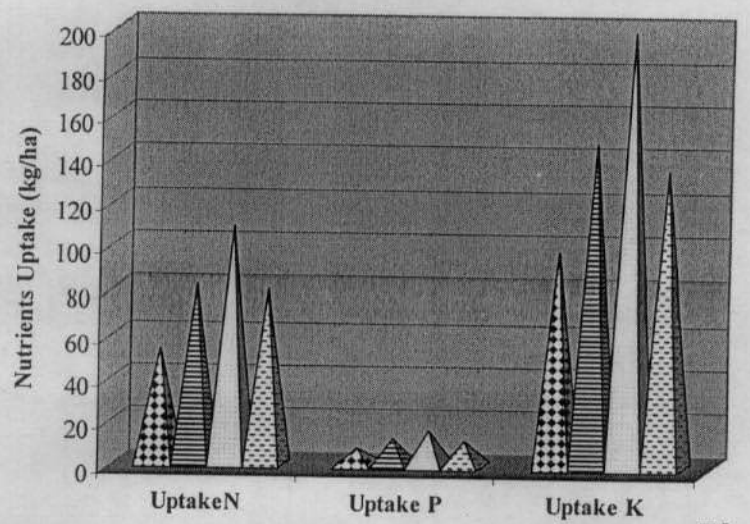


Fig. 5.5 Nutrient Uptake of coleus as influenced by treatments

ensures the both high yields and the maintenance of soil fertility to support a sustained crop production. The theoretical basis involved in this concept of predicting fertilizer needs for crop is well explained under section 4.3.1

The basic parameters used for optimising the fertilizer doses are Nutrient requirement (NR), Soil efficiency (CS), Fertilizer efficiency (CF) and Organic manure efficiency (COM) (Ramamoorthy and Velayutham, 1971). The nutrient requirement values indicated that coleus requires 9.15, 1.38 and 16.38 Kg of N, P and K respectively to produce one tonne of tubers. The results revealed that coleus requires more amounts of N and K than P.

In the present investigation, the soil and fertilizer efficiencies were determined by whole field method developed in the All India Coordinated Research Project on STCR correlation studies (Ramamoorthy *et al.* 1967). The results showed the fertilizer efficiency of 61.6 and 56.60 percent in the case of N and K, which was higher than the soil efficiency 21 and 40.85 per cent. The results point to the need for the application of more amounts of N and K fertilizers for the coleus crop. Where as, in the case of phosphorus the soil efficiency (46.85 %) was higher than the fertilizer efficiency (9.57 %). This indicated that coleus meets its P needs more from the native source than from the fertilizer source.

Contribution of nutrients from organic manure showed that potassium supply from organic manure (57.23 %) was higher than nitrogen (21.05 %) followed by phosphorus (13.59 %). This data revealed that response of coleus to FYM was considerable especially with respect to 'K' (Fig 5.6).

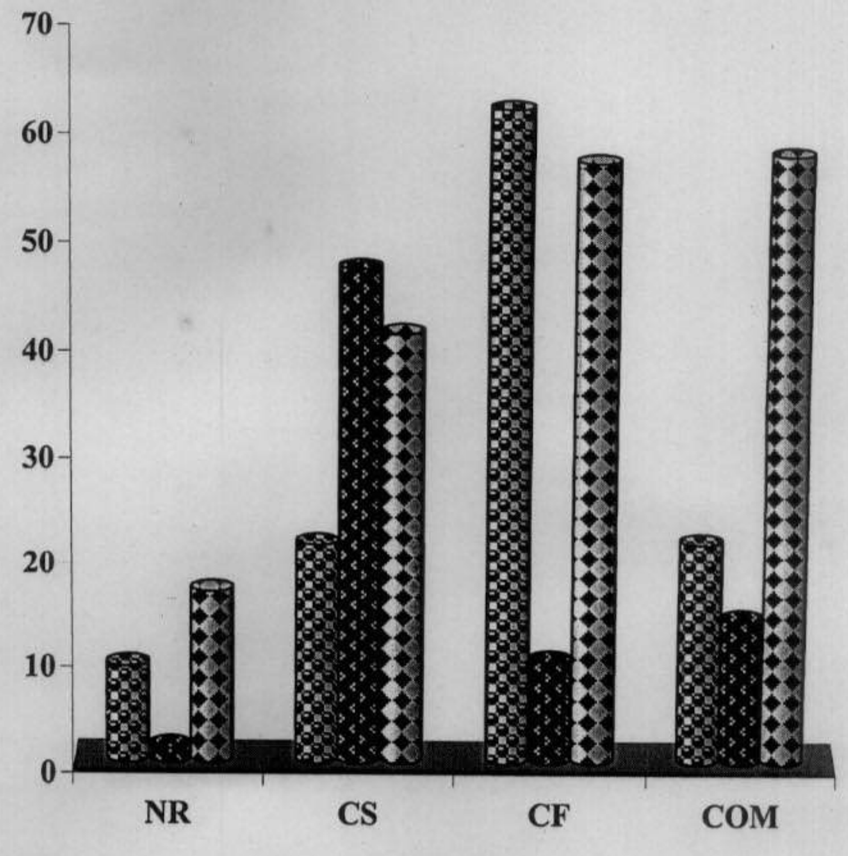


Fig. 5.6 . Nutrient requirements and effeciency of nutrient contribution from soil, fertilizers and FYM for coleus var. Nidhi in laterite soil

5.3.1.1 Fertilizer prescription for targeted yield of coleus

The above mentioned parameters viz., NR, CS, CF and COM were used for computing the prescription equation of N, P_2O_5 and K_2O for coleus crop. The fertilizer prescription developed based on the targeted yield concept is more quantitative, precise and meaningful because both soil and plant analysis are involved for deriving the equation.

The combined use of organic manure and fertilizers will lead to a considerable saving in fertilizers as evident from the targeted yield equations with FYM. This was confirmed by the findings of Duraisamy *et al.*, (1989), Prasad and Prasad (1993) and Santhi (1995). The organic manure enhances soil health by improving physical, chemical and biological properties of the soil and there by the use efficiency of the nutrients will be enhanced.

Based on targeted yield equations, ready reckoners can be prepared for recommending fertilizer dose either as inorganic alone or in combination with organics for specific yield targets of coleus at varying STVs.

