EFFECT OF N, K AND TIME OF K APPLICATION ON PLANT AND RATOON CROPS OF SUGARCANE UNDER MOISTURE STRESS CONDITIONS

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THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE FACULTY OF AGRICULTURE

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FEBRUARY 1993

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*This is to certify that the thesis entitled "**EFFECT OF N, K AND TIME OF K APPLICATION ON PLANT AND RATOON CROPS OF SUGARCANE UNDER MOISTURE STRESS CONDITIONS**" submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **AGRICULTURE** of the Andhra Pradesh Agricultural University, Hyderabad is a record of the bonafied research work carried out by **Sri D.V.NARAYANA RAJU** under my guidence and supervision. The subject of the thesis has been approved by student's Advisory committee.*

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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LIST OF ABBREVIATIONS AND SYMBOLS

N	=	Nitrogen
P	=	Phosphorus
K	=	Potassium
DAP	=	Days After Panting
DAR	=	Days After Ratooning
EC	=	Electrical Conductivity
LAI	=	Leaf Area Index
MSP	=	Millable Stalk Population
LMC	=	Length of Millable Cane(s)
mm	=	Millimetre(s)
cm	=	Centimetre(s)
M^2	=	Square metre(s)
g	=	Gram(s)
Kg	=	Kilogram(s)
@	=	At the rate of
Kg ha^{-1}	=	Kilogram(s) per hectare
t ha^{-1}	=	Tonnes per hectare
%	=	Per cent
r	=	Replications
n	=	Number of plots
S.Ed	=	Standard error difference
CD	=	Critical Difference
*	=	Significant at P = 0.05 level

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(D.V.NARAYANA RAJU)

DECLARATION

I, ***D.V.NARAYANA RAJU*** *hereby declare that the thesis entitled* ***"EFFECT OF N, K AND TIME OF K APPLICATION ON PLANT AND RATOON CROPS OF SUGARCANE UNDER MOISTURE STRESS CONDITIONS"*** *submitted to Andhra Pradesh Agricultural University, Hyderabad for the degree of Doctor of Philosophy in Agriculture is the result of original research work done by me. I also declare that the material contained in the thesis has not been published earlier*

(D.V.NARAYANA RAJU)

ABSTRACT

Author	: **D.V.NARAYANA RAJU**
Title of the thesis	: Effect of N, K and time of K application on plant and ratoon crops of Sugarcane under moisture stress conditions.
Submitted for the award of the degree	: Ph.D.
Faculty	: Agriculture
Discipline	: Agronomy
Major Advisor	: Dr.G.Venkateswara Reddy
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Field experiments were conducted on sugarcane plant crop during 1987-88 and first ratoon crop during 1988-89 in sandy loam soils at Regional Agricultural Research Station, Anakapalle, to study the effect of three levels of N (0, 112 and 224 kg ha^{-1}) in combination with three levels of K (0, 112 and 224 kg K_2O ha^{-1}) and three times of K application (Basal, 60 and 120 days after planting/ratooning) on growth, nutrient uptake, juice quality and yield of cane and sugar.

Shoot population, plant height and leaf area index of plant crop were higher than that of ratoon crop. Plant height of both the crops steeply increased from 120 days to 240 days with a marginal increase subsequently. Leaf area index steadily increased upto 210 days followed by a decline. There was a gradual decline in shoot population from 120 days till harvest in both the crops. All the three characters registered an increase upto 112 kg N ha^{-1} in

plant crop and upto 224 kg N ha^{-1} in ratoon crop. Shoot population and plant height were influenced by early application of K upto 112 kg K_2O ha^{-1} but K had no influence on LAI in both the crops.

With regard to nutrient concentration and their uptake, plant crop had higher per cent of leaf N and its uptake by whole plant; without much difference in sheath K per cent with higher uptake of K by whole plant in plant crop than that of ratoon crop. Increase in N uptake was observed upto 112 kg N ha^{-1} for plant crop and 224 kg N ha^{-1} for ratoon crop. Similar trend was observed with regard to K doses and its uptake. Potassium application increased its concentration in sheaths and uptake in whole plant in both the crops when applied early and had a synergestic effect on uptake of N in whole plnat.

The juice quality (Sucrose and Purity) was superior in ratoon crop than in plant crop. However, the plant crop showed improvement in juice quality upto 112 kg N ha^{-1} and declining effect was observed at 224 kg N ha^{-1}. Potassium application improved the juice quality, while its late application showed the effect more prominently in both the crops.

All the yield influencing stalk characters viz., number, length weight and diameter were higher for plant crop than ratoon crop and beneficial effect of N was observed upto 112 kg ha^{-1} for plant crop and 224 kg ha^{-1} for ratoon crop. Potassium seemed to benefit the weight and diameter of cane under early application, while N improved the stalk number and length. The beneficial role of K on stalk characters was more prominent in ratoon crop. Weight of millable cane was positively correlated with diameter,

while the length of the cane was negatively correlated. Stalk population was positively correlated with length as well as cane weight of plant crop under no K, where as in ratoon crop, it was positively correlated with length under N application and weight with K application.

Plant crop gave higher yield of cane and CCS than ratoon crop in all the treatments and responded upto 112 kg N ha^{-1} followed by a marginal increase in cane yield, with fall in CCS yield at 224 kg N ha^{-1}. Ratoon crop recorded continuous increase in cane and CCS yields upto 224 kg N ha^{-1}. Early application of K at 112 kg K_2O ha^{-1} resulted in improvement in cane and CCS yields of plant and ratoon crops. In line with these trends, response of cane and CCS yields of plant crop to N and K followed quadratic function, while the response of ratoon crop was linear for nitrogen and quadratic for potassium.

The present study on plant and first ratoon crops of sugarcane Var: Co T 8201 gave an insight into the effects of N and K fertiliser application on important growth parameters, nutrient uptake, stalk characters, yield of cane and CCS. Application of 112 kg each of N and K ha^{-1} for plant crop and 224 kg N ha^{-1} with 112 kg K_2O ha^{-1} for ratoon crop; the K can be applied preferably at basal to realise optimum cane and CCS yields from plant and first ratoon crops of this variety.

INTRODUCTION

CHAPTER I

INTRODUCTION

In the agricultural economy of the country, both food and commercial crops have their important contribution. At present the production of food crops is just able to meet the internal requirements of the growing population, whereas the commercial crops has the potentiality of not only meeting the internal requirements but also earns valuable foreign exchange through exports. Among the various crops grown in India, sugarcane has the distinct status of coming under the category of both food as well as commercial crop, being the chief source of sugar and jaggery. In the process of manufacture of sugar from sugarcane, molasses is a valuable byproduct from which alcohol is manufactured and finds wide use in many pharmaceutical and allied industries. Alcohol suitably mixed with petrol is being tried as alternate fuel for automobiles in several countries. Once the country attains the self-sufficiency in the production of sugar and jaggery, export of these commodities holds enormous possibility to earn foreign exchange since many parts of the country are suited to the cultivation of this important crop.

Andhra Pradesh is eminently suited for the cultivation of sugarcane crop. Being one of the largest producers of jaggery in the country, the State is making

rapid strides in the development of sugar industry also. The state produces 115.5 lakh tonnes of sugarcane grown over an area of 1.62 lakh hectares, catering to 33 sugar factories besides a wide spread jaggery industry in thousands of villages. The jaggery market at Anakapalle in Andhra Pradesh is the biggest in South India and second largest in the country.

Sugarcane is cultivated in the State mostly under irrigated conditions though there are some pockets where it is grown purely as a rainfed crop. Even in many irrigated areas, the crop suffers from drought particularly in the formative phase which coincides with hot summer months. This adversely effects the subsequent growth and ultimate yield and quality of the crop. Though this situation is primarily tackled by growing drought tolerant varieties. Other agronomic approaches like soil moisture conservation and use of nutrients like potassium to mitigate the ill effects of drought are also being attempted. While potassium has shown to induce some drought tolerance in crops, the optimum dose and its time of application need to be worked out in detail to derive the full benefit wher ever moisture stress is a problem.

Unlike in other crops, where a single crop is grown from the planted seed material, it is customary all over the

world to take ratoon crops after harvest of plant crop of sugarcane from the same field. In most of the sugarcane growing areas generally one ratoon crop is taken, but in some pockets several ratoons have also being raised successfully. In Andhra Pradesh about 45 to 50 per cent of the total sugarcane area is under ratoons. The chief limitation in growing ratoon crops is that the ratoon is physiologically an inferior unit as compared to plant crop which gives lower cane and sugar yields. Efforts are being made to improve the yields of ratoon crop through application of fertilisers and other cultivation practices like stubble shaving, deep ploughing in inter rows and gapfilling etc. Higher doses of nitrogen and its early application was recommended for ratoon crops to boost the cane and sugar yields. But such information regarding the application of potassium to ratoon crops is limited especially for the recently released varieties of sugarcane.

Sugarcane is valued not only for cane yield but also juice quality. The output of sugar or jaggery per unit area depends on cane yield, juice extraction and the sucrose content of juice. All these attributes are influenced by management and environmental factors, besides the potentiality of the variety. Of the management inputs which profoundly influence the yield and quality of cane, fertiliser application has a key role. Nitrogen and

potassium are the two important nutrients taken by sugarcane crop in high amounts. Nitrogen predominantly influence the growth while potassium has a role in the synthesis and translocation of sugars there by boosting the yields of cane and sugar. A crop of sugarcane (variety Co 419) yielding 120 t ha^{-1} removes 84 kg N and 168 kg K_2O ha^{-1} for plant crop and a ratoon crop yielding 113 t ha^{-1} was found to remove 103 kg N and 223 kg K_2O ha^{-1}. Earlier work with several varieties had indicated the key role of nitrogen in cane production. Optimum level of nitrogen application at the recommended stage of crop growth alone will produce the economic cane and sugar returns, while excessively high doses of nitrogen or its very late application were shown to be not only unproductive but also has a detrimental effect on sugar yields. The recommendations pertaining to nitrogen fertilisation are being widely adopted by farmers. With regard to potassium, data on experimental work on the optimum dose or appropriate time of its application is meagre in both plant and ratoon crops, because the earlier grown sugarcane varieties did not respond to this nutrient. Further the soils had higher potassium status as compared to the present stage. There is every need for a fresh evaluation of the role of potassium with regard to the dose and its time of application, particularly in the recently released cane varieties. The recent steep increase in

fertiliser cost adds a new dimension to the need for research on efficient and economic use of fertilisers for this cost-intensive crop.

Yield in sugarcane is an integrated net effect of stalk characters like their number, length, diameter and weight of the cane. The stalk attributes are primarily of varietal character, but climate as well as management also influence them within certain limits. Mineral nutrition is a dominant agronomic aspect having a role on these attributes and thereby determining the yield. It is necessary to understand as to how and to what extent the nutrition, especially the two important nutrients N and K, affect either positively or negatively, one or more of these stalk attributes, so that a suitable manipulation of fertiliser application can be made to boost the cane yield for a given variety with the ultimate objetive of achieving high economic returns.

Considering the importance of the use of nitrogen and potassium fertilisers in realising the economic yields of cane and sugar, this investigation was taken up on one of the recently released and largely grown sugarcane variety CoT 8201 with the following objectives:

1. To study the performance of plant and ratoon crops when subjected to moisture stress in the formative phase;

2. To assess the response of plant and ratoon crops to different doses of nitrogen and potassium, with the latter being applied at different times;
3. To study the effect of N and K application on growth parameters, uptake of these nutrients in plant, juice quality, important stalk characters and ultimate yield of cane and sugar;
4. To work out the pattern of response functions of cane and sugar yields of plant and ratoon crops for nitrogen and potassium; and
5. To find out the role of mineral nutrition on stalk characters and cane yield by working out suitable simple and multiple correlations.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Sugarcane is a food as well as commercial crop, being the chief source of raw material for the manufacture of pure white sugar and in some areas raw sugar (Khandsari and Jaggery). The cultivation of this crop is mostly confined to the tropical belt of the world and sugar beet is the chief source of sugar in the sub-tropical countries. The growth of the sugarcane crop is favoured by high temperature and relative humidity, bright days with longer duration and adequate soil moisture combined with nutrition. After growth ceases, the accumulation of sucrose in maturity phase is favoured by low minimum temperatures and relative humidity, shorter day length and lower levels of soil moisture. Agronomic practices like fertiliser management and irrigation are adjusted to promote growth or maturity to ultimately derive high cane and sugar production.

2.1 EFFECT OF NITROGEN ON SUGARCANE

Among the nutrients, nitrogen has a profound influence on growth, stalk characters, juice quality and yield of the crop. It has been estimated that a plant crop of Co 419 yielding 120.0 t ha^{-1} removes 84 kg N ha^{-1}, but some of the new varieties introduced recently have been found to remove as high as 150 kg N ha^{-1}. The role of

nitrogen on growth and yield of cane has been the subject of intensive research in India and other cane growing countries.

2.1.1 Effect of Nitrogen On Growth

Though the nitrogen constitutes only around one per cent of the total dry weight of mature cane (Dillewijn, 1952), it plays a role as important as that of carbon, hydrogen and oxygen that constitute more than 90 per cent of the dry matter.

Nitrogen is necessary for cell division and thus for the essential plant tissues and organs (Bevers and Hagman, 1972). The presence of nitrogen increases the volume of the functionally reactive cell plasma (Bergersen, 1971) and contributes to increase the chlorophyll content (Price et al., 1961).

In general, the beneficial effect of nitrogen on sugarcane have been reported from time to time under different agro-ecological zones of India (Yadav, 1980; Prasada Rao, 1981; Kanwar, 1982; Zende 1984; Sanandachari, 1985; Dahiphale et al., 1988; and Patil et al., 1990).

Many researchers reported that the application of nitrogen to cane crops improved the plant vigour (Singh et al., 1971; Garcia and Rosario, 1977; Parashar et al., 1980;

Shukla and Prasad, 1982 and Singh et al., 1991). Beneficial effects of nitrogen on plant height and shoot population in cane crops were also observed by Parashar et al. (1980), Saini and Singh (1985) and Wasnik (1990).

Asokan (1981) and Chauhan et al. (1991) reported that increase in nitrogen levels from 75 to 225 kg ha^{-1} increased the tiller number and length of millable cane. A significant increase in the length of millable cane was also reported when the cane crops were manured with higher doses of nitrogen on clay loam soils of Tamil Nadu (Kannappan et al., 1990). Beneficial effects of increased levels of nitrogen on stalk elongation and weight of the cane was reported by Ashok Raja et al. (1988) and Durai (1988).

Experiments conducted at Anakapalle (Annual Report, 1971) on nitrogen nutrition to sugarcane revealed that graded doses of nitrogen from 0 to 336 kg ha^{-1} increased the stalk population at harvest from 51,300 to 75,800. In another study at the same Research station (Annual Report, 1973) indicated that stalk population at harvest increased from 66,156 to 68,346 ha^{-1} with increase in nitrogen level from 112 to 330 kg ha^{-1}.

Patil et al. (1977) and Yadav and Sharma (1980) observed an increase in shoot population and plant height when cane crops were fertilised with 220 kg N ha^{-1}. Higher

number of tillers and millable canes at harvest with increase in nitrogen level from 75 to 225 kg ha^{-1} was also reported by Khairwal (1974); Patil et al. (1977); Ali et al. (1987); Jayabal et al. (1989) and Jayabal and Chokkalingam (1990).

Cheema and Moolani (1970) observed that nitrogen application of 112 kg and 165 kg ha^{-1} improved the tillering, plant height, leaf area and weight of cane over the control at Sangrur. Narwal and Behl (1979) found the beneficial effect on N at 100 kg ha^{-1} on tillering, plant height, internode length and cane girth as compred to no nitrogen. Likewise, Singh (1973) observed improvement in cane height, number and length of internodes with nitrogen application.

Mathur and Tripathi (1975) stated that nitrogen increased tillering upto 250 kg ha^{-1}; however, maximum millable canes were produced between 100 to 200 kg N ha^{-1}. Similarly, Lal and Lal (1978) observed that application of 200 kg N ha^{-1} increased the number of tillers and millable canes by 11.43 and 5.17 per cent respectively over 150 kg N ha^{-1}.

Srinivasan and Mariakulandai (1969) found that application of 250 kg N ha^{-1} improved tillering, girth and plant height over 150 kg N ha^{-1}. Likewise, Venkataraman

et al. (1978) indicated the beneficial effect of 340 kg N ha^{-1} on plant height, girth, weight per cane and millable canes as compared to 220 kg N ha^{-1}. Nitrogen application improved the tillering upto 250 kg N ha^{-1} but had no effect on prodction of millable canes (Sugumaran et al., 1976).

Srivastava et al. (1986) observed significant increase in tiller number, stalk length and girth of the cane with the application of 200 kg N ha^{-1} as compared to 100 kg N ha^{-1}. Cane length, girth and weight reduced significantly in unfertilised plots and these attributes increased significantly due to application of 150 Kg N ha^{-1} (Singh et al., 1991).

Rao et al. (1990) reported a significant increase in plant height and shoot population at 120th day age and stalk population and length of millable canes at harvest with 100 kg N ha^{-1} over 50 kg N ha^{-1} under rainfed conditions. Similar results were also reported by Kadian et al. (1981) and Prasad et al. (1988).

2.1.2 Nitrogen in Index Tissues and Uptake

Among several factors identified for affecting cane yield and juice quality, leaf nitrogen (3-6 leaves) and sheath moisture (3-6 sheaths) play a dominant role (Parthasarathy and Perumal, 1975; Clements, 1980; Lakshmikantham, 1982).

Among others, Mohan Rao and Narasimham (1956) and Pacheco et al. (1965) reported that increase in leaf N per cent with increased doses of N and its early application reflecting the trend in its concentration in Plant.

Asokan (1981) registered higher sheath moisture values at 150, 220 and 300 days age of the crop due to application of different levels of nitrogen over control (0 N). These results confirmed the earlier findings of Clements (1959).

Ramakrishna Rao et al. (1988) from their studies on nitrogen to sugarcane observed a decline in sheath moisture with advance in age, with a steep fall from 150 days to harvest under different levels of nitrogen from 56 Kg to 112 Kg ha^{-1}.

In an experiment conducted under irrigated conditions on sandy loam soils at Anakapalle, the sheath moisture values of different early maturing varieties tended to increase with increasing the level of nitrogen from 0 to 168 kg ha^{-1} (Ramakrishna Rao et al., 1989). These results confirms the earlier findings of Lakshmikantham (1970) and Dixit et al. (1975).

Among the various factors contributing to yield, uptake of N is important one and it largely depends on its

availability in the soil. Since sugarcane is a long duration crop of giant member of the grass family and produces large amounts of dry matter per unit area and time and requires huge quantities of nutrient elements. Borden (1942) observed a crop of sugarcane producing 125 tonnes of dry matter ha^{-1} in less than two years in Hawaii, removed as much as 309 kg nitrogen, 82 kg phosphorus and 908 kg potassium ha^{-1}. In India, Gupta and Agarwal (1976) claimed that nutrient removal by sugarcane crop is estimated to be 120 kg nitrogen, 196 kg phosphorus and 325 kg potassium ha^{-1}.

Singh (1978) from shajahanpur (U.P.) reported that the sugarcane crop removed 108.3 and 132.1 kg N ha^{-1} and yielded 78.7 and 77.6 t ha^{-1} of cane respectively in two years of study. The removal of nitrogen, therefore varied between 1.38 to 1.70 kg N ha^{-1} per tonne of cane produced, but the former appeared optimum for an average cane yield of 78 t ha^{-1}, as the excess removal of 28.3 kg N ha^{-1} in the latter case during sugar accumulation phase did not deliver any economic yield and proved luxury consumption.

Singh (1978) observed a decline trend in nitrogen uptake with the age of the crop and the maximum quantity of nitrogen was taken up during tillering and minimum during sugar accumulation phase. In the mean results from 2 years of his studies, 69.8 kg N ha^{-1} constituting 58.7 per cent of

the total nitrogen was taken up during tillering, 38.4 kg N ha^{-1} constituting 32.2 per cent during stalk elongation and 11.9 kg N ha^{-1} constituting 9.1 per cent during sugar accumulation period. He reported further that the crop utilised 41.3, 28.1 and 20.2 per cent of the available nitrogen during tillering, growth and sugar accumulation phases respectively.

Yadav and Sharma (1980) described sigmoid pattern of nitrogen accumulation in sugarcane. Plants accumulated 1.7 per cent of the total nitrogen upto 45 days. Thereafter an increase in nitrogen uptake was observed upto maximum tillering stage during which sugarcane accumulated major part of is nitrogen uptake (60 per cent). Similar trend in nitrogen accumulation was observed by Mohan Rao and Narasimham (1952).

Bavaskar et al. (1978) reported higher nitrogen uptake during grand growth period which declined at harvest. Wetselar and Farquhar (1980) also reported decrease in absolute amount of nitrogen in above ground parts at harvest.

2.1.3 Effect of Nitrogen on Juice Quality

Under similar climatic conditons, mineral nutrition of cane governs the juice quality to a great extent and

among the nutrients, nitrogen has a major role in determining the juice quality. Effect of form, quantity, time and method of nitrogen application on juice quality have been studied by several workers (Gill and Singh, 1976; Kadian et al., 1981; Rao et al., 1990 and Sanandachari and Rao, 1991).

Clements (1951) reported heavy application of nitrogen depressed the juice sucrose and phosphoric acid in juice with an increase in the reducing sugar and soluble nitrogen fractions leading to low sugar recovery.

The results of an experiment conducted at Anakapalle Annual Report, 1965) revealed that application of 224 kg N ha^{-1} to variety Co 419 had depressed the sucrose per cent in juice as compared to 0 and 112 kg N ha^{-1}. Maximum juice sucrose per cent was recorded at 0 N which was on par with 112 kg N ha^{-1}. In the subsequent studies at Anakapalle (Annual Report, 1975), highest juice sucrose per cent was observed at 0 N which was superior to that of the other levels at 112, 224 and 336 kg N ha^{-1}; with each successive increment in nitrogen level from 0 to 336 kg ha^{-1}, there was a significant decrese in juice sucrose per cent.

The depressing effect of higher dose of nitrogen on juice quality was reported by several workers (Gupta and Lal, 1975; Ramachandra Reddy et al., 1978; Srinivasan and

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1982; Yadva, 1987; Jayabal et al., 1989 and Jayabal and Chokkalingam, 1990). Kannappan et al. (1990) reported that higher doses of nitrogen upto a level increased the sugar yield but juice quality was adversely affected. This has been confirmed by Parashar et al. (1980); Rao et al. (1990) and Doraisamy and Ramaiah (1991).

Nickell and Tanimoto (1968) stated that excessive nitrogen available at harvest was the prime cause of low sucrose content in juice. Perumal (1980) recorded a negative correlation between nitrogen per cent in index tissues in maturity phase and CCS per cent. Similar results were also reported earlier by Lakshmikantham et al. (1970), Parthasarathy and Perumal (1975).

2.1.4 Effect on Nitrogen on Cane Yield

Nitrogen enhances the vegetative growth and also increases the cane yield upto a certain level only, beyond which the sugar yield is affected due to fall in sucrose content; besides, excess dose of nitrogen tends to increase the pest and disease incidence (Mohan Rao and Narasimham, 1956; Humbert, 1968; Lakshmikantham, 1982 and Singh and Singh, 1983). Optimum level of nitrogen was found to vary depending on the soil fertility status and the variety grown. In India, there is a wide range of nitrogen application (112 to 504 kg ha^{-1}) to sugarcane depending on

the cropping season (12 to 18 months) or plant type (plant or ratoon crops). The optimum dose of nitrogen range between 112 to 400 kg ha^{-1} in Andhra Pradesh, 160 to 230 kg ha^{-1} in Tamil Nadu, 280 to 504 kg ha^{-1} in Karnataka and 390 to 504 kg ha^{-1} in Maharashtra. In sub-tropical belt (North India), the optimum nitrogen dose range between 112 to 225 kg ha^{-1}.

Experimental resuls at Anakapalle (Annual Report, 1965) with Co 419 indicated that 112 kg N ha^{-1} recorded significantly higher cane yield of 83.7 tonnes ha^{-1} as compared to 0 N treatment, while the cane yields were on par at 112 and 224 kg N ha^{-1} levels. Results of another experiment from the same location (Annual Report, 1971) indicated that highest cane yield of 101 t ha^{-1} was obtained with higher level of 336 kg N ha^{-1} which was superior to 0 N but was on par with its preceeding level of 112 kg N ha^{-1}. Prasada Rao (1989) while reviewing the results of research conducted at the same research station recommended 112 and 224 kg N ha^{-1} for plant and ratoon crops respectively for North coastal districts of Andhra Pradesh.

