ECONOMISING NITROGEN IN BRINJAL (*Solanum melongena* L.) USING NITRIFICATION INHIBITORS

By

DURGA. T. B.Sc. (Ag.)

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 AGRONOMY

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM

1994

DECLARATION

I hereby declare that this thesis entitled "Economising nitrogen in brinjal (*Solanum melongena* L.) using nitrification inhibitors" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me, of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellayani,
5-8-1994.

DURGA. T.

CERTIFICATE

Certified that this thesis entitled "Economising nitrogen in brinjal (*Solanum melongena* L.) using nitrification inhibitors" is a record of research work done independently by Mrs. DURGA. T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellayani,
5-8-1994.

Dr. KURUVILLA VARUGHESE
Chairman, Advisory Committee
Associate Professor (NC) of Agronomy,
College of Agriculture,
Vellayani, Thiruvananthapuram.

APPROVED BY

CHAIRMAN

Dr. KURUVILLA VARUGHESE

MEMBERS

Prof. P. CHANDRASEKHARAN

Dr. G. RAGHAVAN PILLAI

Dr. (Mrs) P. SARASWATHY

1.10.94

EXTERNAL EXAMINER

ACKNOWLEDGMENTS

The author wishes to place on record her deep sense of gratitude and indebtedness to :

Dr. Kuruvila Varughese, Associate Professor (NC) of Agronomy, College of Agriculture, Vellayani and Chairman of Advisory Committee for his invaluable help and guidance, timely advice and constant encouragement throughout the course of investigation and preparation of the thesis.

Sri. P. Chandrasekharan, Professor and Head, Department of Agronomy, for going through the thesis and offering valuable suggestions.

Dr. G. Raghavan Pillai, Professor of Agronomy, College of Agriculture, Vellayani for his valuable advice and helpful criticism of the thesis.

Dr. (Mrs.) P. Saraswathy, Professor, Department of Agricultural statistics, College of Agriculture, Vellayani, for her valuable guidance in connection with the designing of the experiment and interpretation of the experimental data.

Sri. Ajithkumar, Junior Programmer, Department of Agricultural Statistics, College of Agriculture, Vellayani for the valuable help in analysing the experimental data. Miss. Anitha, A.V., Mrs. Bindu, S. Kurup, Miss. Geetha, S., Miss. Suneetha, S., Mrs. Rashmi, C.R., Mrs. Reshmi, S., Mrs. Meera Bai, Mrs. Sudha kumari, J.S., Miss. Shalini Pillai, Mr. Jacob John and all Post graduate scholars who helped her at one stage or another during the course of this project work.

The teaching and non-teaching staff of the Department of Agronomy, College of Agriculture, Vellayani for their whole-hearted co-operation and assistance extended throughout the course of this investigation.

The Kerala Agricultural University for awarding a fellowship for the post graduate programme.

Her beloved parents, in-laws, husband, sister and brother for their moral support, inspiration and encouragement throughout the course of this work.

M/s. Athira Computers, Kesavadasapuram for neatly typing the thesis.

And above all to 'The God Almighty' in enabling her to successfully complete this venture.

DURGA, T.

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

cm	-	centimetre
mg	-	milligram
kg	-	kilogram
ha	-	hectare
DAT	-	Days after transplanting
Fig	-	Figure
KAU	-	Kerala Agricultural University
DMP	-	Dry matter production
LAI	-	Leaf area index
RGR	-	Relative growth index
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
%	-	percentage
@	-	at the rate of
viz	-	namely
$kg.ha^{-1}$	-	kilogram per hectare
et al	-	and others
CD	-	critical difference
SE	-	standard error
NI	-	Nitrification inhibitors
FYM	-	Farm yard manure

LIST OF APPENDIX

INTRODUCTION

INTRODUCTION

The importance of vegetables as a protective food and supplier of adequate quantities of carbohydrates, fibre, minerals and vitamins is well known. Eventhough, India is the second largest producer of vegetables in the world, next to China with a production of about 50 million tonnes, from 4.5 million ha of land, the productivity of vegetables is quite low. There is an alarming gap between the availability of vegetables of 135g. day^{-1} $capita^{-1}$ and minimum requirement of 285g. day^{-1} $capita^{-1}$. By the year 2000 A.D., India's population is expected to be one billion requiring more than 110 million tonnes of vegetables, and therefore immediate efforts are to be taken up for boosting up the vegetable production.

The total area under vegetables is hardly 2.0 to 2.5 per cent of the total cropped area. As the availability of more land for vegetable cultivation is severely restricted because of limitation of irrigation facilities, fast urbanisation and industrial development, efforts are needed to raise the productivity levels of vegetables from the existing area itself. Low productivity is mainly attributed to lack of high yielding cultivars and poor field management. Quantity and quality of manures and fertilizers too play a key role in increasing the production and deciding ~~improving~~ the quality of vegetables.

Among the different vegetable crops, brinjal or egg plant (*Solanum melongena* L.) is a popular and favourite crop grown throughout the year in Kerala. It is highly productive and has a nutritional value of 1.4 per cent protein, 0.3 per cent fat and 0.3 per cent minerals. The major factor contributing to the popularity of this vegetable is the relative easiness of its cultivation. This crop responds to a balanced application of fertilizers. The deficiency of nitrogen results in stunted growth and poor yield. Vadivel *et al*., (1988) reported that the brinjal crop responded upto 298 kg N ha^{-1} and withholding nitrogen at any stage of growth of the plant reduces the yield.

Nitrogen is a vitally important plant nutrient and is mainly taken up as nitrate ions by upland crops. More than 80 per cent of nitrogenous fertilizer source used in India is accounted by urea. When urea is applied to a moist soil, it is hydrolised to ammonium-N which is oxidised to nitrite-N and then to nitrate-N. Studies also showed that considerable amount of nitrogen applied as urea is not utilised by the plants as a result of losses due to leaching, volatilisation, nitrification and denitrification. The efficiency of urea can be increased either by split application, placement at proper depth, foliar application, using large sized urea granules, coating the fertilizer or using nitrification inhibitors.

Nitrification inhibitors selectively retard the bacterial transformation of ammonium ions into nitrate in soil. Unlike ammoniumions, nitrates are highly susceptible to losses by denitrification, leaching and run off. Besides, reducing recovery of applied nitrogen, the loss mechanisms have adverse impact on the environement. Nitrification inhibitors has thus greater role to play, much beyond increasing the fertilizer nitrogen use efficiency by slowing down the nitrification process and lengthening the period of nitrogen availability and retaining nitrogen in the ammoniacal form for a prolonged period.

The discovery and use of nitrapyrin (N-serve) as an effective inhibitor of nitrification in soils by Goring (1962) has greatly stimulated the interest in nitrification inhibitors. Numerous compounds have since been proposed for regulating nitrification in soils. However, these chemicals are rather expensive, and they are now replaced by inexpensive indigenously available nitrification inhibitors including oil cakes. The efficiency of retarding nitrification by these locally available nitrification inhibitors has been well documented in low land crop like rice and in a few upland crops (Prasad, 1990). Mixing or coating of urea with these locally available nitrification inhibitors results in saving of nitrogen.

With this background the present study was undertaken using locally available sources of nitrification inhibitors viz, neem cake and coal tar at different levels of nitrogen with the objectives of

1. To study the effect of nitrogen levels on the growth and yield of brinjal.

2. To find out the efficiency of different indigenous nitrification inhibitors and their effect on the nitrogen supply, as well as on growth and yield of brinjal.

3. To find out an economic dose of nitrogen to brinjal involving different levels of N and sources of nitrification inhibitors.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An experiment was conducted in the Instructional farm attached to the College of Agriculture, Vellayani with the objective of finding out the efficiency of nitrification inhibitors in minimising nitrogen loss in brinjal. Nitrogen play a key role in the growth and productivity of most of the crops. Due to the frequent harvest, vegetable crop like brinjal needs a continuous supply of nitrogen for a prolonged period of its growth. Nitrogen is a highly mobile nutrient in the soil and utilisation of applied nitrogen by crops hardly exceeds 50 per cent. The rest is either lost by leaching, denitrification and volatilisation or immobilised by soil microbes. The losses of applied nitrogen from soil vary considerably due to the type of soil, climate, and vegetation. The losses are especially more during *kharif* season due to high frequency and intensity of rainfall. The effective methods of increasing the efficiency of applied nitrogen are either by using the slow release nitrogenous fertilizers or by nitrification inhibitors. The effectiveness of using slow release nitrogenous fertilizers and nitrification inhibitors are well documented in low land crops like rice. However, only very few trials were conducted in the upland crops.

The relevant literature on the effect of nitrogen and nitrification inhibitors on growth and yield of vegetable crops are reviewed hereunder. Reviews related to other crops are also taken into consideration wherever found needful.

2.1 Effect of nitrogen on growth and yield

Reviews relating to the effect of nitrogen on growth and yield of brinjal and other solanaceous crops are briefly reviewed hereunder.

2.1.1 Growth habits

Singh and Sandhu (1970) reported that there was a progressive increase in the height of plants by increasing the level of N in soil upto 100 kg. ha^{-1}. Subramaniam et al (1993) also reported a linear increase in plant height with an increase in N level.

In tomato also, plant height was progressively increased with enhancement of N application upto 150 $kg \cdot ha^{-1}$ (Khan and Misra, 1976; Kuksal et al., 1977; Randhawa et al., 1977; Kooner and Randhawa, 1983; Singh and Sandhu Awasthi, 1985).

Ramachandran and Subbiah (1982) noticed that in chillies an increase in plant height with an increase in N level upto 160 $kg. ha^{-1}$. Similar results were also reported by Rao and Lal (1986) and Natarajan (1990).

Singh and Sandhu (1970) observed that application of N upto 75 $kg \cdot ha^{-1}$ had a profound effect on the formation of secondary branches in brinjal over lower levels. In chillies and tomato also, the enhanced rate of N application increased the number of branches. (Chougule and Mahajan, 1979; Ramachandran and Subbiah, 1982; Srinivas and Prabhakhar, 1982; Manchanda and Singh, 1988; John, 1989; and Natarajan, 1990).

In brinjal and chillies N levels upto 120 $kg \cdot ha^{-1}$ increased the number of leaves per plant (Pillai et al., 1977; Manchanda and Singh, 1988).

Singh and Sandhu (1970) reported that leaf area in brinjal increased with increase in N dose upto 75 kg. ha^{-1} irrespective of the method of application. Pillai et al. (1977) observed that applied N significantly influenced the leaf area index in chillies. Leaf area index was highest at 120 kg. N ha^{-1} compared to 0,40,80 and 160 kg. N ha^{-1}. In tomato also, increase of leaf area index was observed with increasing levels of nitrogen. (Ramakrishna Praseeda and Sulladmath, 1979). Joshi and Nankar (1992) observed that in potato leaf area index became higher with increase in the level of N upto 120 kg. ha^{-1}.

Pillai et al. (1977) reported that applied nitrogen significantly influenced the dry matter production in chillies wherein the maximum dry matter yield was noticed with 160 kg. N ha^{-1} which was superior to 0,40,80 and 120 kg. N ha^{-1}. Chougule and Mahajan (1979), Ramachandran and Subbiah (1982), John (1989), had also reported similar increase in dry matter production with increased rate of N application in solanaceous crops.

2.1.2 Yield Attributes

Singh and Sandhu (1970) reported that in brinjal earliness in flower formation was encouraged with the increase in the level of N from 25 to 50 kg. ha^{-1}. Chougule and Mahajan (1979) stated that the days required for flower initiation and 50 percentage flowering in chillies were significantly affected due to higher doses of N alone. Varis and George (1985) reported that an increase in N level induced earliness in flower initiation of tomato. John (1989) also noticed similar trend in chillies. However, Dod et al. (1992) reported that enhanced rate of N application had delayed the flower initiation in chillies.

It was noticed by Vadivel et al. (1988) that a deficiency in N resulted in the formation of greater number of short styled flowers in brinjal which eventually reduced the fruit yield. John (1989) reported that the increased rate of N application had increased flower production in chillies.

A reduction in number of fruits per plant at high dose of N (160 kg. ha^{-1} in chillies) due to higher flower drop was reported by Ramachandran and Subbiah (1982). Varis and George (1985) noted that the difference between the nitrogen levels had no marked effect on the fruit setting percentage in tomatoes. Percentage of fruit set was significantly increased by the application of N in chillies (John, 1989). A nitrogen dose of 75 kg. ha^{-1} recorded the maximum fruit set of brinjal (32.5%) in the reclaimed alluvial soils of Kuttanadu (KAU, 1990-91)

Ghani et al. (1982) observed that N application upto 150 kg ha^{-1} had favourable influence on number of fruits, in brinjal. Maximum number of fruits per plant (12.9) was observed by the application of 75 kg. N ha^{-1} in brinjal (KAU 1990-91) Subramaniam et al. (1993) observed that application of N accentuated the fruit yield of brinjal linearly registering the highest value under 150 kg.N ha^{-1}.

Fruit number per plant was profoundly influenced by N application in chillies (Khan and Misra, 1976; Chougule and Mahajan, 1979; Ramachandran and Subbiah, 1982; Gupta, 1987; John, 1989 and Natarajan, 1990)

Lal and Singh (1976) reported that nitrogen application failed to influence the fruit length in brinjal. Ghani et al. (1982) reported better fruit length of brinjal with N application upto 150 kg. ha^{-1}.

Chougule and Mahajan (1979) observed higher length of chilli fruits with increasing nitrogen levels. Similar increase in fruit length due to enhanced N application was reported by Mary and Balakrishnan (1990), Vanangamudi et al. (1990) and Dod et al. (1992).

Lal and Singh (1976) observed that N levels were found to have marginal influence on fruit girth, in brinjal. However, 120 and 160 kg N ha^{-1} increased the fruit thickness over 40 kg N ha^{-1}. Ghani et al. (1982) reported maximum fruit girth of brinjal with a higher dose of 150 kg N ha^{-1}. In tomato also, dianetre of fruits increased significantly with the increase in the rates of N upto 90 kg ha^{-1} (Singh and Sandhu Awasthi, 1985). In chillies, higher level of N recorded the highest girth of fruits. (Joseph and Pillai, 1985; John, 1989; Mary and Balakrishnan, 1990; Vanangamudi et al. 1990; Jeyaraman and Balasubramaniam, 1991).

Gupta et al. (1978) reported that there was no difference in fruit size in brinjal due to variation in N between 75 and 150 kg. ha^{-1}. However, in chillies size of fruit was increased by increased level of N application (Gupta, 1987; Manchanda and Singh, 1988).

Lal and Singh (1976) reported no variation among N levels in the case of weight of brinjal fruits. In tomato also fruit weight was appreciably increased with enhancing N level. (Randhawa et al., 1977). Mandal and Arora (1978) observed that N application helped in increasing the fresh weight o potato tubers. Single fruit weight of chillies increased with increasing levels of N (John, 1989). From experiments conducted by KAU, in the reclaimed alluvial soils of Kuttanadu, it was observed that a dose of 75 kg. N ha^{-1} gave the maximum mean fruit weight of 68.8 g (KAU, 1990-91)

2.1.3. Yield

Singh and Sandhu (1970) reported that increase in N from 0 to 75 kg. ha^{-1} applied through soil caused an increase in yield, while 100 kg. N ha^{-1} showed a marked reduction in the yield. Studies conducted at KAU have indicated that the yield of brinjal was profoundly influenced by N levels (KAU, 1980-81). Ghani et al. (1982) reported that application of 150 kg. N ha^{-1} significantly increased the yield of brinjal fruits. In another experiment conducted by KAU, it was observed that N at the rate of 75 kg. ha^{-1} gave maximum fruit yield (KAU, 1990-91). Similar result was also reported by Subramaniam et al. (1993).

Chougule and Mahajan (1979) observed that the yield of green chilli was significantly increased due to higher and medium levels of N i.e., 200 and 150 kg. N ha^{-1} as compared to the lower dose of 100 kg. N ha^{-1}. Srinivas and Prabhakhar (1982) also observed that the crop yield of capsicum increased linearly with the level of nitrogen applied. Similar results were also reported by Narasappa et al. (1985) KAU (1987a, 1990); Gupta (1987); John (1989); Natarajan (1990); Vanangamudi et al. (1990); Jeyaraman and Balasubramaniam (1991).

Randhawa et al. (1977) observed an appreciable increase in marketable and total yield of tomato fruits with higher doses of nitrogen. From the experiments carried out by Satyanarayana and Arora (1984), it was revealed that 150 kg. N ha^{-1} produced higher tuber yield, in potato than 75 kg. N ha^{-1}.

2.2. Nutrient requirement of brinjal

Subbiah et al. (1983) reported that application of 12.5 t. ha^{-1} of FYM in combination with 50 per cent of the recommended fertilizer dose of 100:50:30 kg. ha^{-1} of NPK enhanced the fruit yield of Co.1 variety of brinjal.

From the experiments conducted by KAU it was found that the effect of N was significant, while P and K had not markedly influenced the yield of brinjal and maximum yield was recorded in the treatment receiving 100,40 and 50 kg ha^{-1} of N,P and K respectively (KAU, 1986-87b) Vadivel et al. (1988) observed that the productivity of brinjal depends largely upon the N fertilization and a high dose of 298 kg. ha^{-1} gave maximum yield. In another experiment conducted by KAU in the uplands of Kuttanadu, it was observed that the nutrient combinations of N 75, P 20, K 25 recorded the maximum number of fruits per plant (12.9), fruit set (32.5%), yield (844.5 g. $plant^{-1}$) and mean weight of fruits (68.89) (KAU, 1990-91)

2.3.1. Improving the efficiency of nitrogenous fertilizers

Losses of nitrogen from applied urea can be minimised either by split application, placement at proper depth or by foliar application in different crops.

Prasad et al. (1986) reported that the highest yield (36.7 q. ha^{-1}) and N uptake (103 kg. ha^{-1}) of wheat was obtained with 3 split application of 100 kg. N ha^{-1} as urea. Singh et al. (1988) reported that nitrogen splitting was more effective in sustaining higher grain yield than single application in maize.

From the experiment conducted by Anilakumar and Rajaram (1993), it was found that minimum N loss through ammonia volatilization was observed by deep placement of sulphur coated urea and urea mud balls in wet land rice crop. From the experiments conducted at KAU, it was observed that in tomato variety *Sakthi*, application of 40 kg. N ha^{-1} as basal or with 40 or 30 kg. N ha^{-1} as foliar spray gave significantly higher yield than single application of N (KAU 1991-92)

The efficiency of urea can also be increased by using large sized urea granules, coating the fertilizer and by using nitrification inhibitors, blending of urea with certain indigenous materials like neem cake which retard nitrification.