The ready reckoners value show that, increase in the soil test values means decrease in the fertilizer doses for N, P and K. From these ready reckoners, we can find out the fertilizer doses based on site specific soil test values. For example, if the soil available 'P' is 20 Kg ha^{-1}, we can produce up to 15 tonnes of tuber per hectare without adding phosphatic fertilizers. Thus, fertilizer recommendation based on this approach is meaningful, precise and more quantitative, resulting reduction in cost of fertilizer for farmers.

5.3.2 Optimization of fertilizer based on multiple regression analysis

By utilizing the soil test values, quantity of inorganic fertilizers and the resultant tuber yield of coleus, multiple regression models were developed. Higher

R^2 value is (66 %) important to explain the variation in yield by available and applied nutrients.In this analysis 15 variables comprising of linear, quadratic and interaction termsof soil available and fertilizer N, P and K had 67.4 per cent predictability. In general, the multiple regression equation shows the normal (+, -, -) type of response of linear, quadratic and interaction terms for FN and FP only (Sankar, 1992). This experiment was responding to the normal (+, -, -) type response for FN only. It was not responding normal type (+, -, -) to FP. This may be due to lower phosphatic fertilizer requirement of the coleus.

By using the regression co-efficient of linear, quadratic and interaction terms of FN, a fertilizer adjustment equation was developed and it is given in chapter 4.3.2

5.4 CORRELATION STUDIES

Simple correlation's coefficients were worked out for nutrient uptake, soil available nutrients, applied nutrients with tuber yield of coleus. The uptake of N, P and K was positively correlated with tuber yield, because of the direct influence of uptake on the yield parameter and the inter correlation's between uptake of N, P and K were also significant. Similar results were obtained by Meena (1999).

The correlation between nutrient uptake and soil available nutrients is high because the pre planting soil fertility status was little higher. In the case of applied nutrients, N and K were highly correlated with nutrient uptake than P. This is due to the requirement of applied N and K than applied P for coleus. The tuber yield increased with increasing the soil available nutrients (N, P and K).

Higher positive correlation were obtained for yield with N and K contents tuber than P, because the N and K are very important for the accumulation of carbohydrate and protein content of tuber and there by increasing the size of the tubers.

5.5 RESPONSE OF COLEUS TUBER YIELD TO APPLIED NUTRIENTS

Response of coleus tuber yield with respect to FYM revealed that the F_2 (7.5 t $ha^{-1)}$ level was better than F_3 (15 t ha^{-1}) with a response of 412.83 and 187.96 Kg tuber yield per tonne of FYM (Table 4.27 and Fig 5.7). When considering applied major nutrients N response to coleus was higher than that of P and K with response ratio (Kg yield/Kg applied nutrients) of 26.1, 11.61, and 20.91.This results also proved that the contribution of N from fertilizer (CF'N') was higher than P and K as obtained in chapter 4.3.1.2. It was illustrated in fig 5.8.

5.6 PATH CO EFFICIENT ANALYSIS

5.6.1 Path co efficient analysis of soil nutrients with yield

The analysis was conducted with tuber yield and three soil available nutrients N, P, and K. The soil P exhibited the highest positive direct effect on yield followed by soil K (Fig.5.9). This result indicated that higher available P content in soil directly influenced on the yield. This result also proved that the contribution of P from soil was higher when it was worked out for targeted yield equation (chapter 4.3.1.2). The higher values of correlation co efficients are also supporting the results.

5.6.2 Path analysis of plant nutrients with yield

Path analysis was carried out with tuber yield and six plant nutrients, mainly haulm N, haulm P, haulm K, tuber N, tuber P, and tuber K. haulm K exhibited the highest positive direct effect on yield followed by haulm N (Fig.5.10). The result indicated that higher the K contents in the leaves indicates higher tuber yield. The higher values of correlation co efficient are also supporting the results.