Narasimha Raju and Sharma (1973) observed a significant increase in cane yield when the level of nitrogen was increased from 0 to 150 kg ha^{-1}, but further increase in the level of nitrogen upto 300 kg ha^{-1} did not increase the cane yield significantly. From the studies

conducted at Anakapalle (Annual Report, 1983) with Co A 7601 and Co A 7602 varieties, it was found that maximum sugar yields were obtained when the crop manured with 56 kg and 168 kg N ha^{-1} respectively.

Jayabal et al. (1989) and Jayabal and Chokkalingam (1990) reported from Tamil Nadu that 250 kg N ha^{-1} registered higher cane yield and as the dose increased beyond this level, it failed to improve the cane yield significantly. Kannappan et al. (1990) observed that application of 250 kg N ha^{-1} significantly increased the cane yield over lower levels of nitrogen in clay loam soils of Tamil Nadu.

Doraisamy et al. (1987) and Kathiresan and Narayanasamy (1990) concluded that higher doses of nitrogen at 300 kg ha^{-1} recorded significantly higher cane yield, but the economic dose of nitrogen was found to be 150 kg ha^{-1}. Atchutan et al. (1989) from Cuddalore (Tamil Nadu) reported that 38 per cent increase in cane yield was recorded with 450 kg N ha^{-1} over 0 N.

Recent studies indicated that 150 to 200 kg N ha^{-1} was the optimum dose under Indian sub-tropical conditons (Parashar et al., 1980; Rathi and Singh, 1980; Yadav and Sharma, 1980; Johari et al., 1983 Singh and Singh, 1983; Jafri et al., 1985; Ponnu et al., 1986; Srinvasthava et al.,

1986; and Thakur et al., 1986 and Doraisamy and Ramaiah, 1991). Singh et al. (1981) observed that the response of sugarcane to nitrogen was linear and significant upt 200 kg ha^{-1}.

Saini and Singh (1985) and Trivedi and Saini (1986), working on Terai soils with medium soil fertility at Pant Nagar (U.P.) reported an increase in cane yield upto 19.9 per cent and 16.1 per cent with 150 kg and 120 kg N ha^{-1} respectively over O N. Similarly, Yadav and Sharma (1980) and Yadav (1981), working on loamy soils of Lucknow (U.P.) recorded a conspicuous increase in cane yield due to application of varying levels of N from 0 to 250 kg N ha^{-1} over 0 N.

Panwar et al. (1987) from Haryana reported an increase in cane yield with nitrogen application. Similary Gupta and Bharadwaj, (1973) from Delhi, Patil et al. (1977) from Gujarat, Narwal (1979) and Sharma and Gupta (1990) from Rajasthan, Sudhama Singh and Dua (1990) from Coimbatore (Tamil Nadu); Sharma and Gupta (1991) from U.P. also reported an increase in cane yield with nitrogen application.

Curtes et al. (1985) reported that application of nitrogen at recommended levels boosted the cane yield in Louisiana (U.S.A.). The beneficial effects of nitrogen

fertilisation to sugarcane have also reported by Garcia and Rosariao (1977) from Philippines, Paotun-Po (1974) from Taiwan and Chapman (1982) from Queensland.

2.2 EFFECT OF POTASSIUM ON SUGARCANE

Among all nutrients, sugarcane crop removes potassium in highest amounts and this nutrient is vital for the crop by virtue of its role in synthesis and translocation of sugars. A plant crop of Co 419 variety yielding 120 t ha^{-1} has been found to remove 170 kg K_2O ha^{-1} (Lakshmikantham, 1982).

2.2.1 Effect of Potassium on Growth

Potassium plays both direct and indirect role in the growth and metabolism of green plant. Potassium is known to be required for cell structure, carbon assimilation, photosynthesis, protein synthesis, starch formation, translocation of proteins and sugars, water economy in plants and many other life processes (Beringer, 1978). Potassium is a valuable balancer to nitrogen and desirable associate to phosphorus (Narasimham, 1988). Its application is most essential in soils with high fixation levels, in light soils of humid and sub-humid regions; potassium is a bridge between major metabolic and catabolic processes in sugarcane (Nageswara Rao, 1985).

Potassium deficiency depressed the plant growth (Dillewijn, 1952), reduced tillering and produced slender stalks (Hartt, 1967 and Ramachandran, 1976).

Singh and Singh (1972) observed that potassium deficiency reduced the root development, leaf length, internodal thickness and produced low proportion of schlerenchyma tissue leading to crop lodging. Potassium deficiency lead to impaired growth as well as ability of cane to utilise water, sunlight and applied nitrogenous fertilisers (Humbert, 1978).

Many researchers reported that the vegetative growth of sugarcane is improved by application of potassium fertiliser though not to the extent of nitrogen (Kadian et al., 1981; Patil and Singhte, 1982; Pandian et al., 1989 and Narasimham, 1991).

Potassium application has been found to increase dry weight as well as better elongation of root mass in sugarcane (Shukla and Prasad, 1982). The authors also observed more vigorous growth and stalk elongation with increasing levels of potassium. Similar observations were also recorded by Singh and Sinha (1978) and Patil and Singh (1981).

Singh and Sinha (1987) observed increased stalk elongation and tillering activity in sugarcane with the

application of potassium which might be due to the effective utilisation of greater nutrient through its extensive root system developed. Increase in plant height (Rege et al., 1962 and Mathur, 1972) and more number of millable canes (Rao, 1982) have been reported in sugarcane with the application of 150 to 300 kg K_2O ha^{-1}.

Altaf Ahamed et al. (1975) observed a significant increase in weight and diameter of cane and number and length of internodes when the level of potassium was increased from 0 to 220 kg K_2O ha^{-1}. Perumal and Parthasarathy (1975) observed favourable effects of fertiliser potassium on the length of millable cane and single cane weight. The beneficial effects of potassium applied at 200 kg ha^{-1} on the number of millable canes, weight and diameter of cane was reported by a number of workers (Prasad et al., 1984; Jose, 1985; Panwar et al., 1987; Pandian et al., 1989 and Narasimham, 1991).

2.2.2 Potassium in Index Tissues and Uptake

Potassium is highly mobile in green plant tissues. It promotes turgidity of the plant cells and thereby maintaining the internal pressure of the plant tissue (Humbert, 1978). Hartt (1969) observed that K deficiency decreased the translocation of photosynthates from leaves.

The utiliztion of K varies from vriety to variety and at growth stage, K is taken up at a rapid rate in early growth phases than the later stages of growth (Perumal, 1981). He obsrved that irrespective of variety K absorption was maximum (2.60% to 2.18%) at 4 to 6 months age after which there was a sharp decline at harvest (1.51%). The relationship between potassium concentration in plant tissues in different growth phases with cane and sugar yields was found to be highly positive and significant. The positive association of K per cent at early growth phase with cane and sugar yields was also reported by Brar et al. (1985); Narasimham (1988) and Rao and Sekhon (1989).

Raju and Sharma (1973) reported that application of K resulted in an increase in K concentration in plant tissue.

2.2.3 Effect of Potassium on Juice Quality

Potassium plays an important role in formation and translocation of sugars. It has been found that application of potassium improves chlorophyll of the leaves and the percentage of K in the juice (Grimme, et al., 1971). Potassium is necessary for the proper transformation between hexoses and sucrose as well as their translocation (Dillewijn, 1952 and Narasimham, 1968).

About 60 per cent ash in the sugarcane juices is made up of potassium (Meade and Chen, 1977). Hence, it is natural

that potassium nutrition has a significant influence on juice quality. Improvement in juice quality of sugarcane as a result of potassium application has been reported by Yadav et al. (1983) and Rakkiyappan (1987). Improvemnt in the juice quality may be in the form of brix, purity and sugar recovery (Sharma and Sharma, 1981) or reduction in gum, starch and reducing sugar contents (Gupta and Shukla, 1970).

Mahamuni et al. (1973) observed when optimum quantity of potassium supplied to sugarcane, there was a reduction in reducing sugars, glucose ratio, total nitrogen, non-sugars and increase of CCS per cent.

The opinion on the effect of potassium on cane quality is divided. Lakshmikantnam (1974) opined tht potassium did not improve the cane quality; whereas, Patawardhan and Rege (1954) and Narasimham (1988) observed that potassium additions improves juice quality of some varieties. Havanagi et al. (1956); Jakata (1960) and Gupta and Shukla (1973) observed that potassium effect was most pronounced on the purity of juices.

Samuels and Landrau (1956) observed a linear relationship between cane tonnage and sugar content. Influence of potassium on juice quality was greatest when cane yields were also increased as reported by Innes and Chinloy (1959). After critical apprisal of work on sugarcane

quality, Humbert (1962) proposed 2:1:2 NPK ratio for sugarcane.

Evans (1975) has offered a physiological explanation for the influence of potassium on the quality of cane. Rojas (1960) and Fritz (1974) have observed that cane quality improved only when potassium applications reduced leaf nitrogen coupled with a reduction in moisture content.

Ramalinga Swamy (1990) from Anakapalle found significant improvemnt in per cent juice extraction and per cent purity at 100 kg K_2O ha^{-1} level and that of per cent juice sucrose in cane at 200 kg K_2O ha^{-1} level.

The work of Gupta and Bharadwaj (1973) revealed that application of potassium at 100 kg ha^{-1} improved the per cent juice extraction, per cent sucrose, per cent purity and reduced the non-sugars in juice. Asokan (1981) observed that the application of potassium significanlty increased the per cent juice sucrose and per cent purity. A significant and positive relationship has also been reported between these parameters and sugar yields.

Potassium application retarded deterioration in juice quality and improved juice purity besides reducing pith formation and enhancing respiration and cane yield (Amberger, 1967).

2.2.4 Effect of Potassium on Cane and CCS Yields

In general, the beneficial effects of potassium application on cane yield have been reported in different agro -climatic zones of India and such effect on yield was both direct and through boosting of the uptake and utilization of nitrogen (Gupta and Bharadwaj, 1973; Narayana, 1973; Srinivasan, 1975; Srinivasan and Morachan, 1980; Sharma and sharma 1981; Yadav et al., 1983; Sundara, 1985; and Singh et al., 1989).

Information on increase in cane yield from a unit weight of K_2O and net rupee invested in K fertilisers in different regions of peninsular India has been summarised by Srivastava and Hunsigi (1978). They observed that highest response to potassium was obtained in the sandy loam alluvial soils of Cuddalore followed by ratoon and plant crop grown in red sandy loam soils of Mandya. Lowest response to K was in lateritic soils of Bidar. At Cuddalore (Tamil Nadu), Mandya, Sankeswar and Gangavati (Karnataka), money invested on potassium fertilisers resulted in more than three times profit.

Earlier experiments conducted at Anakapalle (Annual Report 1956-59) with var. Co 419 revealed that application of potassium at 224 kg ha^{-1} significantly increased the mean cane yields (86.5 t ha^{-1}) over control (79.38 t ha^{-1}), but

there was no further increase in cane yield at 448 kg K_2O ha^{-1} level. In recent studies with var. Co 7219, Narasimham (1991) reported increased cane and CCS yields under 112 kg K_2O ha^{-1} at planting by 8.72 and 1.59 t ha^{-1} respectively over no potassium application and the response per kg K_2O applied was reported to be at 114.4 and 17.8 kg of cane and CCS yields respectively.

Field experiments conduced by Ramalinga Swamy (1991) at Anakapalle revealed that cane and sugar yields increased significantly due to application of potassium at 100 Kg K_2O ha^{-1}. Another feature was that N from green manure was better utilised when potassium was combined; in the earlier experiments conducted at the same reserach station (Annual Report, 1970-71) the increase in cane yield was upto 4 t ha^{-1}, while in second batch of experiments (Annual Report, 1975-76) the benefit of K was upto 17 t ha^{-1}, and for ratoon crops 200 Kg K_2O ha^{-1} was found to be optimum.

In trials at Pugalur, Rege et al. (1963) reported that application of 200 Kg K_2O ha^{-1} contributed to maximum cane yield. In a ratoon crop at Pamba, they observed a mean response of 15.4 t ha^{-1} of cane and 0.8 units in CCS per cent at 250 kg K_2O ha^{-1}, but in plant crop, cane yield improved by 15.9 t ha^{-1} with a slight depression in juice quaity. Srivastava and Hunsigi (1978) reported based on the

data from Cuddalore, observed that significant response in cane yield of 25.4 t ha^{-1} with an addtion of 200 kg K_2O ha^{-1}.

Patil et al. (1964) studied the effect of potassium on plant and ratoon crops at Mandya (Karnataka) and found that 1.0 kg of potassium applied to ratoon crop resulted in a minimum response of 0.06 tonnes of cane while the plant crop grown under similar conditions produced 0.01 tonnes of cane at the same level of potassium at 100 kg K_2O ha^{-1}.

Babriwala et al. (1957) reported from Kolhapur (Maharashtra) about the favourable response of combined application of phosphorus and potassium in medium and high rainfall regions in improving the cane and commercial sugar yileds. Dagade (1976) also found at Kolhapur that commercial cane sugar was increased at higher levels of potassium. Subsequently, Patil and Singte (1982) reported from Kolahapur that application of 300 kg K_2O ha^{-1} gave a yield increase of 7 and 12 t ha^{-1} in first and second year of studies respectively. Zende (1984) stated that addition of P and K and F.Y.M. was considered necessary to enhance the response of sugarcane to nitrogen and this holds good for both plant and ratoon crops.

Mathur (1972) found in Uttar Pradesh that application of potassium yielded on an average 0.5 tonnes of more sugar

ha^{-1}. Singh and Tiwari (1972) observed that application of potassium responded on an average of 29 tonnes of cane ha^{-1} over nitrogen application. Gupta and Agarwal (1976) working on loamy soils of medium soil fertility in Lucknow (U.P.) reported increase in yield of cane upto 300 kg K_2O ha^{-1}. Similarly, Shukla and Prasad (1982) working on loamy soils of Varanasi (U.P.) recorded a conspicuous increase in cane yield over control due to application of 150 kg K_2O ha^{-1}.

Samuels and Landrau (1956) studied in Puerto Rico the effect of potassium on yield and quality of sugarcane and found that for every increase of unit in terms of cane tonnage, potassium gave 1.4 times more increase in relative yields of sucrose than for nitrogen and 3.8 times greater than for phosphorus application. Particularly, the relative increase in ratoons was 136% for cane yield and 116% for the yield of sugar.

Walker (1961) reported increased sugar yield in sandy and clay loam soils of British Guiana due to potassium application. Threshold values for exchangeable potassium for sugarcane ranged between 65 to 150 ppm as reported by Duflo (1976). Humbert (1978) reported that highly weathered and leached top soils of tropical region are also likely to respond to potassium dressings.

Rodriguez et al. (1984) from Cuba observed a significant response of cane and sugar yields to potassium application and recommended 100:50:100 kg N, P_2O_5 and K_2O ha^{-1} respectively for getting economic yields. Duflo (1976) reported that the threshold values for exchangeable potassium for sugarcane range from 65 to 150 ppm; it was 125 ppm in Barbados (Saint, 1932) and 65 ppm for sands and loams and 95 ppm for clays and silty soils under general West Indian conditions (Harde and Rodriguez, 1949). In Philippines (Locsin et al., 1956) found a significant increase in cane and CCS yields whenever the exchangeable soil potassium was less than 95 ppm. Between 95 and 120 ppm the response to potassium was variable and above 120 ppm there was no significant response. As the level of exchangeable K falls below 100 ppm in Hawaii and 110 ppm in Louisiana, yield increases from potassium fertilisation are usually obtained (Humbert, 1968).

2.3 TIME OF APPLICATION OF POTASSIUM

Potassium requirements as top dressings are similar to nitrogen requirements. It has been observed that at periods of most active nitrogen adsorption, the maintenance of balanced potassium (K) and nitrogen (N) ratio is of great significance (Kanwar, 1976). Russell (1950) observed that application of potassium by broadcast coinciding with deep ploughing resulted in greatest gain.

1983; Fonseca and Felipe, 1983; Martinez et al., 1983; and Narasimham, 1988, 1989 and 1990).

Husz (1972) could observe response to applied K only in the presence of applied N. Similar trend was observed in the experiments conducted at Gudiattam soils (Gopal Rao et al., 1976). On the other hand, Castellanos et al. (1978) were of the view that the response to N application was more pronounced only if the crop received adequate P and K.

Sundara (1981) mentioned the need for late application of potassium for realising higher cane and sugar yields, at 180 kg K_2O ha^{-1} on sandy loam soils and observed a significant improvement in per cent juice sucrose, per cent purity, cane and sugar yields.

Srivastava and Hunsigi (1978) and Narasimham (1988, 1989) presented data to show that, while potassium application increased its uptake, its role in increasing cane yield was more through higher uptake and better utilization of nitrogen.

The reduction in yield of cane and CCS due to delayed application of nitrogen (at 180th day) was found to be offset by application of an additional dose of potassium at 180th day (Naidu and Srinivasan, 1985). They further observed an increase in cane and CCS yields by 28 and 23.8

per cent respectively when 2.5 per cent potassium chloride was sprayed at 60, 90 and 120 days after planting over unsprayed crop subjected to moisture stress during early stages of crop growth. Similar increase in cane yields were reported when potassium fertilisers were applied in split doses by Gupta and Shukla (1970) and Hunsigi (1981).

The deterioration in juice quality caused by high nitrogen doses can be prevented by increased K doses and good soil aeration (Husz, 1972). Under K deficient conditions, soluble N accumulates which is detrimental to quality of sugarcane juice (Husz, 1972). Adequate supply of K can mitigate this adverse effect, thereby improving the quality of cane juice (Patil et al., 1966).

2.5 ROLE OF NITROGEN AND POTASSIUM NUTRITION TO RATOON CROPS

Ratoons are inferior bio-types as compared to plant crops; while the utilization of applied nitrogen at the recommended level in plant crop was noted to be about 44 per cent while it was about 20 per cent in first ratoon crop of Co419 (Prasada Rao, 1984).

A first ratoon crop of CO 419 yielding 115 t ha^{-1} was observed to remove 103 kg N and 223 kg K_2O ha^{-1} (Lakshmikantham, 1982).

It has been documented that root system of a sugarcane ratoon is relatively less developed than the plant crop (Evans, 1936; Humbert, 1953; Hardy and Smith, 1954 and Trouse, 1967) hence needs heavy doses of nitrogen fertilisation.

Based on response to nitrogen application to ratoon crops in different regions of Andhra Pradesh, Prasada Rao (1980) recommended addition of 112 kg N ha^{-1} over and above the recommended dose of nitrogen for plant crop for obtaining optimum cane and sugar yields.

Kadirvel (1972) reported that the optimum dose for first ratoon crop is 337 kg N ha^{-1} for realising economic yields. Kanwar (1982) from Jullundar opined that realising the first ratoon crop of sugarcane has an immense economic benefits to the farmers as there is a 30 per cent saving in the cost of cultivation compared to the plant crop. The author recommended 225 kg N ha^{-1} and its early application for reaping higher tonnage of cane from ratoon crop, compared 150 kg N ha^{-1} for plant crop. Golden (1982) observed that when the preceeding plant crop received the normal recommended dose of nitrogen fertiliser, higher doses of nitrogen was beneficial far ratoon crop.

Parashar and Prasad (1986) reported from Delhi that higher levels of nitrogen at 200 kg ha^{-1} applied in three

splits increased the ratoon cane yields significantly over 100 kg N ha^{-1}. Similar increase in cane yield from ratoon crops was reported from Gujarat (Patil et al., 1989) with heavy nitrogen doses at 375 kg ha^{-1} over its preceding levels, 225 and 300 kg N ha^{-1}.

Wasnik (1990) from Goa observed a significant increase in cane height, millable canes, diameter, cane and sugar yields with the application of 250 kg N ha^{-1} to the first ratoon crop of sugarcane as compared to 125 kg N ha^{-1} recommended to the plant crop.

Mohan Rao and Narasimham (1954) reported that higher doses of nitrogen and completion of the same within two months after ratooning for realising higher cane yields from ratoon crops. Narasimham (1989) observed significant imporvement in per cent juice purity and per cent juice sucrose due to the application of 120 kg K_2O ha^{-1} to ratoon crop of variety Co 7219, when plant crop did not receive the nutrient.

Potassium has more pronounced effect on ratoon than on the plant crop and response to applied potassium was observed in red, mixed red and black soils (Hunsigi, 1981). He further reported that a consistant response to applied K and one kg potassium (K_2O) resulted in a response varying

from 0.06 to 0.17 tonnes ha^{-1} at 100 kg level of application in red sandy loam soils of Mandya (Karnataka).

Compared to plant crop, the ratoon crop stands to benefit more potassium application (Rao, 1982). Positive response to applied potassium was attributed to low available potassium content of soils owing to continuous depletion by previous cane crops over a long period (Sant and patel, 1952).

In recent studies, Narasimham (1991) reported for variety Co 7219 that potash fertiliser has given increased yields of ratoon crops especially when the plant crop did not receive any potash. Under such situation, there was increase in yield of cane and CCS by 9.37 t ha^{-1} and 1.55 t ha^{-1} respectively by application of 120 kg K_2O ha^{-1} at Anakapalle and of 14.29 t ha^{-1} and 1.82 t ha^{-1} respectively at Rudrur over no potassium application. He further indicated that the yield increase was attributed to early and higher N uptake under potassium application.

2.6 EFFECT OF MOISTURE STRESS ON SUGARCANE CROP

Sugarcane has a high water requirement which ranges from 146 to 172 cm for 12 and 13 month crops respectively (Kingston and Ham; 1975 and Gosnell and Lonsdale, 1977). Work at Anakapalle on variety Co 419 revealed that total

water requirement of the crop to be 1702 hectare cm inclusive of rainfall (Lakshmikantham and Narasimha Rao, 1962 and Lakshmikantham, 1982). Further, the use of underground water for sugarcane production is limited by low soil water table during summer and also scarcity of power for pumping out water. Sugarcane crop therefore faces moisture stress during the formative phase which begins with germination and continues for 3 to 4 months till end of summer, which affects tillering and also the stressed plant become susceptible to pests and diseases, besides recording poor yield and juice quality at harvest.

Water is important for the development and maturity of cane crops as well sugar accumulation (Humbert, 1972). High fibre content and more reducing sugars are seen in cane crops subjected to moisture stress conditions (Clements, 1958). A close relationship between temperature, water consumption and stalk elongation has been observed by Barnes (1953).

The low soil moisture affecting growth of sugarcane resulting reduction in tiller number, internodal length and final cane yield was also reported by Yang (1980). Pitman (1981) reported that water stress affects a number of plant processes and uptake of nutrients and osmoregulation mechanism in plant tissues.

Raj (1983) and Balasubramanian (1985) observed that moisture stress affects the crop growth and final cane yield primarily through evaporation loss and increase in soil temperature thereby affecting the concentration of soil solution, microbial activity and nutrient uptake.

Parashar (1960) reported a faster deteriortion of sucrose and purity in juices of drought affected canes, eventhough these values were higher in the beginning over the normal cane plants. Khan and Samanilogo (1968) reported that for crops grown under high soil moisture and high temperature conditions, the rate of stalk elongation was faster than the crops grown under moisture stress conditions.

Lakshmikantham and Rao (1962), Naidu and Reddy (1976), Singh and Reddy (1976), Naidu et al. (1977) reported that soil moisture stress during the formative phase affected the crop growth and led to decreased cane and sugar yields. Similar results were also reported by Baver (1963), Mongelard (1968), Naidu and Reddy (1976) Chavan et al. (1978), and Yang (1980).

The results of experiments conducted by Narasimha Rao (1969) Todd (1970), Gosnell (1971), Saine et al. (1978), Yang and Chan (1979), Cheema and Moolani (1980), Singh and Reddy (1980), Yang (1980) and Raju (1984) showed that the

soil moisture in the active root zone should be maintained higher than 50 per cent of the available soil moisture for reaping higher cane and sugar yields.

2.7 ROLE OF POTASSIUM IN SUGARCANE PRODUCTION UNDER MOISTURE STRESS

One of the functions attributed to potassium is that it helps the plant to achieve water economy mainly through reduction in water loss through transpiration by stomatal adjustment (Sinha, 1978 and Raja Gopal, 1985.) The ability of a plant to economise on water use i.e., make more efficient use of the available moisture can be specially beneficial during moisture stress/drought periods (Tandon and Sekhon, 1988). Potassium may improve water use efficiency and help to maintain crop yield under moisture stress and reduce the extent of yield losses under such conditions (Saxena, 1985).

The effect of foliar spray of potassium on sugarcane during drought period either alone or with urea concentration has been found to be effective in sandy loam soils of Coimbatore (Naidu and Srinivasan, 1982). The authors further observed that trash mulching with potassium application was beneficial under early drought conditions. There was considerable improvement in juice quality of sugarcane (CO 6806 and CO 6304) with the additional dose of

60 kg K_2O ha^{-1} combined with trash mulch under moisture stress conditions. Beneficial effect of potassium application at 75 kg K_2O ha^{-1} to sugarcane under moisture stress conditions was also reported by Perumal and Pasupati (1984).