From the studies conducted to find out the efficiency of new types of urea materials (sulphur coated urea, urea super granules, lac coated urea) for use in transplanted rice, it was found that urea super granules, and sulphur coated urea gave maximum nitrogen use efficiency (KAU, 1982a). In another experiment conducted at Regional Agricultural Research Station, Pattambi, it was found that sulphur coated urea was the best form for increasing the fertilizer nitrogen use in transplanted rice during both *kharif* and rabi seasons. (KAU, 1984-85)

The experimental results of Manickam et al. (1976) confirmed the efficacies of coating of fertilizers and applying native and cheap nitrification inhibitors like neem cake extracts and also use of N serve in suppressing nitrification. Prasad (1979) reported that slow release N fertilizers, urea treated with nitrification inhibitors, urea briqquettes, super granules and urea mixed or coated with neem cake gave higher fertilizer N efficiency than prilled urea in crops such as rice, maize and sugarcane.

Vijayachandran and Devi (1982) reported that the efficiency of neem cake mixed urea can be increased if a sticking agent like coal tar is used in blending for use in paddy fields.

2.3.2 Use of easily available nitrification inhibitors

Nitrification inhibitors when added with ammoniacal or ammonium forming fertilisers retard nitrification and thus help in minimizing the subsequent losses by denitrification and leaching. Nitrification is brought about by specialized group of bacteria which are obligately aerobic. Nitrification inhibitors retard multiplication and the population build up of these bacteria. (Khandelwal et al., 1977).

The discovery and use of nitrapyrin (N-serve) as an effective inhibitor of nitrification in soils by Goring (1962) has greatly stimulated the interest in nitrification inhibitors. Numerous compounds have since been proposed for regulating nitrification in soils. These chemicals are however very costly, and need to be replaced by inexpensive and locally available nitrification inhibitors which are effective at reasonable rates of application.

Bains et al. (1971) were the first to show that under field conditions, treatment of urea with an acetone extract of dried and crushed neem kernel (which would include more fat and lipid associates) increased the efficiency of applied urea. Patil (1972) reported that neem oil being a cheap indigenous material can be advantageously used for minimizing nitrogen loss and increasing the efficiency of nitrogenous fertilisers, due to its peculiar contents of some secondary chemical constituents or lipid associates. Manickam et al. (1976) reported that the treatments of crushed neem seed, neem cake extract, mahua cake extract, N serve and coal tar with urea appreciably improved the growth and yield of rice as compared to the application of ordinary prilled urea. Hulagur and Shinde (1981) reported that neem oil, *Karanja* and *Kokum* cake treated urea increased dry matter yield and N uptake in rice crop, while mahua cake with urea reduced yield. In another experiment it was found that addition of *marotti* cake at the rate of 100 $kg \cdot ha^{-1}$ gave 30 percent yield increase in rice as compared to the control (KAU, 1982b). Santhi et al. (1986) reported that neem leaf could be used as an inhibitor of nitrification for enhancing the nitrogen use efficiency of fertilisers where neem leaf is available in plenty. However, Awasthe and Misra (1987) observed that though the mineralisation of urea in the soil was delayed by neem seed cake coated urea it did not show any marked difference over split application of urea in terms of rice yield, nitrogen use efficiency and apparent recovery of applied nitrogen. Bhagat and Verma (1989) observed that the cutch obtained from the bark of Acacia catechu effectively inhibited nitrification and that it can be used as a substitute for N-serve. Prasad et al. (1989) studied the effect of application of urea treated with Azhadiracta indica, Pongamia pinnata, Madhucca indica, Ricinus communis, or Onosma hispidum oil to rice crop. Of these, treatments with Onosma hispidum oil and Pongania pinnata gave the highest nitrification inhibition, N uptake at rice yield. Ram et al. (1993) reported that pyrethrum and mentha spent showed better nitrification properties than neem cake.

2.3.3 Effect of nitrification inhibitors on crop growth, yield and uptake of nutrients

2.3.3.1 Neem cake blended urea

Abraham et al. (1975) reported that neem cake can be profitably used to increase the efficiency of urea applied to wetland rice. Shanker et al. (1976) reported that not only yield, but also the uptake of nutrients was increased by blending neem cake with urea. In both transplanted and direct sown crops of rice the uptake of nitrogen and phosphorus was increased in treatments where urea was blended with neem cake. In another study it was observed that AM and neem treated urea favourably increased the grain yield of rice over ordinary prilled urea by split application. (Oommen et al., 1977; Subbiah et al., 1979). Reddy and Shinde (1981) reported that despite poor water management, the mean grain yield from one time basal application of neem cake blended urea was equal to that from split application of ordinary urea under the optimum conditions. Govindaswamy and Kaliyappa (1986) reported that among the modified urea products such as coal tar coated urea, neem cake blended urea and urea super granules in comparison with prilled urea, neem cake blended urea was significantly superior to coal tar coated urea and prilled urea.

Bhatia et al. (1985) reported that drilling of nitrogen with neem cake or FYM at 120 kg N ha^{-1} caused higher uptake of nitrogen than broadcast in wheat, but when FYM and neem cake were applied alone (without urea), the uptake decreased even over control. Fertilizer experiments using N at 0,75 and 100 $kg.ha^{-1}$ and urea blended with various rates of neem and *karanj* cake showed that a mixture of 75 $kg.ha^{-1}$ urea plus 32 $kg.ha^{-1}$ of either neem or *karanj* cake gave wheat yields comparable to those obtained from the 100 $kg.ha^{-1}$ urea treatment (Singh and Sharma, 1991).

Ketkar (1976) observed that neem cake blended urea produced 16.3 per cent higher grain yield over non blended urea in maize. Prasad (1979) reported 23 per cent increase in yield of maize with application of 26 kg neem with 60 kg.N ha^{-1} and 12 per cent increase due to 52 kg neem cake with 120 kg. N ha^{-1}. Singh and Singh (1989) observed that more nitrogen could be made available to maize crop during its growth period on application of neem cake blended urea by reducing the downward movement of the nitrate nitrogen resulting in higher grain yield and nitrogen uptake by the crop.

Subbiah et al. (1979) observed that the mean grain yield of ragi was higher when urea was blended with neem seed crush, the increase being 5.3 per cent over untreated urea at 90 kg.N ha^{-1} level.

Ketkar (1976) and Prasad (1979) reported that neem cake blending of urea increased the sugar cane yields than urea alone. Yadav and Singh (1991) reported that soil application of 150 kg N ha^{-1} as prilled urea, neem and *karanj* cake blended urea, and urea super granules significantly increased the sugarcane yield. There was a numerical increase in the uptake of nitrogen with blending of urea with neem (152 kg. ha^{-1}), urea super granules (153 kg $\cdot$ ha^{-1}) and *karanj* (158 kg.ha^{-1}) over prilled urea.

In cassava the application of neem and mahua cake blended urea favourably increased the growth, dry matter production and yield of the crop. The leaching loss of N was also significantly reduced by blending of urea with neem and *mahua* cake (Sathianathan, 1982).

Tandon (1989) observed that neem cake mixed with urea and applied as basal dressing significantly increased the yield of chilli over split application of urea.

Sharma et al. (1980) found out that the combination of neem cake with urea in the ratio of 1:3 basis economized the dose of urea by 25 per cent in potato.

Jain et al. (1982) observed that blending urea with neem cake increased the seed cotton yield as compared to the split application of prilled urea, and coating urea with neem cake is more beneficial for upland cottón particularly under optimal growing conditions.

2.3.3.2. Neem cake coated urea

Field experiments at IARI, showed that coating of urea with neem cake or applying it with the nitrification inhibitor N-serve can largely increase the efficiency of fertilizer urea as judged by the growth characters, yield components and grain yields of rice. Urea coated with neem cake and that treated with N-serve proeved 148 to 150 per cent as effective as urea, whereas sulphur-coated urea was 116 per cent as effective as urea (Sharma and Prasad, 1980). However, Pandey and Singh (1987) reported that urea super granules (USG), neem cake coated urea (NCU), dicynadiamde (DCD), treated urea and prilled urea were on a par with each other with respect to rice grain yields.

Prasad et al. (1986) reported that the different non-edible oils namely *neem, karanj, mahua, undi* and *ratanjoti* increased yield and uptake of nitrogen by wheat. Singh and Singh (1989) reported that neem oil coated urea was superior to prilled urea and was at par with neem cake blended urea, sulphur coated urea and lac coated urea in increasing yield, nitrogen uptake and efficient utilization of applied nitrogen in calcareous soil by wheat.

In sorghum, it was found that neem cake coated urea performed better than untreated urea at 100 kg N ha^{-1} (Annual Report Mincoi, 1971-72). Ketkar (1976) opined that neem coated urea was more useful for a *kharif* crop like <u>jowar</u> in heavy rainfall years as compared to normal rainfall years for getting maximum yield. Neem coated urea performed better than ordinary prilled urea applied in two splits at 100kg. N ha^{-1} in respect of grain yield of jowar (Rao and Badiger, 1977).

Singh <u>et al</u>. (1988) found that 1/3rd dose of recommended dose of N could be saved by applying 2/3rd dose of N as neem coated urea by two equal splits at planting and at 30 days after sowing in maize. In maize, nimin (neem extract) coated urea produced maximum dry matter production, compared to 3 split application of uncoated urea (Vyas <u>et</u>

al., 1991). In maize, application of urea granules coated with neem cake @ 120 kg N ha^{-1} gave significantly higher values for number of cobs per plant and 1000 grain weight (Wali and Totawat, 1992).

Tandon (1989) reported that neem cake coated urea in banana as top dressing gave appreciable yield increase over the application of prilled urea.

Sivaraj and Iruthayaraj (1980) observed that N-serve blended urea and neem cake coated urea were similar in their effect on boll number and seed cotton yield. Further, blending urea with either N serve or neem extract at a dose of 45 kg N ha^{-1} applied in split doses was beneficial for higher yields and to minimize the losses of nitrogen. Singh and Virk (1987) obtained increased boll numbers and yield per plant of cotton due to neem coated urea. Tandon (1989) reported that for cotton 60 kg N given through neem coated urea was equivalent to 80 kg N as untreated urea. Geethalakshmi and Palaniappan (1992) reported that the highest response ratio in cotton was observed with the application of neem cake (5:1) coated urea at 40 kg N ha^{-1}. Neem cake had greater nitrification inhibition, ensured supply of nitrogen to the crop throughout its growth and thus resulted in efficient nitrogen utilization.

Neem cake coated urea @ 150 kg·N ha^{-1} increased the sugarcane yield to an extent of 20.9 per cent over 150 kg N ha^{-1} of ordinary prilled urea (Parashar et al. 1980).

Yadav (1984) observed that neem coated urea increased the total herbage yield from four harvest of Java citronella by 30 per cent over urea, whereas the increase in yield by neem cake mixed urea over urea was 18.7 per cent.

Ketkar (1976) observed that coating of urea with neem cake didnot exert any significant influence on the green fodder yield of fodder crops.

2.3.3.3 Coal tar coated urea

Bains et al. (1971) reported that treatment of urea with coal tar extract and neem seed extract could increase the efficiency of urea for rice and grain yield increased by 909 and 1339 $kg.ha^{-1}$ using urea treated with acetone extracts of these two materials respectively over the yield given by untreated urea at 100 kg.N ha^{-1}. Basal application of coal tar treated urea mixed with ordinary urea was found to be useful under lowland flooded conditions (KAU, 1981-82). Tandon (1989) reported that basal application of urea treated with coal tar increased the grain yield of rice.

Paramasivam (1991) reported that, from a comparative study on the mineralisation effect of urea formaldehyde (UF), tar coated urea (TCU) and lac coated urea (LCU) it was found that the amount of urea released from LCU and TCU immediately after application in soils was quite high.

Muthuswamy et al. (1975) reported that the maximum grain yield of ragi was recorded in the treatments which received urea treated with coal tar and mahua cake extracts, whereas maximum straw yield was recorded in lac coated urea along with coal tar and *mahua* cake extracts.

2.4. Effect of nitrification inhibitors on mineralisation of urea

Reddy and Prasad (1975) noticed that by applying nitrification inhibitors in urea, large amount of ammoniacal nitrogen was produced while in untreated urea the production of nitrate nitrogen was comparatively higher. Treating urea with nitrification inhibitors recorded significantly more ammoniacal nitrogen than untreated urea (Muthuswamy et al., 1977).

Khandelwal et al. (1977) reported that a commercial neem extract applied in the soil, inhibited the population of Nitrosomonas sp. of bacterium for 4 weeks and that of Nitrobacter sp. for one week. Misra and Chonkar (1978) observed that after 160 days of incubation soil treated with plastic coated urea and neem cake showed appreciably higher levels of ammoniacal nitrogen than soil with urea alone.

Neem cake coated urea was found very effective in retarding nitrification of urea for 2 weeks (Pillai, 1981). Similarly, Rajkumar and Sekhar (1981) found that neem cake was more effective in inhibiting nitrification of urea in alkali soils than 2 amino 4 chloro 6 methyl pyrimidine (AMP). Urea blended with neem cake, urea coated with coal tar and application of neem cake in moist soils prior to urea application favoured the production of ammoniacal nitrogen and nitrite nitrogen, whereas nitrate nitrogen formation was significantly inhibited (Sarkunnan and Bidappa, 1981).

Sahrawat (1982) reported that soil samples treated with nitrification inhibitors contained lower amounts of nitrate than the untreated samples during the 15 days of study though the effectiveness of the inhibitors to retard nitrate formation decreased with time. Sathianathan (1982) reported that a faster rate of decline in ammoniacal content accompanied by a faster increase in nitrate content was observed in untreated urea, while the oil cakes inhibited the nitrification, thereby the nitrate content was significantly lower than prilled urea.

In a laboratory experiment at IARI, with a sandy clay loam soil for studying the mineralisation pattern of fertilizer grade urea, neem and sulphur coated and N serve treated urea, it was found that neem cake coating of urea slowed down the release of mineral nitrogen from urea as well as inhibited the nitrification of released ammonium nitrogen (Thomas and Prasad, 1982). Application of neem products like neem leaf and neem cake to wetland did not show any adverse effect on the population of heterotrophic microflora, nitrifying bacteria, while it decreased significantly due to addition of neem cake and fresh and dried neem leaf with urea (Santhi et al., 1986).

The concentration of nitrate-nitrogen in soils which received the N through neem cake blending was lower at the initial stages and was higher at the later stages compared to the concentration of nitrate nitrogen in soils fertilized with urea alone. The reverse trend was noticed in the case of ammoniacal nitrogen (Singh and Singh, 1986). Korah and Shingte (1988) reported that among the six non-edible oil cakes namely neem, *karanja, pilu, kusum, pisa* and *castor* used to study the mineralisation pattern of nitrogen in two typical soils namely medium black calcareous and lateritic soils, neem cake has the highest rate of nitrification followed by *castor, karanja, pilu, kusum* and *pisa cake* respectively in the descending order.

Singh and Singh (1989b) reported that neem oil coated urea, sulphur coated urea and lac coated urea maintained higher amount of nitrate-nitrogen in the soil throughout the growth period of wheat as compared to urea and neem cake blended urea. Blending urea with neem cake significantly increased ammoniacal nitrogen content in the soil, showing retarded nitrification of applied urea due to neem cake (Tiwari, 1989).

From a green house experiment conducted at Patnagar to study the utility of briquetted urea as a slow release nitrogenous fertilizer and neem cake coated urea as a nitrification inhibitor, for their role in enhanced nitrogen utilization in comparison to ordinary urea fertilizer, it was found that comparatively higher nitrate nitrogen status was observed in ordinary source of nitrogen during the first half of the experimental period, whereas neem cake treated urea accounted for higher nitrate status at four week stage, closely followed by briquetted urea (Singh et al., 1991). In contrast to a sharp increase in nitrite and nitrate levels of nitrogen within a period of seven to 15 days with untreated urea, gradual increase in nitrite and nitrate nitrogen levels upto a period of one month when soils were treated with nimin coated urea was observed in the laboratory experiment. The rate of hydrolysis of the two forms, prilled urea and nimin coated urea did not reveal any notable difference, indicating that the neem extract coating had negligible influence on the activity of urease enzyme (Vyas et al., 1991).

2.5. Economics in using nitrification inhibitors

Hughes and Welch (1970) reported that blending urea with N-serve or neem cake coated urea resulted in a saving of 15 kg.N ha^{-1} in most of the upland crops. Sivaraj and Iruthayaraj (1980) observed that blending of urea with N-serve or neem cake coated urea, resulted in a saving of 15 kg.N ha^{-1} in cotton. Mixing of urea with neem cake in 3:1 ratio economized the dose of urea by 25 per cent in potato (Sharma et al., 1980) Prasad et al. (1981) observed that by the application of neem cake coated urea over untreated urea, a net profit of Rs. 965.58 was obtained in rice. From a study conducted at the Paddy Experiment station, Ambasundaram it was revealed that in *kharif* season, placement of urea super granules, neem blended urea and coal tar coated urea at higher N levels has produced significantly higher yield than prilled urea and in rabi season, urea super granule placement at lower level of nitrogen produced equal yield as that of neem cake, coal tar and urea super granule applied at higher N levels resulting in a saving of 25 per cent N (Rajagopalan and Subrahmaniam, 1989). Neem cake, *karanj* cake blended urea and urea super granule showed higher yield as compared with prilled urea in sugarcane and with the use of these materials, the efficiency of nitrogen use was enhanced upto 50 kg. N ha^{-1} (Yadav and Singh, 1991). De _et al_. (1992) reported that three splits of 70 kg. N ha^{-1} as neem extract coated urea saved more than 30 kg. N ha^{-1} compared to prilled urea and increased the grain yield in rice.

The review above revealed that the growth characters of brinjal viz., height, number of branches and leaves per plant, LAI, yield attributes like time of attaining 50 per cent flowering, percentage of fruit set, number of flowers and fruits per plant, fruit characters like length, girth, volume and weight of fruits and yield were markedly influenced by nitrogen levels. Upto 75 to 100kg. ha^{-1} N, increased the above growth characters. The higher doses above 75 kg. N ha^{-1} showed varying response to growth and yield attributes. Similarly, the yield were influenced by N levels upto 75 to 100 kg. ha^{-1}, though there were reports that the crop responded upto 300 kg. ha^{-1}.

The nitrogen use efficiency of urea was appreciably improved by split application, placement at proper depth, foliar application, using large sized urea granules, coating the fertilizer, using nitrification inhibitors or by blending or coating of urea with certain indigenous materials like neem cake which retard nitrification. The review above indicated that different oil cakes viz., neem, *karanj*, *mahua*, *pilu*, *kusum*, *pisa* and *castor* and other nitrification inhibitors like N-serve, AMP have significantly improved the nitrogen use efficiency by retaining nitrogen as ammoniacal nitrogen and slowly converting it to nitrate nitrogen. Among the various cakes, neem cake was found to be better than others in improving the growth and yield of both the low land and upland crops. The mixing or coating of fertilizer can same the nitrogen to a tune of 15-20 kg. ha^{-1} in different crops. Since there is little work on the application of nitrification inhibitors in upland crops especially in vegetables the project work was selected.

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigation carried out at the Instructional Farm attached to the College of Agriculture, Vellayani, envisages the possibility of economising nitrogen in brinjal using nitrification inhibitors. The materials used and the methods adopted for the study are briefly described below:

3.1 MATERIALS

3.1.1 Experimental site

The experiment was carried out at the Instructional Farm, attached to the College of Agriculture, Vellayani. The farm is located at 8.5^{O}N latitude and 76.9^{O}E longitude at an altitude of 29 m above mean sea level.