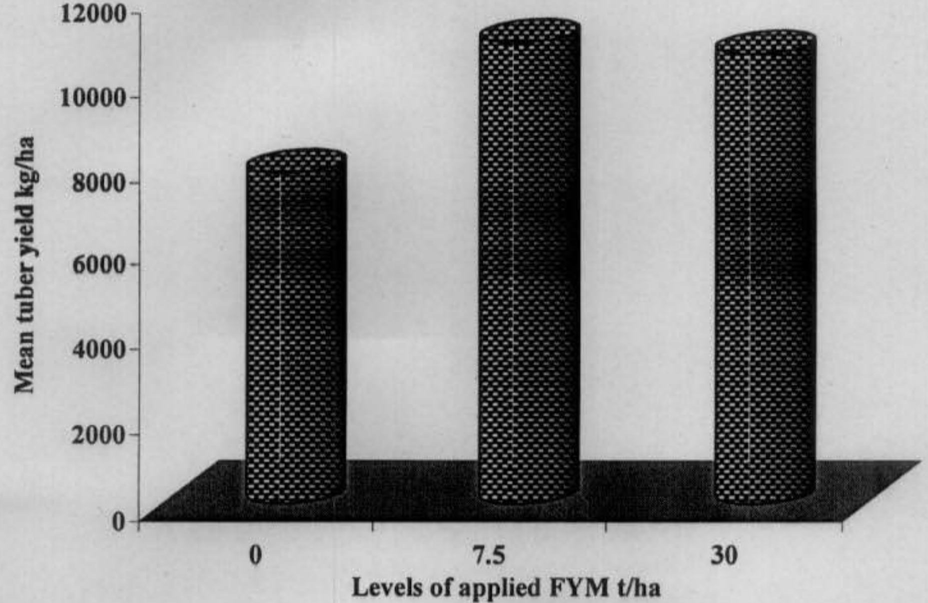


Fig 5.7. Response of coleus to applied FYM

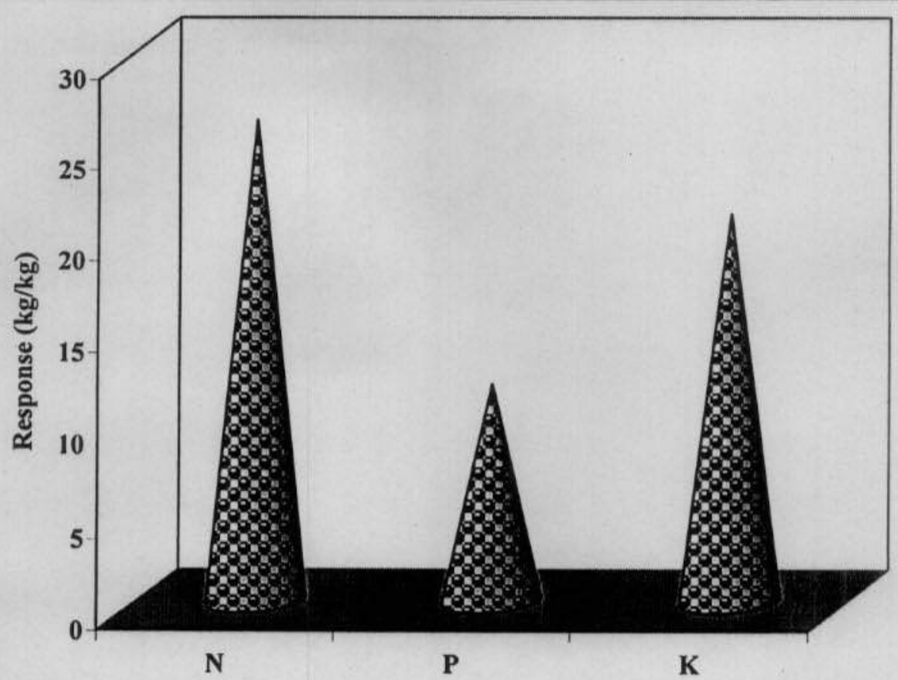


Fig 5.8. Response of coleus tuber yield to applied fertilizer

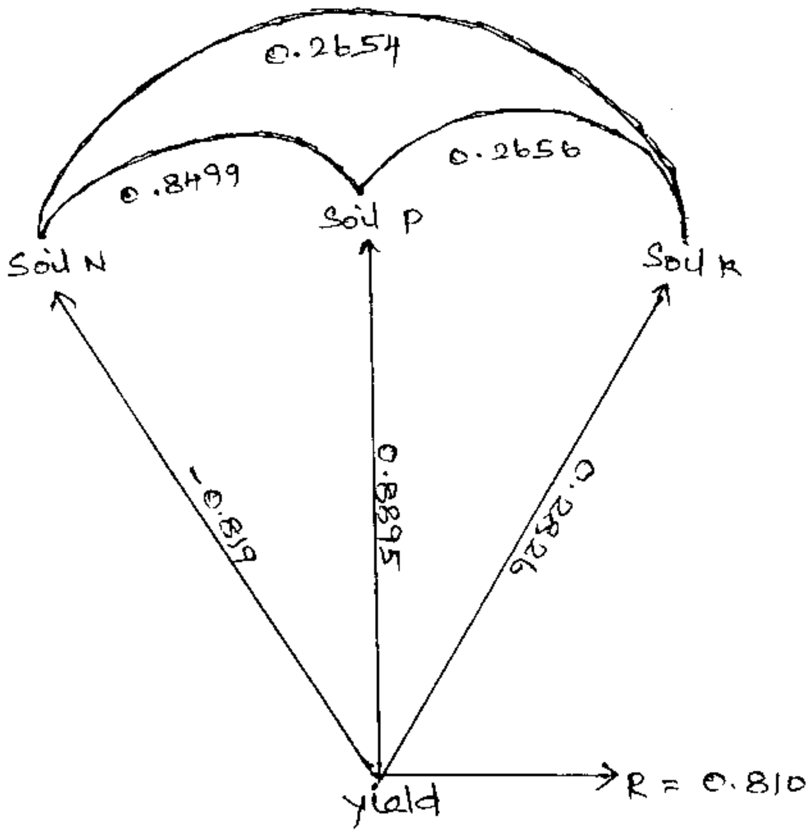


Fig 5.9. Path diagram for major Soil nutrients with Tuber Yield

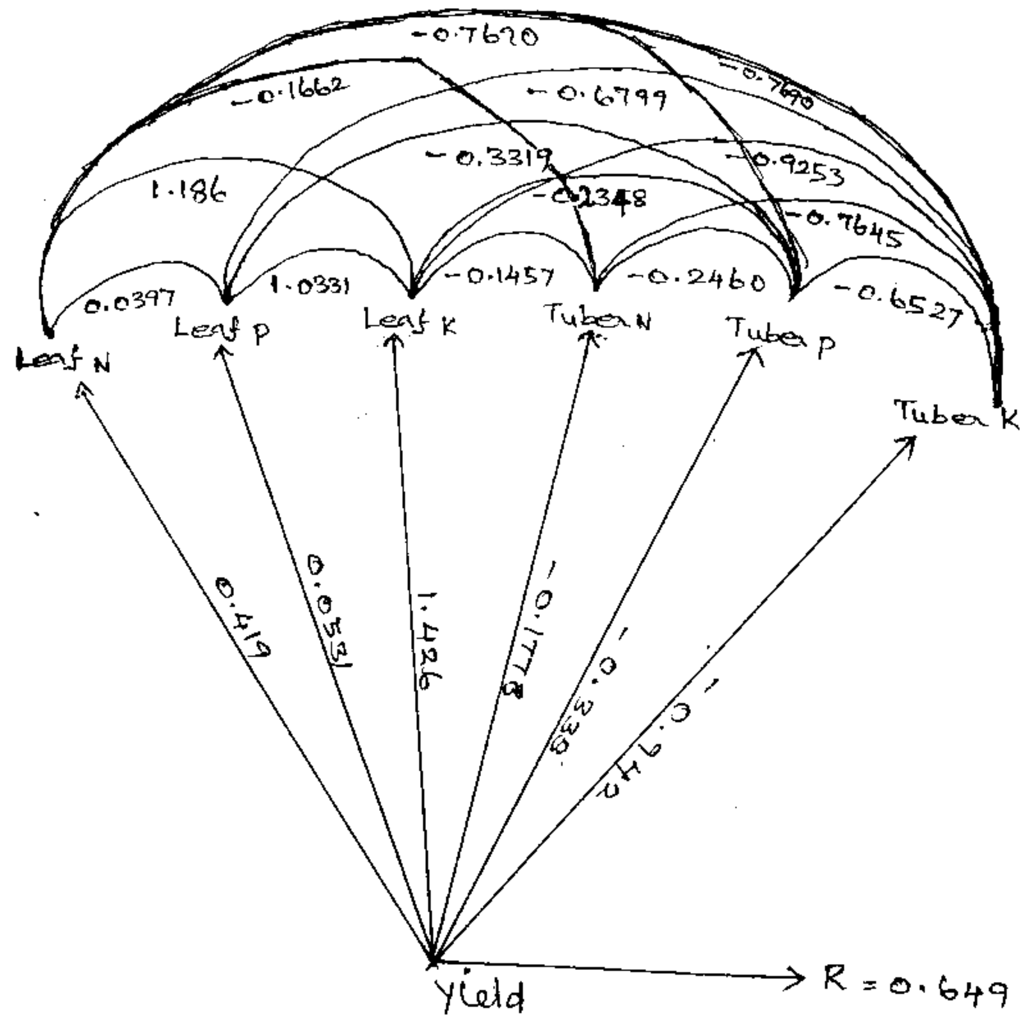


Fig. 5.10. Path diagram for Plant nutrients with Tuber Yield

The highest direct negative effect was manifested by tuber K followed by tuber P and tuber N. Even though this characters having negative direct, their indirect effects through haulm N, haulm K were positive and high, explaining the positive correlation co efficient.

The results indicated the higher concentration of K in the haulm reflects higher tuber yield. This findings also supported by their higher correlation co efficient with yield. Where as lesser contents of these nutrients in halum indicates low yield, from the results it can be inferred that without assessing the under ground tubers, by simply assessing the N and K status in the haulms, the tuber yield production of that plant can be predicted.

Summary

6. SUMMARY

The emphasis on soil test based balanced fertilization has become much more relevant in the present scenario of high fertilizer costs and yield maximization programmes. To establish the soil test based balanced fertilizer prescription for coleus variety Nidhi an investigation was carried out at the College of Horticulture, Vellanikkara. For this study the technique of inductive methodology developed by Ramamoorthy (1968) as followed in AICRP for investigations on STCR correlation studies was adopted.

The field experiments consisted of fertility gradient experiment (FGE) and STCR experiment using fertilizers and organic manure. The fertility gradient experiment was conducted during May - June 2002 in the farm attached to the College of Horticulture. The fertility gradient was created by applying graded doses of N, P and K fertilizers and raising fodder maize variety Co-1 in one and the same field. The fodder yield, soil nutrient status and nutrient uptake by the gradient crop showed an increasing trend from strip I to strip III, and showed a slight decline in strip IV. It proved the development of fertility gradient in the field.

The STCR experiment was conducted during July - November 2002 in the same filed, with the crop coleus after the harvest of the gradient crop. The treatment structure consisted of four levels of N (0, 20, 40, 80 Kg ha^{-1}), three levels of P (0, 45, 90 Kg P_2O_5 per ha) and five levels of K (0, 25, 50, 100, 200 Kg ha^{-1}) along with three levels of FYM (0, 7.5 and 15 t ha^{-1}) fitted in a response surface design.

The results of the experiment are summarized as follows,