The results of the experiments conducted in alluvial soils of Lucknow (U.P.) on potassium nutrition of sugarcane under limited water supply indicated a significant increase in the cane production, per cent juice extraction and per cent juice sucrose in cane (Yadav et al., 1986).

Yadav and Prasad (1986) studied the response of sugarcane to potassium under moisture stress conditions at Lucknow (U.P.) during summer season on a sandy loam soil of alkaline reaction and found that the yield of sugarcane even with one irrigation was highest with improved juice extraction from cane by 2.4 per cent, under application of 240 kg K_2O ha^{-1}.

Narasimham (1991) reported from Anakapalle that K application helped drought tolerance of rainfed cane crops in maturity phase. The beneficial effects of Kaoline as foliar spray on sugarcane raised under rainfed conditions was also reported from Anakapalle (Annual Report, 1989).

The foregoing review of earlier work on nitrogen and potassium nutrition to sugarcane crop in relation to growth parameters of plant and ratoon crops and its nutrient requirements, effect of moisture stress on sugarcane crop, stalk characters, yield and juice quality of sugarcane crop, as regards growth parameters, stalk characters yield and quality, and role of potassium in alleviating its detrimental effect reviews a broad account on these aspects in several parts of India and some other cane growing countries of the world. Such information with particular reference to the comparative performance of plant and ratoon crops under moisture stress in terms of important yield attributes, cane yield and juice quality is called for with respect to the recently introduced new varieties under specific soil and climatic conditions.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted at Regional Agricultural Research Station, Anakapalle (Andhra Pradesh) during the years 1987-88 and 1988-89, to investigate the effect of three levels each of nitrogen and potassium with three times of application of potassium on growth, nutrient uptake, yield and quality of plant (1987-88) and first ratoon (1988-89) crops of sugarcane variety Co T 8201 under moisture stress conditions during the formative phase (April and May). The particulars of location, its climate, soil characteristics, experimental details, analytical procedures for soil and plant analysis, statistical techniques for experimental data analysis are given in detail in this chapter.

3.1 LOCATION

The Regional Agricultural Research Station, Anakapalle, the place of present investigation is in Visakhapatnam district, Andhra Pradesh. Anakapalle is the regional agricultural research centre for North Coastal Zone, one of the seven agro-climatic zones of Andhra Pradesh under the concept of National Agricultural Research Project (NARP). It is on the Eastern side of the peninsular India situated at 83°-01' East longitude, 18°-45' North latitude

with an altitude of 28.62 metres above mean sea level and 22 kilo-metres from Bay of Bengal. Anakapalle is located on the Madras - Culcutta National Highway No.5 with a distance of 35 km from an industrial city of Visakhapatnam. It is well known for traditional sugarcane cultivation, jaggery making with a famous regulated market yard, the second largest of this type in the country for jaggery export.

3.2 CLIMATE

Anakapalle falls in the belt of tropical humid climate. The average annual rainfall is 1141.2 mm (mean for 10 years from 1980 to 1989), distributed over 56 rainy days. The distribution of rainfall, as percentage of annual precipitation, is 61 per cent (695.9 mm) during South-West monsoon (June to September), 28 per cent (319.6 mm) during North-East monsoon (October to January) and 11 per cent (125.7 mm) during summer period (February to May). The maximum temperature fluctuates between 29°C to 36.8°C, while the variation in minimum temperature is in between 17.3°C to 26.6°C. The mean relative humidity is 86.5 per cent at 7.00 hours and 54.7 percent at 14.00 hours. The monthly mean meteorological data for the last ten years (1980 to 1989) were presented in Table 1.

Table 1: Mean monthly meteorological data (mean for 10 years, 1980-89)

Month	Temperature (°C)		Rainfall (mm)	Rainy days	Relative Humidity (%)		Sunshine hours	Evaporation (mm) in pan evapore meter
	Maxi-mum	Mini-mum			7.00 hours	14.00 hours	day^{-1}	day^{-1}
January	29.8	17.3	15.3	0.7	89	48	8.7	3.9
February	29.0	18.9	23.0	0.9	90	47	9.4	5.9
March	34.4	21.8	19.6	1.0	89	46	9.2	5.9
April	36.2	25.6	17.6	1.3	86	50	9.3	7.0
May	36.8	26.6	65.5	4.1	85	55	8.7	7.0
June	35.0	26.4	128.7	7.9	81	56	4.9	5.6
July	33.0	25.5	181.2	10.0	87	65	4.8	4.7
August	32.7	25.4	185.2	9.8	88	65	4.8	4.6
September	33.0	24.9	200.8	10.1	90	67	5.5	4.0
October	32.3	23.2	223.4	6.9	87	60	7.7	4.2
November	30.6	20.1	77.0	2.8	82	50	8.1	3.8
December	29.8	17.9	3.9	0.5	84	47	8.2	3.9
Total/Average	32.7	22.8	1141.2	56.5	86.5	54.7	7.4	5.0

Rainy day:- 2.5mm rainfall day^{-1}

3.2.1 Seasonal Conditions

The mean monthly meteorological data of rainfall, number of rainy days, maximum and minimum temperatures, relative humidity, sunshine hours and evaporation from open pan evaporimeter recorded during 1987-88 and 1988-89 are presented in Table 2 and 3 and graphically represented in Figs. (1A), (1B) and (1C) and Figs. (2A), (2B) and (2C) respectively.

During 1987-88 season, the mean maximum temperature was highest (37°C) in June while it was lowest (17°C) in January. The total rainfall received during the year was 1251.0 mm in 55 rainy days. Out of the total rainfall about 50 per cent (640.8 mm) was received during October (244.4 mm) and November (396.4 mm). The mean relative humidity at 7.00 hours was maximum (91 per cent) in March and November and it was minimum (79 per cent) in July. At 14.00 hours maximum relative humidity (69 per cent) was recorded in November and it gradually dropped down to 41 per cent in February. The average numbr of sunshine hours were maximum in February (10.1 hours day^{-1}) while they were minimum (4.3 hours day^{-1}) in July. The evaporation from open pan evaporimeter was maximum in May (6.7 mm day^{-1}) and it was minimum (3.3 mm day^{-1}) in November.

Table 2. Mean monthly meteorological data during the crop period (Plant crop, 1987-88).

Month	Temperature (°C)				Relative humidity (%)				Rain fall (mm day^{-1})		Rainy days		Sun shine hours day^{-1}		Evaporation (mm day^{-1})	
	Maximum		Minimum		At 7.00 hrs		At 14.00 hrs.									
	A[x]	DN[xx]	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
February '87	31.3	- 2.3	17.6	+ 1.3	86	+4	41	+6	0	+23.0	0	+ 0.9	10.1	- 0.7	5.3	+ 0.6
March '87	33.0	+ 1.4	20.7	+ 1.1	91	-2	52	-6	65.6	-46.0	2.0	-1.0	8.9	+0.3	5.2	+0.7
April '87	35.5	+0.7	24.6	+1.0	88	-2	54	-4	31.0	-13.4	2.0	-0.7	9.2	+0.1	6.6	+0.4
May '87	36.4	+0.4	25.1	+1.5	90	-5	59	-4	76.8	-11.3	3.0	+1.1	9.5	-0.8	6.7	+0.3
June '87	37.0	-2.0	26.9	-0.5	85	-4	55	+1	64.6	+64.1	5.0	+2.9	6.3	-1.4	5.8	-0.2
July '87	34.9	-1.9	26.5	-1.0	79	+8	53	+12	66.4	+114.8	5.0	+5.5	4.3	+0.5	5.8	-1.1
August '87	33.5	-0.8	25.5	-0.1	87	+1	64	+1	175.0	+10.2	10.0	-0.2	5.9	-1.1	5.4	-0.8
September '87	34.3	-1.3	25.3	-0.4	90	0	65	+2	125.2	-75.6	9.0	+1.1	6.2	-0.7	4.8	-0.6
October '87	32.2	+0.1	23.8	-0.6	90	-3	66	-6	244.4	-21.0	8.0	-1.1	7.7	0	4.4	-0.2
November '87	29.5	+1.1	21.4	-1.3	91	-9	69	-19	396.4	-319.4	10.0	-7.2	5.8	+2.3	3.3	+0.5
December '87	29.0	+0.8	18.1	-0.2	89	-5	63	-16	5.6	-1.7	1.0	-0.5	7.7	+0.5	3.6	+0.3
January '88	30.3	-0.5	17.0	+0.3	90	-1	51	-3	0	+15.3	0	+0.7	8.4	+0.3	3.5	+0.4

A[x] : Actual, DN[xx] : Deviation from normal; Rainy day : 2.5 mm rainfall day^{-1}

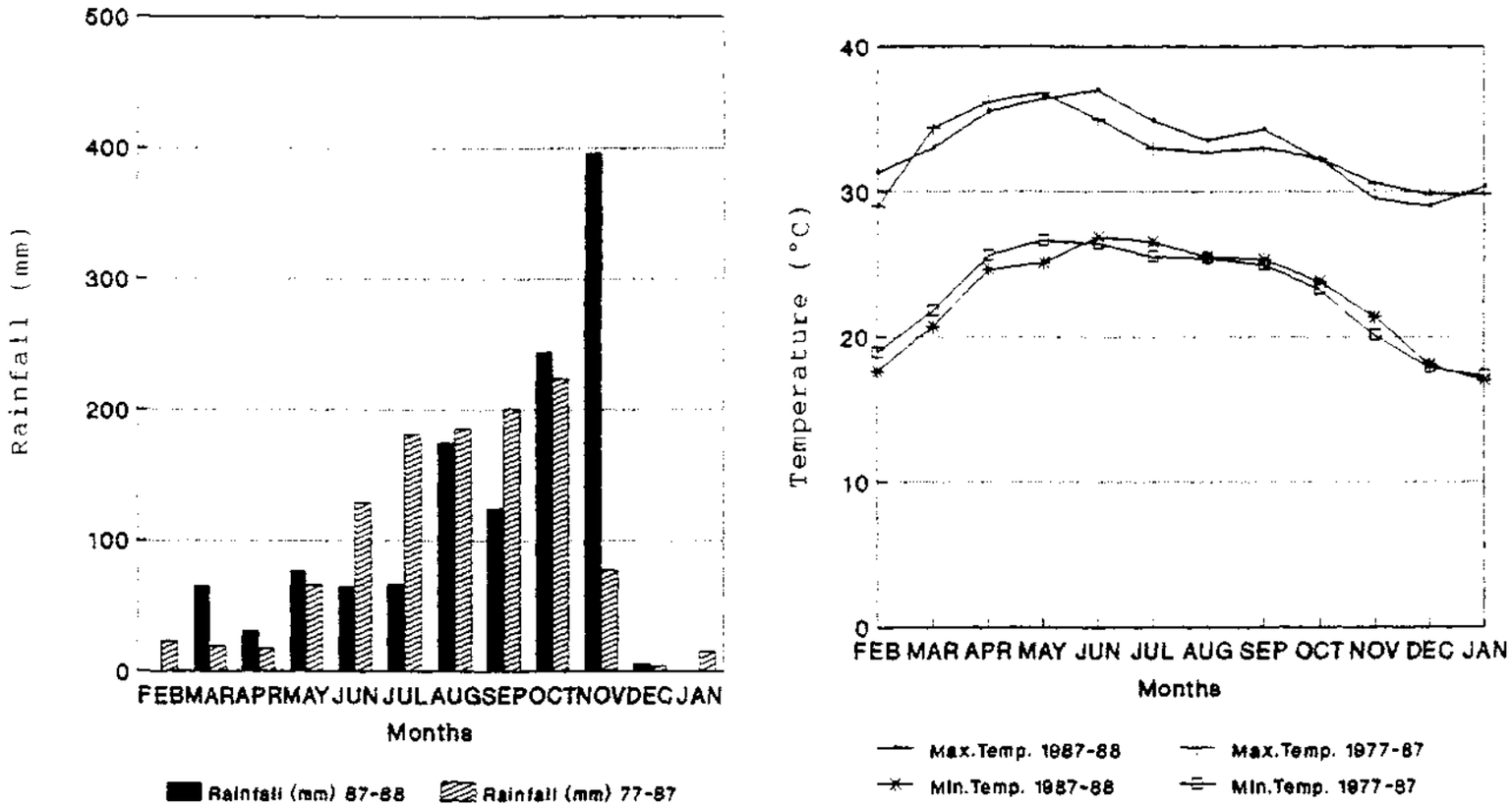

Fig.1: Monthly meteorological data during plant crop season (1987-88) and mean for 10 years (1977-87)

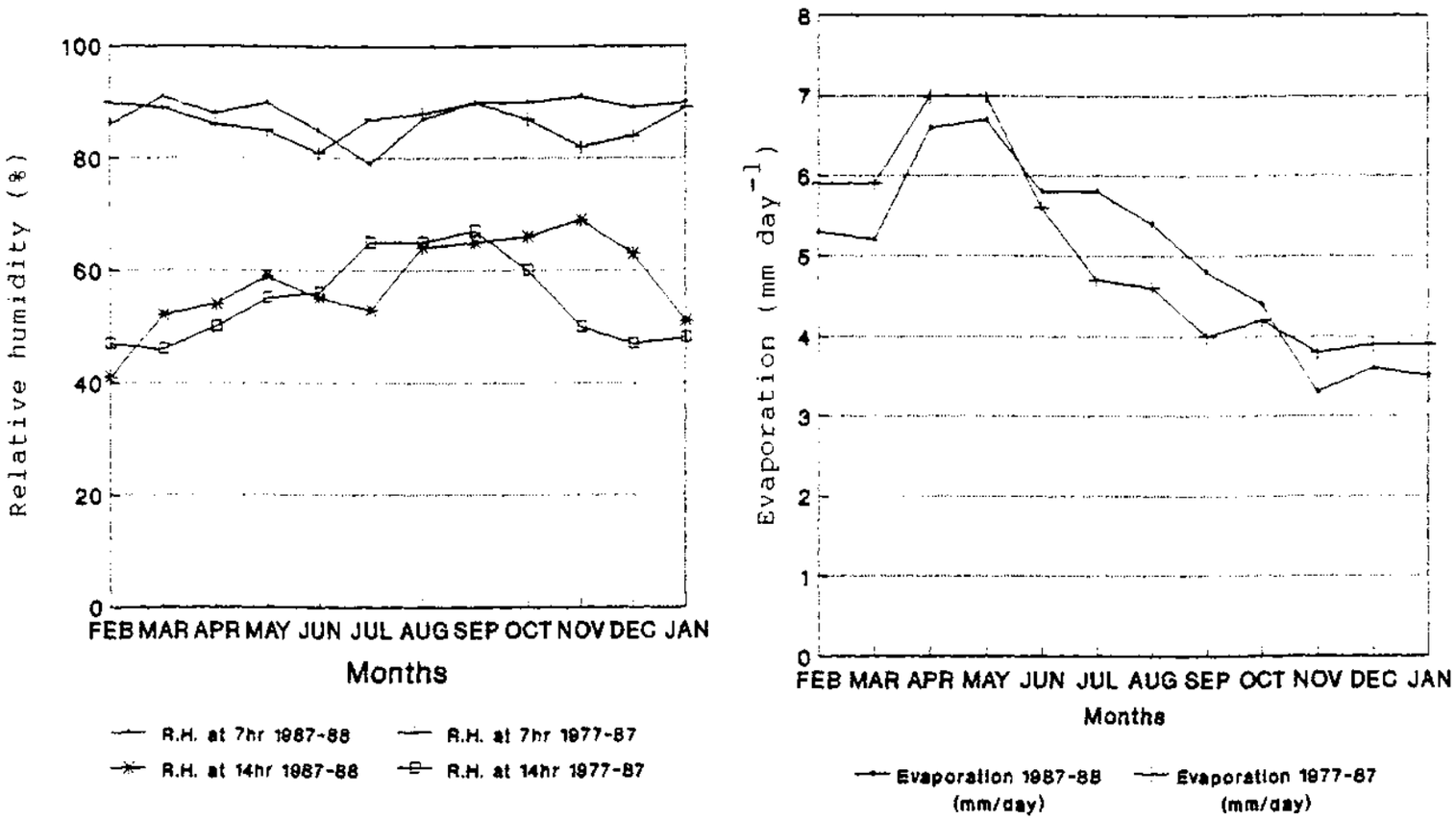

Fig.1(b): Monthly meteorological data during plant crop season (1987-88) and mean for 10 years (1977-87)

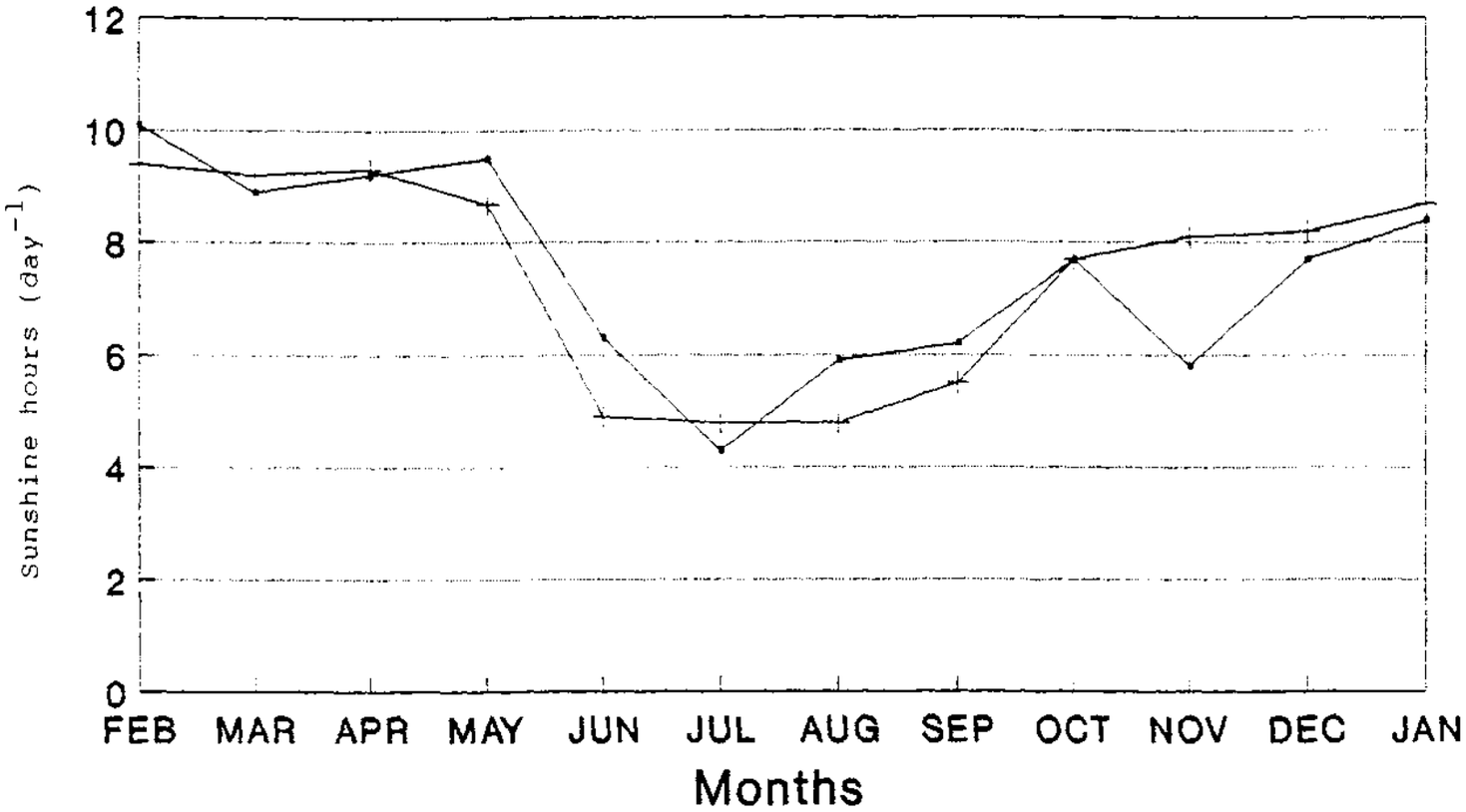

Fig.1(c): Monthly meteorological data during plant crop season (1987-88) and mean for 10 years (1977-87)

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Table 3. Mean monthly meteorological data during the crop period (Ratoon crop, 1988-89).

Month	Temperature (°C)				Relative humidity (%)				Rain fall (mm day^{-1})		Rainy days		Sun shine hours day^{-1}		Evaporation (mm day^{-1})	
	Maximum		Minimum		At 7.00 hrs		At 14.00 hrs.									
	A[x]	DN[xx]	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
February '87	32.2	-2.8	18.7	+0.2	89	-1	49	-4	28.6	-10.6	2	-1.0	9.5	+1.1	4.5	+1.3
March '87	34.4	-0.3	23.1	-1.3	93	-3	51	-3	0.4	+24.2	0	+1.0	9.2	-0.2	5.5	+0.3
April '87	35.7	+0.5	24.3	+1.8	90	-3	51	+1	32.6	-10.0	3	-1.7	9.1	0	6.2	+0.5
May '87	36.7	-0.4	26.3	+0.3	87	0	58	-2	28.2	+39.3	2	+2.2	8.6	+0.3	5.8	+1.0
June '87	37.0	-2.6	24.2	+2.2	81	+2	56	0	57.6	+71.1	3	+3.5	5.2	+1.0	5.8	+0.1
July '87	33.0	+0.6	25.3	+0.2	91	-6	69	-8	204.2	-33.0	11	-2.0	4.1	+0.4	4.3	+0.6
August '87	30.3	+2.0	25.6	-0.4	92	-4	73	-7	109.6	+60.4	10	-0.2	4.7	+0.3	3.7	+0.2
September '87	32.5	+0.8	25.0	+0.2	93	-3	75	-8	346.0	-150.1	14	-3.5	5.1	+0.3	3.0	+0.8
October '87	32.5	-1.2	22.7	+0.6	85	+2	56	+7	210.8	+18.5	7	+1.4	8.3	-1.5	3.7	+0.4
November '87	31.4	-1.8	19.4	+0.3	76	+9	41	+15	7.0	+85.2	1	+2.6	8.7	-0.9	3.1	+0.2
December '87	30.3	-1.0	18.4	-0.8	83	+1	45	+8	0.8	+3.4	0	+0.6	8.4	-0.8	3.8	0
January '88	30.3	-1.5	16.8	+0.9	88	-2	48	+1	0	+12.6	0	+0.5	8.9	-0.6	4.1	-0.4

A[x] : Actual; DN[xx] : Deviation from normal; Rainy day : 2.5 mm rainfall day^{-1}

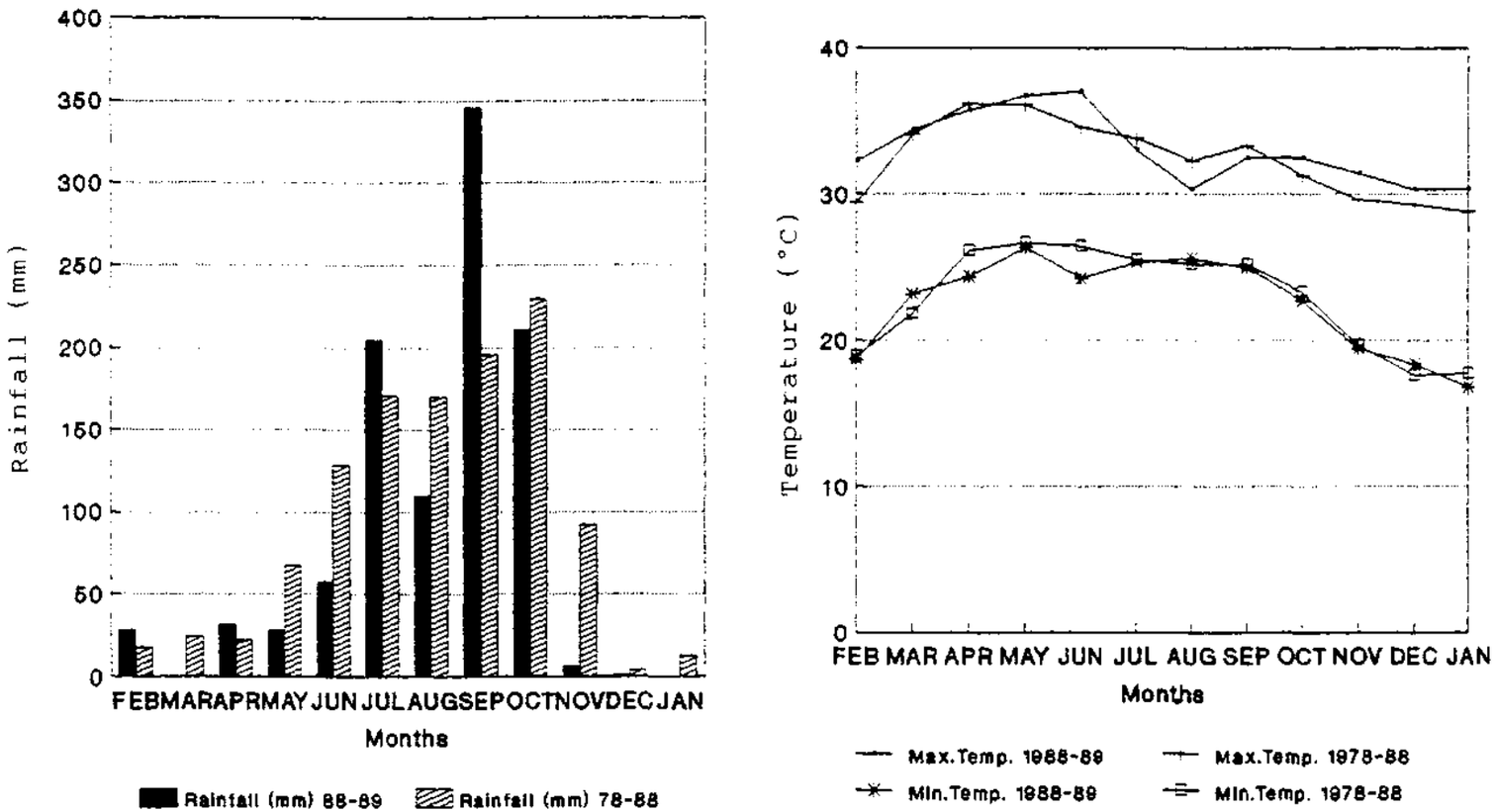

Fig.2: Monthly meteorological data during Ratoon crop season (1988-89 and mean for 10 years (1978-88)