3.1.2. Soil

The soil of the experimental area was of red sandy clay loam type. The data on the physico-chemical properties of the experimental site are given below.

Table 1. Physico chemical properties of soil

A. Mechanical composition

Sl. No.	Parameters	Content in soil (%)	Method used
1.	Coarse sand	36.35	Bouyoucos Hydrometer method (1962)
2.	Fine sand	15.00	
3.	Silt	17.50	
4.	Clay	30.00	Bouyoucos (1962)

B. Chemical composition

Sl. No.	Parameters	Content	Rating	Method used
1.	Available N	230.5 kg/ha^{-1}	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
2.	Available P_2O_5	40 $kg \cdot ha^{-1}$	Medium	Bray colorimetric method (Jackson, 1973)
3.	Available K_2O	115 $kg \cdot ha^{-1}$	Low	Ammonium acetate method (Jackson, 1973)
4.	pH	5.0	Acidic	pH meter with glass electrode (Jackson, 1973)

3.1.3. Cropping history of the field

The experimental site was lying fallow for 6 months before the experiment and prior to it, it was under bulk crop of ginger.

3.1.4. Season

The experiment was conducted during the *kharif* season of 1993.

3.1.5. Weather conditions

The data on weather parameters viz., rainfall, mean maximum temperature, mean minimum temperature and relative humidity during the cropping period collected from the meteorological observatory of the College of Agriculture, Vellayani are presented in Fig. 1. and in Appendix 1.

3.1.6. Seed material

The test variety of brinjal used for the study was *Surya* a bacterial wilt resistant one developed by Kerala

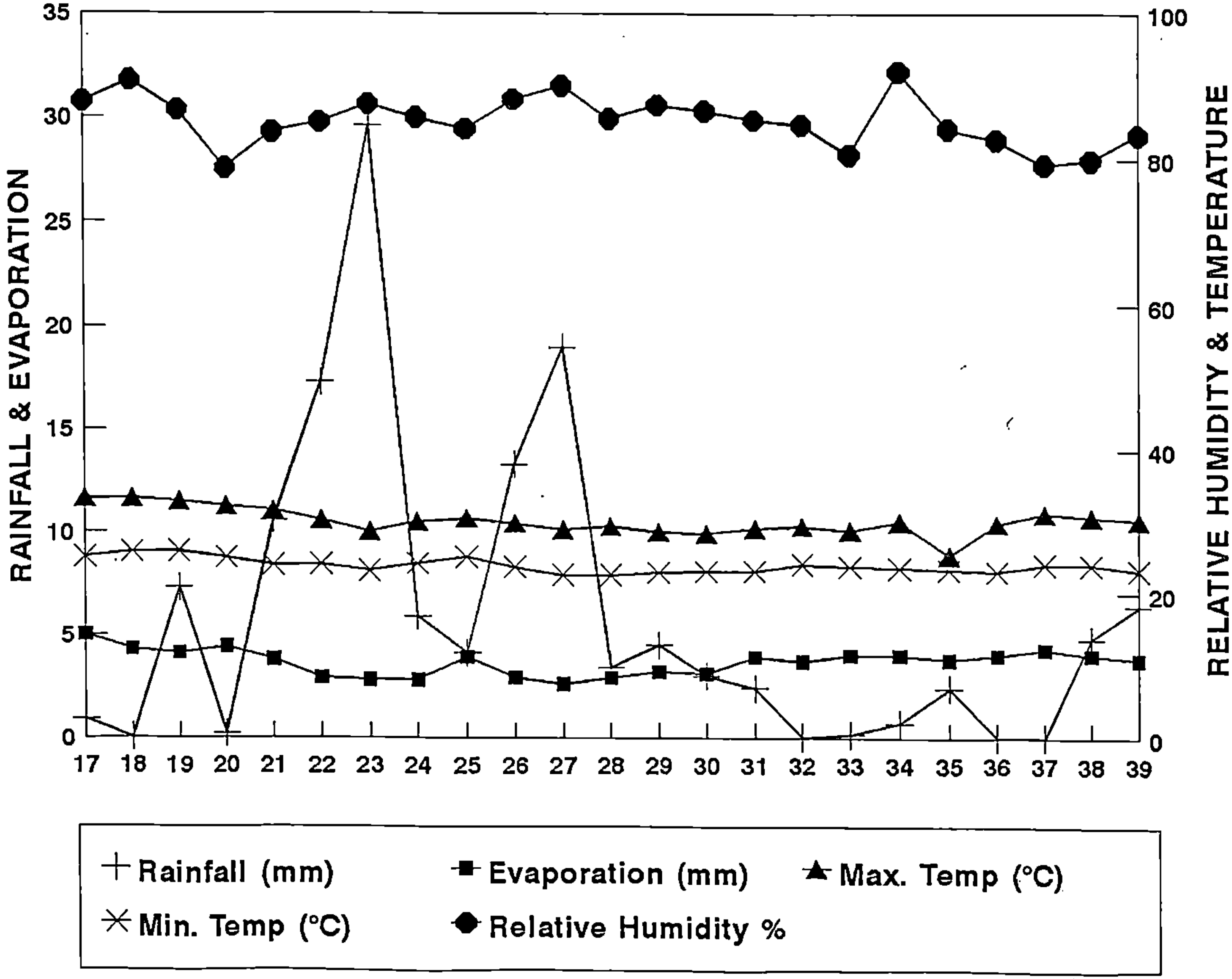

Fig. 1. Weather condition during the cropping period

Agricultural University, by single plant selection from a segregating population of SM-6. Bacterial wilt is a serious menace for the cultivation of solanaceous vegetables in Kerala. This is a spreading non prickly variety with purple oval fruits having an average fruit weight of 50 g, fruit yielding 0.7 to 1.31 $kg.plant^{-1}$.

3.1.7. Source of seed material

Seeds of the variety *Surya* was obtained from the Olericulture department of College of Horticulture, KAU, Vellanikkara.

3.1.8. Manures and fertilizers

Farm yard manure (0.4% N, 0.3% P_2O_5 and 0.2% K_2O), Urea (46%N), Mussorie rock phosphate (20-24% P_2O_5) and Muriate of potash (60% K_2O) were used. The urea modified materials used in the experiment were neem mixed urea, need cake coated urea and coal tar coated urea. Neem cake mixed urea was prepared by mixing urea with powdered neem cake passing through a 20 mesh sieve in the ratio of 5:1. For preparing neem cake coated urea, x coal tar solution was also used in addition to neem cake and urea. Coal tar solutiono was prepared by the dissolving two kg coal tar in 1.5 liters of kerosene and this solution was added to the fertilizer taken in a polyethylene bag at the rate of two ml per 100 g and the contents were throughly mixed. Urea coated with coal tar was prepared by mixing 100 kg urea with a solution of one kg coal tar dissolved in 1.5 litres of kerosene.

A common dose of P_2O_5 and K_2O at the rate of 40 and 25 kg. ha^{-1} respectively was given uniformly as per the package of practices of KAU (...).

3.2. Methods

3.2.1. Nursery

3.2.1.1. Land preparation

The land was dug twice, weeds were removed, clodes broken and levelled and fine seed beds was taken. Two nursery beds of 5 x 2 m^2 each were taken.

3.2.1.2. Seeds and sowing

A seed rate of 500 g. ha^{-1} as recommended in the package of practices of KAU, was adopted. Seeds were sown uniformly by broadcasting and then BHC five per cent dust was applied along the border of the beds to prevent the attack of ants, and termites.

3.2.1.3. After cultivation

Irrigation was given twice daily. Weeding was done thrice. First at seven days after sowing, second at 14 days after sowing and third at 21 days after sowing.

3.2.1.4. Plant protection

Two sprays of of malathion @ 0.2 per cent was given at 14 days after sowing and at 21 days after sowing to control grass hoppers.

3.2.2. Mainfield

3.2.2.1. Land preparation

The main field was ploughed thrice with power tiller and clods were broken. Field was then laid out into three blocks and each block into 12 plots of size 4.5m x 3.6m.

3.2.2.2. Manuring

Package of practices recommendation of KAU was followed for the rate and time of application of manures and fertilizers except N. Farm yard manure at the rate of 25 t ha^{-1} was uniformly applied at the time of ploughing. Phosphorus and potassium were applied to all the plots in the form of mussorie rock phosphate and muriate of potash respectively. Nitrogen was applied according to the treatments. The entire dose of P_2O_5 and half dose of K_2O was applied basally. The remaining dose of K_2O was applied 50 days after transplanting. The modified urea materials namely neem cake mixed urea, neem cake coated urea and coal tar coated urea were applied basally while ordinary urea was applied in 3 splits (half at planting and remaining part in two equal splits at 25 and 50 days after transplanting).

3.2.2.3. Transplanting

A light irrigation was given to the nursery beds before pulling out the seedlings and 30 days old healthy seedlings were carefully removed with a ball of earth around the roots to avoid transplanting shock. Small channels were taken in the plots at a spacing of 60 cm between rows and seedlings were planted at a spacing of 75 cm. Irrigation and shade was given immediately after transplanting to enable the seedling to withstand the stress.

3.2.2.4. After cultivation

One week after transplanting, gap filling was completed using the seedlings raised in small polythene bags. Regular weeding and raking of the soil was carried out. Periodical light irrigations were given in the absence of rainfall.

3.2.2.5. Plant protection

As a prophylatic measure to control the fruit and shoot borer of brinjal and to check the fruit rot, carbaryl (0.15%), and zineb (0.2%) respectively were sprayed in the experimental field.

3.2.2.6. Harvesting

The first harvest of fruits was taken 50 days after transplanting and subsequent harvest at weekly intervals.

3.3. Technical programme

3.3.1. Design and layout

The experiment was laid out as a factorial experiment in randomised block design with 12 treatment combinations - The layout plan is shown in Fig. 2.

Replications - 3

Treatment combinations - 12

Treatment details

(a) Levels of nitrogen (N) (3)

n_3 - 100% of recommended dose of nitrogen (75.00 kg N ha^{-1})

n_2 - 75% of recommended dose of nitrogen (56.25 kg N ha^{-1})

n_1 - 50% of recommended dose of nitrogen (37.50 kg N ha^{-1})

(b) Sources of nitrogen (S) (4)

s_1 - Common prilled urea

s_2 - Neem cake mixed urea

s_3 - Neem cake coated urea

s_4 - Coal tar coated urea

N

Replication I

n_3s_4	n_1s_1	n_3s_3	n_1s_4	n_1s_2	n_2s_3
n_2s_1	n_1s_3	n_3s_1	n_2s_4	n_3s_2	n_2s_2

Replication II

n_1s_2	n_3s_2	n_2s_1	n_3s_3	n_2s_4	n_1s_1
n_2s_3	n_1s_4	n_3s_4	n_2s_2	n_3s_1	n_1s_3

Replication III

n_3s_4	n_2s_2	n_3s_3	n_2s_4	n_2s_3	n_3s_1
n_1s_2	n_1s_1	n_2s_1	n_3s_2	n_1s_3	n_1s_4

A - Levels of nitrogen (3)

n_1 - 50% of the recommended dose of N (37.50 kg N ha^{-1})
n_2 - 75% of the recommended dose of N (56.25 kg N ha^{-1})
n_3 - 100% of the recommended dose of N (75 kg N ha^{-1})

B - Sources of nitrification inhibitors (4)

s_1 - urea
s_2 - neem cake mixed urea
s_3 - neem cake coated urea
s_4 - coal tar coated urea

Design : Factorial experiment in RBD

Fig. 2. Lay out plan of the experimental plot

Treatment combinations

t_1 - n_3s_1 (100% recommended dose of N+ Prillled urea)

t_2 - n_3s_2 (100% recommended dose of N+ Neemcake mixed urea)

t_3 - n_3s_3 (100% recommended dose of N+ Neemcake coated urea)

t_4 - n_3s_4 (100% recommended dose of N+ Coal tar coated urea)

t_5 - n_2s_1 (75% recommended dose of N+ Prillled urea)

t_6 - n_2s_2 (75% recommended dose of N+ Neemcake mixed urea)

t_7 - n_2s_3 (75% recommended dose of N+ Neemcake coated urea)

t_8 - n_2s_4 (75% recommended dose of N+ Coal tar coated urea)

t_9 - n_1s_1 (50% recommended dose of N+ Prillled urea)

t_{10} - n_1s_2 (50% recommended dose of N+ Neemcake mixed urea)

t_{11} - n_1s_3 (50% recommended dose of N+ Neemcake coated urea)

t_{12} - n_1s_4 (50% recommended dose of N+ Coal tar coated urea)

3.4. Biometric observations

Biometric observations were taken from tagged plants selected at random in the net plot and average values of five plants were recorded. First biometric observation was taken 1 month after transplanting and subsequent observations at 15 days interval. For taking observations on dry matter production and chemical analysis studies one row of plants was ear marked for destructive sampling.

3.4.1. Growth studies

Observations were recorded at 30, 45, 60, 75 and 90 DAT, for the following parameters.

3.4.1.1. Height of the plant

Height of the plant was measured from the base of the plant to the growing tip of the tallest branch and expressed in cm.

3.4.1.2. Number of branches

The total number of branches in the plant was counted and was recorded as mean branch number

3.4.1.3. Number of leaves plant^{-1}

The total number of leaves in each plant was counted and expressed as mean leaf number.

3.4.1.4. Leaf area index (LAI)

Using a LI - 300 leaf area meter, the leaf area of plant in each plot was measured. The leaf area index was worked out from the data on the total area and the corresponding ground area as follows (Williams, 1946).

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

3.4.1.5. Dry matter production

From the destructive sample row, one plant was uprooted carefully. Leaves, stem and roots were separated dried in shade and then in the oven for 3 weeks. The dry weight was recorded and expressed as the total dry matter production in $kg.ha^{-1}$.

3.4.1.6. Relative growth rate (RGR)

The rate of increase in dry weight per unit dry weight per unit time expressed as mg day^{-1} was calculated by the following formula suggested by Blackmann (1919).

$$RGR = \frac{\log_e w_2 - \log_e w_1}{t_2 - t_1}$$

w_1 - Dry weight of the plant at time t_1

w_1 - Dry weight of the plant at time t_2

3.4.2. Yield and yield attributes

3.4.2.1. Time of 50 per cent flowering

Total number of plants flowered was counted daily in each plot and the date on which 50 per cent of the plant flowered was noted.

3.4.2.2. Number of flowers per plant

The total number of flowers in each plant of the observational row was counted and expressed as mean number per plant.

3.4.2.3. Percentage of fruit set

The flowers in the observational plants were tagged and the number of flowers shed were counted and from this the percentage of fruit set was worked out.

3.4.2.4. Number of fruits per plant

The total number of fruits in the observational plants was counted and expressed as mean fruit number.

3.4.2.5. Length of fruits

The length of the harvested fruits from the observational plants was measured and expressed as mean length in cm.

3.4.2.6. Girth of fruit

The girth of the fruits were recorded by winding thread around the middle most length of the individual fruits and expressed as mean length in cm.

3.4.2.7. Volume of fruits

The total volume of the fruit were measured by volume displacement method and mean volume expressed as cm^3.

3.4.2.8. Yield of brinjal (total weight)

The total weight of fruits was recorded from all the plots and the yield in $kg \cdot ha^{-1}$ was expressed.

3.4.2.9. Harvest index

Harvest index was worked out based on the fruits yield and total plant yield obtained from the net plot using the following formula and expressed in percent as suggested by Donald (1962).

$$\text{Harvest index in percentage} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.5. Analytical procedures

3.5.1. Plant analysis

Stem, leaves and roots of plants were separated and dried in the oven at 80^{o}C till constant weights were achieved. The samples were then ground to pass through a 0.5 mm mesh sieve in a Wiley mill. Then, 0.5g of samples were weighed out and analysis was carried out as per standard procedures.

3.5.1.1. Uptake of nitrogen

Total nitrogen content was estimated by modified microkjeldhal method (Jackson, 1973) and the values were expressed as percentage. Uptake of nitrogen was calculated by multiplying the nitrogen content of the plant with the total dry weight of the plant. The uptake values were expressed in $kg \cdot ha^{-1}$.

3.5.1.2. **Uptake of phosphorus**

Phosphorus content was estimated colorimetrically (Jackson, 1973) by developing colours by vanado molybdo phosphoric method. The yellow colour developed was read using Klett summerson photoelectric colourimeter. Phosphorus content was multipled with total dry weight of the plants to give the uptake of phosphorus by the plants in $kg \cdot ha^{-1}$.

3.5.1.3. **Uptake of potassium**

Total potassium content in the plants were estimated by the flame photometric method. Total potassium uptake was calculated by multiplying the dry weight and the total potassium content and the uptake values were expressed in $kg \cdot ha^{-1}$.

3.5.2. Soil analysis

Soil samples were taken from the experimental area before the start of the experiment and at 15 days interval. Available nitrogen status of the soil were estimated using alkaline potassium permanganate method (Subbiah and Asija 1956) at 15 days intervals while available phosphorus and potassium by Bray colourimetric method (Jackson 1973) and available potash by ammonium acetate method (Jackson, 1973) respectively.

3.5.3. Economic analysis

Economic analysis was carried out using partial budgeting technique (Singh, 1977 and Johl and Kapur, 1981).

3.5.4. Statistical analysis

The data relating to each character in the experiment were analysed using the analysis of variance technique. The characters like plant height, number of branches and number of leaves per plant and periodical nutrient removal were analysed in split plot fashion as these observations are correlated over time (Gomez and Gomez, 1984).

RESULTS

RESULTS

A field experiment was conducted in the Instructional Farm, attached to the College of Agriculture, Vellayani to study the effect of different nitrogen levels, nitrification inhibitors and their interactions on the growth and yield of brinjal. The experimental data collected were statistically analysed to bring out the main effect of nitrogen, nitrification inhibitors and their interactions. The results obtained are presented under the following sections :

4.1 Growth characters

4.1.1 Height of the plants

The influence of different nitrogen levels and sources of nitrification inhibitors on the height of the plants is presented in Table 2.

The plant height was found to increase with the highest level of N but this increase was markedly visible only after 60 DAT.

Table 2. Effect of different N levels and sources of nitrification on plant height

Treatments	Height (cm) 30 DAT	45DAT	60DAT	75DAT	Harvest	Mean
n_3	19.33	26.69	44.02	52.74	57.07	39.97
n_2	18.27	26.31	42.66	47.48	54.70	37.88
n_1	17.00	24.46	38.41	43.70	49.39	34.59
s_1	18.40	25.28	39.58	45.83	50.70	35.95
s_2	18.58	26.44	43.10	49.09	55.85	38.61
s_3	17.78	25.17	41.24	48.77	54.52	37.49
s_4	18.00	26.39	42.86	48.20	53.83	37.86
Mean	18.20	25.82	41.69	47.97	53.72	

Effect	F	CD	SE
N	19.281^{**}	1.811	0.905
S	2.457^{*}	2.091	1.040
N x S	1.389^{ns}	-	2.561
Periods (P)	614.494^{**}	1.702	0.851
NP	2.428^{*}	2.948	2.084
SP	0.680^{ns}	-	2.407
NSP	0.574^{ns}	-	

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

The s_2, s_3 and s_4 sources of nitrification inhibitors influenced this character similarly while ordinary prilled urea (s_1) was not found to improve the plant height.