The tuber yield increased from strip I to strip III (6920, 7162, 13530 Kg ha^{-1}) and showed reduction in strip IV (99.1 Kg ha^{-1}) that is higher fertility level. Uptake of N, P and K increased gradually from strip I to strip III and showed slight reduction in strip IV. The strip wise mean uptake of nutrients was recorded as 52.9, 81.86, 108.6 and 80.20 Kg ha^{-1} N, 8.39, 12.57, 16.19 and 11.78 Kg ha^{-1} for P, 97.92, 148.27, 199.06 and 135.98 Kg ha^{-1} for K in strip I, II, III and IV respectively. The uptake of K was maximum then followed by N and P.

Optimization of fertilizer doses for different yield targets were worked out for coleus by using Nutrient Requirement (NR), soil efficiency (CS), Fertilizer efficiency (CF) and organic manure efficiency (COM). The nutrient requirement of coleus variety Nidhi were estimated to be 9.15, 1.38 and 16.38 Kg ha^{-1} N, P_2O_5 and K_2O respectively to produced one tonne of tuber. The soil efficiencies were worked out as 21, 46.85 and 40.85 per cent for N, P_2O_5 and K_2O respectively for coleus in the laterite soil.

In the laterite soil, the contribution of nutrients from the fertilizer for coleus was calculated as 61.6, 9.57 and 56.60 percent N, P_2O_5 and K_2O respectively. The per cent contribution of nutrients from FYM for coleus in laterite soil were calculated as 21.05, 13.59 and 57.23 per cent N, P_2O_5 and K_2O respectively.

The fertilizer prescription equations for specific yield targets of coleus variety Nidhi in laterite soil were derived as follows.

$$FN = 14.85\,T - 0.34\,SN$$

$$F\,P_2O_5 = 14.42\,T - 11.21\,SP$$

$$F\,K_2O = 28.93\,T - 0.87\,SK$$

Where,

FN, F P_2O_5, F K_2O - Fertilizer N, P_2O_5 and K_2O respectively in

T - Target yield of tuber in t ha^{-1}

SN, SP, SK - Soil available N, P and K in Kg ha^{-1} respectively.

172212

With FYM

$$FN = 14.85\ T - 0.34\ SN - 0.34\ ON$$

$$F\ P_2O_5 = 14.42\ T - 11.21\ SP - 3.25\ OP$$

$$F\ K_2O = 28.93\ T - 0.87\ SK - 1.22\ OK$$

Where,

ON, OP and OK are quantities of N, P and K supplied through organic manure in Kg ha^{-1}

Multiple regression models calibrated with yield as dependent variable and STVs for available N, P and K and applied nutrients as independent variables had 67.4 per cent predictability. Among the three fertilizer nutrients, FN only showed the normal type (+, -, -) of response.

The fertilizer adjustment equation for varying levels of soil available N for maximum tuber yield (t ha^{-1}) of coleus in laterite soil was derived as FN = 168 SN-0.07SN, where FN is fertilizer N (Kg ha^{-1}). SN is available N (Kg ha^{-1}) is soil. The behaviour of applied P and K was found to produce responses other than normal and hence optimization could not be done for fertilizer P and K at varying soil test values.

Simple correlations coefficient was worked out for Nutrient uptake, soil available nutrients, applied nutrients with the tuber yield of coleus. Available nutrients showed higher positive correlation than that of applied nutrients. The uptake of nutrients (N, P and K) also significantly correlated with yield of coleus.