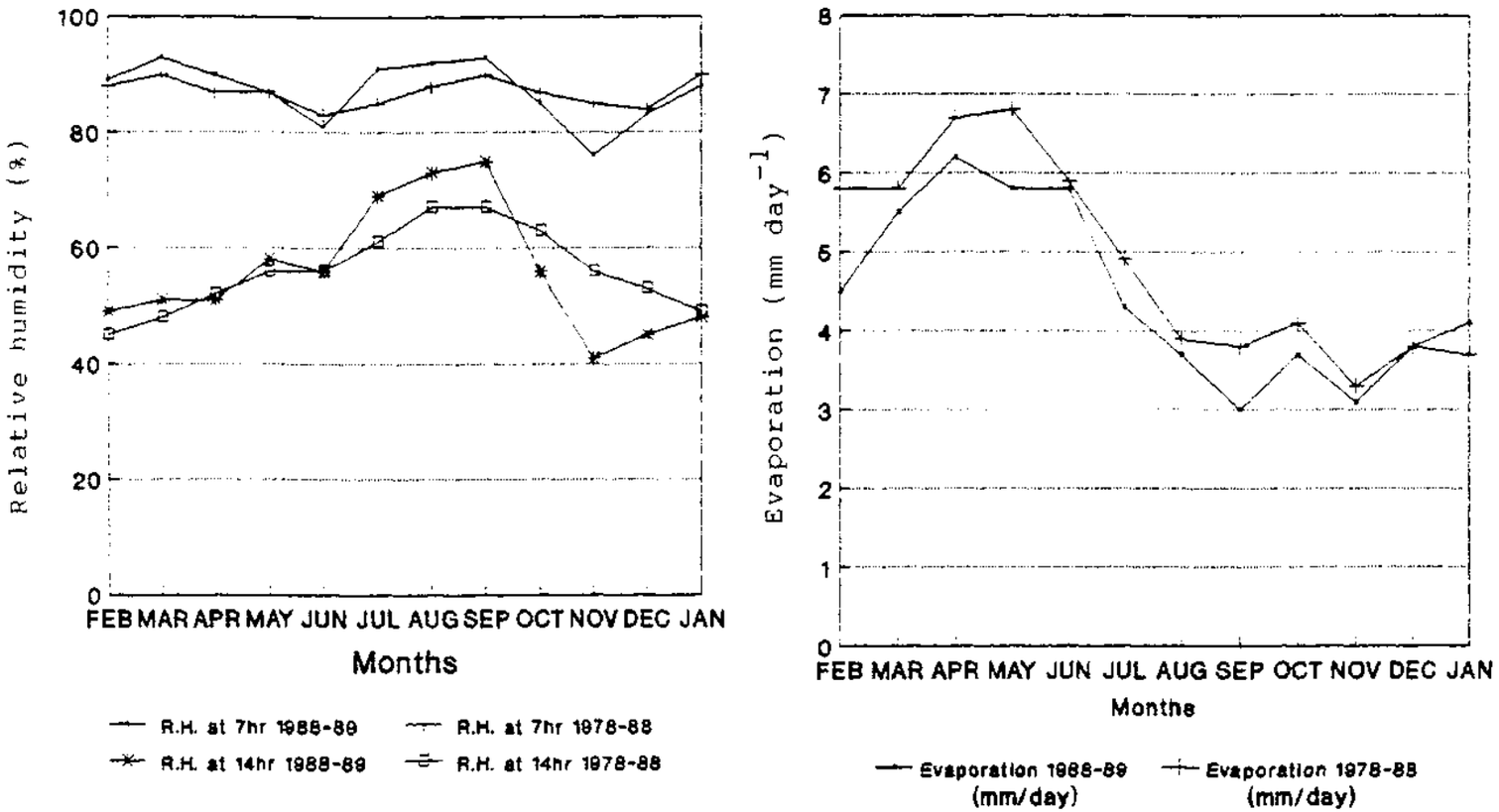

Fig.2(b): Monthly meteorological data during Ratoon crop season (1988-89) and mean for 10 years (1978-88)

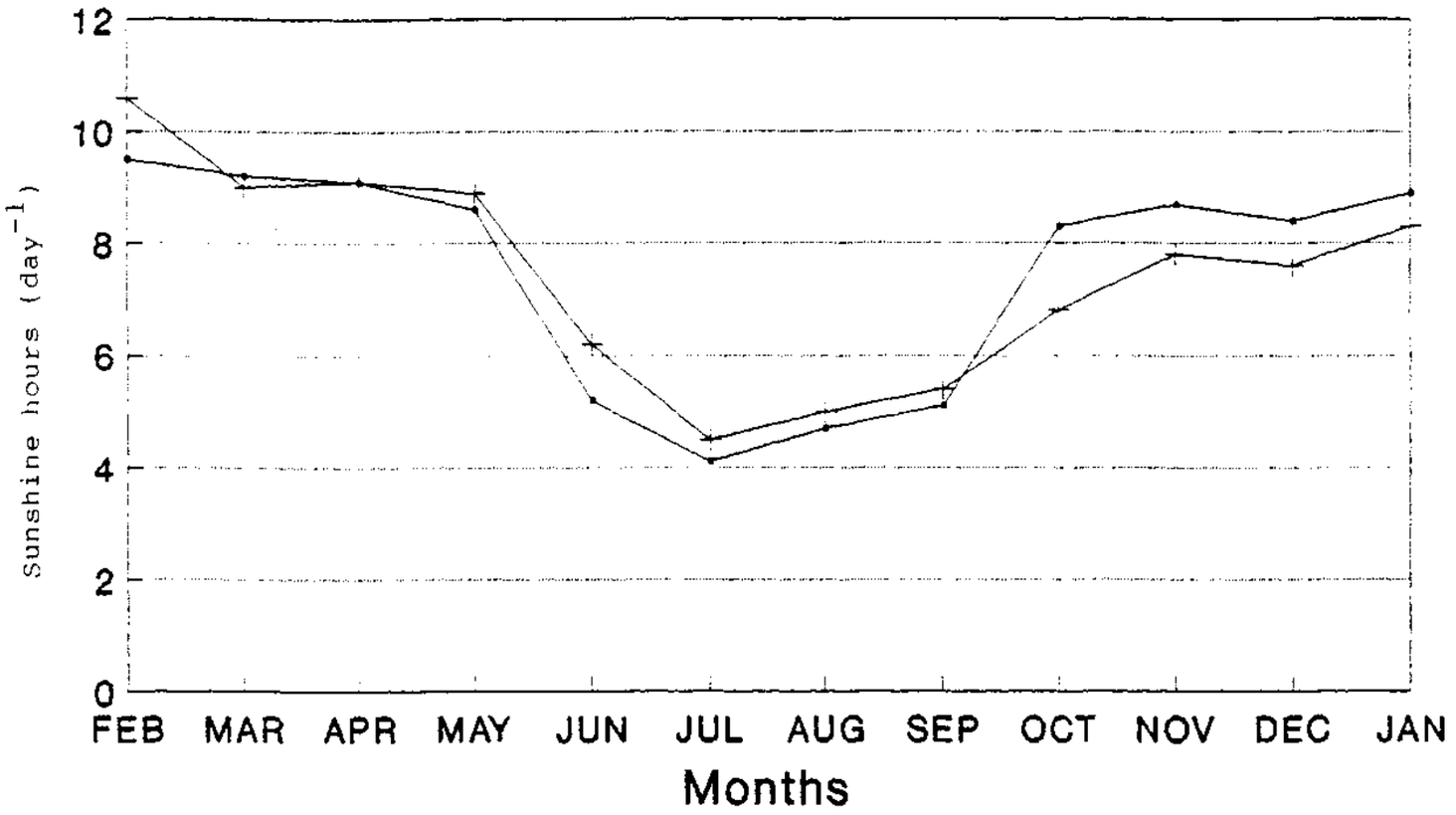

Fig.2(c): Monthly meteological data during Ratoon crop season (1988-89) and mean for 10 years (1978-88)

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The seasonal conditions during 1987-88 and 1988-89 were more or less similar in respect of weather parameters except rainfall. The total rainfall received during 1988-89 season was 1025.8 mm distributed in 53 rainy days. More than 50 per cent (556.8 mm) of the total rainfall was received in September (346.0 mm) and October (210.8 mm). There was more rainfall (107.8 mm) during summer period (April and May) during 1987-88 season as compared to 1988-89 season (60.8 mm) during the same perriod.

3.3 SOILS

Soil samples from 0 to 30 cm depth were collected from the experimental fields during 1987-88 and 1988-89 before planting and at the time of ratooning respectively and the soil samples were analysed for their physical and chemical properties.

The experimental site is an alluvial soil formed by deposits from the neighbouring Sarada river over centuries and calssified as fine loamy typic ustochrepts. Texturally it is sandy loam to sandy. The soil is neutral in soil reaction, low in salinity, low in organic carbon and mineralisable N; the available p_2O_5 is high and available K_2O is medium and the results of the soil analysis data were as follows.

Physical and chemical properties of the soil of experimental site (0 to 30 cm depth)

S.No.	Constituent	1987-88 Plant crop	1988-89 Ratoon crop
A.	Physical characters:		
1.	Mechanical analysis		
	Sand %	80.7	74.8
	Silt %	12.0	15.4
	Clay %	6.0	9.2
2.	Bulk density (g cc^{-1})	1.148	1.146
B.	Chemical characters:		
1.	pH (1:2.5 extract)	7.3	7.0
2.	E.C. (Millimhos cm^{-1})	0.048	0.053
3.	Organic carbon (%)	0.358	0.363
4.	Minaralisable nitrogen (kg ha^{-1})	220.0	238.0
5.	Available P_2O_5 (kg ha^{-1})	55.0	58.0
6.	Available K_2O (kg ha^{-1})	240.0	248.0

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELDS

Details of the crops grown in the experimental fields during the preceding four years of the present investigation were:

Year	Plant crop field cropping scheme	Ratoon crop field cropping scheme
1983-84	Ragi - Blackgram	Ragi - Cowpea
1984-85	Sugarcane	Sugarcane
1985-86	Ragi - Sesamum	Sesamum - Balckgram
1986-87	Groundnut - Ragi	Bajra - Ragi

3.5 EXPERIMENTAL DETAILS

Field experiments were conducted with variety CoT 8201 during 1987-88 and 1988-89 seasons with sugarcane plant and first ratoon crops, respectively and the experimental techniques adopted were as follows.

3.5.1 Treatments (Plant and Ratoon crops)

a) Main plot treatments

Level of Nitrogen (kg ha^{-1}):

N_o : 0

N_1 : 112

N_2 : 224

b) Sub-plot treatments

Level of potassium (kg K_2O ha^{-1}) and time of application:

K_1 T_1 : 112 kg applied at planting/ratooning

K_1 T_2 : 112 kg applied at 60 DAP/DAR

K_1 T_3 : 112 kg applied at 120 DAP/DAR

K_2 T_1 : 224 kg applied at planting/ratooning

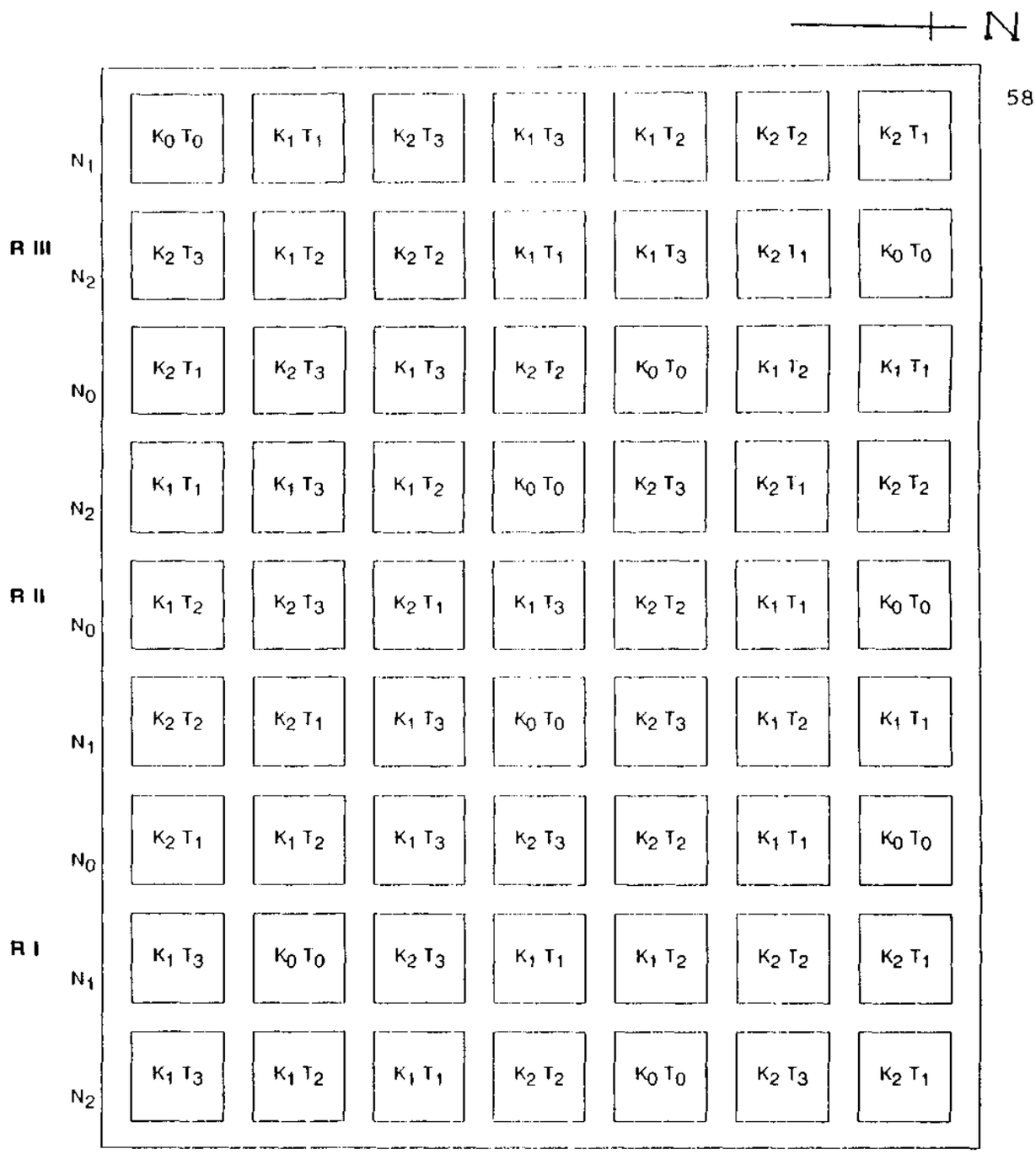
K_2 T_2 : 224 kg applied at 60 DAP/DAR

K_2 T_3 : 224 kg applied at 120 DAP/DAR

K_o T_o : Control (no potash)

3.5.2 Experimental Design

The experiment was conducted in split plot design assigning level of nitrogen as main plot treatments and

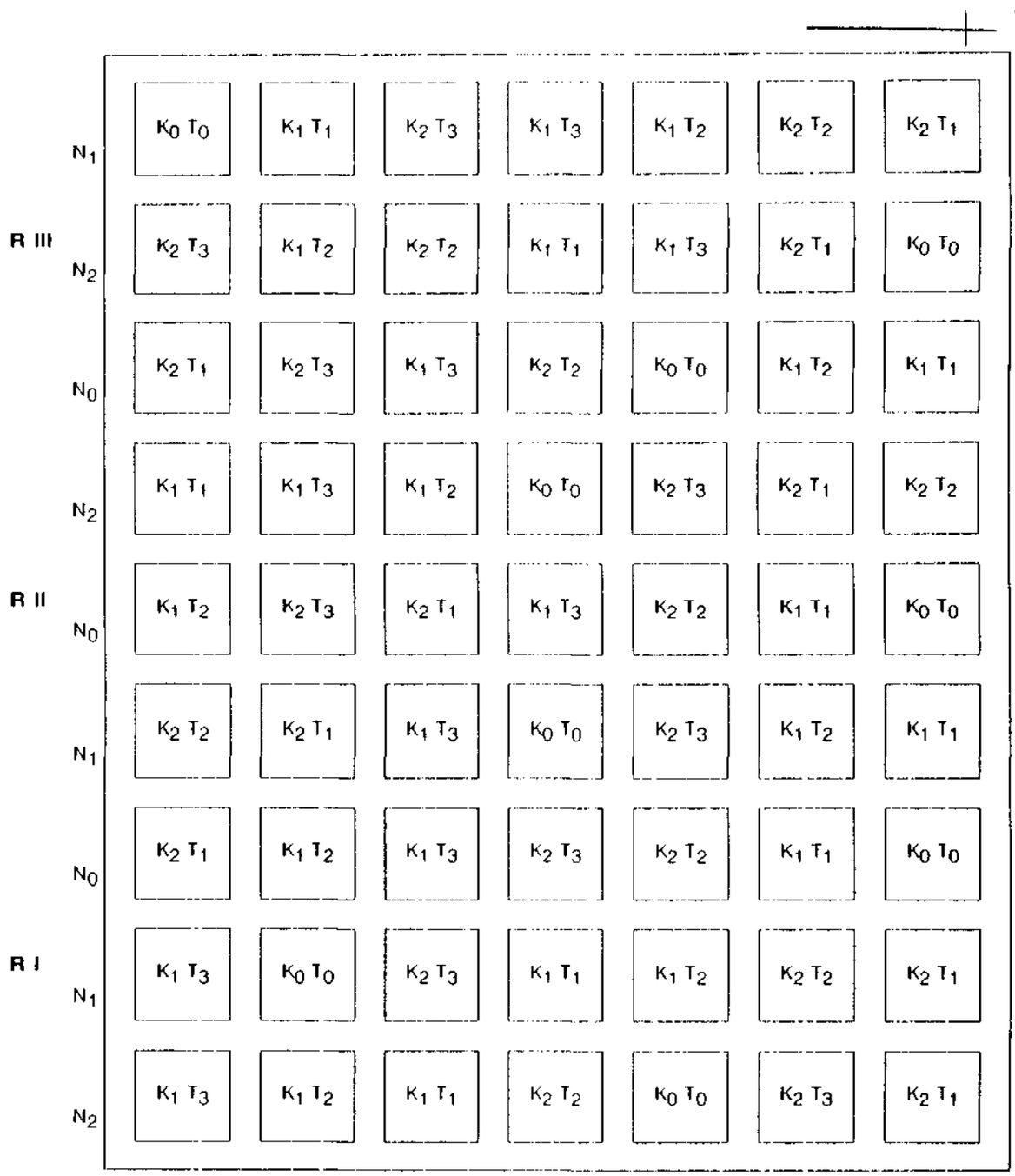


TREATMENTS:

MAIN PLOTS: Nitrogen Levels (Kg ha^{-1})	SUB PLOTS Potassium Levels (Kg K_2O ha^{-1}) and its time of application	
N_0 - 0	K_1 T_1 - 112 applied at planting	
N_1 - 112	K_1 T_2 - 112 applied at 60 days after planting	
N_2 - 224	K_1 T_3 - 112 applied at 120 days after planting	
	K_2 T_1 - 224 applied at Planting	
	K_2 T_2 - 224 applied at 60 days after planting	
	K_2 T_3 - 224 applied at 120 days after planting	
	K_0 T_0 - No potassh application (control)	

Design : Split-Plot
Replications : 3
Plot Size:
Gross : 10 × 9.6M
Net : 8 × 6.4M

Fig. 3: Layout Plan of the Experimental Plot, Plant Crop (1987 - 88)



TREATMENTS:

MAIN PLOTS: Nitrogen Levels (Kg ha^{-1})	SUB PLOTS Potassium Levels (Kg K_2O ha^{-1}) and its time of application	
N_0 - 0	K_1 T_1 - 112 applied at ratooning	Design : Split-Plot
N_1 - 112	K_1 T_2 - 112 applied at 60 days after ratooning	Replications : 3
N_2 - 224	K_1 T_3 - 112 applied at 120 days after ratooning	Plot Size:
	K_2 T_1 - 224 applied at ratooning	Gross : 10 × 9.6M
	K_2 T_2 - 224 applied at 60 days after ratooning	Net : 8 × 6.4M
	K_2 T_3 - 224 applied at 120 days after ratooning	
	K_0 T_0 - No potassh application (control)	

Fig. 4: Layout Plan of the Experimental Plot, Ratoon Crop (1988 - 89)

level of potassium and time of potassium application as sub-plot treatments and were replicated thrice. The field layout plans for both plant (1987-88) and first ratoon (1988-89) crops (mentioned as ratoon crop in this study) were depected in Fig. 3 and Fig.4 respectively.

3.5.3 Plot Size

Gross : 10 x 9.6 m = 96.0 m^2

Net : 8 x 6.4 m = 51.2 m^2

3.5.4 Variety

The variety choosen was Co T 8201. The parentage of this variety is Co 740 x Co 775. It is a mid season maturing variety and matures at 11 to 12 months. The cane stalks are medium thick and green in colour with bud grove having a gap between bud and the grove. It is a non-lodging, high yielding type, resistant to red rot and smut diseases.

3.6 FIELD OPERATIONS

The following field operations were carried out during the crop period.

3.6.1 Field Preparation and Planting

The experimental fields were ploughed with mould board plough followed by disc harrowing thrice to get a fine

tilth and levelled by working a plank. Deep furrows were formed at 80 cm apart with "Ridgemer". The experimental plots were demarcated by forming cross channels at 10 metres apart, used as irrigation channels during pre-monsoon and post-monsoon period and as drainage channels during monsoon period when necessary.

Disease free three-budded setts of Co T 8201 variety from immature cane crop (7 to 8 months age) at 40,000 three budded setts ha^{-1} were planted in deep furrows on 4th February, '87. A separate uniform bulk crop with Co T 8201 variety was also planted during second week of February, '87 to take up the ratoon studies during 1988-89 season. Seed setts were treated with 0.01 per cent malathion and 0.02 per cent Bavistin solution to control pests and diseases respectively transmitted through setts.

3.6.2 Fertilisers

Nitrogen in the form of urea was applied to plots treatment wise in two split doses, 30 and 70 per cent at 45 and 120 days after planting respectively for plant crop (1987-88) and in two equal split doses, immediately after stubble shaving and at 120 days after ratooning for ratoon crop (1988-89). Potassium in the form of muriate of potash was applied for both plant and ratoon crops as specified in 3.5.1. However, for bulk crop raised during 1987-88 season,

only nitrogen in the form of urea was applied at 112 kg ha^{-1} uniformly in two equal split doses at 45 and 90 days after planting. Fertilisers were applied by pocketing at 5 cm away and 7.5 cm depth nearer to the root zone and irrigated after application of fertiliser.

3.6.3 Gap Filling

Gap filling was done wherever necessary at 25 days after planting in plant crop with three budded setts and with the settlings of the same age in ratoon crop, 15 days after stubble shaving.

3.6.4 Weeding and Hoeing

Plant and ratoon crops were kept weed free till 90 days age by manual weeding and hoeing thrice during each season.