4.1.2 Number of branches

An increase in the level of N was found to increase the number of branches also (Table 3). But, this marked difference in the number of branches was seen only from 60 DAT onwards.

The neem cake mixed urea (s2) source of nitrification inhibitors was found to be the best and the source of ordinary prilled urea (s_1) the least.

4.1.3 Number of leaves per plant

The influence of the different levels of N and sources of nitrification inhibitors on the number of leaves per plant at different periods of crop growth are presented in Table 4.

The N levels, sources of nitrification inhibitors the periods of crop growth and its interactions with nitrogen

Table 3. Effect of different N levels and sources of nitrification inhibitors on number of branches

Treatments	Number of branches 30 DAT	45DAT	60DAT	75DAT	Harvest	Mean
n_3	1.23	3.33	6.90	10.12	11.16	6.55
n_2	1.04	2.61	4.58	8.02	8.93	5.04
n_1	0.68	2.14	3.31	6.33	7.12	3.92
s_1	0.80	2.49	4.39	7.50	8.50	4.73
s_2	1.11	3.02	5.52	8.91	9.90	5.70
s_3	1.00	2.58	5.05	7.97	8.86	5.09
s_4	1.02	2.69	4.75	8.25	9.02	5.15
Mean	0.98	2.69	4.93	8.15	9.07	

Effect	P	CD	SE
N	67.371**	0.471	0.235
S	4.561**	0.544	0.272
N x S	0.491 ns	-	0.347
Periods(P)	731.451**	0.359	0.179
NP	13.971**	0.623	0.440
SP	0.848 ns	-	0.508
NSP	0.323 ns	-	-

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

Table 4. Effect of different N levels and sources of nitrification inhibitors on number of leaves

Treatments	30 DAT	45DAT	60DAT	75DAT	Harvest	Mean
	Number of leaves					
n_3	13.13	26.25	97.02	98.28	95.95	66.13
n_2	7.77	24.27	73.91	85.77	78.66	54.08
n_1	5.75	16.25	58.70	71.09	66.66	46.69
s_1	8.20	19.30	70.95	78.70	72.11	49.86
s_2	9.58	23.79	80.72	90.51	85.47	58.02
s_3	9.00	22.49	76.55	86.26	81.54	55.17
s_4	8.75	23.44	77.97	84.72	82.58	55.50
Mean	8.88	22.25	76.55	85.05	80.42	

Effect	F	CD	SE
N	116.199**	3.055	1.527
S	8.134**	3.527	1.763
N x S	0.590^{ns}	-	4.321
Periods(P)	1141.603**	3.006	1.503
NP	13.620**	5.207	3.682
SP	1.095^{ns}	-	4.252
NSP	0.971^{ns}	-	

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

were found to be significant. A significant increase in the number of leaves per plant was observed with an increase in N level. The n_3 level of N recorded maximum number of leaves and was significantly higher than at n_2 and n_1 levels from 60 DAT onwards.

The s_1 source of nitrification inhibitor was not found to produce more leaves per plant than the other nitrification inhibitors.

At the earlier period of growth, significant effect of N was seen at the highest level along. At later stages ie. from 60 DAT onwards a marked difference in the production of leaves per plant was seen with an increase in N. Maximum number of leaves was recorded at 75 DAT.

4.1.4 Leaf Area Index

The influence of different N levels and sources of nitrification inhibitors on LAI of the plants is presented in Table 5.

Table 5. Effect of different N levels and sources of nitrification inhibitors on LAI

Treatment	30 DAT	60 DAT	Harvest
n_3	0.025	0.772	0.884
n_2	0.020	0.658	0.674
n_1	0.017	0.492	0.575
$F_{2, 22}$	7.269**	28.531**	55.583**
SE	0.0016	0.0264	0.0212
CD	0.0047	0.0773	0.0621
s_1	0.017	0.598	0.661
s_2	0.021	0.711	0.750
s_3	0.022	0.636	0.722
s_4	0.022	0.617	0.712
$F_{3, 22}$	1.245^{ns}	2.637^{ns}	2.335^{ns}
SE	0.00183	0.0304	0.02446
CD	--	--	--

* - 5% level of significance

** - 1% level of significance

ns - Not significant

The LAI was significantly influenced by the application of N at different N levels. The sources of nitrification inhibitors or its interaction with N levels were not seen to be influencing the LAI at any of the growth stages. The higher the N, the higher was the LAI. This can be observed at 30 DAT, 60DAT and at harvest stage.

4.1.5 Relative growth rate (RGR)

The influence of various treatments on RGR of the plant is presented in Table 6. RGR were computed at 30-60 DAT and 60-90 DAT.

The effect of treatments on RGR was observed only after 60 DAT. A significant increase in RGR was found at the highest level of applied N. The different nitrification inhibitors had no influence on RGR.

4.1.6 Dry matter production (DMP)

The effect of different N levels and sources of nitrification inhibitors on DMP is shown in Table 7.

Table 6. Effect of different N levels and sources of nitrification inhibitors on RGR

Treatment	RGR (mg. day^{-1})	
	Between 30-60 DAT	Between 60-90 DAT
n_3	68	11
n_2	73	8
n_1	69	8
$F_{2,\ 22}$	2.780^{ns}	5.782^{**}
SE	1.541	0.84
CD	--	2.465
s_1	72	8
s_2	67	11
s_3	71	8
s_4	71	8
$F_{3,\ 22}$	1.778^{ns}	1.712^{ns}
SE	1.779	0.970
CD	--	--

* - 5% level of significance

** - 1% level of significance

ns - Not significant

Significant variation is seen in DMP at the different levels of nitrogen at 30 and 60DAT and at harvest. An increase in the dose of N resulted in an increase in the DMP.

Among the various sources of nitrification inhibitors s_2 was found to result in an increase in DMP at 30 DAT and at harvest stage, while no significant difference in DMP was seen at 60 DAT with respect to the inhibitors.

4.2. Yield attributes

4.2.1. Time of 50 per cent flowering

The mean number of days taken for 50 per cent flowering is given in Table 8. The significant interaction observed for the factors need not be given importance as the main effect of the individual factors were not significant.

4.2.2. Number of flowers and fruits per plant and percentage of fruit set

The influence of various levels of N and sources of nitrification inhibitors on number of flowers per plant,

Table 7. Effect of different N levels and sources of nitrification inhibitors on dry matter production (DMP)

Treatment	Dry matter production kg·ha^{-1} 30 DAT	60 DAT	Harvest
n_3	125.85	972.81	1357.15
n_2	93.88	839.99	1053.96
n_1	78.21	622.95	784.89
$F_{2, 22}$	48.824**	55.514**	199.968**
SE	3.474	23.703	20.245
CD	10.19	69.52	59.38
s_1	90.09	781.06	1010.65
s_2	113.47	840.60	1156.45
s_3	96.12	814.48	1049.66
s_4	97.57	811.51	1044.57
$F_{3, 22}$	48.186**	0.792^{ns}	7.301**
SE	4.011	27.370	23.377
CD	11.77	--	68.56

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

Table 8. Interaction of different levels of N and sources of nitrification inhibitors on time of 50 per cent flowering (In days)

	s_1	s_2	s_3	s_4	Mean
n_3	32.00	29.66	28.66	32.33	30.66
n_2	30.00	30.66	32.66	28.33	30.41
n_1	30.00	28.66	28.33	31.00	29.50
Mean	30.66	29.66	29.88	30.55	

Effect	F	CD	SE
N	2.168^{ns}	–	0.417
S	1.042^{ns}	–	0.481
N x S	5.165^{**}	2.447	0.834

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

Table 9. Effect of different N levels and sources of nitrification inhibitors on number of flowers per plant, percentage of fruit set and number of fruits per plant

Treatment	No. of flowers per plant	Percentage of fruit set	No. of fruits per plant
n_3	53.91	40.77	22.00
n_2	49.83	40.12	20.00
n_1	33.50	37.84	12.75
$F_{2, 22}$	270.677**	6.340**	156.377**
SE	0.656	0.611	0.389
CD	1.926	1.792	1.141
s_1	45.11	37.44	17.22
s_2	47.77	42.27	20.11
s_3	45.66	38.59	17.77
s_4	44.44	40.01	17.88
$F_{3, 22}$	3.613**	8.677**	8.040**
SE	0.758	0.705	0.449
CD	2.223	2.069	1.318

* - 5 % level of significance

** - 1 % level of significance

ns - not significant

percentage of fruit set and number of fruits per plant are given in Table 9.

Additional increase in N was found to result in an additional increase in the number of flowers and fruits per plant, while the percentage of fruit set was not benefited by n_3 level of N.

The s_2 source of nitrification inhibitor showed a significant increase in the production of flowers, fruits and percentage of fruit set in comparison with other sources of nitrification inhibitors.

4.2.3. Length, girth, volume and weight of fruits

The effect of different N levels and sources of nitrification inhibitors on fruit characters are presented in Table 10.

The fruit characters viz. length, girth, volume and weight of fruits were influenced by the N levels. The n_3 level of N significantly increased all the fruit characters than n_1 and n_2. Fruits obtained from plants treated with n_3

Table 10. Effect of different N levels and sources of nitrification inhibitors on length, girth, volume and weight of fruits

Treatments	Length of fruits (cm)	Girth of fruits (cm)	Volume of fruits (cm^3)	Weight of fruits (g)
n_3	7.38	17.21	97.58	48.25
n_2	7.03	14.84	91.75	45.27
n_1	6.84	12.17	86.58	43.67
$F_{2, 22}$	7.031^{**}	62.104^{**}	7.728^{**}	48.857^{**}
SE	0.103	0.320	1.979	0.332
CD	0.302	0.938	5.806	0.975
s_1	6.88	13.75	87.66	42.66
s_2	7.24	15.06	93.66	46.97
s_3	7.06	15.00	92.77	46.61
s_4	7.15	15.15	93.77	46.69
$F_{3, 22}$	1.660^{ns}	3.197^{**}	1.614^{ns}	28.623^{**}
SE	0.119	0.369	2.285	0.384
CD	--	1.084	--	1.126

* - 5% level of significance

** - 1% level of significance

ns - Not significant

level of N recorded a significant increase in length, and volume in comparison to those obtained from plants treated with n_1 level of N. Girth and weight of fruits were found to increase in their magnitude corresponding to an increase in N. The sources of nitrification inhibitors influenced the fruit characters of girth and weight of fruits. The sources of s_1 was found to be inferior to the other sources of nitrification inhibitors, which produced more or less the same result in the case of girth and weight of fruits.

4.2.4 Yield

The effect of different levels of N and sources of nitrification inhibitors on yield are presented in Table 11.

Yield showed significant difference due to variation in N levels. Maximum yield was shown by n_3 level of N (75 kg. N ha^{-1}) followed by n_2 (56.25 kg. N ha^{-1}) and n_1 (37.50 kg. N ha^{-1}).

The sources of nitrification inhibitors also showed significant difference in the case of yield. Maximum yield was obtained from neem cake mixed area (s_2), which was

Table 11. Effect of different N levels and sources of nitrification inhibitors on yield of brinjal

Treatments	Yield kg. ha^{-1}
n_3	21510.90
n_2	19555.36
n_1	12466.54
$F_{2, 22}$	156.337**
SE	380.596
CD	1116.318
s_1	16839.34
s_2	19664.00
s_3	17382.54
s_4	17491.18
$F_{3, 22}$	8.041**
SE	439.470
CD	1289.013

* - 5% level of significance

** - 1% level of significance

ns - Not significant

superior to coal tar coated urea and ordinary prilled urea which was found to be on a par with each other.

4.2.5 Harvest index

The influence of various N levels and sources of nitrification inhibitors on harvest index is presented in Table 12.

The harvest index varied significantly with the variation in levels of N. A quadraatic trend was noticed in this case. The n_2 level of N (56.25 kg N ha^{-1}) showed the maximum HI value of 0.417 and it decreased to 0.382 at the n_3 level.

The different sources of nitrification inhibitors didnot significantly influence the H.I.

4.3 Chemical analysis

4.3.1 Uptake of N

The mean values of uptake of N at 30DAT, 60DAT and at harvest are presented in Table 13.

Table 12. Effect of different N levels and sources of nitrification inhibitors on harvest index

Treatments	Harvest index
n_3	0.382
n_2	0.417
n_1	0.328
$F_{2, 22}$	30.924^{**}
SE	0.0079
CD	0.0234
s_1	0.368
s_2	0.383
s_3	0.373
s_4	0.378
$F_{3, 22}$	0.511^{ns}
SE	0.0092
CD	--

* - 5% level of significance

** - 1% level of significance

ns - Not significant

Table 13. Effect of different N levels and sources of nitrification inhibitors on N uptake

Treatment	N uptake kg·ha^{-1}		
	30 DAT	60 DAT	Harvest
n_3	11.04	85.47	119.34
n_2	7.72	73.70	92.63
n_1	6.43	54.69	68.82
$F_{2, 22}$	63.796**	53.772**	166.434**
SE	0.297	2.118	1.959
CD	0.873	6.212	5.740
s_1	7.62	68.43	88.67
s_2	9.59	73.74	101.59
s_3	8.13	71.69	92.35
s_4	8.27	71.30	91.78
$F_{3, 22}$	5.976**	0.800^{ns}	6.059**
SE	0.343	2.445	2.262
CD	1.008	--	6.635

* - 5% level of significance

** - 1% level of significance

ns - Not significant

Significant variation in N uptake was noticed among the different levels of N at 30DAT, 60DAT and at harvest. The n_3 level recorded the highest uptake of N followed by n_2 and n_1.

Among the various sources of nitrification inhibitors s_2 recorded maximum uptake of N at 30DAT and at harvest. At all stages the ordinary prilled urea gave lesser uptake of N than other treatments.

4.3.2 Uptake of P

The effect of treatments on P uptake is summarized in Table 14.

The effect of N levels, sources of nitrification inhibitors and its interaction did not influence the P uptake of the plant at any of the growth stages.

4.3.3. Uptake of K

The effect of N level, sources of nitrification inhibitors on K uptake at 30 DAT, 60DAT and at harvest are presented in Table 15.

Table 14. Effect of different N levels and sources of nitrification inhibitors on P uptake

Treatment	P uptake $kg\ ha^{-1}$		
	30 DAT	60 DAT	Harvest
n_3	10.31	15.30	19.86
n_2	10.18	15.16	19.81
n_1	10.10	15.27	19.89
$F_{2,\ 22}$	0.499^{ns}	0.894^{ns}	0.0741^{ns}
SE	0.150	0.080	0.142
s_1	10.11	15.25	19.81
s_2	10.33	15.28	19.92
s_3	10.24	15.22	19.77
s_4	10.13	15.23	19.91
$F_{3,\ 22}$	0.307^{ns}	0.078^{ns}	0.202^{ns}
SE	0.173	0.093	0.164

* - 5% level of significance

** - 1% level of significance

ns - Not significant

Table 15. Effect of different N levels and sources of nitrification inhibitors on K uptake

Treatment	K uptake $kg.ha^{-1}$		
	30 DAT	60 DAT	Harvest
n_3	10.73	91.23	115.76
n_2	10.76	92.52	116.37
n_1	10.83	91.40	115.97
$F_{2,\ 22}$	0.459^{ns}	0.438^{ns}	0.191^{ns}
SE	0.080	1.058	0.719
s_1	10.78	91.45	111.75
s_2	10.83	91.73	116.29
s_3	10.80	91.91	116.16
s_4	10.67	91.79	115.98
$F_{3,\ 22}$	0.556^{ns}	0.0240^{ns}	0.075^{ns}
SE	0.093	1.221	0.830

* - 5% level of significance

** - 1% level of significance

ns - Not significant

No significant variation in uptake of K was noticed due to different N levels, sources of nitrification inhibitors or their interaction at any of the growth stages.

4.3.4. Available nutrient status of the soil after the experiment

The mean values for available nitrogen, phosphorous and potassium content in the soils after the experiment is presented in Table 16.

It was observed that the different levels of N and sources of nitrification inhibitors or their interaction effect did not influence the available nitrogen, phosphorus and potassium content in the soils.

4.3.5 Nitrogen status of the soil at intervals

The effect of different N levels and sources of nitrification inhibitors on the available N status in the soil at 15 days interval is shown in Table 17.

Table 16. Effect of different N levels and sources of nitrification inhibitors on soil nutrient status after the experiment

Treatment	N (kg·ha^{-1})	P_2O_5 (kg·ha^{-1})	K_2O (kg·ha^{-1})
n_3	249.30	48.27	106.27
n_2	236.76	48.29	105.57
n_1	232.05	48.45	104.95
$F_{2, 22}$	2.134^{ns}	0.149^{ns}	1.424^{ns}
SE	6.103	0.259	0.553
s_1	229.96	48.20	106.46
s_2	242.51	48.42	105.78
s_3	238.33	48.33	104.91
s_4	246.69	48.40	105.24
$F_{3, 22}$	1.026^{ns}	0.119^{ns}	1.142^{ns}
SE	7.047	0.299	0.638

* - 5% level of significance

** - 1% level of significance

ns - Not significant

Table 17 Effect of different N levels and sources of nitrification inhibitors on N status of the soil

Treatments	Available N content in soils kg·ha^{-1}						
	Days after transplanting						
	15	30	45	60	75	90	Mean
n_3	468.82	380.95	288.50	286.94	268.12	255.58	324.82
n_2	485.57	385.65	274.39	263.41	254.01	243.03	317.68
n_1	464.05	395.13	280.67	252.44	246.17	238.33	312.80
s_1	462.03	378.22	267.60	259.23	250.87	236.24	309.03
s_2	476.66	403.49	282.24	267.60	257.14	248.78	322.65
s_3	478.00	367.95	282.23	261.33	252.96	244.60	314.51
s_4	474.57	399.31	292.68	282.23	263.42	252.96	327.53
Mean	472.81	387.24	281.19	267.60	256.10	245.64	

Effect	F	CD	SE
N	0.525^{ns}	–	23.62
S	0.732^{ns}	–	12.86
N x S	0.452^{ns}	–	33.08
Periods(P)	100.82**	26.683	18.861
NP	0.422^{ns}	–	33.08
SP	0.137^{ns}	–	37.74
NSP	0.405^{ns}	–	–

* – 5% level of significance
** – 1% level of significance
ns – Not significant

The mean available N content in the soils did not vary significantly with levels of N during the different periods. A significant decrease in available N content in soils was noticed from 15DAT onwards and this trend continued upto the final harvest (Vide Table 17).

No significant different in available N content of the soil was noticed with respect to different sources of nitrification inhibitors or its interaction with the different N levels.