The study is useful to adjust the fertilizer doses between the specific objective and available resources of coleus farmers of the state.

References

REFERENCES

Ahmed, S.M.A. 1985. Evaluation of soil tests - Nitrogen methods for efficient and economic fertilizer use - Sorghum (*Sorghum bicolor* (L) Moench). M.Sc.(Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, p.86

Ahmed, R.S. Reddy, K.C. and Khadke, K.M. 2000. Soil test based optimal fertilizer requirement for attaining different yield targets of castor (*Recinus communis*) in dry land alfisols. *Indian J. Agric. Sci.* 71: 24-27

Anderson, R.L. and Nelson, L.A. 1975. A family of involving intersecting straight lines and concomitant experimental design useful in evaluating response to fertilizer nutrients. *Biometrics* 31:303-318

Andi, K. 1998. Soil test crop response studies under integrated plant nutrition system for bhendi – sunflower cropping sequence on inceptisols. Ph.D thesis, Tamil Nadu Agricultural University, Coimbatore, p.144

Balmukand, B.H. 1928. The relation between yield and soil nutrients. *J. Agric. Sci.* 18: 602-629

Baskaran, S., Thangavel, P., Arunachalam, G., Raniperumal,S. and Kandaswamy, P. 1994. Prescription based fertilizer recommendation for tapioca. *Madras Agric. J.* 81: 220-222

Boopathi, P.M. 1995. Soil test crop response studies on blackgram for efficient phosphorus use. M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, p.126

Bray, R.H. 1948. *Diagnostic Techniques for Soils and Crops*. The American Potash Institute, Washington, p.53

Cate, R.B. and Nelson, L.A. 1965. A rapid method of correlation of soil test analysis with plant response data. *Tech.Bull.* North Carolina State University, Releigh, p.48

Cate, R.B. and Nelson, L.A. 1971. A simple statistical procedure for partitioning soil test correlation data into two classes. *Proc.Soil Sci.Amer* 35: 656-658

Colwell, J.D. 1968. Calibration and assessment of soil tests for estimating fertilizer requirements and an evaluation of soil testing. *Aust. J. Soil Res.* 6: 93-103

Dev, G. 1997. Soil fertility evaluation for balanced fertilization. *Fert.News* 42:23-34

Duraisamy, P., Raniperumal. and Baskaran, S. 1989. Fertilizer tailoring with organics for the needed yield target - Ragi. *Fert. News* 34: 33-39

Geetha, K. 1983. Nutritional management in coleus (*Coleus parviflorus* Benth.). M.Sc. (Ag.) thesis, Kerala Agricultural University, Vellanikkara,p.92

GKVK, 2002. *Annual Report.* All India coordinated project for investigations on soil test crop response correlations. University of Agricultural Sciences, GKVK, Bangalore, p.61

Goswami, N.N., Bapat, S.R. and Pathak, V.N. 1986. Studies on the relationship between soil tests and crop responses to phosphorous under field conditions. *International Symposium on Soil fertility Evaluation, March 4-8, 1986.* New Delhi, p.359

Grewal, J.S., Verma, M.S. and Bist, B.S. 1979. Method, time and level of application of nitrogen to potato grown in acidic brown hill soils of Simla. *Indian J. Agric. Sci.* 49: 683-688

Gupta, A. and Saxena, M.C. 1975. Response of potato to nitrogen and phosphorus fertilization. *Indian J. Agron.* 20: 265-268

Hanway, J.J. 1971. Relating laboratory test results and field crop response: principles and pratice. *International Symposium on Soil Fertility Evaluation, Febrauary 10-14, 1971.* New Delhi, *Abstract*:33

* Hanway, J.J. and Heidal, H. 1952. Soil analysis methods as used in Iowa State College Soil Testing Laboratory. *Agric. Bull.* 57: 1-13

Hassan, M. A., Jose, A. I., Sureshkumar, P. and Premakumari, S. 2001. Soil Fertility Maps and Fertilizer Recommendations for Kerala: Soil Test Based Fertilizer Recommendations for Targeted Yields of Crops. *AICRP for investigations on STCR,* IISS, Bhopal, p.228

Heady, E.O. and Ray, H.E. 1971. Application of soil test data fertilizer response research and economic models in improving fertilizer use. *International Symposium Soil Fertility Evaluation, April 10-14, 1971.* New Delhi, *Proc. I*: 1073-1082

IISS. 1999. *Annual Report 1993-98.* All India Coordinated Research project for Investigations on Soil Test Crop Response Correlation, Indian Institute of Soil Science, Bhopal, p.87

IISS. 2001. *Progress Report 1998-2001.* All India Coordinated Research project for Investigations on Soil Test Crop Response Correlation, Indian Institute of Soil Science, Bhopal, p.200

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice-Hall of India Pvt. Ltd., New Delhi, p.327

Jayalakshmi, M. 2001. Soil Test Crop Response studies on ginger in laterite soils of Kerala. M. Sc. (Ag.) thesis, Kerala Agricultural University, Trichur, p.110

KAU. 1978. *Research Report 1975-76*. Directorate of Research, Kerala Agricultural University, Vellanikkara, p.134

KAU. 1989. *NARP-Status Report – Southern Zone-vol. I*. Kerala Agricultural University, Directorate of Extension, Mannuthy, Trichur, p.168

KAU. 1996 a. *Research Report 1993-94*. Directorate of Research, Kerala Agricultural University, Vellanikkara, p.176

KAU. 1996 b. *Package of Practices Recommendation - Crops 96*. Directorate of Extension, Kerala Agricultural University, Mannuthy, Trichur, p.247

KAU. 2003. *Annual progress Report 2001-2003*. All India Coordinated Research Project for Investigations on Soil Test Crop Response Correlation. Kerala Agricultural University, Vellanikkara, p.39

Krishanappa, K.S. and Shivashankara, K.T. 1981. Effects of time and method of application on varying levels of nitrogen on yield and yield attributes of potato. *Madras Agric. J.* 68: 183-188

Loganathan, S., Kelkiah, J. and Thangavelu, S. 1995. Fertilizer application to groundnut based on soil test crop response equations. *Madras Agric. J.* 82: 195-198