3.6.5 Irrigation

Irrigations were given at weekly intervals till last week of March for both plant and ratoon crops and created moisture stress by withholding irrigations in April, May and till the onset of monsoon rains in June. Altogether five irrigations to the plant crop (1987-88) and seven irrigations to the ratoon crop (1988-89) were given before moisture stress period excluding the rainfall of 65.6 and

29.0 mm received during 1987-88 and 1988-89 seasons respectively. During grand growth phase (June-October) which synchronised with monsoon rains, the crops did not receive any irrigations. In the post-monsoon period during maturity phase (November till harvest), plant and ratoon crops received two irrigations in the respective years. However, the bulk crop raised during 1987-88 season received irrigations at weekly intervals during formative phase and at three weeks intervals during maturity phase, as per recommendation.

3.6.6 Plant Protection

Malathion at 0.02% (2 ml in 1 litre of water) was sprayed twice at 5th and 6th month age on the exposed cane stalks of plant and ratoon crops after removing the bottom dried and semi-dried leaves to control the scale insect.

3.6.7 Earthing up

Earthing up was done during first week of July for plant crop by manual labour. For ratoon crop, deep ploughing to a depth of 12 cm was done with cattle drawn ridge plough at 10 days after stubble shaving to cut away the soil on either side of the clump and to till the compacted inter-row space to aerate the soil.

3.6.8 Propping

Propping was done twice for both plant and ratoon crops at 6th and 8th month age by "trash twist" method to keep the cane crops erect and to prevent from lodging.

3.6.9 Harvesting

Plant and ratoon crops were havested during last and first week of January, '88 and '89 seasons respectively. At harvest time, two border rows on either side of the experimental plot and one metre width each on either side of the cane rows were left as outskirts, and the cane in the remaining net plots were harvested separately in each treatment and the cane yields were recorded.

The bulk crop raised during 1987-88 season for ratoon studies was harvested during first week of February, 1988. Trash left over in the field was removed after harvest. Cane stubbles were shaved to the ground level by manual labour using sharp edge spades to force deeper buds to develop and in order to ensure deeper root system in the ratoon crop. Other operations and harvest of net plot for recording the cane yield were similar to that of plant crop.

3.7 OBSERVATION ON GROWTH PARAMETERS

All the data recorded on growth parameters, nutrient indices and their uptake, stalk characters and yield of cane

and commercial cane sugar (CCS) given in seperate tables represent the mean values of three replications.

3.7.1 Germination

The numbr of germinated buds in each treatment from the net plot in plant crop was recorded at 35 days after planting and expressed as percentage of the total number of buds originally planted.

3.7.2 Plant Height

Twenty primary shoots were randomly earmarked in each treatment of plant and ratoon crops and the height of each shoot was measured from base upto the topmost visible due-lap leaf joint at 120, 180, 240 and 300 days age of the crops.

3.7.3 Shoot Population

Shoot population from each net plot was counted in plant and ratoon crops at bi-monthly intervals from 120 days age to 300 days age. The shoots thus recorded were computed per hectare.

3.7.4 Leaf Area Index (LAI)

Leaf Area of plant and ratoon crops was recorded at 150 and 210 days age and at harvest time. Cane stalks in one

metre row length from each treatment were taken separately from the sample rows and all the green leaves except spindle leaf were taken for this study.

The leaf area was calculated with the help of planimeter by taking 40 leaves at random. The length (L) and maximum breadth (B) of the leaves were measured and the correction factor (K) was computed as suggested by Bhatla and Sharma (1978). The LAI was calculated by using the following formula as given by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Area occupied by the plant}}$$

3.8 SOIL ANALYSIS

Soil samples were analysed for mechanical composition and chemical constituents based on the standard procedures given by Piper (1950) and Jackson (1973).

3.8.1 SOIL REACTION (pH)

The pH of the soil was determined in 1: 2.5 soil water suspension using a glass electrode pH meter (Jackson, 1973).

3.8.2 Electrical Conductivity (EC)

The E.C. of 1:2 soil water extract was determined using conductivity bridge (Jackson, 1973).

3.8.3 Organic Carbon (OC)

Organic carbon was estimated as per the standard procedure given by Walkley and Black (1934), as suggested by Jackson (1973).

3.8.4 Mineralisable Nitrogen

Mineralisable nitrogen was estimated by alkaline permanganate metthod as described by Subbaiah and Asija (1956).

3.8.5 Available Phosphorus

Available phosphorus in soil was estimated as per Olsen's method by extraction 0.5 M $NaHCo_3$ adjusted to pH 8.5 (Olsen and Dean, 1965) and colour intensity was read at 660 mu using red filter in klett Summerson photo-electric colorimeter.

3.8.6 Available Potassium

Available potassium was determined in extract of N neutral ammonium acetate as per the procedure given by Jackson (1973) using a flame photometer.

3.8.7 Mechanical Analysis

Bouyoucos Hydrometer method was followed for the estimation of mechanical composition of soils (Piper, 1950).

3.8.8 Bulk Density (BD)

The bulk density (BD) of the soil was determined by using core sampler as per the procedure given in USDA (1973) and expressed in g/cc on dry basis.

3.9 CHEMICAL ANALYSIS OF PLANT SAMPLES

Nitrogen in 3-6 leaves and moisture as well as potassium in 3-6 sheaths were determined, taking these plant parts as the index tissues for respective nutrients (with spindle leaf and attached sheath as first and counting downward), as per the system evolved by Clements (1952) and adopted at the Regional Agricultural Research Station, Anakapalle in all the nutrition satudies (Lakshmikanthem, 1983).

Nitrogen in 3-6 leaves and moisture and potassium in 3-6 sheaths at 120, 180, 210 and 270 days age and the per cent composition of nitrogen and potassium from whole plant at 150, 210 and 270 days age were analysed for plant and ratoon crops based on the standard chemical analysis techniques (A.O.A.C., 1975 and Jackson, 1973).

3.9.1 Sheath Moisture

Five primary stalks were sampled at random from the sample rows in each treatment. The 3-6 leaf sheaths were separated from the cane stalks and used for determination

of moisture. After taking fresh weight, the sheaths were dried in oven at 80°C for 48 hours and the dry weights were recorded and the per cent moisture was computed on green weight basis.

3.9.2 Nitrogen (N) in 3-6 leaves

The mid lamina portion of 3-6 leaves without mid ribs was taken adopting the same procedure mentioned in 3.9.1 and dried to a constant weight and powdered in a Wiley Mill. One gram of finely powdered leaf material was used for nitrogen estimation following the standard "Kjeldahl" method (A.O.A.C., 1975).

3.9.3 Potassium (K) in 3-6 Sheaths

The oven dried sheath samples, after taking weighments for moisture estimation were finely powdered. One gram of the dry sheath sample was taken into a 50 ml Erlenmayer Flask and digested with 20 ml of triacid mixture on an electric hot plate till the digested material was finally colourless. Potassium in the extract was estimated after suitable dilution using a Flame Photometer (Piper, 1950).

3.9.4 Uptake of N and K in Whole Plant

Uptake of nitrogen and potassium was estimated from plant and ratoon crops at 150, 210, and 270 days age of the

crop. Cane stalks in one metre row length were harvested to the base from the sample rows in each treatment. The fresh weight of the sample was recorded and then chopped with chaff cutter. Chopped plant material at 200 g was taken, dried in an electric oven and dry weight per unit area of sample was computed. The dried sample was powdered and one gram of powdered sample was taken for each estimation of nitrogen and potassium in whole plant. The total uptake of nitrogen and potassium was computed from per cent nutrient and drymatter of whole plant, and expressed in kg ha^{-1}.

3.10 CHEMICAL ANALYSIS OF CANE JUICE

The cane juice in sampled canes (whole clumps of 10 canes) from each treatment were analysed for sucrose and purity in November and December and at harvest time in January for both plant and ratoon crops. Glucose content in cane juice was estimated at harvest time in January.

3.10.1 Sucrose

Brix readings from raw cane juice using brix hydrometer calibrated at 27.5°C, pol readings from direct polarisation of undiluted clarified cane juice by using polarimeter were recorded. The juice sucrose values were determined with uncorrected brix values and polarimeter readings by using the table values as indicated by Brown and Zerban (1941) and expressed in per cent.

3.10.2 Glucose

Glucose was estimated by titrating the filtered juice with 5 ml of Fehling's A (alkaline tartrate solution) and 5 ml of Fehling's B (standard copper sulphate solution); knowing the juice titre value, the percentage of glucose in cane juice was determined (Brown and Zerban, 1941).

3.10.3 Coefficient of Purity

The coefficient of purity of juices was calculated using the formula (Brown and Zerban, 1941).

$$\text{Coefficient of purity} = \frac{\text{Sucrose}}{\text{Corrected brix}} \times 100$$

3.11 OBSERVATION ON STALK CHARACTERS AT HARVEST

3.11.1 Number of Millable Canes (NMC)

The total number of millable canes at harvest time was counted in each treatment in all replications from the net plot area and the number of millable canes thus recorded were computed per hectare.

3.11.2 Lenth of Millable Cane (LMC)

The length of millable cane was recorded on 20 canes selected at random from each treatment at harvest time. The length of each cane was measured in cm and mean length of millable cane was recorded.

3.11.3 Number of Internodes

The total number of internodes in each of the twenty sampled canes were counted and the average number of internodes per cane was reported.

3.11.4 Diameter of Cane

The diameter of twenty sampled canes was measured with vernier calipers at bottom, middle and top portion of each cane and the average diameter of each sampled cane was worked out and expressed in centemetres.

3.11.4 Weight of Single Cane

The weight of 20 sampled canes was recorded and the mean weight thus obtained was expressed as weight of single cane in kilograms.

3.12 CANE AND CCS YIELDS AT HARVEST

3.12.1 Cane Yield

The weight of all the canes in the net plot in each treatment in the three replications was recorded in kg and was converted to tonnes ha^{-1}.

3.12.2 Estimated Yield of Commercial Cane Sugar

Commercial cane sugar (CCS) yield ha^{-1} for each treatment was calculated by using the formula developed by Winter (1897).

$$\text{Estimated C.C.S. yield t ha}^{-1} = (S - (B-S)\ 0.4)\ 0.75 \times \frac{Y}{100}$$

Where S = Per cent sucrose in juice

B = Corrected brix

Y = Cane yield in t ha^{-1}

3.13 STATISTICAL ANALYSIS OF EXPERIMENTAL DATA

The data collected from both plant and ratoon crop experiments were subjected to statistical analysis by adopting appropriate method of "Analysis of Variance" described by Fisher (1948). The significance of the treatment effects was judged with the help of F (Variance ratio) test. Significance of difference between treatment means was tested using critical difference (CD) at P = 0.05 level of probability. Besides these, response equation functions simple correlations (r) and multiple regressions (R) were worked out to study the response to levels of N and K in plant and ratoon crops, relationship and association of different stalk characters with cane yield were computed by using the formulae as suggested by Heady and Dillon (1961) Snedecor and Cochran (1976) and Panse and Sukhatme (1978). Regression analysis was also done by the method described by Heady and Dillon (1961) to study the crop response to nitrogen and potassium.

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

Investigations on the effect of N and K, each at three levels and three times of K application on growth, nutrient indices, yield attributes, juice quality, yield of cane, commercial cane sugar (CCS) and nutrient uptake by plant and first ratoon crops of sugarcane (Co T 8201) were carried out at Regional Agricultural Research Station, Anakapalle during 1987-88 and 1988-89 seasons respectively. The potassium induced tolerance to moisture stress during summer period (April and May) was also studied. Statistical analysis of data collected on various aspects of growth, nutrient indices and their uptake, cane yield and juice quality were presented. The relationship between mineral nutrition during grand growth phase with yield of cane and CCS and important stalk characteristics with cane yield were studied through appropriate correlations. Response of sugarcane to levels of N and K was studied through response curves and the entire data on plant and ratoon crops were presented in this chapter.

4.1 GERMINATION OF CANE SETTS

The mean germination per cent of planted setts did not vary significantly due to treatments (Tables 4). The per cent germination of setts varied from 65.46 to 66.50 in different treatments.

Table 4. Germination (%) of setts as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		67.89	64.04	65.40	65.72	65.52	
112	T_1	66.00	65.57	64.16	65.24		66.50
	T_1	64.83	64.85	65.05	64.91		65.03
	T_2	65.18	65.57	67.70	66.15		65.68
	T_3 Mean	65.34	65.33	65.64		65.43	
224	T_1	67.42	68.40	67.44	67.75		
	T_1	64.65	64.68	66.15	65.16		
	T_2	64.95	65.12	65.52	65.20		
	T_3 Mean	65.67	66.07	66.37		66.04	
Grand mean for N levels		65.85	65.46	65.92			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	No	0.970	-
Between two levels of potassium means (K)	No	0.678	-
Between two times of potassium application means (T)	No	0.830	-
Between two N means at the same level of K	No	1.337	-
Between two K means at the same level of N	No	1.174	-
Between two K means at the same level of T	No	1.174	-
Between two T means at the same level of K	No	1.174	-
Control Vs other K treatments	No	0.896	

4.2 PLANT HEIGHT

Plant height of both plant and ratoon crops was reacorded at 120, 180, 240 and 300 DAP/DAR.

4.2.1 Plant Crop

There was a steep increase in plant height from 120 (140.1 cm) to 240 DAP (278.6 cm) and a marginal increase from 240 (278.6 cm) to 300 DAP (300.0 cm) irrespective of treatments. Levels of N had significant effect on plant height at all the stages of observation (Table 5 and Fig. 5). Application of N upto 112 kg ha^{-1} significantly increased the plant height at all the stages of observation. However, the difference in plant height due to 112 and 224 kg N ha^{-1} was significant during later stage i.e. grand growth phase (180 and 240 DAP) only. There was significant increase in plant height due to potassium application compared to control (K_o) at all the stages of observation. Significant difference in plant height was not observed between 112 and 224 kg K_2O ha^{-1}. Time of K application had significant influence on plant height. The data recorded at 120 and 300 DAP indicated that basal application of K (T_1) significantly increased the plant height compared to late application at 120 DAP (T_3). Similarly, observations recorded at 180 and 240 DAP indicated that basal application

Table 5. Plant height (cm) at different crop growth stages of plant crop as influenced by N, K and time of K application

Treatment		120 DAP					180 DAP					240 DAP					300 DAP				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		84.3	111.4	113.2	102.9		146.0	199.4	211.6	185.7		239.8	283.6	299.0	274.1		257.6	300.3	306.4	288.1	
112	T_1	89.4	113.9	120.9		109.3	164.0	212.4	221.0		202.4	254.5	293.8	306.0		288.9	271.3	315.7	328.8		306.5
	T_2^1	85.7	115.4	119.6		108.0	157.7	208.6	217.8		197.1	247.7	290.9	299.4		281.2	267.5	316.0	321.6		303.7
	T_3^2	84.4	110.8	117.1		104.8	152.0	203.3	214.6		191.5	241.9	281.8	291.8		275.1	265.5	308.3	312.7		296.4
	Mean	86.5	113.4	119.2	106.3		157.9	208.1	217.8	194.6		248.0	288.8	299.1	278.6		268.1	313.3	321.0	300.8	
224	T_1	90.4	119.8	121.5			166.4	218.2	232.2			254.5	294.1	309.2			271.8	320.3	330.6		
	T_2^1	87.8	118.2	121.3			159.0	217.6	221.6			249.2	298.4	301.3			269.1	322.7	325.3		
	T_3^2	86.2	112.6	117.7			151.7	207.3	219.8			240.8	290.9	303.6			260.5	312.8	318.2		
	Mean	88.1	116.9	120.2	108.4		159.0	214.4	224.5	199.3		248.2	294.5	304.7	284.4		267.1	318.6	324.7	303.5	
Grand mean for N levels		86.9	114.6	118.8			156.7	209.5	219.8			246.9	289.0	299.8			266.2	313.7	320.5		
			r = 3					n = 63													

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	2.18	6.04	Yes	3.37	9.36	Yes	3.11	9.24	Yes	3.34	10.44
Between two levels of Potassium means (K)	No	1.06	-	No	2.78	-	No	2.96	-	No	3.21	-
Between two times of Potassium application means (T)	Yes	1.05	2.16	Yes	2.43	4.93	Yes	3.50	7.08	Yes	3.62	7.72
Between two N means at the same level of K	No	2.58	-	No	4.38	-	No	4.38	-	No	4.58	-
Between two K means at the same level of N	No	1.49	-	No	3.44	-	No	4.54	-	No	4.72	-
Between two K means at the same level of T	No	1.49	-	No	3.44	-	No	4.54	-	No	4.72	-
Between two T means at the same level of K	No	1.49	-	No	3.44	-	No	4.54	-	No	4.72	-
Control Vs other K treatments	Yes	1.14	2.30	Yes	2.62	5.33	Yes	3.70	6.48	Yes	3.96	8.46

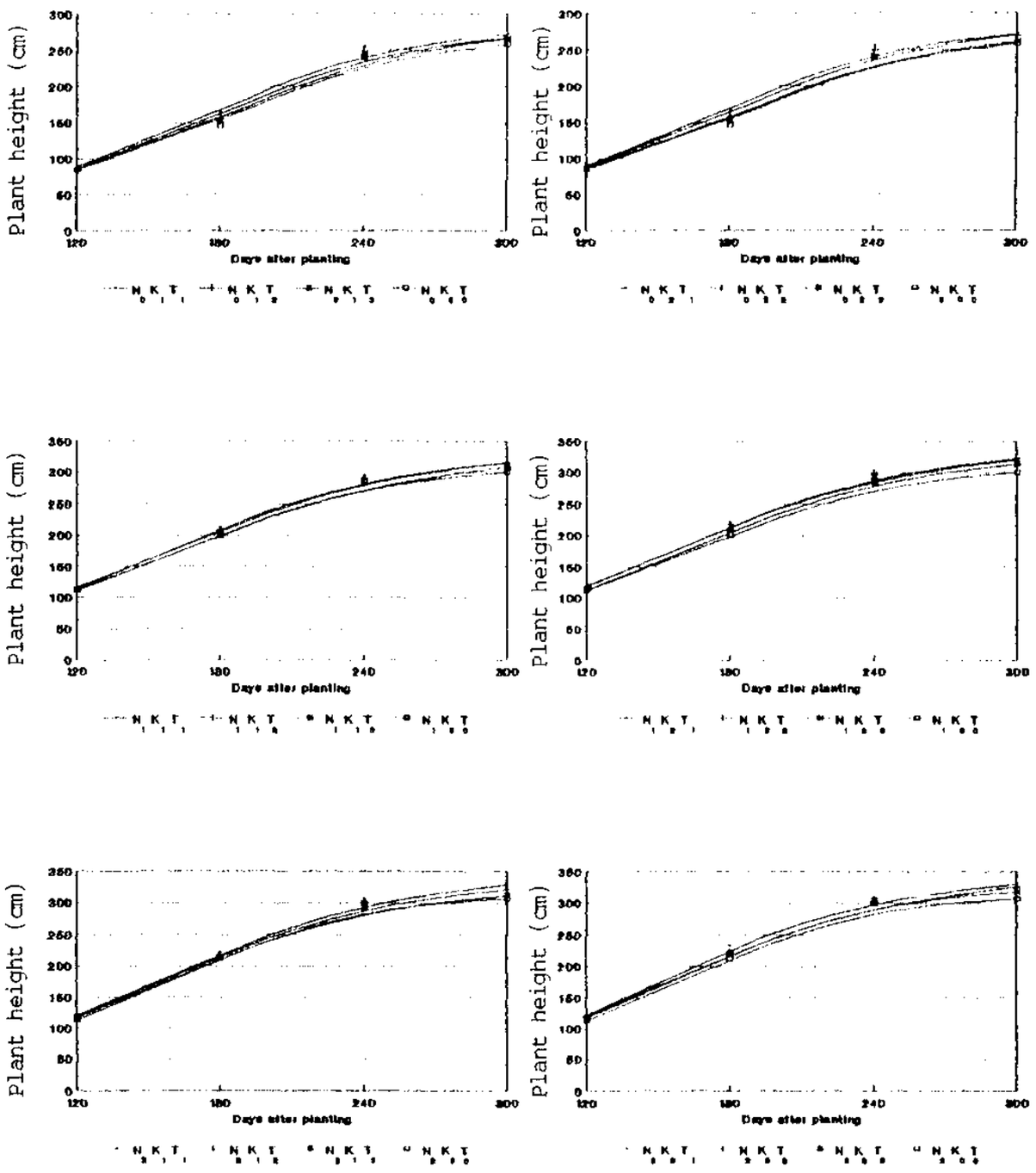


Fig.5: Plant height (cm) at different crop growth stages (Plant crop)

of K (T_1) significantly increased the plant height over late application at 60 (T_2) and 120 (T_3) DAP. Plant height recorded at 180 DAP revealed that the application of K at 60 DAP (T_2) was significantly superior to 120 DAP (T_3). However, both the treatments (T_2 and T_3) were at par at 240 DAP. The interaction between N and K levels and K levels and its time of application were not significant.

4.2.2 Ratoon Crop

As in the case of plant crop, there was a steep increase in plant height from 120 (94.8 cm) to 240 DAR (223.6 cm) with marginal increase there after upto 300 DAR (254.3 cm). Increase in the level of N from 0 to 112 kg ha^{-1} and from 112 to 224 kg ha^{-1} significantly increased the plant height at all the stages of observation. (Table 6 and Fig.6). Application of K significantly increased the plant height over no application. Both at 112 and 224 kg K_2O ha^{-1} the plant height increased with the increase in the level of K at 180 DAR only. Plant height did not vary significantly due to time of K application during later stages of crop growth. At 120 DAR there was significant increase in plant height with early application of K (T_1) was found superior to T_2 while T_2 was found superior to T_3. Interaction between N and k levels or k and its time of application were not significant.

Table 6. Plant height (cm) at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		120 DAR					180 DAR					240 DAR					300 DAR				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		74.3	88.2	98.1	86.9		138.2	145.9	180.9	155.0		191.8	215.0	230.2	212.3		215.8	244.7	260.8	240.4	
112	T_1	87.4	98.4	111.2		100.0	146.2	160.2	193.2		171.1	207.1	231.5	242.6		228.1	238.4	256.9	272.7		257.6
	T_2	83.9	92.5	108.8		96.6	144.1	153.0	189.5		167.6	205.6	228.8	238.1		225.8	239.5	257.8	269.9		257.3
	T_3	77.6	89.4	103.7		91.6	144.2	152.9	188.6		166.4	202.8	222.8	235.3		222.7	239.8	252.3	264.5		254.9
	Mean	82.9	93.4	107.9	94.8		144.8	155.4	190.4	162.4		205.2	222.7	238.7	222.2		239.2	255.7	269.0	254.6	
224	T_1	85.0	102.7	115.5			154.6	170.2	202.3			210.5	232.7	243.9			240.2	260.7	276.3		
	T_2	85.5	98.1	110.9			152.1	168.7	198.1			207.7	232.5	242.1			241.7	263.8	271.5		
	T_3	83.0	92.3	103.7			145.8	168.3	198.4			206.8	230.8	237.6			238.6	260.5	274.1		
	Mean	84.5	97.7	110.0	97.4		150.8	169.1	199.6	171.2		208.3	232.2	241.2	227.2		240.2	261.7	273.9	258.6	
Grand mean for N levels		82.4	94.5	107.4			140.5	159.9	193.0			204.6	207.7	238.5			236.3	256.7	270.0		
		r = 3					n = 63														

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	1.69	4.68	Yes	3.03	8.40	Yes	2.81	7.81	Yes	3.48	10.95
Between two levels of Potassium means (K)	No	1.40	-	Yes	2.43	5.16	No	2.78	-	No	3.21	-
Between two times of Potassium application means (T)	Yes	1.71	3.47	No	2.97	-	No	3.01	-	No	3.36	-
Between two N means at the same level of K	No	2.50	-	No	4.42	-	No	4.08	-	No	5.12	-
Between two K means at the same level of N	No	2.42	-	No	4.21	-	No	3.85	-	No	4.38	-
Between two K means at the same level of T	Yes	2.42	5.17	No	4.21	-	No	3.85	-	No	4.38	-
Between two T means at the same level of K	Yes	2.42	5.17	No	4.21	-	No	3.85	-	No	4.38	-
Control Vs other K treatments	Yes	1.85	3.75	Yes	3.21	6.52	Yes	2.94	5.90	Yes	3.20	6.84

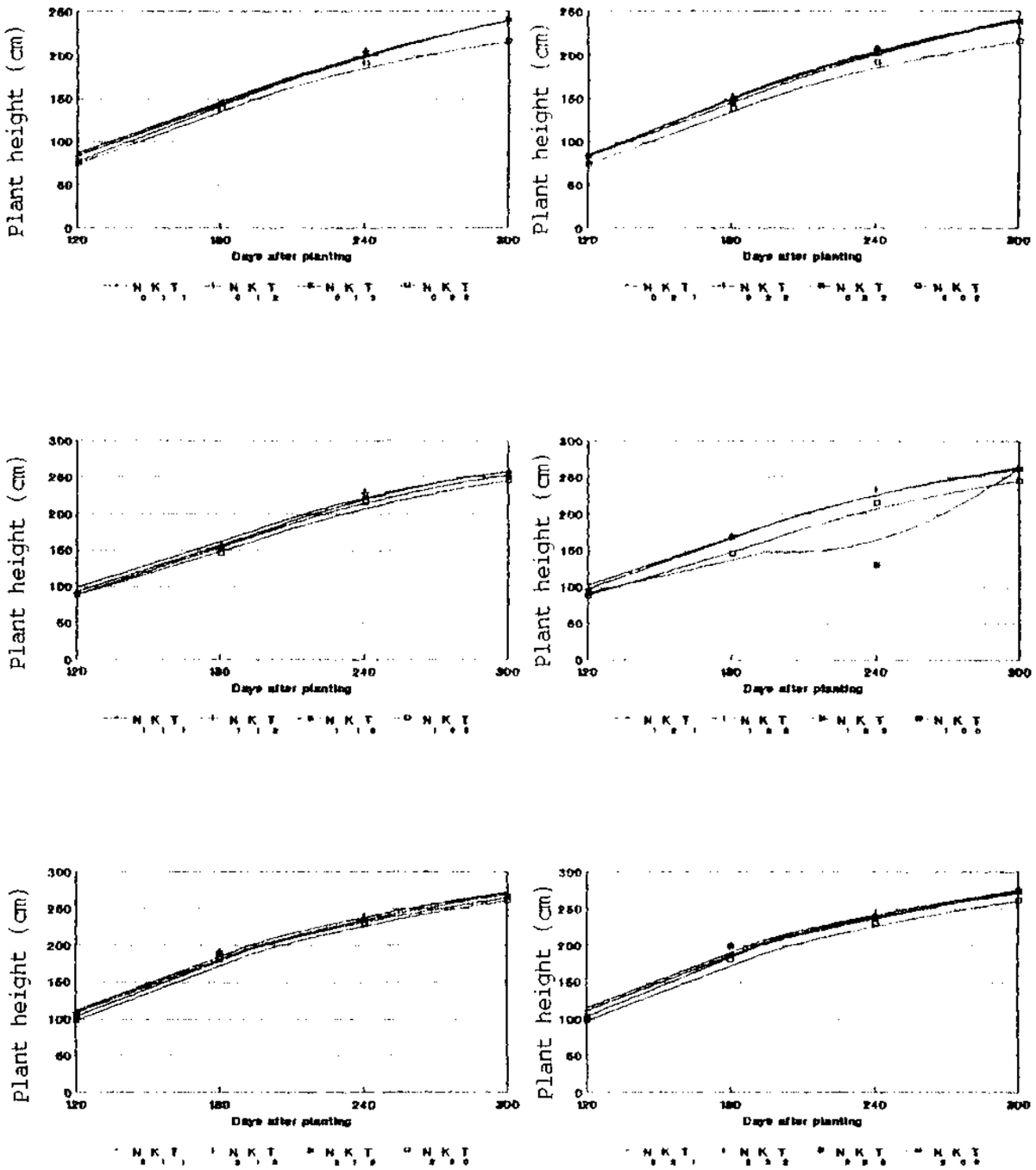


Fig.6: Plant height (cm) at different crop growth stages (Ratoon crop)

4.3 SHOOT POPULATION

The data on shoot population of both plant and ratoon crops were recorded at 120, 180, 240 and 300 days age of the crop.