4.4. Economic analysis

The partial budgeting of different N levels and sources of nitrification inhibitors in brinjal is presented in Table 18. The n_3 level of N gave the highest return per rupee of 1.73 followed by n_2 (1.57) and n_1 (1.01). Among the different sources of nitrification inhibitors the neem cake mixed urea (s_2) gave the maximum return per rupee (1.60) followed by coal tar coated area (1.42) and neem cake coated urea (1.41). The ordinary prilled urea gave the least value (1.32) of return per rupee invested.

Table 18. Partial budgeting of different N levels and sources of nitrification inhibitors in brinjal (Return per Rupees)

Source of nitrification inhibitors	N levels			
	n_1	n_2	n_3	Mean
s_1	1.72	1.49	0.77	1.32
s_2	1.80	1.72	1.28	1.60
s_3	1.69	1.56	0.98	1.41
s_4	1.73	1.54	1.01	1.42
Mean	1.73	1.57	1.01	

** Data not statistically analysed.

DISCUSSION

5. DISCUSSION

A field experiment was conducted in the Instructional Farm, attached to the College of Agriculture, Vellayani to study the effect of different N levels and nitrification inhibitors on the growth and yield of brinjal. The results presented in Chapter IV are discussed below.

5.1 Growth parameters

The different levels and the sources of nitrification inhibitors profoundly influenced the plant growth parameters viz. height of the plant, number of branches and leaves per plant (Tables 2, 3 and 4). The n_3 level of N (75 kg N ha^{-1}) showed a marked influence in increasing the vegetative growth of plants. The higher level of N might have increased the uptake of other nutrients which resulted in increased metabolic activities leading to more vegetative growth. From the results presented in Table 2 it can be seen that the height of the plant increased with higher levels of N. The influence of N in promoting the vegetative growth of the plants is well established and as such the increase in plant height with incremental doses of N

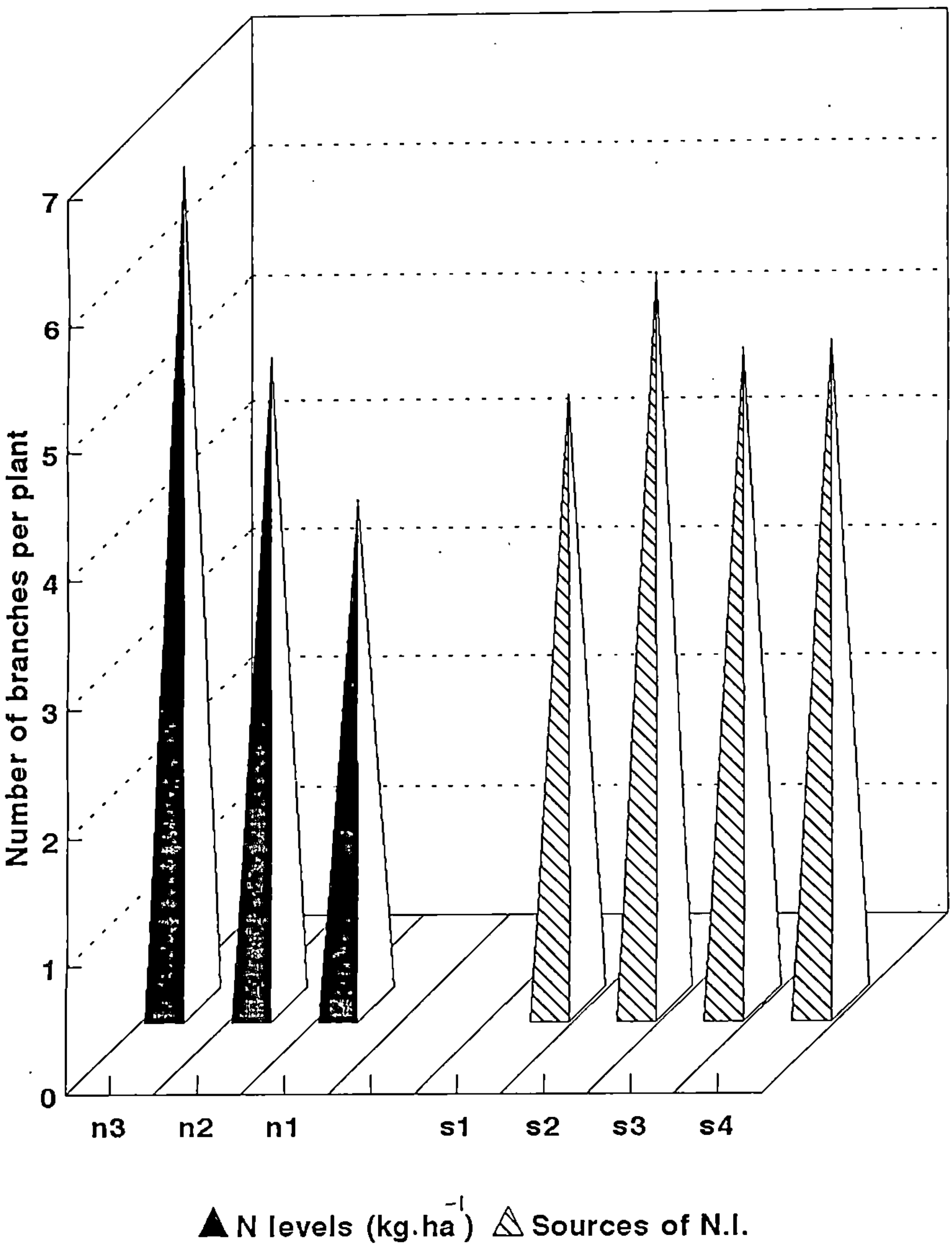

Fig. 3. Effect of different treatments on number of branches per plant

is quite natural (Tisdale et al., 1985). Significant increase in plant height of brinjal due to higher doses of N is obtained in this study in confirmity with the results obtained by Singh and Sandhu (1970), and Subramanian et al. (1993).

The total number of branches produced per plant was significantly influenced by the application of incremental doses of N. The increase in number of branches due to application of higher doses of N might be due to high content of N in the plant tissue which might have helped in the assimilation of protoplasm resulting in greater cell division and formation of more tissues and vigour of the plant. The results corroborated with the findings of Singh and Sandhu (1970) and Subramaniam et al. (1993).

Incremental doses of N appreciably increased the number of leaves per plant. The role of N in increasing the leafiness of crops is also well documented. (Russel, 1973). The increase in number of leaves by N fertilization is due to the accelerated development of lateral buds on the main stem and delay in senescence of older leaves. This is in agreement with the results obtained by Pillai et al. (1977) and Manchanda and Singh (1988).

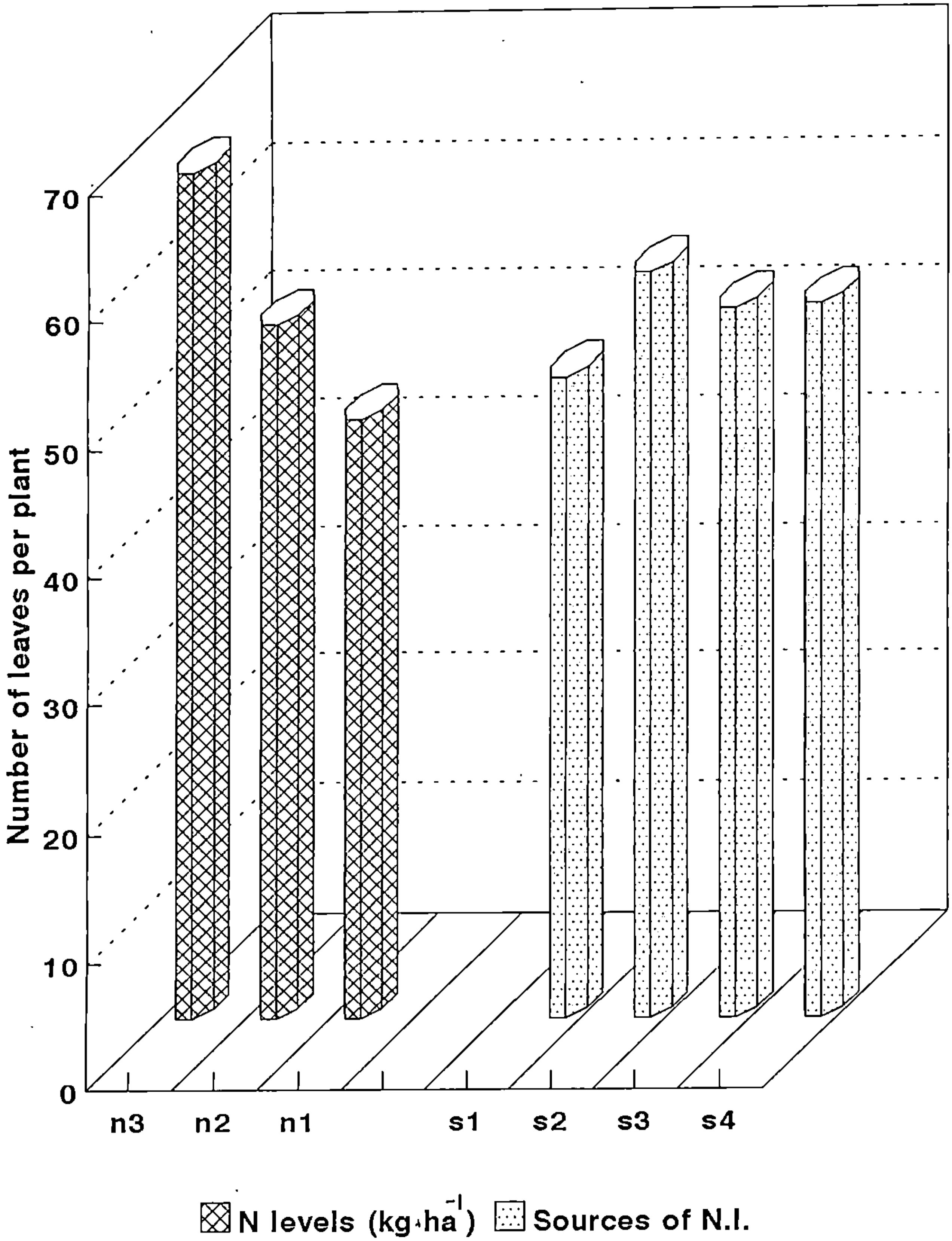

Fig. 4. Effect of different treatments on number of leaves per plant

The treatment of neem cake mixed urea (s_2) recorded more height of plants, number of branches per plant and leaves per plant. The ordinary prilled urea invariably gave the least values with respect to these growth parameters throughout the crop growth period. Neem cake coated urea and coal tar coated urea also favourably influenced the growth parameters. The treatments with nitrification inhibitors would have uniformly provided N to the crop, which favoured crop growth for prolonged periods and thereby favourably influencing the growth attributes viz., plant height, number of branches and leaves per plant. By checking the nitrification process and leaching losses, a continued availability of N throughout the growth period of the crop was brought about, in these treatments. Similar increases in growth attributes in cotton was reported by Seshadri (1976) in cassava, by Sathianathan (1982) and Vinod (1988), in Japanese mint, by Ram et al. (1987) and Sarkar (1986) in jute.

5.2 Growth analysis

Growth analysis viz. LAI and RGR were measured at 30, 60 and 90 DAT and the results are summarized in Tables 5 and 6. Growth analysis is an useful tool in studying the complex interactions between plant growth and environment.

N application at 75 kg. ha^{-1} increased the LAI at all stages of observation compared to other two lower levels. The LAI is a function of leaf number and size. Obviously higher level of N favoured the above two aspects and thereby increased the LAI. Naturally, under lower levels of N, the leaf production rate and leaf expansion is lesser. Russel (1973) reported that as the N supply increases the extra protein produced allows the plant leaves to grow larger and hence to have more surface area available for photosynthesis. Thus higher levels of N might have resulted in higher LAI. Increase in LAI through higher N application in brinjal was reported by Singh and Sandhu (1970) and in other solanaceous vegetables by Ramachandran and Subbiah (1982), Joshi and Nankar (1992).

The RGR was influenced by N levels only at 60-90 DAT stage and higher N level showed its superiority over lower levels. The higher uptake of N under highest level (75 kg. ha^{-1}) could be the probable reason for better RGR than the lower levels of N tried in this experiment.

The sources of different nitrification inhibitors did not influence the LAI or RGR either under lower or higher levels of N.

5.3 Dry matter production (DMP)

The data pertaining to the DMP are presented in Table 7. The influence of higher levels of N on DMP was seen from the initial stages of crop growth and continued upto the harvest. In general, the maximum increase in DMP was seen between 30-60 DAT stage. At this stage the percentage increase in DMP was to the tune of 721 and at 60 DAT to harvest stage the increase was only 30. The DMP showed a linear response to the increase in N level. The plant height, number of branches and leaves per plant and fruits per plant were increased by an increase in N level, which ultimately reflected in the DMP also. Nitrogen being an integral part of chlorophyll decides the photosynthtic efficiency of the crop. The enhanced vegetative growth might have contributed to higher dry matter yield as reported by Black (1973). Similar results of more DMP due to application of increased rate of N in solanaceous crops has been

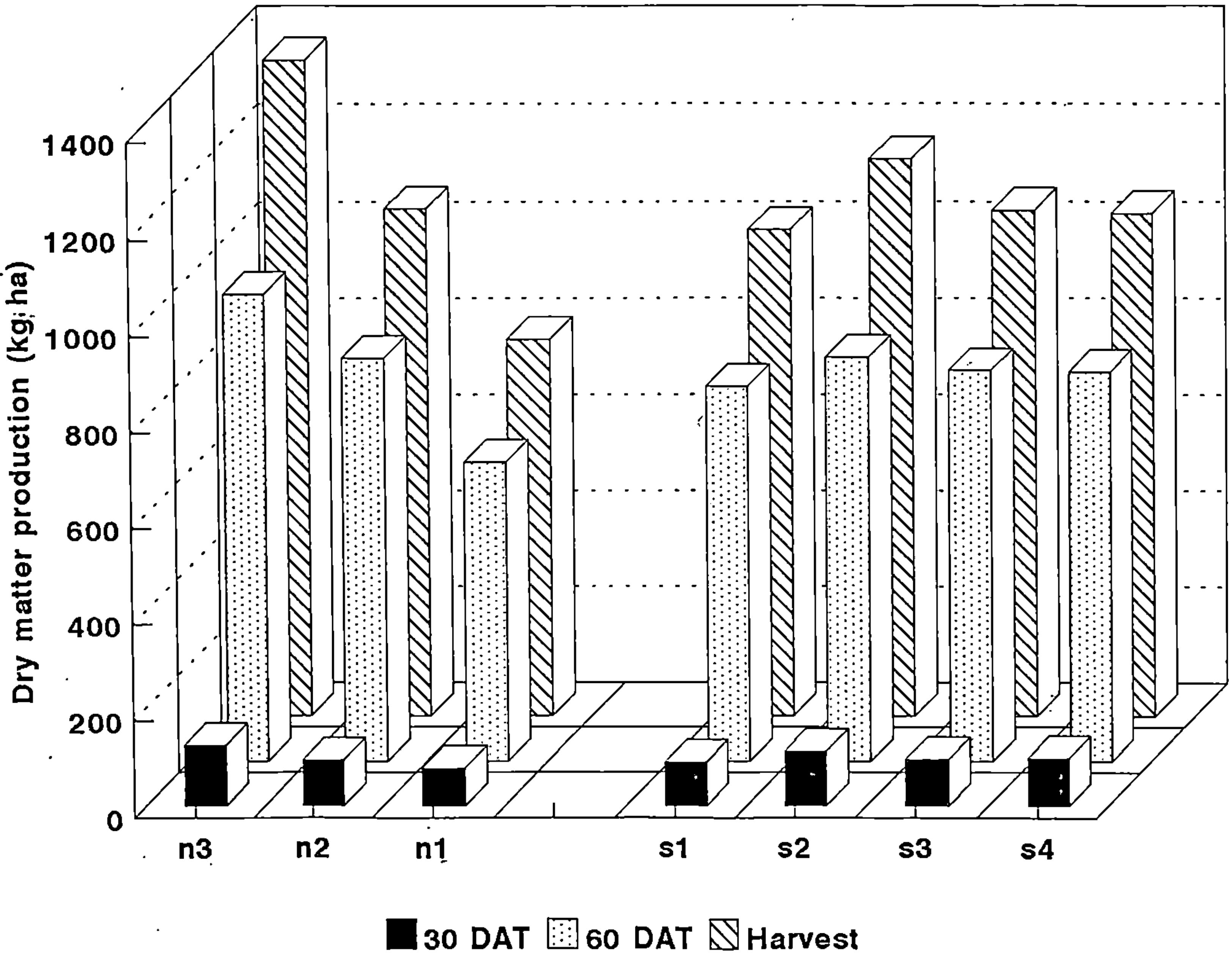

Fig. 5. Effect of different treatments on DMP at 30 DAT, 60 DAT and at harvest

documented by Ramachandran and Subbiah (1982) and John (1989).

The nitrification inhibitors also positively influenced the DMP of the crop. At the initial stages of growth ie. at 30 DAT, neem cake mixed urea (s_2) recorded superiority in DMP over other treatments. The other sources of nitrification inhibitors namely coal tar coated area (s_4), neem cake coated urea (s_3) and ordinary prilled urea (s_1) were on a par with each other in DMP at 30 DAT and at harvest. The better growth and increased fruit production in s_2, resulted in better DMP in this treatment. Similar results of increased DMP with the use of nitrification inhibitors has been reported by Ram et al. (1987) in Japanese mint, Sarkar (1986) in jute and Vyas et al. (1991) in maize.