Loue, A. 1979. Fertilization and mineral nutrition of the potato. *Potash Rev* 11: 7

Maene, L. 2001. Global potassium fertilizers situation: current use and perspectives. (eds. Paricha, N.S. and Bansal, S.K.). *Proceedings of International Symposium on Importance of Potassium in Nutrient Management for Sustainable Crop Production in India, December 6-8, 2001,* New Delhi, India, pp.226-238

Mandal, R.C., Singh, K.D., Maini, S.B. and Magoon, M.L. 1971. Response of sweet potato to plant spacing and nitrogen fertilization. *Indian J. Agron.* 16: 85-87

Maragatham, S. 1995. Soil Test Crop Response Correlation Studies on Sunflower (*Helianthus annus* L.) in inceptisols. M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, p.127

Meena, S. 1999. Soil test crop response correlation studies on onion (*Allium cepa*) in altisol. M. Sc. (Ag.) thesis, ANGRAU, Rajendra Nagar, Hyderabad, p.96

Mercykutty, J. 1989. Soil fertility evaluation for efficient and economic use of fertilizers with azospirillum for ragi. Ph.D thesis, Tamil Nadu Agricultural University, Coimbatore, p.156

Mica, B. 1969. Effect of fertilizing on the nutrient uptake and nutrient content of potato tubers. *European Potato* 12: 151-156

* Mitscherlich, E.A. 1909. Das Gestez des abnehmenden Bodenertrages. *Landw. jb* 38: 537-552

Morita, T. 1967. Effect of application time of nitrogenous fertilizers on the top growth, tuber formation and its development of sweet potatoes. *J. Jap. Soc. Hort. Sci.* 36: 114-121

Murugappan, V. 1985. Soil test crop response studies on sugarcane for efficient fertilizer use. Ph.D. thesis, Tamil Nadu Agricultural University, Coimbatore, p.164

Nambiar, E.P., Jacob, C.I. and Nair, T.J. 1977. Digital expression of soil fertility - A new approach to the interpretation of soil test data and formulation of fertilizer recommendation. *Agri.Res.J.Kerala* 16:201-209

Nambiar, I.P.S., Sadanandan, N. and Kunju, M.U. 1976. Effect of graded doses of nitrogen on growth and yield of sweet potato H-42 in red loam soils. *Agric. Res. J. Kerala* 14: 118-120

Natarajan, S. 1991. Soil test based fertilizer prescription for irrigated cropping sequence in Iruur series of lower Bhavani project. Ph.D thesis, Tamil Nadu Agricultural University, Coimbatore, p.158

Parker, F.W., Nelson, N.L., Winters, E. and Miles, I.E. 1952. The broad interpretation and application of soil test information. *Agron. J.* 43: 105-112

Piper, C.S. 1966. *Soil and Plant Analysis.* Hans Publication, Bombay, p.225

Prasad, B. and Prasad, J. 1993. Integrated nutrient management for needed yield target of rice (*Oryza sativa* L) in varying soil fertility of calcareous soil. *Ann.Agric.Res.*14: 402-406

Ramamoorthy, B. 1968. *Annual progress report-1967-68.* All India Co-ordinated Soil Test Crop Response Correlation Scheme, Jabalpur, p.160

Ramamoorthy, B. 1974. *Project Co-ordinator's Report.* VI Workshop of All India Co-ordinated Soil Test Crop Response Correlation Project, Jabalpur, p.158

Ramamoorthy, B. 1993. Soil Fertility and Fertilizer Use Aspects for Increasing Rice Production, Tamil Nadu Agricultural University, Coimbatore, p.54

Ramamoorthy, B. 1994. Integrated plant nutrient application for improving soil fertility. Agricultural College, Andra Pradesh Agricultural University, Bapatla, p.49

Ramamoorthy, B., Narashiman, R.K. and Dinesh, R.S. 1967. Fertilizer application for specific yield targets of Sonora 64 (Wheat). *Indian Fmg.* 17: 43-45

Ramamoorthy, B. and Pathak, V.N. 1969. Soil fertility evaluation key to targeted yields. *Indian Fmg.* 18: 29-33

Ramamoorthy, B. and Velayutham, M. 1971. Soil Test Crop Response Correlation work in India - World Soil Resources Report No.41, FAO, Rome, p.105

Ramamoorthy, B. and Velayutham, M. 1974. Soil testing for high fertilizer use efficiency. *Indian Fmg.* 24: 80-84

Ramamoorthy, B. and Velayutham, M. and Mahajan, V.K. 1975. Recent trends in marking fertiliser recommendations based on soil tests under fertilizer response constraints in India. *FAI Seminar on Optimising Agricultural Production under limited availability of fertilisers*, Nov. 4-7, *1974.* New Delhi, *Proc. FAI* :335-346

Randhawa, N.S. and Velayutham, M. 1982. Research and development programms for soil testing in India. *Fert. News* 27: 35-64

Raniperumal, S., Baskaran, S., Duraisamy, P. and Chellamuthu, S. 1988. Soil test crop response studies with organic and inorganic nutrients - Finger millet (*Eleusine coracana* G.). *Madras Agric. J.* 75: 180-184

Raniperumal, S., Chandrasekharan, A., Natarajan, K., Mani, S. and Ramanathan, P. 1982. *Soil Test Crop Response Studies in the state of Tamil Nadu.* Tamil Nadu Agricultural University, Coimbatore, p.78

Raniperumal, S., Chandrasekaran, A., Natarajan, K., Mani, S. and Ramanathan, P. 1984. *Soil Test Crop Response Studies in the State of Tamil Nadu-Bulletin,* Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, p.89

Raniperumal, S., Duraisamy, P., Baskaran, S. and Chellamuthu, S. 1987. Rationalized fertilizer prescription for rice - alfisol alluvium based on soil test - crop response studied. *Madras Agric. J.* 74: 312-319

Raniperumal, S., Ramanathan, P., Manickam, T.S. and Mani, S. 1984. *Rationalized Fertilizer Prescription for Rice-Bulletin,* Tamil Nadu Agricultural University, Coimbatore, p.76

Raniperumal, S., Ramanathan, P., Mani, S., Jayaraman, C. and Manickam, T.S. 1986. Rationalized fertilizer prescription for groundnut based on soil test crop response studies. *Oilseeds J.* 16:19-23