4.3.1 Plant Crop

Highest shoot population was recorded at 120 DAP which decreased sharply there after. Application of 112 kg N ha^{-1} (N_1) significantly increased the shoot population over no N (N_o) at all the stages of observation. Further increase of N upto 224 kg ha^{-1} did not significantly increase the shoot population at any stage of the crop growth (Table 7). Potash application increased the shoot population at all the stages of crop growth compared to no application. However, between 112 and 224 kg K_2O ha^{-1} there was no significant difference at all. Between times of K application, it was found that basal appliation (T_1) had significantly higher shoot population compared to the appplication at 120 DAP (T_3) when observed at 240 DAP. None of the interactions were significant.

4.3.2 Ratoon Crop

Irrespective of doses of N, K and times of K

Table 7. Shoot population (000's ha^{-1}) at different crop growth stages of Plant crop as influenced by N, K and time of K application.

Treatment		120 DAP					180 DAP					240 DAP					300 DAP				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		101.367	120.673	124.939	115.994		76.693	80.664	81.705	79.687		71.420	79.297	78.451	76.389		67.482	75.865	77.836	73.728	
112	T_1	103.253	117.837	129.629		118.934	79.361	83.267	86.523		83.932	73.508	79.752	83.031		79.372	73.110	79.486	82.968		79.206
	T_2	104.611	118.384	131.244		119.383	80.664	84.830	84.174		83.645	71.484	80.859	82.993		78.199	71.316	80.252	81.763		77.804
	T_3	103.906	120.892	130.142		119.082	78.586	83.794	85.482		83.370	69.531	80.664	81.119		77.344	69.500	78.768	80.566		76.754
	Mean	103.923	119.037	130.336	117.765		79.537	83.964	85.393	82.964		71.508	80.425	82.048	78.109		71.309	79.502	81.765	77.525	
224	T_1	101.187	130.142	131.564			79.766	85.220	89.459			77.018	82.031	84.830			74.632	81.856	82.982		
	T_2	100.259	130.328	131.472			78.256	86.873	88.072			74.848	81.976	80.404			72.778	80.432	80.280		
	T_3	101.119	128.683	129.751			79.930	84.227	88.203			74.158	79.865	83.725			71.585	79.786	80.315		
	Mean	100.855	129.718	130.929	120.500		79.317	85.107	88.576	84.333		75.220	81.288	82.986	79.838		73.065	80.691	81.192	78.316	
Grand mean for N levels		102.243	124.420	129.390			79.037	83.982	86.230			73.086	80.636	82.079			71.515	79.492	80.958		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	1.845	5.822	Yes	1.248	3.465	Yes	0.661	1.836	Yes	0.684	2.137
Between two levels of Potassium means (K)	No	1.136	-	No	0.829	-	No	0.741	-	No	0.798	-
Between two times of Potassium application means (T)	No	1.368	-	No	1.015	-	Yes	0.907	1.827	No	0.892	-
Between two N means at the same level of K	No	1.996	-	No	1.688	-	No	1.155	-	No	1.098	-
Between two K means at the same level of N	No	1.758	-	No	1.536	-	No	1.283	-	No	1.158	-
Between two K means at the same level of T	No	1.758	-	No	1.536	-	No	1.283	-	No	1.158	-
Between two T means at the same level of K	No	1.758	-	No	1.536	-	No	1.283	-	No	1.158	-
Control Vs other K treatments	Yes	1.432	3.054	Yes	1.096	2.224	Yes	0.980	2.092	Yes	1.285	2.745

Treatment		120 DAR					180 DAR					240 DAR					300 DAR				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		87.500	91.081	95.182	91.254		76.562	80.924	82.747	80.078		72.135	75.390	78.190	75.238		69.857	72.591	75.455	72.635	
112	T_1	97.721	95.573	100.716		98.559	82.747	84.570	88.151		85.970	75.130	77.213	81.184		78.938	72.982	75.195	79.948		76.888
	T_2	91.862	95.443	99.284		96.734	80.404	85.156	88.672		85.822	72.982	77.799	80.729		77.854	70.703	76.627	79.752		76.320
	T_3	88.652	92.408	96.917		93.219	80.143	84.794	88.400		85.332	73.828	75.716	78.516		76.357	72.786	75.736	78.497		76.055
	Mean	92.745	94.475	98.972	95.397		81.098	84.840	88.408	84.781		73.980	76.919	80.143	77.011		72.157	75.862	79.399	75.806	
224	T_1	97.005	98.047	103.190			84.180	86.133	90.039			78.159	78.710	82.333			75.195	76.758	81.250		
	T_2	96.708	98.568	102.539			83.948	85.789	90.950			74.284	78.385	82.942			73.745	75.976	81.119		
	T_3	90.164	93.773	97.401			84.404	85.008	89.239			73.698	76.302	80.078			73.549	75.154	80.580		
	Mean	94.626	96.796	101.043	96.944		84.177	85.637	90.076	86.630		73.347	77.799	82.118	78.421		74.163	75.963	80.983	76.609	
Grand mean for N levels		92.802	94.985	99.318			81.170	84.625	88.314			74.302	77.074	80.710			72.688	75.438	79.514		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	1.400	4.054	Yes	1.313	3.646	Yes	1.26	3.125	Yes	0.923	2.563
Between two levels of Potassium means (K)	No	1.312	-	No	1.046	-	No	0.866	-	No	0.732	-
Between two times of Potassium application means (T)	Yes	1.606	3.554	No	1.281	-	Yes	1.060	2.263	No	0.897	-
Between two N means at the same level of K	No	2.665	-	No	1.911	-	No	1.613	-	No	1.341	-
Between two K means at the same level of N	No	2.272	-	No	1.812	-	No	1.499	-	No	1.268	-
Between two K means at the same level of T	No	2.272	-	No	1.812	-	No	1.499	-	No	1.268	-
Between two T means at the same level of K	No	2.272	-	No	1.812	-	No	1.499	-	No	1.268	-
Control Vs other K treatments	Yes	1.735	3.520	Yes	1.385	2.807	Yes	1.145	2.323	Yes	0.969	1.966

application, maximum shoot population was obtained at 120 DAR which decreased gradually in the advanced stages of crop growth (Table 8). Consistent and signficant increase in shoot population was observed with increase in the level of nitrogen from 0 to 224 kg ha^{-1} at all the stages of crop growth. However at 120, 180 and 240 DAR the differences between 0 and 112 kg N ha^{-1} were not significant. The increase in shoot population with 224 kg N ha^{-1} was signficant compared to 0 and 112 kg N ha^{-1} at all the stages of sampling. Application of potash resulted in significantly higher shoot population over control (K_o) at all the stages of observation. No significant difference in shoot population was observed between 112 (k_1) and 224 (k_2) kg K_2O ha^{-1} levels at all the stages of observation. Application of K at ratooning (T_1) significantly increased the shoot population at 120 and 240 DAR compared to the application of K at 120 DAR (T_3) while such differences were not observed at 180 and 300 DAR. The interaction effects between N and K or K and its time of application were not significant.

4.4 LEAF AREA INDEX (LAI)

Leaf area indices at 150 and 210 days (grand growth phase) and at harvest were recorded for both plant and ratoon crops.

4.4.1 Plant Crop

Leaf area index was low in the initial stages (150 DAP) but reached a peak by 210 days followed by a gradual decrease upto harvest (Table 9 Fig. 7). Application of N at 112 kg ha^{-1} significantly increased the LAI over '0' level of N at all the stages of crop growth. The difference in LAI between 112 and 224 Kg N ha^{-1} was not significant at all the stages of sampling. Levels of K and its time of application had no significant influence on the LAI at any stage of crop growth. None of the interaction effects were significant.

4.4.2 Ratoon Crop

Ratoon crop had lower LAI than plant crop. Every increase in the level of N from '0' to 224 kg ha^{-1} significantly increased the LAI at all the stages of crop growth (Table 10 Fig.8). On the other hand, K levels and time of its application had no significant influence on LAI at any stage of crop growth. Interactions between N and K., and K and its time of application had no significant effect on LAI.

4.5 PERCENT SHEATH MOISTURE IN 3-6 LEAF SHEATHS

The data on per cent sheath moisture (3-6 leaf sheaths) of both plant and ratoon crops were recorded at 120, 180, 210 and 270 days age of the crop.

Table 9. Leaf Area Index (LAI) at different crop growth stages of Plant Crop as influenced by N, K and time of K application

Treatment		150 DAP					210 DAP					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		2.89	4.57	4.64	4.03		3.00	5.38	5.47	4.62		1.98	2.74	2.83	2.52	
112	T_1	2.96	4.46	4.58		4.05	3.12	5.33	5.45		4.67	2.05	2.79	2.93		2.59
	T_2	2.87	4.45	4.61		4.03	3.02	5.49	5.39		4.67	2.02	2.77	2.86		2.59
	T_3	2.74	4.38	4.52		3.91	3.00	5.34	5.45		4.63	1.95	2.69	2.76		2.50
	Mean	2.86	4.43	4.57	3.95		3.05	5.39	5.43	4.62		2.01	2.75	2.85	2.54	
224	T_1	3.00	4.62	4.66			3.14	5.45	5.55			2.14	2.74	2.89		
	T_2	3.00	4.57	4.67			3.11	5.47	5.55			2.17	2.82	2.91		
	T_3	2.84	4.48	4.51			3.05	5.41	5.50			2.05	2.77	2.77		
	Mean	2.95	4.56	4.61	4.04		3.10	5.44	5.53	4.69		2.12	2.78	2.86	2.58	
Grand mean for N levels		2.90	4.50	4.60			3.04	5.35	5.45			2.04	2.74	2.82		

r = 3 n = 63

Conclusions:

Particulars	150 DAP			210 DAP			At harvest		
	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.108	0.328	Yes	0.099	0.298	Yes	0.084	0.253
Between two levels of Potassium means (K)	No	0.096	-	No	0.087	-	No	0.079	-
Between two times of Potassium application means (T)	No	0.079	-	No	0.079	-	No	0.085	-
Between two N means at the same level of K	No	0.243	-	No	0.219	-	No	0.196	-
Between two K means at the same level of N	No	0.198	-	No	0.173	-	No	0.183	-
Between two K means at the same level of T	No	0.198	-	No	0.173	-	No	0.183	-
Between two T means at the same level of K	No	0.198	-	No	0.173	-	No	0.183	-
Control Vs other K treatments	No	0.089	-	No	0.072	-	No	0.065	-

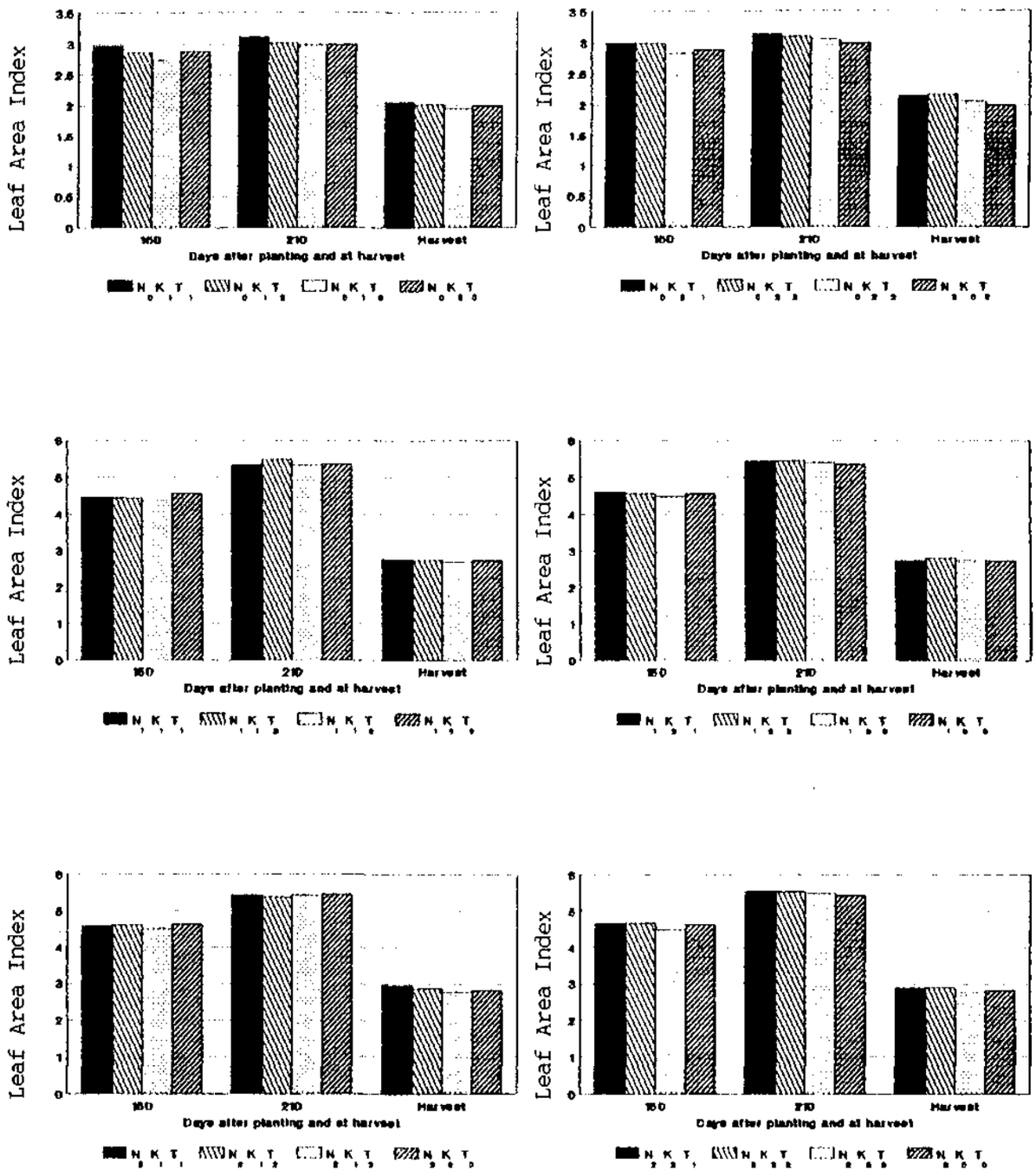


Fig.7: Leaf Area Index (LAI) at different crop growth stages (Plant crop)

Table 10. Leaf Area Index (LAI) at different crop growth stages of ratoon crop as influenced by N, K and time of K applications

Treatment		150 DAR					210 DAR					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		2.78	3.92	4.95	3.88		2.96	4.59	5.46	4.34		1.96	2.52	2.94	2.47	
112	T_1	2.75	3.91	4.89		3.85	2.99	4.66	5.39		4.39	1.98	2.54	2.88		2.52
	T_2	2.80	3.86	5.06		3.91	2.89	4.64	5.42		4.33	2.06	2.50	2.99		2.53
	T_3	2.76	3.94	4.29		3.88	2.92	4.69	5.47		4.39	2.00	2.62	2.96		2.51
	Mean	2.77	3.90	4.96	3.88		2.93	4.66	5.43	4.34		2.01	2.55	2.94	2.50	
224	T_1	2.70	4.01	4.88			3.18	4.60	5.52			2.15	2.52	3.00		
	T_2	2.80	4.18	4.79			3.02	4.54	5.50			2.08	2.58	2.96		
	T_3	2.76	3.99	4.92			2.99	4.69	5.58			2.03	2.52	2.94		
	Mean	2.75	4.06	4.86	3.89		3.06	4.61	5.53	4.40		2.09	2.54	2.97	2.53	
Grand mean for N levels		2.76	3.98	4.92			2.99	4.63	5.48			2.04	2.54	2.95		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.116	0.349	Yes	0.134	0.403	Yes	0.072	0.217
Between two levels of Potassium means (K)	No	0.102	-	No	0.116	-	No	0.068	-
Between two times of Potassium application means (T)	No	0.089	-	No	0.103	-	No	0.062	-
Between two N means at the same level of K	No	0.237	-	No	0.286	-	No	0.196	-
Between two K means at the same level of N	No	0.198	-	No	0.213	-	No	0.182	-
Between two K means at the same level of T	No	0.198	-	No	0.213	-	No	0.182	-
Between two T means at the same level of K	No	0.198	-	No	0.213	-	No	0.182	-
Control Vs other K treatments	No	0.093	-	No	0.112	-	No	0.082	-

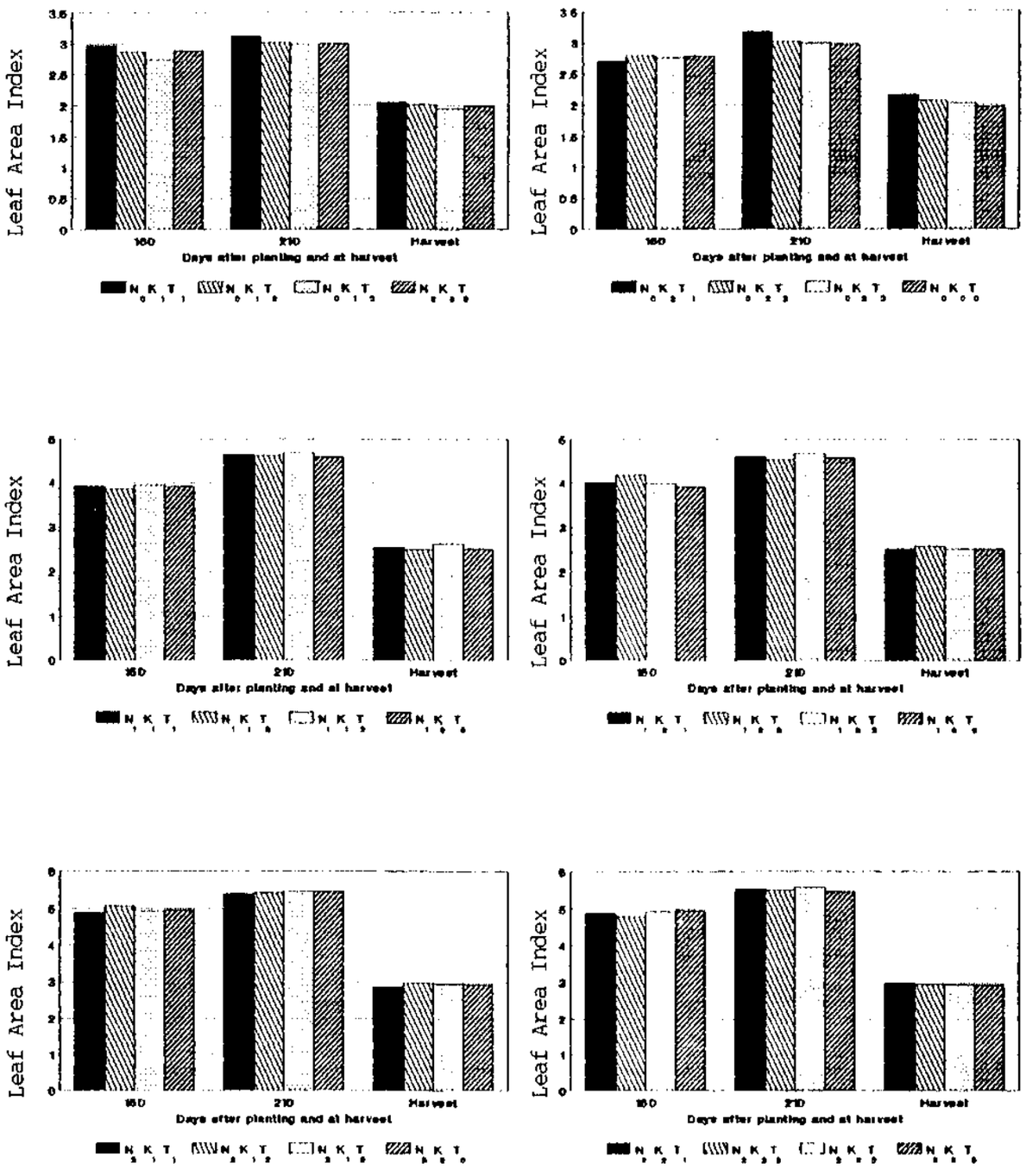


Fig.8: Leaf Area Index (LAI) at different crop growth stages (Ratoon crop)

4.5.1 Plant Crop

The per cent sheath moisture (3-6 leaf sheaths) gradually increased from 120 (83.84%) to 180 DAP (84.19%) followed by a decrease at later stages (80.99%). The per cent sheath moisture increased significantly with increase in the level of N from '0' to 112 kg ha^{-1} at all the stages of sampling (Table 11 Fig.9). Further increase of N upto 224 kg ha^{-1} had no significant influence on per cent sheath moisture at all the stages of crop growth. Significantly higher per cent sheath moisture was observed due to the application of 224 kg K_2O ha^{-1} (84.55%) as compared to 112 kg K_2O ha^{-1} (84.03%) at 180 DAP only. There was significant rise in the per cent sheath moisture due to application of K over control (K_o) at all the stage of crop growth. Application of K at planting (T_1) or at 60 DAP (T_2) significantly increased the per cent sheath moisture over late application at 120 DAP (T_3) when recorded at 120 DAP. However, such differences in per cent sheath moisture were not observed in the later stages of crop growth. Interaction between N and K was significant at 210 and 270 DAP only. Significant increase in sheath moisture per cent at K_1 and K_2 compared to K_o was observed at N_o, N_1 and N_2 levels. However, the difference between K_1 and K_2 was significant only at N_2 level as K_2 had highest sheath moisture at 210 DAP. At a given level of K there was increase in sheath

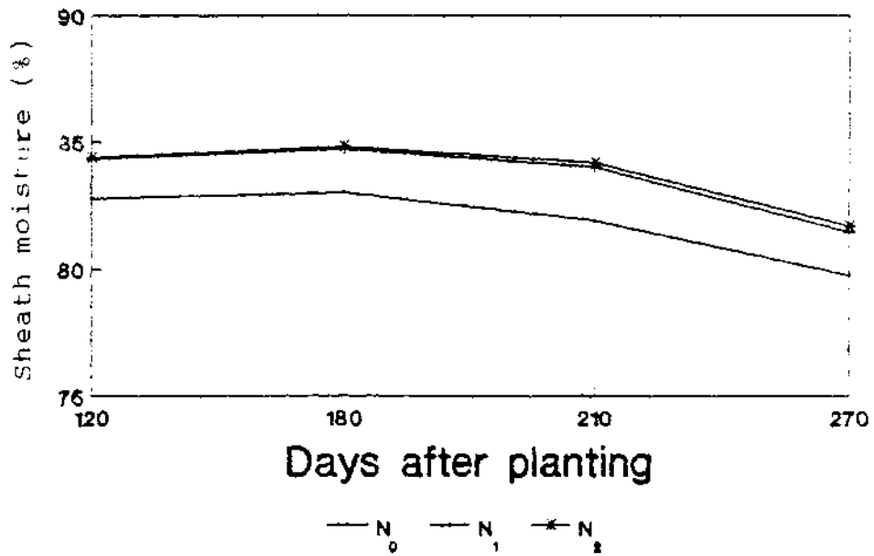
Table 11. Sheath moisture (%) in 3-6 sheaths at different crop growth stages of Plant crop as influenced by N, K and time of K application.