5.4 Yield attributes

5.4.1 Number of flowers and fruits per plant and fruit setting percentage

The results presented in Table 9 indicated that the number of flowers per plant, percentage of fruit set, and

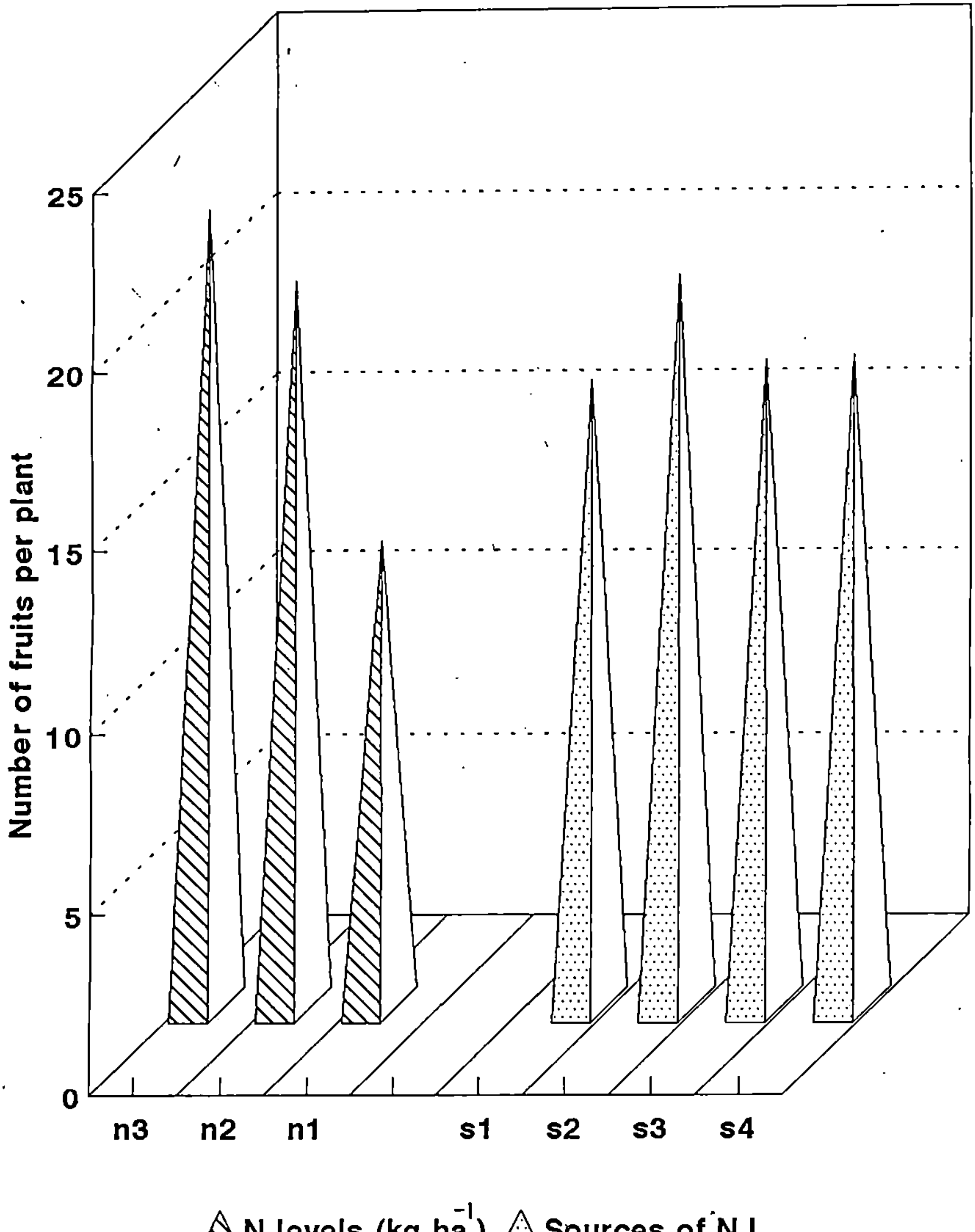

Fig. 6. Effect of different treatments on number of fruits per plant

number of fruits per plant were favourably influenced by the levels of N and sources of nitrification inhibitors. The enhanced levels of N linearly increased the flower and fruit production of the crop. The results indicated that the brinjal crop needs higher doses of N for better production of flowers and fruits. Similar increase in the yield attributes with higher levels of N was noticed by Ramachandran and Subbiah (1982), Varis and George (1985), Gupta (1987) and John (1989).

The sources of nitrification inhibitor namely, neem cake mixed urea (s_2) gave remarkable increase in flower and fruit production and setting percentage. The other sources showed only marginal increase in percentage of fruit set and fruit production over s_1. The better retention of ammoniacal nitrogen might have helped in the prolonged supply of N in s_2 which might be the reason for better expression of yield attributes. The results corroborated with the findings of Som et al. (1992) in brinjal, Wali and Totawat (1992) in maize.

5.4.2 Length, girth, volume and weight of fruits

The fruit characters viz. length, girth, volume and weight of fruits (Table 10) were markedly influenced by the N

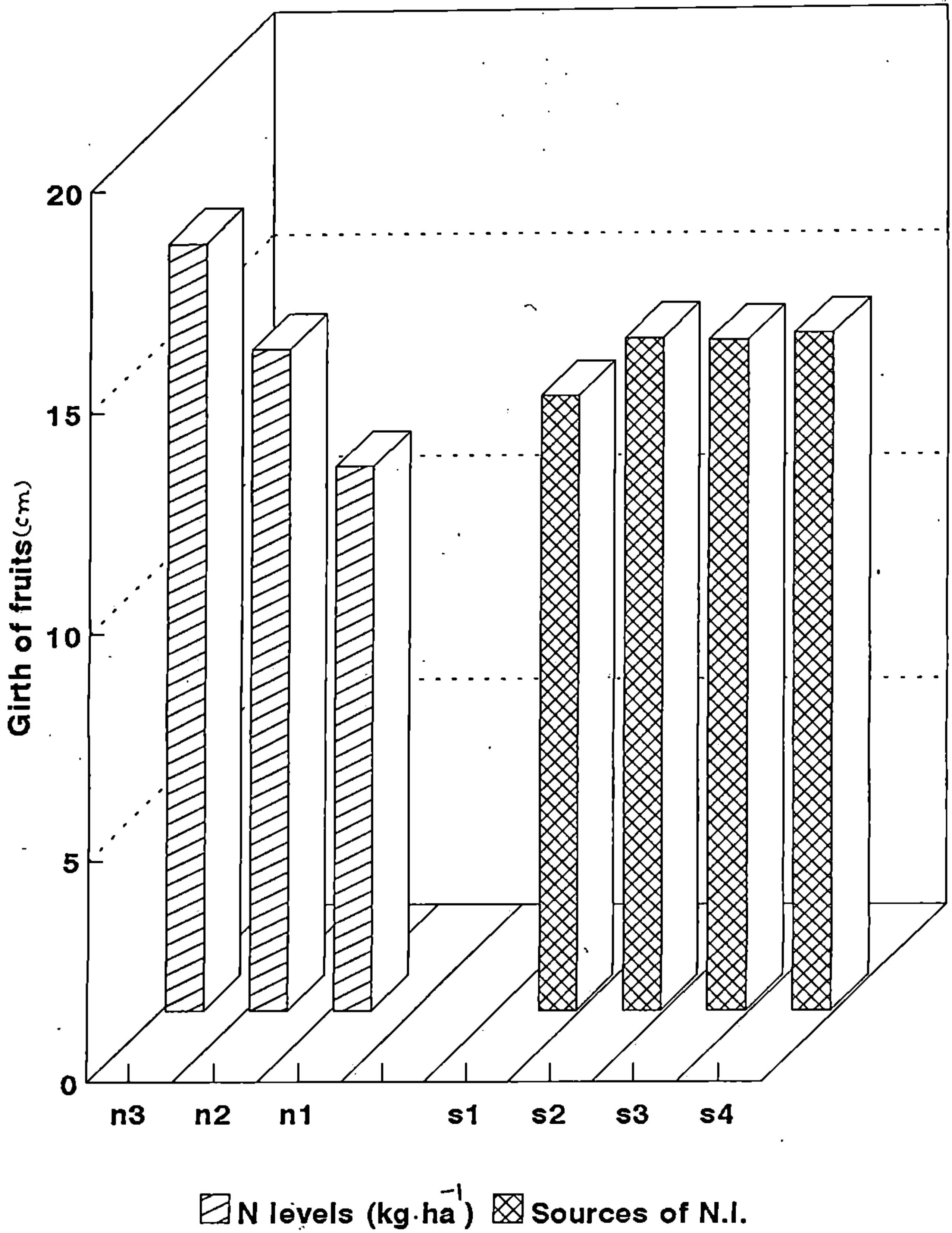

Fig. 7. Effect of different treatments on girth of fruits

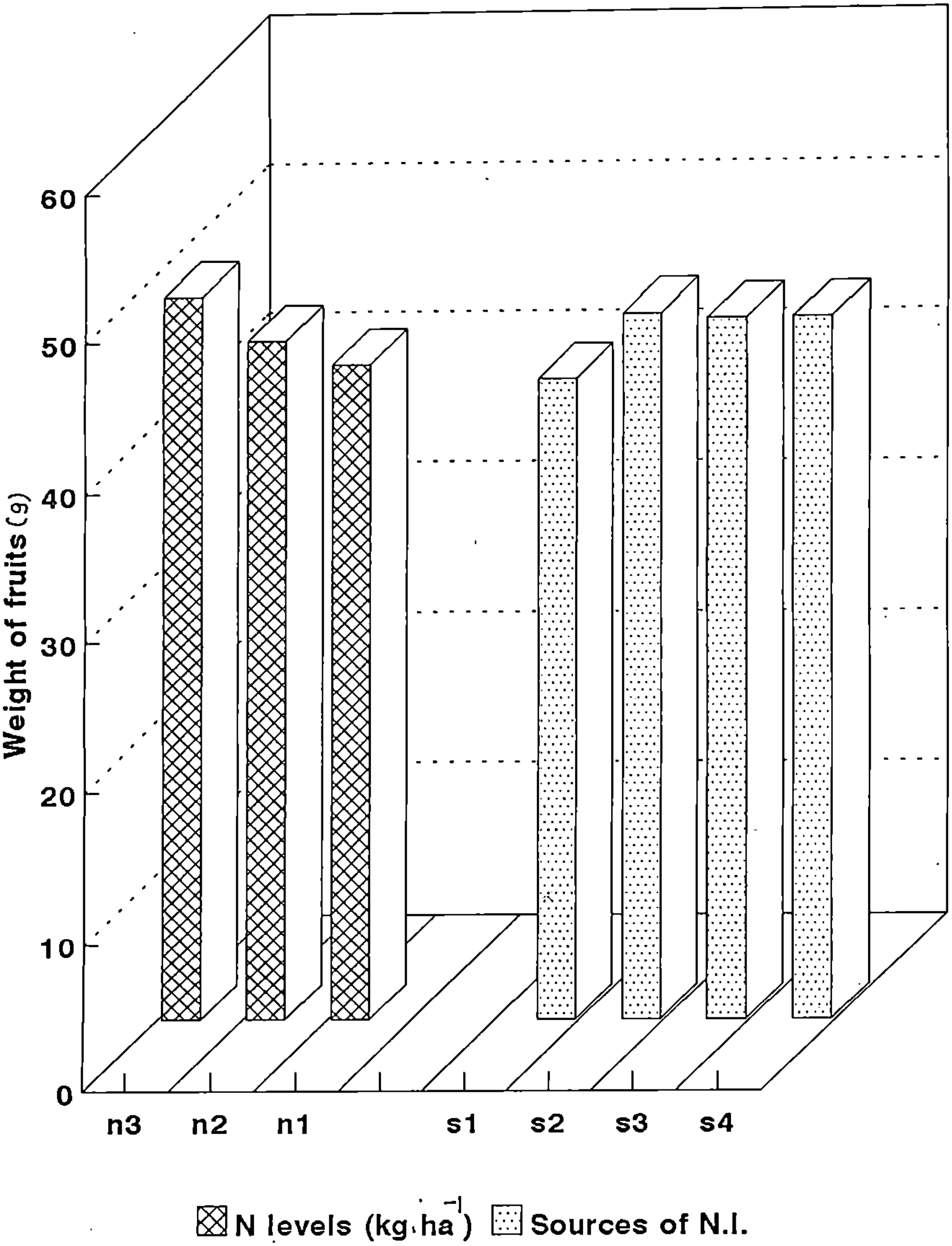

Fig. 8. Effect of different treatments on weight of fruits

levels. Maximum fruit length, girth, volume and weight was recorded in n_3 level and was superior to the lower levels. The n_2 level also improved the fruit characters over n_1. The results clearly revealed that n_3 level (75 $kg \cdot ha^{-1}$ of N) was required by the crop for exhibiting maximum values of the yield attributes. This might probably be due to enhanced availability of N. Similar results of better fruit length, girth, volume and weight with increased application of N in solanaceous crops has been obtained by Gupta et al. (1978), John (1989), Manchanda and Singh (1988).

The sources of nitrification inhibitors viz. neem cake mixed urea, neem cake coated urea and coal tar coated urea gave an increase in fruit girth, and weight of fruits which were on par with each other. The coating of fertilizers might have lowered the conversion of N from ammoniacal to nitrate form of N and thus would have slowly released the nitrate N. This inturn might have helped in an uniform and continued supply of N to the crop. This continued supply of N ultimately helped the crop to give large fruits. Similar results were noticed by Vinod (1988) wherein increase in size of tubers have been recorded with the use of nitrification inhibitors to cassava.

5.5 Yield

The mean data on fruit yield are presented in Table 11. Both the N levels and sources of nitrification inhibitors influenced the fruit yield.

Nitrogen level at 75 kg. ha^{-1} (n_3) gave a remarkable increase in the fruit yield over the other two lower levels. The yield increase of n_3 over n_2 and n_1 was to a tune of 9.99 and 72.50 per cent respectively. The enhanced fruit yield in n_3 level may be is attributed to the quick growth and higher production of flowers, better fruit set and more number of fruits per plant. The yield contributing characters viz., length, girth, volume and weight of fruits were also enhanced under n_3 level, which ultimately reflected in the final fruit yield. Similar increase in fruit yield in brinjal with increased levels of N was noticed by Singh and Sandhu (1970), Gupta et al. (1978), KAU (1980-81, 1990-91), and Subramaniam et al. (1993). In other solanaceous crops like chillies and tomato similar increase in fruit yield due to enhanced N application was reported by Randhawa et al. (1977); Chougule and Mahajan (1979); Ramakrishna Praseeda and Sulladmath

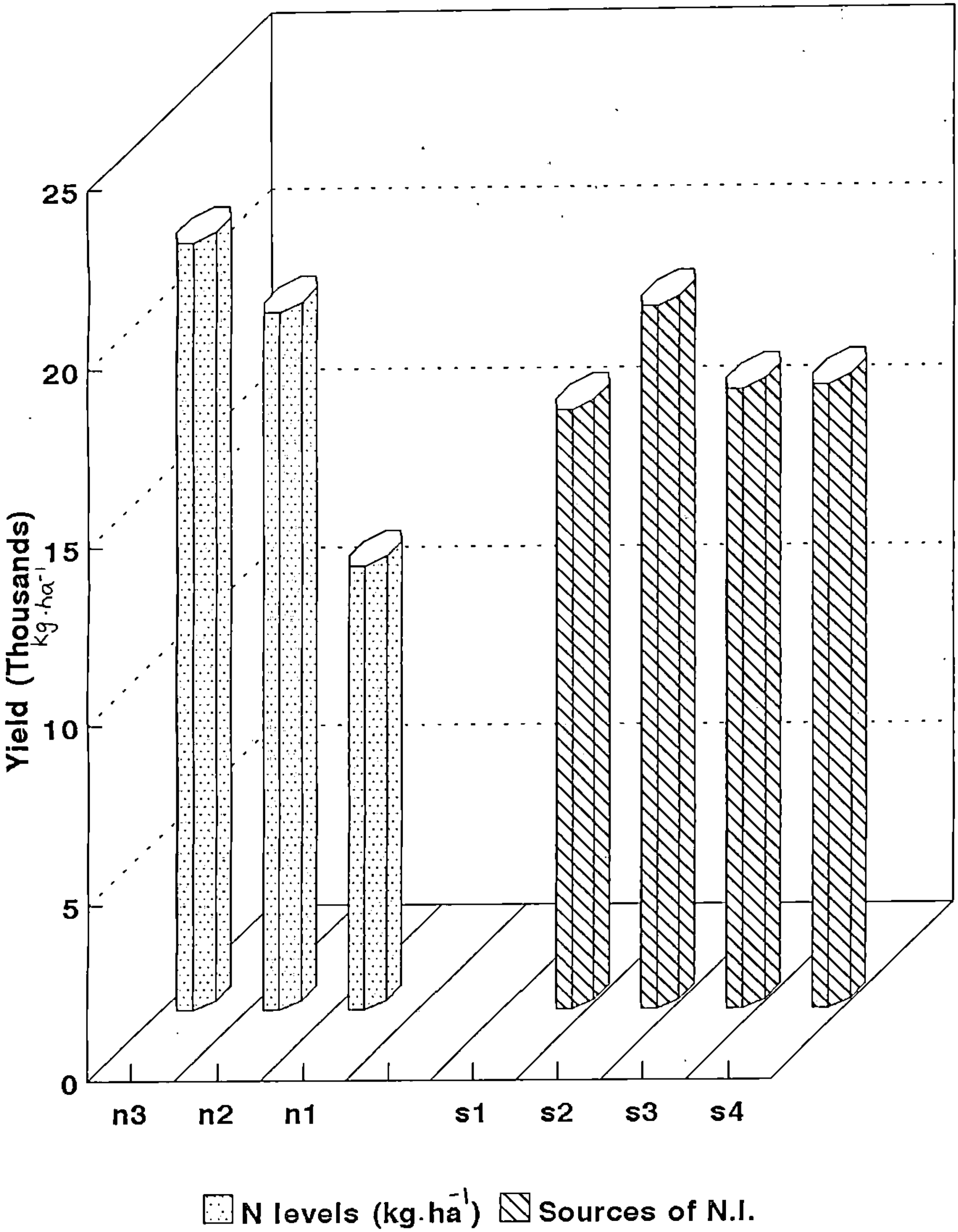

Fig. 9. Effect of different treatments on yield of brinjal

(1979), Srinivas and Prabhakar (1982), and Narasappa et al. (1985). The n_2 (56.25 kg N ha^{-1}) level also significantly increased the fruit yield over n_1 (37.50 kg N ha^{-1}) level. At the lowest level of N, fruit yield was considerably reduced due to lower rate of flower production, fruit set and reduced values of other yield attributes. The yield response per kg of N applied was found to be 378 kg in n_2 and 241 kg in n_3. The physical and economic optimum dose of N was worked out to be 72.76 and 72.60 kg N ha^{-1}.

The sources of nitrification inhibitors also showed significant variation in the case of yield. Plants treated with neem cake mixed urea (s_2) produced the maximum yield followed by coal tar coated urea (s_4) and neem cake coated urea (s_3) and ordinary prilled urea (s_1) which were on a par with each other. The percentage increase in yield of s_2, s_3 and s_4 in comparison to s_1 are 16.77, 3.22 and 3.87 respectively. The brinjal crop needs a continous supply of nitrogen for prolonged flowering. The ammoniacal N released after urea hydrolysis, undergo the process of nitrification brought about by nitrifying bacteria. The nitrates produced are easily leached away, and this type of leaching loss is more so during the *kharif* season.

Triterpenes, a useful compound in neem cake checks the nitrification process and provides the plants with more N from the same amount of fertilizers as reported by Vasanth (1993). By inhibiting the nitrification process, the absorbable form of N is released very slowly thereby making the nitrate nitrogen available to the crop for a longer period. The plants grown with ~~under~~ ordinary prilled urea, though applied in split dose, might have been quickly converted to nitrate nitrogen, and due to its retention in the soil for a short period, would have been experiencing N deficiency. This deficiency ultimately reduced the crop growth and yield attributes resulting in lower yield. Increased yields of brinjal with the use of nitrification inhibitors is in confdrmity with the results obtained by Muthuswamy et al. (1975) and Subbiah et al. (1979) in ragi; Singh and Singh (19890) in maize, Khandelwal et al. (1977) and Mishra et al. (1991) in wheat and Som et al. (1992) in brinjal.