Rao, E.V.S.P. and Arora, P.N. 1979. Studies on uptake of nitrogen by potato crop. *Indian J. Agron.* 24: 442-444

Rao, S. A. and Srivastava, S. 2001. Soil test based fertilizer recommendations for targeted yields of crops. *Proc. of the National Seminar on Soil testing for balanced and integrated use of fertilizers and manures*, Indian Institute of Soil Science, Bhopal, p.326

Rao, H.M. and Subramanian, T.R. 1994. Fertiliser needs of vegetable crops based on yield goal approach in alfisols of southern India. *J. Indian Soc. Soil Sci.* 42: 565-568

Reddy, K. C.K., and Ahmed, R. S. 1999. Soil test based fertilizer recommendation for groundnut grown in rice fallows (Inceptisols) of Jugtial in Andhra Pradesh. *J. Oilseeds Res.* 16:257-262

Reddy, K.C.K., Sankar, G.R.M. and Velayutham, M. 1985. *All India Co-ordinated Research Project for Investigations on Soil Test - Crop Response Correlation - Instruction Manual.* CRIDA, ICAR, Hyderabad. p.168

Reddy, K.C.K., Singh, K.D. and Velayutham, M. 1987. Balanced fertilization of rice based on soil testing. *Symposium on nutrient management in rice based cropping system, September 28-October 1, 1987*, ICAR, New Delhi - IRRI, Manila, New Delhi, pp.315-328

* Russel, E.W. 1973. *Soil Conditions and Plant Growth.* The English Language Book Society and Longman, London, p.265

Sankar, G.R.M. 1986. On screening of regression models for selection of optimal variable subsets. *J. Ind. Soc. Ag. Statistics* 38: 161-168

Sankar, G.R.M. 1992. Application of statistical model - building and optimization techniques in fertilizers use research. *Dry Land Agriculture - State of Art* *of Research in India* (eds. Somani, L.L., Vittal, K.P.R. and Venkateswarlu, B). Scientific Publishers, Jodhpur, pp.653-671

Sankar, G.R.M., Reddy, K.C.K., Ramesam, M. and Rao, B.R.C.P. 1987. A model building algorithm for fertilizer optimization with soil - depth parameters. *Andhra Agric. J.* 34: 65-66

Sankar, G.R.M., Reddy, K.C.K., Sonar, K.R. and Daftardar, S.Y. 1989. Multi collinearity in soil test crop response data. *J. Maharashtra Agric. Univ.* 16: 259-260

Sankar, G.R.M., Sonar, K.R., Velayutham, M. and Reddy, K.C.K. 1985. Screening soil and fertilizer nutrients for sorghum yield prediction using path co-efficient analysis. *J. Maharashtra Agric. Univ.* 10: 314-317

Santhi, R. 1995. Soil test crop response studies under integrated plant nutrition system for rice - rice - pulse sequence. Ph.D thesis, Tamil Nadu Agricultural University, Coimbatore, p.176

Santhi, R., Natesan, R. and Selvakumari, G. 2002. Soil test crop response correlation studies under integrated plant nutrition system for onion in Inceptisols of Tamil Nadu. *J. Indian. Soc. Soil Sci.* 50: 489-492

Scholenberger, C.J. and Dreibelbis, F.R. 1930. Analytical methods in base exchange investigation in soils, *Soil Sci* 30: 161-173

Selvakumari, G., Santhi, G.R., Natesan, R. and Mathan, K.K. 1998. STCR studies under IPNS for optimizing fertilizer dose. *IISS Newsl.* 1: 3

Sharma, B.M., Singh, K.D. and Ghosh, A.B. 1990. Soil test based fertiliser recommendations for economic yield of wheat and maize. *Indian J. Agric. Res.* 24: 225-229

Sharma, R.C., Singh, M. and Sad, K.C. 1976. Relative response of potato to three source of potassium. *Indian J. Agron.* 21: 341-348

Shukla, D.N. and Rao, L.G.G. 1974. Effect of split application of potassium on uptake and translocation of major nutrients by potato varieties. *Potash Rev.* 11: 2

Shukla, D.N. and Singh, S.J. 1975. Effect of method and levels of potassium on tuber efficiency and rate of bulking in potato varieties. *Fert. News* 20: 29-30

Singh, K.D. and Mandal, R.C. and Maini, S.B. 1973. A note on effect of nitrogen levels of tuber yield and quality of *Dioscorea alata*. *Indian J. Agron.* 18: 100-101

Singh, K.D. and Maini, S.B. 1969. Effect of soil Vs foliar application of nitrogen on tuber yield and quality of (a) Cassava and (b) Coleus. *Annual Report*, CTCRI, Thiruvananthapuram, p.146

Singh, K.D. and Sharma, B.M. 1978. Fertilizer recommendations based on soil tests for targeted yields of different crops. *Fert. News* 23: 38-42

Singh, R., Singh, M. and Dixit, M. L. 2000. Soil test based balanced fertilizer recommendation for cotton and wheat crops. *Haryana Fmg.* 30: 14-16

Snedecor, G.W. and Cochran, W.G. 1968. *Statistical Methods*. Oxford and IBH Publishing Co., New Delhi, p.368

Sreekumari, M.T. and Abraham, K. 1985. Variation and correlation studies in Chinese potato (*Coleus parviflorus* Benth.). *J. Root crops* 11:77-81

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *Curr. Sci.* 25: 259-303

Sumam, S.V. 1988. Soil fertility evaluation for efficient and economic use of organics and inorganics - Maize CO 1. Ph.D thesis, Tamil Nadu Agricultural University, Coimbatore, p.186

Swadija, K.O. 1997. Soil Test Crop Response Studies on cassava in laterite soils of Kerala. Ph.D thesis, Kerala Agricultural University, Vellanikkara, Trichur, p.146

Swadija, K.O., Sobhana, S. and Padmaja, P. 1993. Fertilizer recommendation based on soil tests for targeted yields. (ed. Nair, R.C.) *Proc. of the Fifth Kerala Science Congress, January 5-10, 1993*, Kottayam, pp.182-184

Swadija, O.K., Sreedharan, C., Nair, V.M. and Saraswathi, P. 1998. Soil Test Crop Response Studies for optimization of fertilizer dose for cassava in laterite soil. *J.Root Crops* 24:147-155