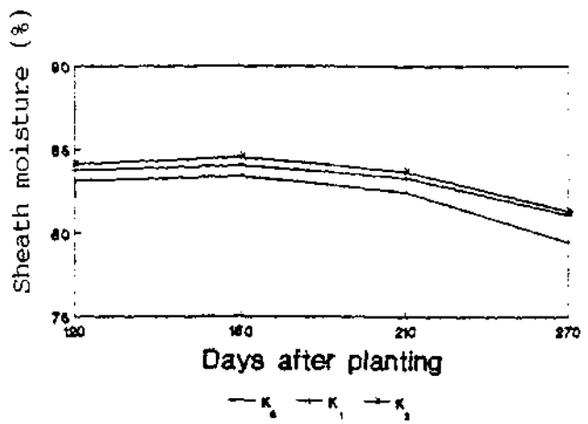
Treatment		120 DAP					180 DAP					210 DAP					270 DAP				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		82.55	83.35	83.57	83.15		83.15	83.95	83.17	83.42		81.58	82.85	82.99	82.47		79.11	79.32	79.90	79.44	
112	T_1	82.62	84.52	84.68		84.22	82.62	84.52	84.68		84.30	82.39	83.85	83.98		83.52	80.35	81.35	81.40		81.07
	T_2	82.50	85.09	84.73		84.35	82.51	85.09	84.73		84.35	82.47	83.83	84.00		83.62	79.26	81.94	82.01		81.21
	T_3	82.52	83.64	83.67		83.32	82.52	84.64	85.20		84.25	80.88	84.44	84.24		83.42	79.82	81.44	82.21		81.36
	Mean	82.55	84.42	84.36	83.78		82.55	84.75	84.87	84.03		81.91	84.07	84.07	83.34		79.81	81.57	81.78	81.07	
224	T_1	83.31	85.03	85.13			83.31	85.03	85.63			81.85	84.78	84.55			79.89	81.67	81.78		
	T_2	83.51	85.06	85.20			83.51	85.06	85.20			82.52	84.12	84.79			79.63	82.04	82.37		
	T_3	82.53	83.77	83.78			83.53	84.77	85.21			82.01	84.19	84.68			80.33	82.08	82.32		
	Mean	83.12	84.62	84.70	84.15		83.45	84.96	85.02	84.55		82.07	84.37	84.67	83.70		79.95	81.93	82.16	81.34	
Grand mean for N levels		82.79	84.35	84.39			83.02	84.72	84.83			81.93	84.01	84.18			79.77	81.48	81.71		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.102	0.283	Yes	0.087	0.241	Yes	0.241	0.668	Yes	0.333	0.924
Between two levels of Potassium means (K)	No	0.194	-	Yes	0.152	0.309	No	0.154	-	No	0.139	-
Between two times of Potassium application means (T)	Yes	0.225	0.458	No	0.187	-	No	0.186	-	No	1.170	-
Between two N means at the same level of K	No	0.251	-	No	0.209	-	Yes	0.211	0.328	Yes	0.398	0.267
Between two K means at the same level of N	NO	0.318	-	No	0.264	-	Yes	0.207	0.419	Yes	0.184	0.372
Between two K means at the same level of T	No	0.318	-	No	0.264	-	No	0.207	-	No	0.184	-
Between two T means at the same level of K	No	0.318	-	No	0.264	-	No	0.207	-	No	0.184	-
Control Vs other K treatments	Yes	0.243	0.498	Yes	0.201	0.409	Yes	0.158	0.329	Yes	0.241	0.485





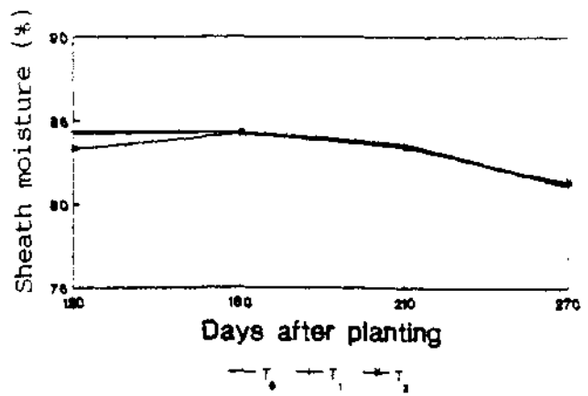


Fig.9: Sheath moisture (%) at different crop growth stages (plant crop)

moisture at N_1 over N_o only. A similar trend can be seen at 270 DAP also.

Sheath moisture (%) at 210 DAP

N level	K level			CD (P=0.05)
	K_o	K_1	K_2	
N_o	81.58	81.91	82.07	A. 0.328
N_1	82.85	84.07	84.37	B. 0.419
N_2	82.99	84.07	84.67	

Sheath moisture (%) at 270 DAP

N level	K level			CD (P=0.05)
	K_o	K_1	K_2	
N_o	79.11	79.81	79.95	A. 0.287
N_1	79.32	81.57	81.93	B. 0.373
N_2	79.90	81.78	82.16	

A = Between two N means at the same level of K

B = Between two K means at the same level of N

4.5.2 Ratoon Crop

Almost similar trend as in plant crop was observed in leaf sheath moisture content in ratoon crop (Table 12 and

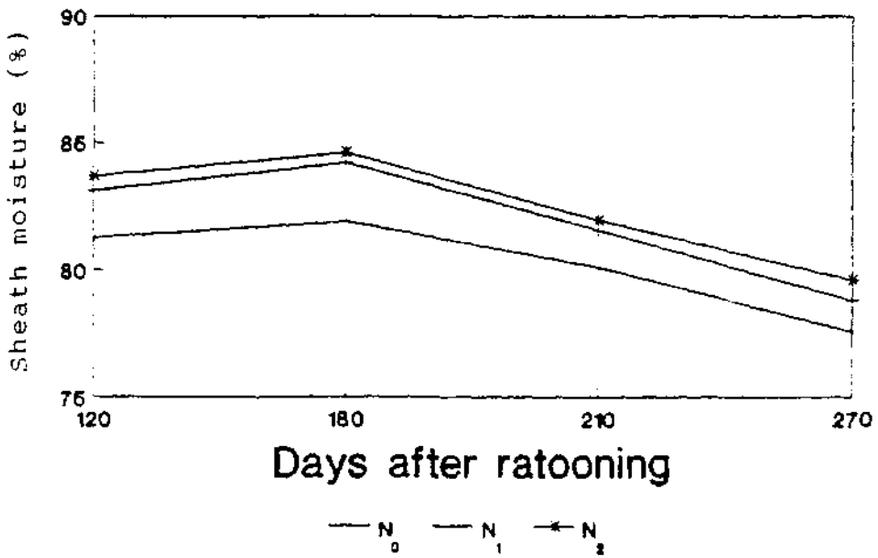
Table 12. Sheath Moisture (%) in 3-6 sheaths at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

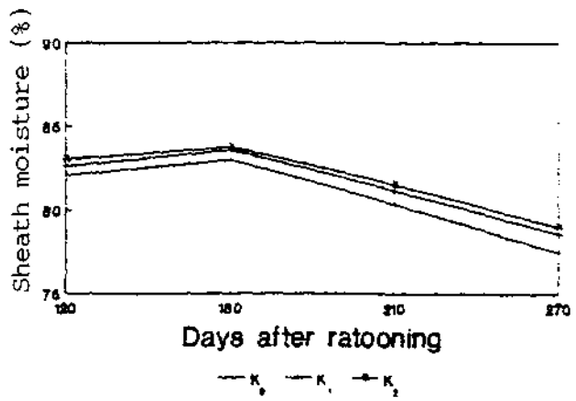
Treatment		120 DAR					180 DAR					210 DAR					270 DAR				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		80.67	82.47	83.20	82.11		81.45	83.39	84.16	83.00		79.22	80.27	81.56	80.35		76.01	77.88	78.83	77.46	
112	T_1	81.51	83.37	83.90		83.12	81.78	84.38	84.70		83.69	80.29	81.56	81.90		81.43	77.70	78.76	79.49		78.92
	T_2	80.90	83.32	83.96		82.96	81.62	84.47	84.68		83.67	79.91	81.60	81.99		81.36	77.58	78.90	79.30		78.80
	T_3	80.81	82.60	83.28		82.50	81.58	84.38	84.53		83.65	80.16	81.57	81.67		81.32	77.71	78.92	79.21		78.85
	Mean	81.07	83.10	83.71	82.63		81.66	84.41	84.64	83.57		80.12	81.58	81.65	81.18		77.66	78.53	79.33	78.61	
224	T_1	82.13	83.61	84.16			82.65	84.14	84.82			80.49	82.08	82.24			78.06	79.20	80.31		
	T_2	81.84	83.64	84.10			82.26	84.30	84.70			80.34	81.97	82.30			77.97	78.98	80.06		
	T_3	81.22	82.08	83.90			82.36	84.31	84.78			80.28	82.06	82.20			78.01	79.02	80.20		
	Mean	81.73	83.41	84.05	83.06		82.32	84.38	84.77	83.79		80.37	82.04	82.25	81.55		78.01	79.07	80.19	79.01	
Grand mean for N levels		81.30	83.14	83.79			81.91	84.21	84.62			80.13	81.59	81.98			77.58	78.81	79.63		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.078	0.216	Yes	0.094	0.260	Yes	0.115	0.318	Yes	0.185	0.512
Between two levels of Potassium means (K)	Yes	0.011	0.228	Yes	0.096	0.193	Yes	0.112	0.225	Yes	0.123	0.249
Between two times of Potassium application means (T)	Yes	0.138	0.277	No	0.118	-	No	0.138	-	No	0.150	-
Between two N means at the same level of K	No	0.203	-	No	0.155	-	No	0.185	-	No	0.125	-
Between two K means at the same level of N	No	0.206	-	No	0.167	-	No	0.195	-	No	0.212	-
Between two K means at the same level of T	No	0.206	-	No	0.167	-	No	0.195	-	No	0.212	-
Between two T means at the same level of K	No	0.206	-	No	0.167	-	No	0.195	-	No	0.212	-
Control Vs other K treatments	Yes	0.150	0.303	yes	0.120	0.258	Yes	0.149	0.302	Yes	0.162	0.329





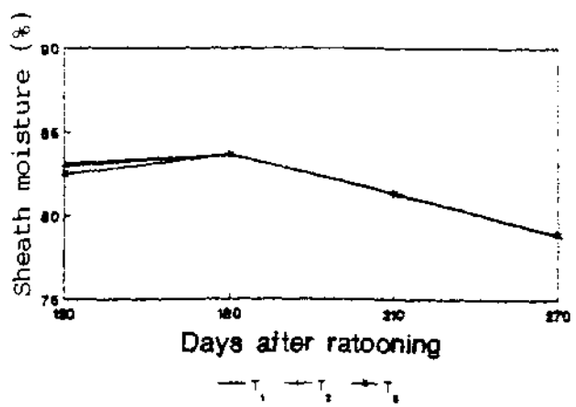


Fig.10: Sheath moisture (%) at different crop growth stages (ratoon crop)

Fig.10). The per cent moisture in leaf sheath increased with every increase in N level from '0' to 112 and from 112 to 224 kg ha^{-1} at all the stages of sampling. Similarly the per cent sheath moisture due to K levels (112 to 224 kg K_2O ha^{-1}) over control (k_o) was significant at all the stages of crop growth. Between K levels, there was increase in sheath moisture content with the increase in K application at all the stages of crop growth. Time of application of K had no significant effect on sheath moisture at any stage of crop growth except at 120 DAR where basal application of K (T_1) or application at 60 DAR (T_2) had higher sheath moisture content than appplication at 120 DAR (T_3). All the interaction effects had no significant influence on sheath moisture content.

4.6 NITROGEN IN 3-6 LEAVES

Nitrogen per cent in 3-6 leaves was estimated at 120, 180, 210 and 270 days in both plant and ratoon crops.

4.6.1 Plant Crop

The N content (Table 13 Fig.11) was highest at 120 DAP (1.68%) and decreased at later stages of crop growth (1.32%). There were significant differences in leaf N due to levels of nitrogen at all stages of sampling. The per cent leaf N significantly increased due to application of 112 kg

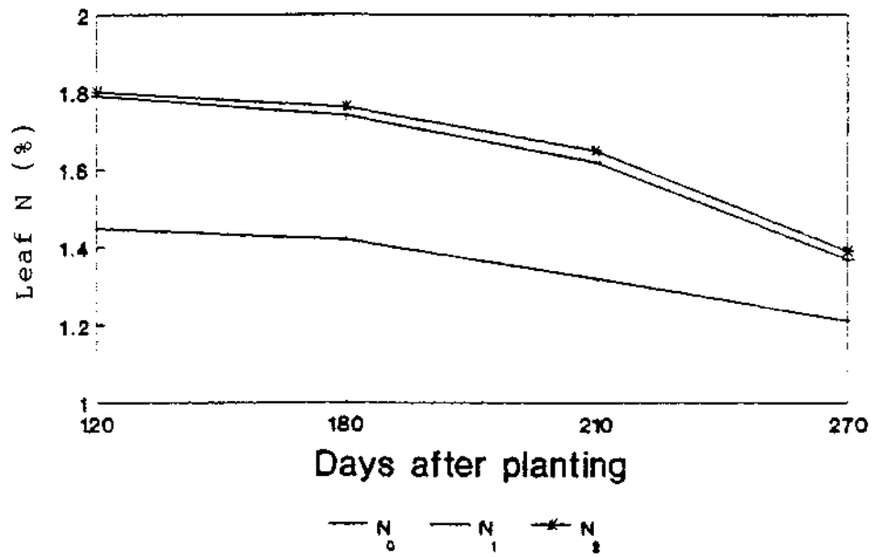
Table 13. Leaf N (%) in 3-6 leaves at different crop growth stages of Plant crop as influenced by N, K and time of K application.

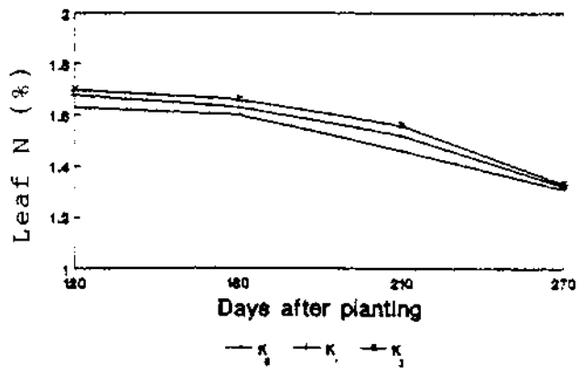
Treatment		120 DAP					180 DAP					240 DAP					300 DAP				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.33	1.76	1.79	1.63		1.37	1.69	1.73	1.60		1.28	1.51	1.57	1.46		1.18	1.36	1.38	1.31	
112	T_1	1.47	1.78	1.79		1.69	1.42	1.72	1.76		1.65	1.31	1.62	1.63		1.54	1.21	1.37	1.39		1.32
	T_2	1.47	1.78	1.78		1.69	1.42	1.72	1.76		1.65	1.31	1.63	1.64		1.55	1.21	1.34	1.39		1.32
	T_3	1.47	1.78	1.79		1.69	1.42	1.73	1.76		1.65	1.31	1.62	1.64		1.54	1.21	1.37	1.39		1.33
	Mean	1.47	1.78	1.79	1.68		1.42	1.72	1.76	1.63		1.31	1.62	1.64	1.52		1.21	1.36	1.39	1.32	
224	T_1	1.47	1.81	1.81			1.43	1.76	1.78			1.34	1.65	1.69			1.21	1.38	1.39		
	T_2	1.47	1.81	1.82			1.44	1.76	1.77			1.34	1.65	1.70			1.21	1.38	1.39		
	T_3	1.48	1.81	1.82			1.44	1.76	1.78			1.34	1.66	1.69			1.21	1.38	1.39		
	Mean	1.47	1.81	1.81	1.70		1.44	1.76	1.78	1.66		1.34	1.65	1.69	1.56		1.21	1.38	1.39	1.33	
Grand mean for N levels		1.45	1.79	1.80			1.42	1.74	1.76			1.32	1.62	1.65			1.21	1.37	1.39		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.059	0.178	Yes	0.046	0.139	Yes	0.049	0.148	Yes	0.038	0.115
Between two levels of Potassium means (K)	No	0.028	-	No	0.021	-	No	0.032	-	No	0.023	-
Between two times of Potassium application means (T)	No	0.033	-	No	0.030	-	No	0.045	-	No	0.042	-
Between two N means at the same level of K	No	0.079	-	No	0.073	-	No	0.079	-	No	0.067	-
Between two K means at the same level of N	No	0.064	-	No	0.061	-	No	0.065	-	No	0.050	-
Between two K means at the same level of T	No	0.064	-	No	0.061	-	No	0.065	-	No	0.050	-
Between two T means at the same level of K	No	0.064	-	No	0.061	-	No	0.065	-	No	0.050	-
Control Vs other K treatments	Yes	0.033	0.066	Yes	0.029	0.058	Yes	0.030	0.060	No	0.026	-





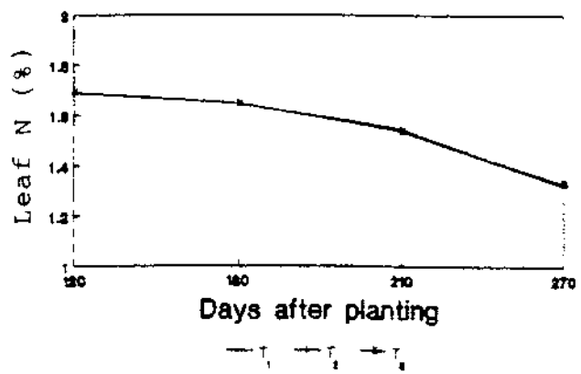


Fig.11: Leaf N (%) at different crop growth stages (plant crop)

N ha^{-1} over no nitrogen. Further increase of N had no significant effect. Similar trend was observed at all the stages of crop growth. The differences in leaf N values due to 112 and 224 kg K_2O ha^{-1} were not significant, but both were significantly superior over control (K_o) at all the stages of crop growth except at 270 DAP. Time of application had no significant effect on leaf N content at any stage.

The interaction effects between N and K and K and its time of application were not significant.

4.6.2 Ratoon Crop

As in the case of plant crop, the leaf N content of ratoon crop was higher (1.58%) at 120 DAR and it decreased gradually (1.30%) by 270 DAR (Table 14 Fig.12). Application of 224 Kg N ha^{-1} resulted significantly higher leaf N values over no N at all the stages of sampling. There was increase in leaf N content with every increase in N level upto 180 DAR only. Application of 112 and 224 kg K_2O ha^{-1} significantly improved the leaf N content over no K application at all the stages of crop growth.

The leaf N content did not vary significantly due to time of K application at any stage of observation. None of the interaction effects were significant.

Table 14. Leaf N (%) in 3-6 leaves at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		120 DAR					180 DAR					210 DAR					270 DAR				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.31	1.52	1.69	1.50		1.30	1.52	1.67	1.53		1.30	1.57	1.59	1.48		1.18	1.33	1.30	1.28	
112	T_1	1.45	1.64	1.76		1.63	1.35	1.55	1.72		1.56	1.32	1.59	1.67		1.54	1.19	1.35	1.35		1.30
	T_2	1.46	1.64	1.76		1.63	1.36	1.55	1.72		1.56	1.32	1.58	1.67		1.54	1.19	1.34	1.35		1.30
	T_3	1.32	1.52	1.69		1.52	1.37	1.55	1.72		1.56	1.32	1.59	1.67		1.54	1.19	1.34	1.35		1.30
	Mean	1.41	1.60	1.74	1.58		1.36	1.55	1.72	1.58		1.32	1.58	1.67	1.52		1.19	1.34	1.35	1.30	
224	T_1	1.45	1.68	1.78			1.40	1.59	1.73			1.34	1.65	1.69			1.20	1.35	1.36		
	T_2	1.45	1.69	1.78			1.39	1.58	1.73			1.35	1.65	1.68			1.20	1.36	1.36		
	T_3	1.32	1.55	1.74			1.39	1.58	1.73			1.35	1.65	1.69			1.20	1.36	1.36		
	Mean	1.41	1.64	1.77	1.60		1.39	1.58	1.73	1.60		1.35	1.65	1.69	1.56		1.20	1.36	1.36	1.31	
Grand mean for N levels		1.39	1.60	1.74			1.36	1.56	1.71			1.33	1.61	1.66			1.19	1.35	1.35		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.043	0.134	Yes	0.036	0.114	Yes	0.029	0.091	Yes	0.032	0.100
Between two levels of Potassium means (K)	No	0.031	-	No	0.029	-	No	0.024	-	No	0.026	-
Between two times of Potassium application means (T)	Yes	0.036	0.071	No	0.032	-	No	0.027	-	No	0.028	-
Between two N means at the same level of K	No	0.082	-	No	0.062	-	No	0.043	-	No	0.049	-
Between two K means at the same level of N	No	0.072	-	No	0.057	-	No	0.038	-	No	0.041	-
Between two N means at the same level of T	No	0.072	-	No	0.057	-	No	0.038	-	No	0.041	-
Between two T means at the same level of K	No	0.072	-	No	0.057	-	No	0.038	-	No	0.041	-
Control Vs other K treatments	Yes	0.031	0.067	Yes	0.023	0.047	Yes	0.019	0.037	Yes	0.019	0.041

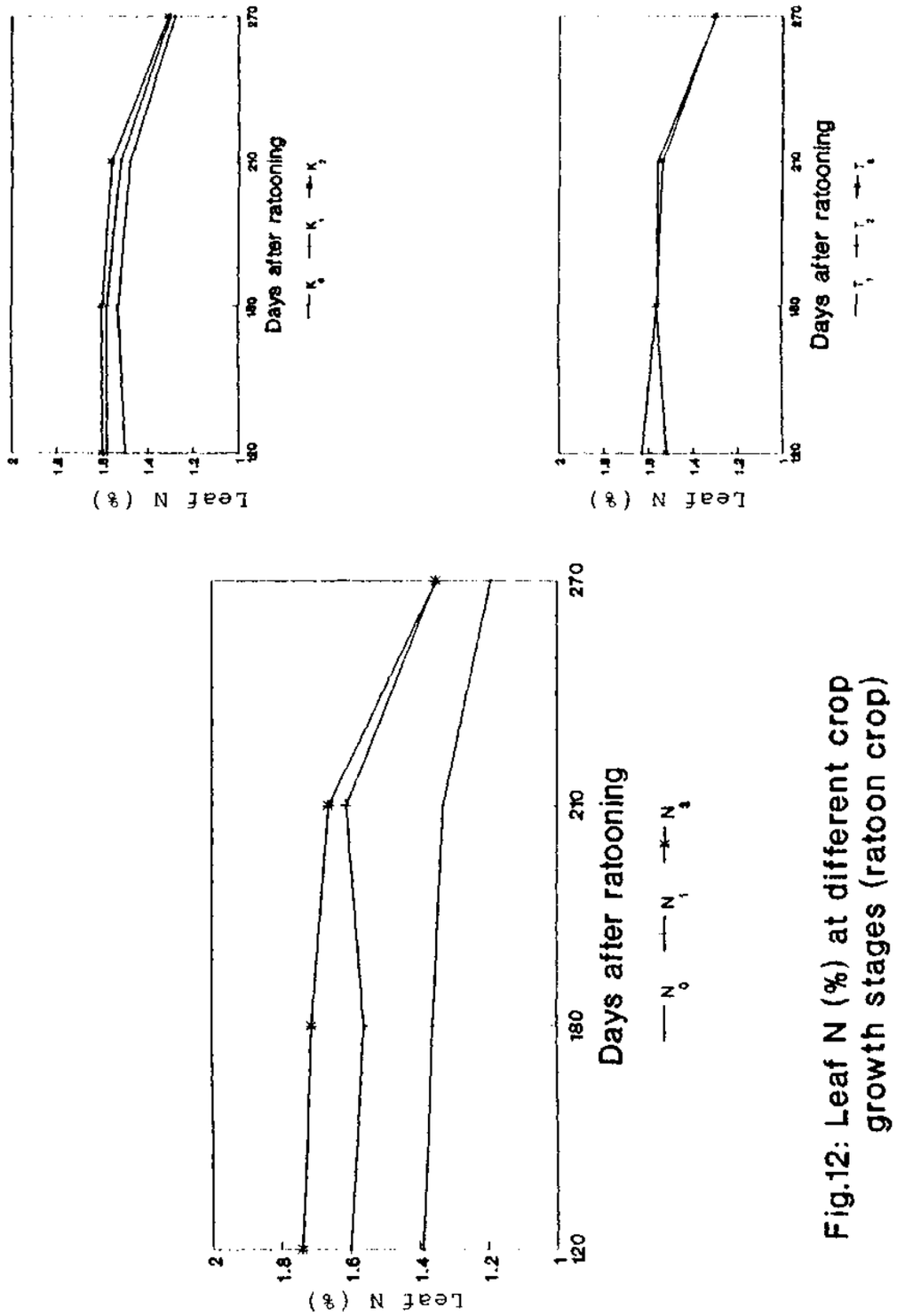


Fig.12: Leaf N (%) at different crop growth stages (ratoon crop)

4.7 POTASSIUM IN 3-6 SHEATHS

Potassium per cent in 3-6 leaf sheaths was estimated at 120, 180, 210 and 270 DAP/DAR.