5.6 Chemical analysis

5.6.1. Nutrient uptake

The different levels of N have significantly influenced the N uptake at 30 DAT, 60DAT and at harvest

(Table 13). Among the levels of N, 75 kg·ha^{-1} N (n_3) level recorded the highest uptake at all stages of crop growth. The increased uptake of N by higher rates of application of the nutrient is a well estblished phenomenon. Similar results were also reported by Joseph (1982) and John (1989) in chillies; and Paulraj and Perumal (1980) in tomato. Among the various sources of nitrifiction inhibitors, neem cake mixed urea recorded the maximum uptake of N at 30DAT and at harvest stage, followed by coal tar coated urea and neem cake coated urea. The neem cake mixed urea due to its better nitrogen use efficiency would have resulted in better utilization of applied nitrogen by the crop. The nitrification rate might have been reduced by the chemicals in neem cake, making continued availability of N throughout the growth stages, and this might have resulted in better uptake by the crop. The results are in confirmity with the findings of Sathianathan (1982) and Vinod (1988) in cassava, Prasad et al. (1986), Singh and Singh (1989), and Ahmed and Baroova (1992) in wheat.

The P and K uptake were not influenced by N level or by the nitrification inhibitors (Tables 14 & 15).

Conflicting results were reported about the response of nitrification inhibition by mixing and coating of neem cake.

In the present study, the mixing of neem cake with urea resulted in better availability of N than coating.

5.6.2 Soil analysis after the experiment

The data on available nutrient status of the soil after the experiment presented in Table 16, revealed that the available nitrogen, phosphorus and potassium content in the soil was not altered by levels of N or nitrification inhibitors. Similar trend in nutrient status was reported by Mathew (1987) in paddy with the use of slow release sources of nitrogen and Vinod (1988) in cassava.

5.6.3 Nitrogen status of the soil at periodic intervals

The results presented in Table 17 revealed the effect of different N levels and sources of nitrification inhibitors on available nitrogen content of the soils in kg. ha^{-1} at 15 days interval. The different N levels did not show any significant influence on the nitrogen status of the soil at periodic intervals. The available N content of the soil is reduced in accordance with the crop growth. In general, the maximum depletion of soil N was noticed between 15-30 DAT. However, the difference in the soil N status due to different treatments on a particular stage was not noticed.

5.7. Economic analysis

The partial budgeting of different levels of N and sources of nitrification inhibitors on brinjal is presented in Table 18. Partial budgeting method is preferred in this study than the usual benefit-cost ratio, since benefit cost is commonly used in the analysis of perennial crops where discounting of cost and benefit is done. The data clearly revealed that the n_3 (75 kg. N ha^{-1}) level of N gave the highest return per rupee of 1.73. Among the different sources of nitrification inhibitors tried, Rs. 1.60 were obtained by spending a rupee in neem cake mixed urea. Hence it can be concluded that treating urea with nitrification inhibitors is economically beneficial. Mixing of neem cake at n_2 level of N is comparable to using urea alone at n_3 level.

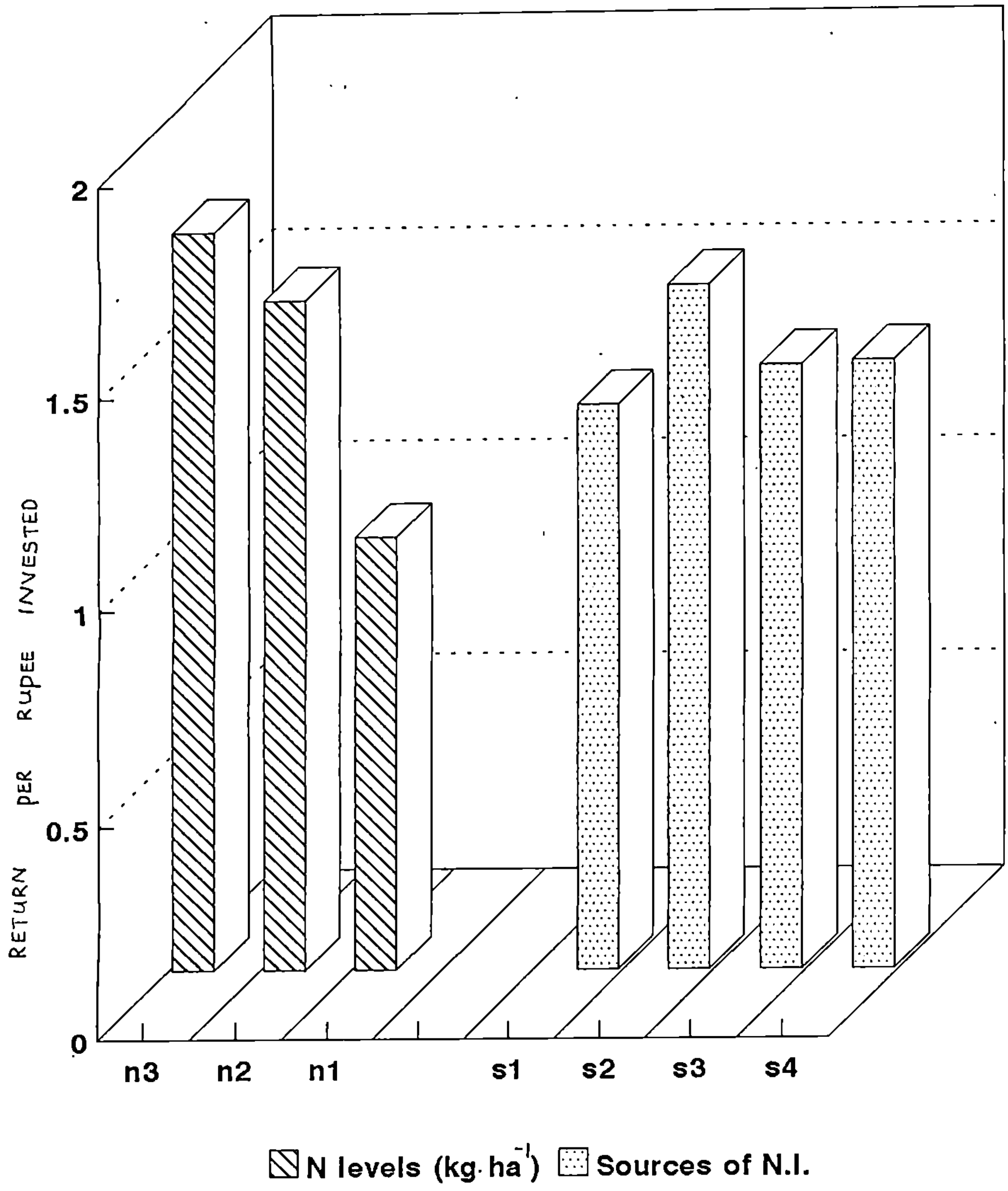

Fig. 10. Partial budgetting of levels of N and sources of nitrification inhibitors in brinjal

SUMMARY

SUMMARY

An investigation was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during *kharif* season of 1993 to evaluate the effect of different N levels and nitrification inhibitors on the growth and yield of brinjal. The experiment was laid out in as factorial one in randomised block design with three replications. The treatments consisted of combination of three levels of nitrogen viz. n_3-100 per cent of the recommended dose (75 kg. N ha^{-1}) n_2 - 75 per cent of the recommended dose (56.25 kg. N ha^{-1}) n_1 - 50 per cent of the recommended dose (37.50 kg. N ha^{-1}) and the four nitrification inhibitors viz., s_1-ordinary prilled urea, s_2-neem cake mixed urea, s_3-neem cake coated urea and s_4-coal tar coated urea. The important results of the study are summarised below.

1. Plant height was significantly influenced by different nitrogen levels and source of nitrification inhibitors. Maximum height was seen at n_3 level of nitrogen which was markedly higher than n_2 and n_1. The sources of nitrification inhibitors viz. s_2, s_3 and s_4 recorded better plant height than s_1.

2. Branches per plant also differed significantly by the different treatments. 100 per cent of the recommended dose of N and neem cake mixed urea showed maximum number of branches per plant.

3. The increasing levels of nitrogen showed its superiority in the case of number of leaves per plant also. The source of nitrification inhibitor through neem cake mixed urea alone showed its superiority over the other sources tried.

4. LAI was significantly influenced by the N levels alone and n_3 recorded the maximum values.

5. The RGR differed only during 60-90 DAT with higher values of n_3 levels of N. The RGR was not influenced by different sources of nitrification inhibitors or its interaction with N levels.

6. The DMP was linearly increased with an increase in N levels. The neem cake mixed urea also showed its superiority in DMP over other sources of nitrification inhibitors tried, at 30 DAT at harvest.

7. The time of attaining 50% flowering stage was not influenced by the treatments.

8. Number of flowers and fruits per were appreciably influenced by the different N levels and sources of nitrification inhibitors. Nitrogen at 75 $kg{\cdot}ha^{-1}$ and neem cake mixed urea recorded the maximum production of flowers and fruits per plant and fruit set in brinjal.

9. Fruit characters viz. length, girth, volume and weight of fruits was also favourably influenced by different N levels. The n_3 level of N significantly increased all the fruit characters as compared to n_2 and n_1. Neem cake mixed urea, neem cake coated urea and coal tar urea also improved the fruit characters viz., girth and weight of fruits over ordinary prilled urea.

10. The fruit yield was remarkably increased by an increase in N levels. The n_3 level increased the fruit yield to a tune of 9.99 and 72.50 percentage over n_2 and n_1. The physical and economic optimum for N levels was worked out as 72.77, and 72.60 $kg{\cdot}ha^{-1}$ of N respectively. Among the different sources of nitrification inhibitors, neem cake

mixed urea alone gave a significant increase in fruit yield.

11. Different levels of N alone showed significant variation in the case of harvest index.

12. The N uptake of the crop markedly varied due to the levels of N and sources of nitrification inhibitors. Better uptake was noticed at n_3 level of N and s_2 source of nitrification inhibitor.

13. The P and K uptake was not influenced by the N level or the sources of nitrification inhibitors.

14. The N status of the soil decreased with the plant growth from 15 DAT onwards, to the harvesting stage. The levels of N and the sources of nitrification inhibitors didnot influence the final N status in the soil.

15. The partial budgeting of levels of N and sources of nitrification inhibitors revealed that return per rupee invested on N level was 1.73, 1.51, 1.01 in n_3, n_2 and n_1 levels respectively. Similarly a return per rupee of

1.60, 1.42, 1.41 and 1.32 was obtained in s_2, s_4, s_3 and s_1 sources of nitrification inhibitors.

The present study revealed that 75 per cent of the recommended dose of nitrogen i.e., 56.25 kg. N ha^{-1} mixed with neem cake is optimum for the growth and yield of brinjal.

Future line of work

1. The nitrogen use efficiency is low in the case of upland crops, and the possibilities of enhancing the nitrogen use efficiency with other locally available nitrification inhibitors may be tried.

2. In the present study, the crop responded upto the highest level of nitrogen tested. Hence, it may be imperative if the response of higher levels of N are also studied.

3. More elaborate study on the liberation of nitrate nitrogen and losses of N may be studied.

REFERENCES

REFERENCES

Abraham, C., Sadanandan, N. and Sasidhar, V.K. (1975). Study on the comparative performance of urea and neem coated urea on the yield and yield attributes of rice variety Thriveni. Agric. Res. J. Kerala. 13(2): 136-140.

Ahmed, A.A. and Baroova, S.R. (1992). Efficiency of nitrogen sources in rice (Oryza sativa) and their residual effect on wheat (Tritium aêstium). Indian J. Agron 37(1): 55-59.

Anilakumar, K. and Rajaram, K.P. (1993). Effect of urea forms on ammonia volatilization recovery and yield of lowland rice in sandy laterite soils. J. of Tropical ag. 31(1): 53-59.

Annual Report (1971-72). All India Co-ordinated Agronomic Experiment Scheme, Mincoi p. 23.

Awasthe, R.K. and Mishra, B. (1987). Yield and N uptake by rice relation to nitrogen release from modified urea materials in a submerged soil. J. Indian soc. soil Sci. 35(1): 52-57.

Bains, S.S., Prasad, R. and Bhatia, P.C. (1971). Use of indigenous materials to enhance the efficiency of fertilizer nitrogen for rice. Fertl. News. 16(3): 30-33.

Bhagat, R.M. and Verma, T.S. (1989). Possible utilization of cutch as an inhibitor of nitrification Crop. Res. 2(2) 226-229.

Bhatia, B.K., Vinod kumar and Dahiya, S.S. (1985). Effect of methods of urea application with farm yard manure and neem cake on wheat yield and nitrogen uptake. Indian J. Agron. 30 (2): 150-153.

Black, C.A. (1973). Soil plant relationship (2nd ed.) Wilely Eastern Pvt. Ltd. New Delhi. pp. [illegible].

Blackmann, V.H. (1919). The compound interest law and plant growth. Ann. Bot. 88: 353-360

Chougule, A.B. and Mahajan, P.R. (1979). Effect of varying levels of plant population, nitrogen, phosphorus and potash on growth and yield of chilli (Capsicum annuum. L.) Veg. Sci. 6(2): 73-80.

De, G.C., Das, S. and Pal, D. (1992). Efficiency of neem extract coated urea on transplanted summer rice. Indian J. Agron. 37(1): 163-165.

Dod, V.N., Joshi, A.T., Kale, P.B. and Kulwal, L.V. (1992). Effect of different levels of nitrogen in split doses on yield and quality of red ripe chilli (Capsicum annuum. L.) cv. G-3 P K V Res. J. 16(1): 96-97.

Donald, C.M. (1962). In search of yield. J. Aust. Inst. Agr. Sci. 28: 171-178.

Geethalakshmi, V. and Palaniappan, S.P. (1992). Influence of indigenous nitrification inhibitors and levels of N on dry matter production, nitrogen uptake and nitrogen recovery by cotton. J. Indian Soc. Soil Sci. 40(2) 380-382.

Ghani, P., Copeswar Sounda., Soma, M.G., Patra, A.P. and Jena, P.K. (1982). Effect of different levels of nitrogen, phosphorus and spacing on fruit yield of brinjal. O. J. Hort. 10 (1): 24-27.

Gomez, A. Kwanchai and Gomez, A. Arturo (1984). Statistical procedures for agricultural Research (2nd ed.) John Wiley & sons, Inc. pp. 139-154.

Goring, C.A.I. (1962). Control of nitrofication by 2-chloro-6 (trichloromethyl) pyridine. Soil Sci. 92 431-439.

Govindaswamy, K.N. and Kaliyappa, C. (1986). Effect of modified ureae on lowland rice. Madras Agric. J. 73(1): 17-22.

Gupta, A. (1987). Response of sweet pepper to irrigation and nitrogen fertilization. Veg. Sci. 14(1): 98-100.

Gupta, A., Shukla, V., Srinivas, K. and Rao, J.V. (1978). Response of brinjal (Solanum melongena L.) to nitrogen, phosphorus and potassium fertilizer with different plant spacings. Indian J. Hort. 35 (4): 352-358.

Hughes, T.D. and Welch, L.F. (1970). 2-chloro-6 (trichloromethyl) pyridine as nitrification inhibitor for anhydrous ammonia applied in different seasons. Agron J. 62: 821-824.

Hulagur, B.F. and Shinde, J.E. (1981). Evaluation of non-edible oil cakes on the uptake of urea nitrogen by low land rice crop. Madras Agric J. 68(1): 36-42.

Jackson, M.L. (1973). Soil chemical analysis (2nd ed.) Prentice Hall of India (pvt.) Ltd. New Delhi. pp. 1-498.

Jain, S.C., Katty, G.V., Jain, N.K. and Iyer, R.J. (1982). Efficacy of blended urea in upland cotton under different nutrient levels and field conditions. J. Indian Soc. Soil Sci. 30(2): 224-226.

Jeyaraman, S. and Balasubramaniam, R. (1991). Effect of different levels of potassium and nitrogen on yield of irrigated chilli. Madras Agric J. 78(9-12) 519-520.

Johl, S.S. and Kapur, T.R. (1981). Fundamental of Farm Business management. Kalyani publishers, New Delhi, pp. 467.

John, S.C. (1989). Nutrient management in vegetable chilli (Capsicum annuum L.) var. Jwala sakhi. Thesis submitted to Kerala Agricultural University, Vellanikkara for M.Sc. (Ag.) degree (Unpublished).

Joseph, P.A. (1982). Effect of nitrogen, phosphorus and potash on the growth and yield of chilli variety plant C-I. Thesis submitted to Kerala Agricultural University Vellanikkara for M.Sc. (Ag.) degree (Unpublished).

Joseph, P.A. and Pillai, B. (1985). Effect of N, P and K in the growth and yield of chilli variety plant C-1. Agric. Res. J. Kerala. 23(1): 15-82.

Joshi, P.K. and Nankar, J.T. (1992). Effect of nitrogen and irrigation on growth and yield of potato (Solanum tuberosum. L.). Research Bulletin Marathwada Agrl. Univ. 16 (2): 1-4.

KAU, Research Report (1980-81). Studies on the effect of different levels of NPK on the yield of brinjal. pp. 158.

KAU, Research Report (1981-82a). Increasing nitrogen use efficiency in low land rice p: 5

KAU, Research Report (1981-82b). Non edible oil cakes in increasing nitrogen use efficiency of rice. p. 5.

KAU, Research Report (1981-82c). Effect of coal tar treated urea in low land rice p : 5

KAU, Research Report (1984-85). Increasing fertilizer N efficiency in rice. pp. 57-58.

KAU, Research Report (1986-87a). Studies on the effect of graded doses of NPK on the yield and other agronomic characters of chillies, 219-220.

KAU, Research Report (1986-87b). Studies on effect of different levels of NPK on yield of brinjal. p: 219

KAU, Research Report (1987-90). Nutrient management in vegetable chilli (Capsicum annum) var. Jwala Sakhi. pp. 80-81.

KAU, Research Report (1990-91). Effect of different levels of NPK on the yield of brinjal in the uplands of kuttanadu: p. 30.

KAU, Research Report (1991-92). Foliar fertilization in tomato. p. 29.

Ketkar, C.M. (1976). Utilization of neem (Azhadirachta indica Juss) and its by-products. Final technical report., Khadi and Village Industries Commission, Bombay. p. 290.

Khan, I. and Mishra, R.S. (1976). Effect of nitrogen phosphorus and potash on the growth and yield of tomato (Lycopersion esculentum mill) var. Sioux. Prog. Hort. 7(4): 45-52.

Khandelwal, K.C., Singh, D.P. and Kapoor, k.P. (1977). Mineralisation of urea treated with neem extract and response of wheat. Indian J. Agric Sci. 47(6): 267-270.

Kooner, K.S. and Randhawa, K.S. (1983). Effect of different levels and sources of nitrogen on growth and yield of tomato. Punjab Agri. Uni. J. Res. 20(3) 255-260.

Korah, P.A. and Shingte, P.K. (1988). The mineralisation of nitrogen from non-edible oil cakes in medium black calcareous and lateritic soils. Agric. Res. J. Kerala. 22(2): 215-227.