Tamboli, B. D. and Sonar, K. R. 1999. Soil test based fertilizer requirement for specific yield targets of wheat and chickpea in vertisols. *J. Indian Soc. Soil Sci.* 46: 472-473

Tandon, H.L.S. 1994. *Fertilizers and their Integration with Organics and Bio-fertilizers: Fertilizers, Organic Manures, Recyclable Wastes and Bio-fertilizers Components of Integrated Plant Nutrition.* FDCO, New Delhi, pp.12-35

TNAU, 1994. *Annual Report.* All India Coordinated Project for Investigation on Soil Test Crop Response Correlation. Tamil Nadu Agricultural University, Coimbatore. p.374

* Troug, E. 1960. Fifty years of soil testing. *Trans 7th Int. Congr. Soil Sci.* 4: 46-52

Varis, E. 1973. The effects of increased N, P and K rates on the chemical composition of potatoes. *J. Soc. Agric. Soc. Finland* 45: 468-482

Velayutham, M. 1979. Fertilizer recommendation based on targeted yield concept problems and prospects. *Fert. News* 24: 12-20

* Velayutham, M. and Reddy, K.C.K. 1990. Nutrient management based on Soil Test Crop Response Correlation Research. (*ed.* Singh, K.D.) *Soil fertility and fertilizers use*, IFFCO, New Delhi, p.135

Velayutham, M., Reddy, K.C.K. and Sankar, G.R.M. 1985. All India Co-ordinated Research Project on Soil Test Crop Response Correlation and its impact on agricultural production. *Fert. News* 30: 80-95

Walkley, A. and Black, J.A. 1934. An examination of the direct method for determining soil organic matter and a proposed modification of the chromic acid filtration method. *Soil Sci.* 37: 93-101

Watnabe, P.S. and Olsen, S.R. 1965. Test of an ascorbic acid method for determining phosphate in water and NH_4HCO_3 extracts from soil. *Proc. Soil Sci. Amer.* 29: 677-678

* Waugh, D.L. and Fitts, J.W. 1966. Soil test interpretation studies: Laboratory and potted plant. *Tech. Bull. North Carolina State. Agric. Exp. Stn* 3: 110-134

* Waugh, D.L. and Fitts, J.W. 1966. Soil test interpretation studies: Laboratory and potted plant. *Tech. Bull. North Carolina State. Agric. Exp. Stn.* 3: 110-134

Yong, C.W. 1970. Effect of length of growing season and N, P, K fertilizers on the yield of 5 varieties of sweet potatoes on peat soils. *Malay. Agric. J.* 47: 453-464

* Originals not seen

SOIL TEST CROP RESPONSE STUDIES ON COLEUS (*Solenostemon rotundifolius* Poir J. K. Morton) IN THE LATERITE SOILS OF KERALA

By

M. NAGARAJAN

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Soil Science and Agricultural Chemistry

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR-680 656

KERALA, INDIA

2003

ABSTRACT

Investigation entitled " Soil Test crop response studies on coleus in laterite soil of Kerala" consisting of two experiments namely fertility gradient experiment and STCR experiment was conducted during 2002 in the farm attached to the College of Horticulture, Vellanikkara.

Objective of the study was to develop soil test based balanced fertilizer recommendation for specific yield targets of coleus in laterite soils of kerala and provide a basis for fertilizer recommendation for maximum and economic tuber yield at varying soil test values.

The fertility gradient experiment was conducted to create desired gradient in soil fertility in one and the same field by applying graded doses of N, P, and K fertilizers and raising fodder maize var.Co.1. After development of fertility gradient, the STCR experiment was conducted in the same field with the test crop, coleus variety Nidhi.The treatment structure consisted of four levels of N (0,20,40, and 80 kg ha^{-1}), three levels of P_2O_5 (0,45 and 90 kg ha^{-1}) and five levels of K (0, 25, 50, 100, 200 kg ha^{-1}) along with three levels of FYM (0, 7.5 and 15 t ha^{-1})

The nutrient requirement of coleus, variety Nidhi were estimated to be 9.15,1.38 and16.38 kg ha^{-1} N, P_2O_5 and K_2O respectively to produce one tonne of tuber. The soil efficiencies worked out as 21,46.85 and 40.85 per cent for N, P2O5 and K2O respectively for coleus in laterite soil. The contribution of nutrients from the fertilizers for coleus was calculated as 61.6,9.57 and 56.60 per cent for N, P2O5 and K2O respectively.

From the above basic data, fertilizer prescription equation for specific yield targets of coleus variety Nidhi in the laterite soil were derived as follows,

Without FYM

$$FN = 14.85T - 0.34SN$$

$$FP2O5 = 14.42T - 11.21SP$$

$$FK2O = 28.98T - 0.87SK$$

FN, F P_2O_5, F K_2O - Fertilizer N, P_2O_5 and K_2O respectively

T - Target yield of tuber in t ha^{-1}

SN, SP, SK - Soil available N, P and K in kg ha^{-1} respectively

With FYM

$$FN = 14.85\ T - 0.34\ SN - 0.34\ ON$$

$$F\ P_2O_5 = 14.42\ T - 11.21\ SP - 3.25\ OP$$

$$F\ K_2O = 28.93\ T - 0.87\ SK - 1.22\ OK$$

Where,

ON, OP and OK are quantities of N, P and K supplied through organic manure in kg ha^{-1}

Multiple regression models calibrated with yield as dependent variable and STVs for available N, P and K and applied nutrients as independent variables had 67.4 per cent predictability. Among the three fertilizer nutrients, FN only showed the normal type (+, -, -) of response.

The fertilizer adjustment equation for varying levels of soil available N for maximum tuber yield (t ha^{-1}) of coleus in laterite soil was derived as FN= 168 SN, where FN is fertilizer N (kg ha^{-1})· SN is available N (kg ha^{-1}) is soil. The behavior of applied p and K was found to produce responses other than normal and hence optimization could not be done for fertilizer P and K at varying soil test values.

Simple correlations coefficient was worked out for Nutrient uptake, soil available nutrients, applied nutrients with yield of coleus. Available nutrients showed higher positive correlation than that of allied nutrients. The uptake of nutrients (N, P and K) also significantly correlated with yield of coleus.

This study is useful to adjust fertilizer doses based on the specific objective and available resources of coleus farmers of the state.