Kuksal, R.P., Singh, R.D. and Yadàv, J.P. (1977). Effect of different levels of nitrogen and phosphorus in fruit and seed yield of tomato variety Chaubattia-red. Prog.Hort. 9(2): 13-20.

Lal, S. and Singh, D.N. (1976). Response of hybrid brinjal to N fertilization. Indian J. Hort. 33(3&4): 258-261.

Manchanda, A.K. and ~~Bhopa~~l Singh, B. (1988). Effect of plant density and nitrogen on growth and fruit yield of bell pepper (Capsicum annuum. L.) Indian J. Agron. 33(4): 445-447.

Mandal, N.N. and Arora, P.N. (1978). Effect of nitrogen spacing and planting material on the yield of potato. Veg. Sci. v(2): 72-78.

Manickam, T.S., Augustine Selvaseelan, D. and Krishnamoorthy, K.K. (1976). Nitrification of úrea treated with nitrification inhibitors coated fertilizers and slow acting fertilizers in soils. Fert. News. 21(9): 64-66.

Mary, S.S. and Balakrishnan, R. (1990). Effect of irrigation, nitrogen and potassium on pod characters and quality in chilli (Capsium annuum. L.) cv. K-2. South Ind. Hort. 38(2): 86-89.

Mathew, B.P. (1981). Fate and efficiency of urea based fertilizer N for rice. Thesis submitted to Kerala Agricultural Universtiy for M.Sc. (Ag.) degree Vellanikkara, (Unpublished).

Mishra, K.C. and Chonkar, P.K. (1978). Possible utilization of neem cake for inhibiting nitrification in soil. J. Indian Soc. Soil Sci. 26(1): 90-92.

Mishra, S.S., Singh, S.J., Gogoi, A.K. and Sinha, K.K. (1991) Nitrogen use efficiency as influenced by nitrogen and weed management in rice-wheat sequence. Indian J. Agron. 36 (3): 308-312

Muthuswamy, P., Raju, G.S.N. and Krishnamoorthy, K. (1975). Mineralization of urea coated with nitrification inhibitors. J. Ind. Soc. Soil Sci. 23 (3): 332-335.

Muthuswamy, P., Raju, G.S.N. and Krishnamoorthy, K. (1977). Effect of nitrification inhibitors on the mineralization of urea in soil. Madras Agric. J. 63(5):290-292.

Narasappa, K., Nagabhushanam Reddy, E. and Parthasarathy Reddy, V. (1985). Effect of nitrogen fertilization on chilli (Capsium annuum. L.) cv. Sindhur. South Ind. Hort. 33(3): 158-163.

Natarajan, S. (1990). Standardisation of nitrogen application for chilli (Capsium annuum. L.) grown under semidry condition South Ind. Hort. 38(6): 315-318.

Oommen, M., Sadanandan, N., Mohammed Kunju, U. and Sasidhar, V.K. (1977). Effect of slow release nitrogenous sources on growth and yield of rice variety Jaya. Agric. Res. J. Kerala 15(1): 24-28.

Pandey, J. and Singh, R.P. (1987). Effect of urea, slow release fertilizers and nitrificatin inhibitors on the yield of rainfed lowland rice. Indian J. Agron. 32 (4): 303-305.

Paramasivam, P. (1991). Comparative mineralisation effect of slow release fertilizers insoils of Cholavandan basin tract. Madras Agric. J. 78 (5-8): 156-160.

*Parashar, K.S., Prasad, R., Sharma, R.P., Sharma, S.N. and Singh, S. (1980). Efficiency of urea, nitrification treated urea and slow release nitrogen fertilizer for sugarcane. Z. Pflazen Bottenkd. 143: 262-267.

Patil, N.D. (1972). Neem oil as nitrification inhibitor. Fertl. News. 17(9): 37-39.

Paulraj and Perumal. R. (1980). Effect of sources and split application of N on nutrient uptake by tomato. Madras Agric. J. 67(2): 106-108.

Pillai, K.G. (1981). Agronomic practices to improve the N-use efficiency of rice. Fertl. News. 26(2): 3-9.

Pillai, A.A.O., Irrulappan, I., Doraipandian, A. and Jayapal, R. (1977). Response of chillies to nitrogen. Fertl. News. 22(7): 22-24.

Prasad, R. (1979). Increasing fertilizer nitrogen efficiency with slow release fertilizer and nitrification inhibitors Fertl. News. 24(9): 25-33.

Prasad, R. (1990). "Fertilizer use efficiency". In "Agronomic Research Towards sustainablle Agriculture" Singh, K.N. and Singh, R.P. (eds.) Published by Indian Society at Agronomy, New Delhi pp 57-69

*Prasad, R., Sharma, S.N., Prasad, M. and Reddy, R.N.S. (1981). Efficient utilization of nitrogen in rice-wheat rotation. Proc. Symp. Crop management to meet the new challenges. Indian society of Agronomy, Natl. Symp. Hissar. pp. 34-43.

Prasad, B., Prasad, R. and Prasad, J. (1986). Evaluation of nitrification retardation property of non-edible oils and their influence on yield and N uptake by wheat in calcareous soil J. Indian Soc. Soil Sci. 34(2): 281-285.

Prasad, R., Prasad, B. and Prasad, J. (1989). Effect of some nonedible oils on retardation of nitrification, yield and nitrogen uptake by rice (Oryza sativa) in calcareours soil. Indian J. Agric. Sci. 59(4): 291-294.

Rajagopalan, S. and Subramaniam, M. (1989). Efficiency of different nitrogen fertilizers on rice Madras Agric. J. 76(12): 703-704.

Rajkumar, S. and Sekhar, G.S. (1981). Nitrification inhibitors for low land rice. Fertl. News. 26(11): 34-38.

Ram, M.B.N., Chatterjee, R.L. Yadav. and Singh, D.V. (1987). Effect of different nitrogen carries on growth, accumulation pattern and yield of essential oil in Japanese mint. Indian J. Agron. 32(4): 417-424.

Ram, M.B.N., Patra, D.D., Subrahmanyan, K. and Singh, D.V. (1993). Nitrification inhibitory properties in mentha spent and pyrethrum flowers. J. Ind. Soc. Soil Sci. 41(1): 176-177.

Ramachandran, S. and Subbiah, K.K. (1982). Effect of plant density and graded levels of nitrogen on growth attributes of chillies. South Ind. Hort. 30(2): 266-268.

Ramakrishna Praseeda, H.S. and Sulladmath, U.V. (1979). Effect of NPK on yield and yield components of Hybrid Tomato 'Karnataka' Mysore J. Agric. Sci. 13: 271-274.

Randhawa, K.S., Nandpuri, K.S. and Daljit Singh. (1977). The effect of N, P and K fertilization on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) cultivars. Veg. Sci. 4(1): 61-65.

*Rao, V. and Badiger, M.K. (1977). Nitrogen in soils and crops of Karnataka. UAS monograph series, No. 3.

Rao, E.H. and Lal, G. (1986). Response of chilli (Capsium annuum. L.). Variety pant C-1 to varying levels of nitrogen and spacing. Veg. Sci. 13(1): 17-21.

Reddy, R.N.S. and Prasad, R.C. (1975). Studies on the nitrification inhibitors treated urea in soil J. Ind. Soc. Soil Sci. 26(2): 304-312.

Reddy, M.N. and Shinde, J.E. (1981). Neem cake blended urea for efficient use of fertiliser nitrogen by flooded rice under poor water management. Fert. News. 26(2): 21.

Russel, E.W. (1973). Soil conditions and plant growth (10th edn.) Longman group limited London. pp. 573.

Sahrawat, K.L. (1982). Comparative evaluation of karanjin and extracts of karanjin and extracts of karanja (Pongamia glabra) and neem (Azadiracta indica L.). Seeds for retardation of nitrification of urea in soil. J. Ind. Soc. Soil Sci. 30(2): 156-160.

Santhi, S.R., Palaniappan, S.P. and Purushothaman, D. (1986). Influence of neem leaf on nitrification in a low land rice soil. Pl. [illegible] Soil. 93(1): 133-135.

Sarkar, A. (1986). Studies on nitrogen sources in jute Indian J. Agron. 32 (2): 148-150.

Sarkunnan, V. and Biddappa, C.C. (1981). Effect of neem cake blended urea on the exchangeable ammonia and yield and uptake of nitrogen by low land rice. Mysore J. agric. Sci. 15(4): 540-543.

Sathianathan, K.M. (1982). Increasing nitrogen use efficiency in upland soils. Thesis submitted to the Kerala Agricultural University, Vellanikkara for M.Sc. (Ag.) degree (Unpublished).

Satyanarayana, V. and Arora, P.N. (1984). Effect of N and K on yield and yield attributes of potato (var. kufri Bahar). Indian J. Agron. 30(3): 292-295.

*Seshadri, V. (1976). Effect of rates and sources of nitrogen on growth, nitrogen uptake and yield of cotton. Thesis submitted to the IARI, New Delhi for M.Sc. (Ag.) degree. (Unpublished).

Shanker, H., Babu Ram and Rathi, K.S. (1976). Effect of neem cake blended urea on the yield and uptake of nutrients by rice grown under transplanted and direct sown conditions. J. Indian Soc. Soil Sci. 24(2): 211-213.

Sharma, S.N. and Prasad, R. (1980). Relative efficiency of urea, nitrification inhibitor treated urea and sulphur coated urea for rice. Indian J. Agron. 25(3): 403-409.

Sharma, R.C., Grewal, J.S., Sharma, A.K. and Sharma, H.C. (1980). Relative efficiency of CAN, dimethyl urea, urea and urea mixed with neem cake for potato. Indian J. Agric. Sci. 50 (2): 152-157.

Singh, I.J. (1977). Elements of Farm Management Economics (2nd edn.). East West Press Private Limited pp: 68-83

Singh, B. and Sandhu Awasthi, O.P. (1985). Response of tomato cultivars to nitrogen fertilization under mid hills of Himachal Pradesh. Veg. Sci. 12(2): 64-68.

Singh, K. and Sandhu, D.S. (1970). Effect of soil and foliar application of nitrogen on the vegetative growth and yield of brinjal (Solanum melongena. L.) Punjab Hort. J. 10(1&2): 103-110.

Singh, R.D. and Sharma, N.N. (1991). Study on the effect of blending urea with neem and karanj cake on nitrogen use efficiency in wheat. Soils and Fert. 54(7): 1041.

Singh, M. and Singh, T.A. (1986). Leaching losses of nitrogen from urea as affected by application of neem cake. J. Ind. Soc. Soil Sci. 34: 767-773.

Singh, M. and Singh, T.A. (1989a). Effect of neem cake on leaching loss of nitrogen, grain yield and efficiency use of nitrogen in maize in a molisol. Fertl. News. 34(7): 39-45.

Singh, M. and Singh, T.A. (1989b). Comparision of neem (Azadirachta indica) oil coated urea with some other coated urea fertilizers on an alkaline calcareous soil. J. Indian Soc. Soil Sci. 37(2): 314-318.

Singh, D. and Virk, J.S. (1987). Neem cake blended urea for efficient use of nitrogen in cotton. J. Res. Punjab Agric Univ. 24(3): 382-387.

Singh, R.P. and Singh, P.P. and Nair, K.P.P. (1988). Utility studies on controlled release of N fertilizers and nitrification inhibitors in maize grain yield, quality and soil N status. India J. Agron. 33(2): 143-146.

Singh, R.P., Singh, P.P. and Nair, K.P.P. (1991). Studies on controlled release of N fertilizer and nitrification inhibitors. Indian J. Agrl. Res. 25(2): 59-63.

Sivaraj, A. and Iruthayaraj. M.R. (1980). Effect of nitrogen inhibitors under different levels and time of application on seed cotton yield. Madras Agric. J. 67(12): 807-810.

Som, M.G., Hashim., Mandal, A.K. and Maity, T.K. (1992). Influence of organic manures on growth and yield of brinjal (Solanum melongena . L). Crop. Res. 5(1): 80-84.

Srinivas, K. and Prabhakar, B.S. (1982). Response of capsicum to nitrogen fertilization. Veg. Sci. 9(2): 71-74.

Subbiah, B.V. and Asija, G.L. (1956). A rapid proccedure for the estimation of available nitrogen in soils. Curr. Sci. 25 (8): 259-260.

Subbiah, S., Ramanathan, K.M., Honora, J. Francis. and Kothandaraman, G.V. (1979). Effect of neem cake blended urea application on the yield and nutrient uptake of rice (IR-20). Madras Agric. J. 66(12): 789-793.

Subbiah, K., Sundarajan, S. and Muthuswami, S. (1983). Effect of varying levels of organic and inorganic fertilizers in the yield and nutrient uptake in brinjal. South Ind. Hort. 31(6): 287.

Subramanian, K.S., Selvaraj, K.V. and Selvakumari, G.C. (1993). Influence of moisture regimes and nitrogen on growth and yield of brinjal (Solanum melongena. L.). South Ind. Hort. 41 (1): 16-21.

Tandon, H.L.S. (1989). Nitrogen recommendation for higher fertilizer efficieny. Fertl. News. 34(12): 63-71.

Thomas, J. and Prasad, R. (1982). Studies on mineralisation of neem and sulphur coated and N-serve treated urea. Fertl.News. 27(10): 30-44.

Tisdale, S.L., Nelson, Wl. and Beaton, J.D. (1985). Soil fertility and fertilizers (4th edn). Macmillan Publishing Co. New York. pp. 735.

Tiwari. A. (1989). Effect of neem cake blending of urea on ammoniacal nitrate content in vertisol. J. Indian Soc. Soil Sci. 37 (4): 830-831.

Vadivel, E., Balasubramanian, S. and Kannan Bapu, J.R. (1988). A note on nitrogen fertilization and spacing for brinjal. South. Ind. Hort. 36(4): 203-204.

Vanangamudi, K. Subramanian, K.S. and Bhaskaran, M. (1990). Influence of irrigation and nitrogen on the yield and quality of chilli fruit and seed. Seed Res. 18(2): 114-116.

Varis, S. and George, A.T. (1985). The influence of mineral nutrition on fruit yield, seed yield and quality in tomato. Hort. Sci. 60(2): 373-376.

Vasanth, K. Thimakapura. (1993). Rediscovering neem. Sci. Rep. 30(4): 9-12.

Vijayachandran, P.K. and Devi, P.N. (1982). A comparative study of different forms of urea under heavy rainfall conditions for paddy. Fertl. News 27(8): 36-38.

Vinod, G.S. (1988). Slow release nitrogen in cassava nutrition. Thesis submitted to the Kerala Agricultural University, Vellanikkara for M.Sc. (Ag.) degree (unpublished).

Vyas, B.N. Godrej, N.B. and Mistry, K.B. (1991). Development and evaluation of neem extract as coating for urea fertilizer. Fertl. News. 36(2): 19-25.

*Wali, P. and Totawat, K.L. (1992). The effect of neem cake coated urea on the morphological characters, yield attributes and yield of maize (Zea mays. L.) Intern J. Trop. Agric. 10(3): 186-191.

Williams, R.F. (1946). THe physiology of plant growth with special reference to the concept of net assimilation rate. Ann. Bot. 10: 41-72.

Yadav, R.L. (1984). Efficient use of nitrogen fertilizer in medical and aromatic plants Fertl. News 29(11); 18-25.

*Yadav. M.D. and Singh, K.D.N. (1991). Transformations of applied nitrogen in relation to its availability to sugarcane in calcareous soil. J. Indian Soc. Soil Sci. 39(2): 292-297.

* Originals not seen

APPENDIX

Appendix I

Weather data during the cropping period

Standard week	Maximum (°C) Temperature	Minimum (°C) Temperature	Relative humidity %	Rainfal (mm)	Evaporation (mm)
17	33.2	25.1	87.80	0.90	5.0
18	33.3	25.8	90.70	0.00	4.3
19	32.9	25.9	86.70	7.30	4.1
20	32.2	25.0	78.75	0.20	4.4
21	31.6	24.0	83.70	10.60	3.8
22	30.3	24.1	85.10	17.30	2.9
23	28.7	23.2	87.55	29.60	2.8
24	30.0	24.2	85.70	5.90	2.8
25	30.5	25.1	84.15	4.10	3.9
26	29.8	23.7	88.20	13.30	2.9
27	28.9	22.6	90.07	19.00	2.6
28	29.4	22.6	85.57	3.40	2.9
29	28.6	23.0	87.42	4.50	3.2
30	28.4	23.1	86.84	3.00	3.1
31	29.1	23.1	85.35	2.40	3.9
32	29.4	24.1	84.75	0.00	3.7
33	28.8	23.8	80.70	0.17	4.0
34	30.0	23.6	92.00	0.71	4.0
35	25.4	23.4	84.20	2.42	3.8
36	29.8	23.1	82.70	0.00	4.0
37	31.2	24.1	79.30	0.00	4.3
38	30.7	24.0	79.90	4.80	4.0
39	30.3	23.3	83.40	6.40	3.8

ECONOMISING NITROGEN IN BRINJAL (*Solanum melongena* L.) USING NITRIFICATION INHIBITORS

By

DURGA. T. B.Sc. (Ag.)

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 AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1994

ABSTRACT

An experiment was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani during *kharif* 1993 to find out the possibilities of economising the use of nitrogen for brinjal utilizing nitrification inhibitors. The different treatments tried involved the combinations of three levels of nitrogen viz, 75 kg. N ha^{-1} (n3), 56.25 kg.N ha^{-1} (n2) and 37.50 kg.N ha^{-1} (n1) and four sources of nitrification inhibitors viz., ordinary prilled urea (s_1), neem cake mixed urea (s_2), neem cake coated urea (s_3) and coal tar coated urea (s_4).

The experiment was conducted as a factorial randomised block design with three replications. The results of the study revealed that levels of nitrogen exerted a profound influence on all the growth characters, yield attributes and uptake of nitrogen by the crop. With increasing levels of nitrogen from 37.50 to 75 kg. ha^{-1} the height of the plant, number of branches per plant, number of leaves per plant, LAI, RGR, DMP, number of flowers and fruits per plant, fruit characters viz., length, girth, volume and weight of fruits, yield and nitrogen uptake, markedly increased.

Sources of nitrification inhibitors also showed a significant influence on most of the growth characters and yield attributes. Among the sources tried, neem cake mixed urea (s_2) showed its superiority with respect to number of branches and leaves per plant, DMP, number of flowers and fruits per plant, percentage of fruit set and yield. The different sources of nitrification inhibitors did not show any variation in the uptake of nutrients by the crop and also on the available nitrogen status of the soil at different intervals.

The economic analysis through partial budgeting indicated that a return of 1.73 per rupee invested was obtained by using 75 kg.N ha^{-1}, and 1.57 and 1.01 by using 56.25 and 37.50 kg.N ha^{-1} respectively. Among the sources of nitrification inhibitors tried, neem cake mixed urea gave a maximum return per rupee of 1.60 followed by coal tar coated urea (1.42), neem cake coated urea (1.41) and ordinary prilled urea (1.32).