4.7.1 Plant Crop

Sheath K content increased from 120 (1.92%) to 210 (2.00%) DAP followed by a slight fall (1.92%) at 270 DAP (Table 15 Fig.13). Application of 112 kg N ha^{-1} significantly improved the per cent sheath K over no application at 120 and 210 DAP. Further increase in N application had no significant effect at any stage of crop growth. There was significant increase in K content due to K application over no application at all the stages, while at 180 DAP significant increase in K content was observed with K_2 over K_1 level. Application of K at planting and at 60 DAP had significantly higher sheath k content over its late application at 120 DAP when sampled at 120 days only.

The interaction between N and K or K and its time of application had no significant influence on sheath K content.

4.7.2 Ratoon Crop

Levels of N had significant effect on K content of leaf sheaths at all the stages of crop growth. There were no significant difference between N_1 and N_2 levels at all the

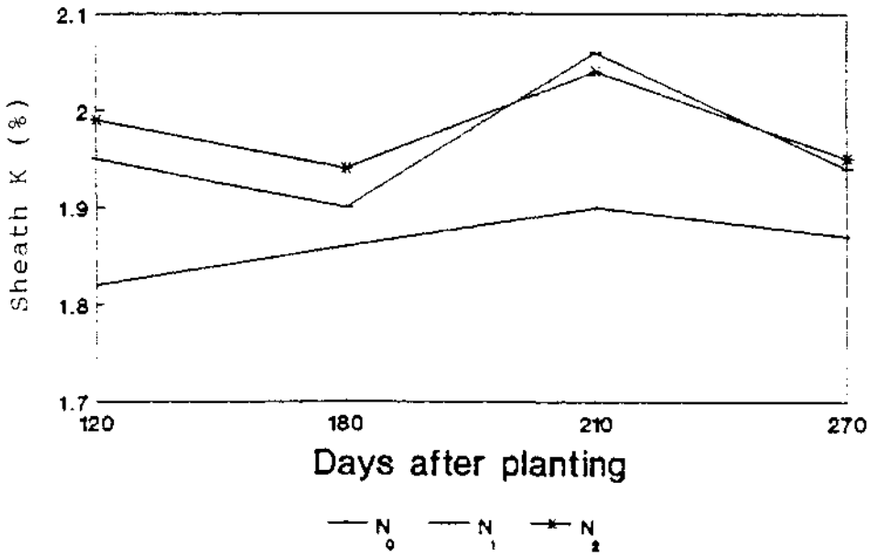
Table 15. Sheath K (%) in 3-6 sheaths at different crop growth stages of Plant crop as influenced by N, K and time of K application.

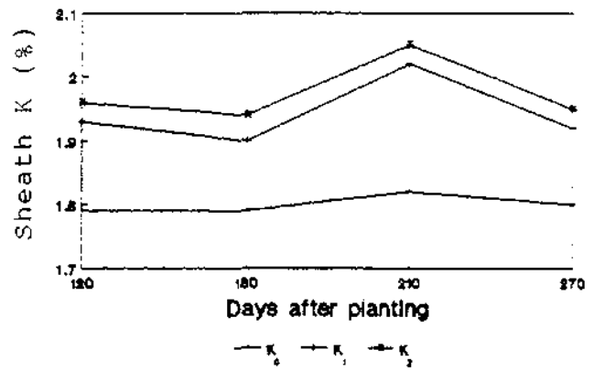
Treatment		120 DAP					180 DAP					210 DAP					270 DAP				
Potassium levels ($kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.71	1.81	1.84	1.79		1.76	1.81	1.79	1.79		1.80	1.82	1.84	1.82		1.79	1.81	1.80	1.80	
112	T_1	1.84	2.03	2.11		2.01	1.86	1.92	1.89		1.92	1.89	2.09	2.06		2.04	1.86	1.98	2.02		1.96
	T_2	1.84	2.00	2.11		2.01	1.85	1.87	1.92		1.89	1.90	2.08	2.05		2.02	1.88	1.92	1.95		1.92
	T_3	1.73	1.86	1.83		1.82	1.84	1.94	2.02		1.95	1.92	2.10	2.08		2.04	1.88	1.95	1.94		1.93
	Mean	1.80	1.96	2.02	1.93		1.84	1.91	1.94	1.90		1.90	2.09	2.06	2.02		1.85	1.95	1.97	1.92	
224	T_1	1.92	2.08	2.10			1.92	1.94	2.00			1.95	2.12	2.10			1.92	2.00	2.00		
	T_2	1.93	2.08	2.09			1.89	1.89	1.94			1.94	2.01	2.08			1.88	1.97	1.98		
	T_3	1.78	1.81	1.87			1.94	1.91	2.03			1.94	2.13	2.06			1.93	1.94	1.95		
	Mean	1.88	1.99	2.02	1.96		1.92	1.91	1.99	1.94		1.94	2.12	2.08	2.05		1.91	1.97	1.98	1.95	
Grand mean for N levels		1.82	1.95	1.99			1.86	1.90	1.94			1.90	2.06	2.04			1.87	1.94	1.95		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.029	0.088	Yes	0.027	0.081	Yes	0.031	0.093	Yes	0.026	0.078
Between two levels of Potassium means (K)	No	0.023	-	Yes	0.019	0.038	No	0.027	-	No	0.021	-
Between two times of Potassium application means (T)	Yes	0.025	0.051	No	0.026	-	No	0.029	-	No	0.024	-
Between two N means at the same level of K	No	0.046	-	No	0.058	-	No	0.052	-	No	0.048	-
Between two K means at the same level of N	No	0.042	-	No	0.032	-	No	0.038	-	No	0.041	-
Between two K means at the same level of T	No	0.042	-	No	0.032	-	No	0.038	-	No	0.041	-
Between two T means at the same level of K	No	0.042	-	No	0.032	-	No	0.038	-	No	0.041	-
Control Vs other K treatments	Yes	0.027	0.054	Yes	0.029	0.058	Yes	0.032	0.064	Yes	0.023	0.046





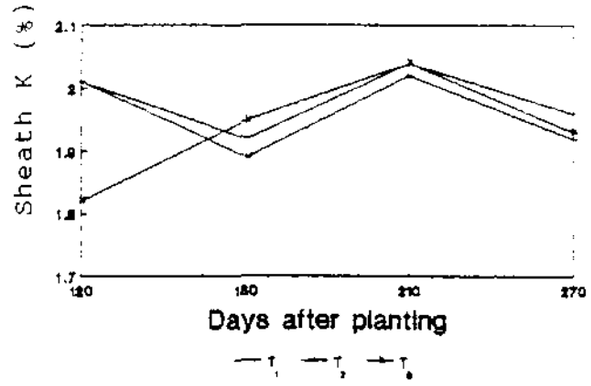


Fig.13: Sheath K (%) at different crop growth stages (plant crop)

Table 16. Sheath K (%) in 3-6 sheaths at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		120 DAR					180 DAR					210 DAR					270 DAR				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levles (kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.76	1.80	1.82	1.79		1.70	1.76	1.80	1.75		1.68	1.77	1.79	1.75		1.77	1.80	1.80	1.79	
112	T_1	1.86	1.90	1.98		1.97	1.79	1.88	1.88		1.90	1.81	1.86	1.90		1.92	1.82	1.94	2.00		1.96
	T_2	1.88	1.92	1.98		1.99	1.80	1.88	1.89		1.90	1.83	1.85	1.89		1.92	1.81	1.91	2.02		1.96
	T_3	1.74	1.80	1.83		1.80	1.81	1.89	1.90		1.91	1.82	1.86	1.92		1.93	1.83	1.97	2.01		1.97
	Mean	1.83	1.87	1.93	1.88		1.80	1.88	1.89	1.86		1.82	1.86	1.90	1.86		1.82	1.96	2.01	1.93	
224	T_1	1.97	2.00	2.12			1.90	1.95	1.98			1.92	1.98	2.02			1.90	1.98	2.10		
	T_2	1.99	2.04	2.09			1.88	1.93	1.97			1.93	1.97	2.00			1.89	1.96	2.09		
	T_3	1.75	1.81	1.84			1.90	1.94	1.98			1.92	1.99	2.03			1.90	1.98	2.08		
	Mean	1.90	1.95	2.02	1.96		1.89	1.94	1.98	1.94		1.92	1.98	2.02	1.97		1.90	1.97	2.09	2.01	
Grand mean for N levels		1.85	1.90	1.95			1.83	1.89	1.91			1.84	1.90	1.94			1.85	1.94	2.01		
		r = 3					n = 63														

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.028	0.084	Yes	0.021	0.065	Yes	0.026	0.082	Yes	0.024	0.074
Between two levels of Potassium means (K)	Yes	0.022	0.047	Yes	0.018	0.038	Yes	0.019	0.041	Yes	0.021	0.044
Between two times of Potassium application means (T)	Yes	0.0225	0.053	No	0.020	-	No	0.022	-	No	0.019	-
Between two N means at the same level of K	No	0.038	-	No	0.032	-	No	0.036	-	No	0.038	-
Between two K means at the same level of N	No	0.034	-	No	0.029	-	No	0.032	-	No	0.036	-
Between two K means at the same level of T	No	0.034	-	No	0.029	-	No	0.032	-	No	0.036	-
Between two T means at the same level of K	No	0.034	-	No	0.029	-	No	0.032	-	No	0.036	-
Control Vs other K treatments	Yes	0.026	0.056	Yes	0.031	0.066	Yes	0.029	0.062	Yes	0.031	0.066

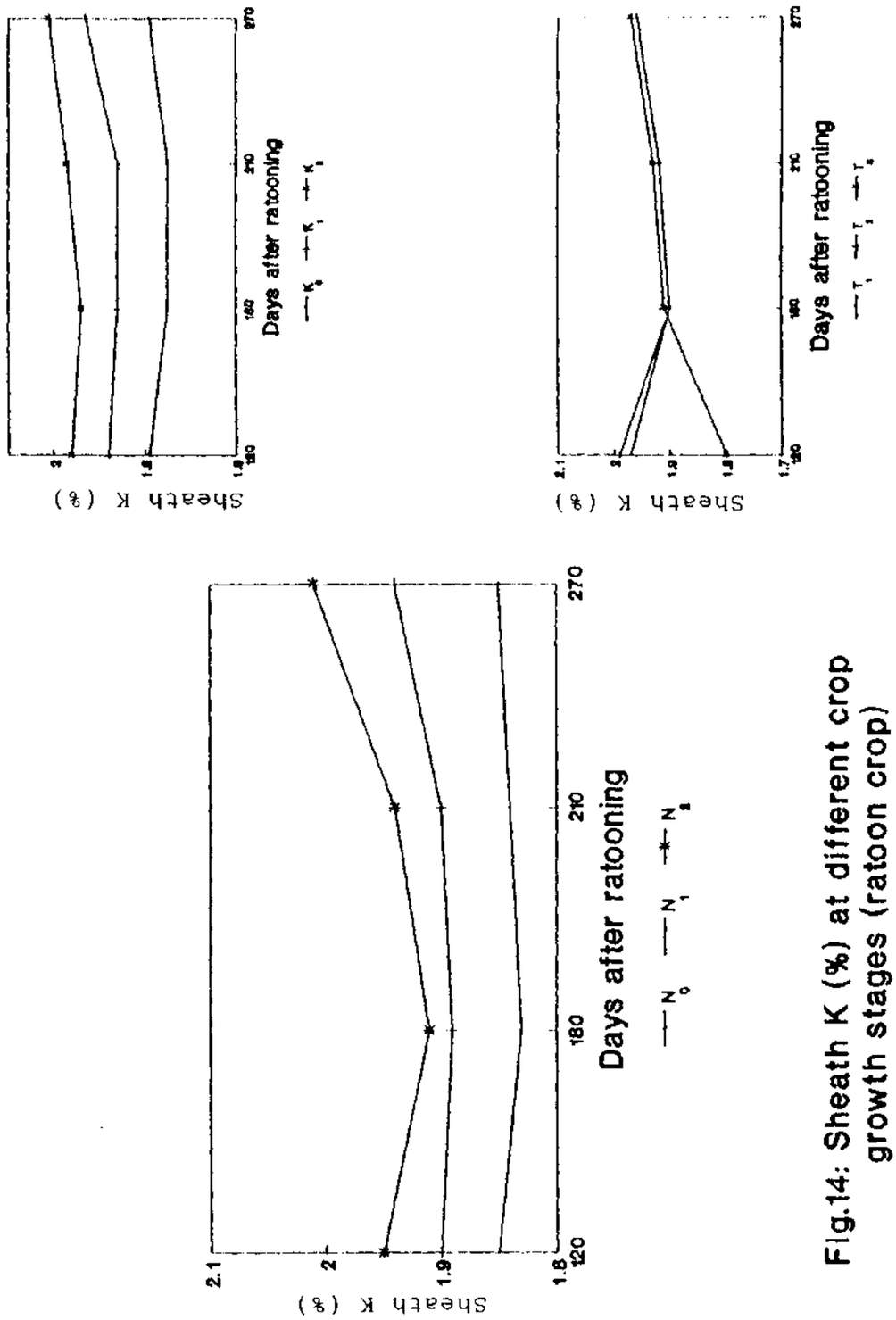


Fig.14: Sheath K (%) at different crop growth stages (ratoon crop)

stages with regard to sheath K content. However, K content was significantly higher with N_2 over N_o at all the stages. Higher K content was observed with N_1 and N_o at 270 DAR only. There was significant increase in K content due to K appplication over no application and also significant improvement in K content was observed with K_2 over K_1 at all stages of sampling. Application of K at ratooning and at 60 DAR were at par but significantly enhanced sheath K per cent over late application at 120 DAR (Table 16 Fig.14). None of the interactions had significant effect on sheath K content.

4.8 NITROGEN CONTENT AND UPTAKE IN WHOLE PLANT

Nitrogen content and its uptake in whole plant was estimated at 150, 210, 270 DAP/DAR and at harvest in both plant and ratoon crops.

4.8.1 N Content in Whole Plant

4.8.1.1 Plant crop

Irrespective of the treatments, N per cent in whole plant was highest at 150 DAP and it gradually decreased at harvest (Table 17). Application of N at 112 and 224 Kg ha^{-1} significantly influenced the whole plant N content over control (N_o) at all the stages of crop growth. However, the difference between N_1 and N_2 levels was not significant at any stage of crop growth except at 270 DAP. Potassium

Table 17. Nitrogen (%) in whole plant at different crop growth stages of Plant crop as influenced by N, K and time of K application.

Treatment		150 DAP					210 DAP					270 DAP					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		0.565	0.616	0.643	0.608		0.322	0.459	0.477	0.419		0.238	0.289	0.294	0.274		0.229	0.247	0.252	0.243	
112	T_1	0.588	0.663	0.713		0.661	0.345	0.499	0.523		0.463	0.251	0.299	0.341		0.303	0.233	0.256	0.260		0.252
	T_2	0.584	0.659	0.695		0.653	0.346	0.498	0.521		0.462	0.251	0.289	0.345		0.301	0.233	0.256	0.262		0.253
	T_3	0.575	0.655	0.706		0.654	0.345	0.491	0.522		0.462	0.251	0.294	0.346		0.302	0.232	0.257	0.262		0.252
	Mean	0.582	0.659	0.705	0.649		0.345	0.496	0.522	0.455		0.251	0.294	0.344	0.296		0.233	0.256	0.261	0.250	
224	T_1	0.583	0.695	0.722			0.350	0.513	0.546			0.257	0.307	0.364			0.234	0.261	0.268		
	T_2	0.574	0.686	0.718			0.359	0.510	0.545			0.251	0.303	0.364			0.234	0.263	0.269		
	T_3	0.585	0.685	0.720			0.356	0.511	0.545			0.252	0.303	0.365			0.237	0.264	0.267		
	Mean	0.581	0.689	0.720	0.663		0.355	0.511	0.545	0.471		0.253	0.304	0.364	0.308		0.235	0.263	0.268	0.255	
Grand mean for N levels		0.579	0.666	0.702			0.346	0.497	0.526			0.250	0.298	0.346			0.233	0.258	0.263		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.023	0.074	Yes	0.021	0.064	Yes	0.012	0.038	Yes	0.007	0.022
Between two levels of Potassium means (K)	No	0.020	-	No	0.032	-	No	0.009	-	No	0.005	-
Between two times of Potassium application means (T)	No	0.022	-	No	0.038	-	No	0.011	-	No	0.005	-
Between two N means at the same level of K	No	0.044	-	No	0.069	-	No	0.053	-	No	0.030	-
Between two K means at the same level of N	No	0.036	-	No	0.058	-	No	0.039	-	No	0.022	-
Between two K means at the same level of T	No	0.036	-	No	0.058	-	No	0.039	-	No	0.022	-
Between two T means at the same level of K	No	0.036	-	No	0.058	-	No	0.039	-	No	0.022	-
Control vs other K treatments	Yes	0.018	0.038	Yes	0.020	0.043	Yes	0.010	0.022	Yes	0.004	0.009

application at 112 and 224 Kg K_2O ha^{-1} significantly increased the N content in whole plant over no application of K (control).But, there was no significant difference among K_1 and K_2 levels at all the stages of sampling. Time of application of K had no significant influence on N content of whole plant at any stage of crop growth. None of the interaction effects were significant.

4.8.1.2 Ratoon crop

Similar to plant crop, N content in whole plant of ratoon crop (Table 18) was higher at 150 DAR and it gradually decreased at later stages. Nitrogen application at 224 kg ha^{-1} significantly increased the N content in whole plant over no application at all the stages of sampling. The differences due to 112 and 224 kg N ha^{-1} or 0 and 112 kg N ha^{-1} were not significant. Potassium levels at 112 and 224 kg K_2O ha^{-1} being at par, significantly increased the N percent in whole plant over no K (control) at all the stages of crop growth. Time of application of K did not alter the N content in whole plant significantly. The interaction effects between N and K levels and K and its time of application were not significant.

4.8.2 Nitrogen Uptake

Nitrogen uptake in whole plant was estimated at 150,

Table 18. Nitrogen (%) in whole plant at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		150 DAR					210 DAR					270 DAR					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		0.502	0.537	0.580	0.540		0.251	0.327	0.388	0.322		0.229	0.286	0.337	0.284		0.201	0.224	0.248	0.224	
112	T_1	0.553	0.601	0.661		0.618	0.331	0.386	0.435		0.391	0.287	0.306	0.347		0.316	0.233	0.266	0.294		0.273
	T_1^1	0.552	0.604	0.658		0.618	0.333	0.388	0.439		0.393	0.286	0.305	0.346		0.316	0.234	0.267	0.290		0.272
	T_1^2	0.551	0.602	0.659		0.618	0.333	0.387	0.439		0.393	0.287	0.306	0.349		0.316	0.234	0.269	0.291		0.272
	T_1^3 Mean	0.552	0.604	0.656	0.605		0.332	0.387	0.438	0.386		0.287	0.306	0.347	0.313		0.234	0.267	0.292	0.264	
224	T_1	0.568	0.639	0.682			0.345	0.394	0.452			0.291	0.310	0.352			0.244	0.280	0.318		
	T_1^1	0.567	0.640	0.686			0.345	0.396	0.455			0.294	0.311	0.354			0.242	0.284	0.318		
	T_1^2	0.566	0.642	0.687			0.344	0.396	0.453			0.292	0.311	0.352			0.244	0.281	0.320		
	T_1^3 Mean	0.567	0.640	0.785	0.631		0.345	0.395	0.453	0.398		0.292	0.311	0.353	0.319		0.243	0.282	0.319	0.281	
Grand mean for N levels		0.551	0.609	0.659			0.326	0.382	0.439			0.281	0.305	0.348			0.233	0.267	0.296		
		r = 3					n = 63														

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N_i)	Yes	0.032	0.099	Yes	0.028	0.088	Yes	0.019	0.059	Yes	0.018	0.057
Between two levels of Potassium means (K_j)	No	0.029	-	No	0.026	-	No	0.013	-	No	0.017	-
Between two times of Potassium application means (T_j)	No	0.031	-	No	0.025	-	No	0.016	-	No	0.020	-
Between two N means at the same level of K	No	0.048	-	No	0.049	-	No	0.023	-	No	0.030	-
Between two K means at the same level of N	No	0.041	-	No	0.036	-	No	0.017	-	No	0.026	-
Between two K means at the same level of T	No	0.041	-	No	0.036	-	No	0.017	-	No	0.028	-
Between two T means at the same level of K	No	0.041	-	No	0.036	-	No	0.017	-	No	0.028	-
Control Vs other N treatments	Yes	0.030	0.063	Yes	0.028	0.059	Yes	0.012	0.023	Yes	0.018	0.038

210, 270 DAP/DAR and at harvest in both plant and ratoon crops.

4.8.2.1 Plant crop

Nitrogen uptake (Table 19 Fig.15) increased significantly with every increase in N application at all the stages of investigation except at harvest at which both 112 and 224 kg N ha^{-1} applications were at par. However, the uptake of N was significantly more with 112 and 224 Kg N ha^{-1} levels compared to control. Application of K resulted in significant increase in uptake of N at all the stages of crop growth compared to control. There was significantly higher N uptake due to the application of 224 kg K_2O ha^{-1} compared to 112 kg K_2O ha^{-1}. Basal application of K (T_1) significantly increased the N uptake at 150, 210 and 270 DAP over its late application at 120 DAP. However, the uptake of N was higher when K applied at 60 DAP (T_2) when sampled at 150 DAP.

The interaction between N and K or K and its time of application had no significant influence on N uptake.

4.8.2.2 Ratoon crop

Nitrogen uptake increased significantly with every increase in nitrogen application from 0 to 224 kg ha^{-1} (Table 20 Fig.16) at all the stages of crop growth. There was significant increase in N uptake in whole plant with K

Table 19. Uptake of N (Kg ha^{-1}) in whole plant at different crop growth stages of Plant crop as influenced by N, K and time of K application.

Treatment		150 DAP					210 DAP					270 DAP					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		62.49	98.44	112.40	91.11		59.99	112.78	122.45	98.41		56.64	93.00	101.37	83.67		67.03	93.02	96.29	85.45	
112	T_1	71.38	110.92	128.77		109.24	72.28	127.44	139.80		116.39	62.07	104.38	120.30		99.52	74.00	98.89	104.75		94.98
	T_2	75.10	106.96	124.68		105.64	68.44	124.15	135.98		113.47	61.32	95.66	121.06		97.31	72.49	98.76	105.93		93.67
	T_3	73.31	105.32	125.53		106.75	66.93	121.13	132.38		112.04	60.44	97.76	119.51		93.36	67.69	97.71	101.08		90.82
	Mean	75.93	107.73	126.33	103.33		69.22	124.24	136.05	109.83		61.28	99.27	120.29	93.61		71.39	98.45	103.92	91.26	
224	T_1	81.50	118.08	136.75			75.36	135.69	147.75			67.95	109.20	133.22			75.28	106.90	110.06		
	T_2	76.74	115.38	134.98			71.10	132.86	148.29			64.73	107.80	133.30			72.96	103.62	108.27		
	T_3	83.36	127.14	135.79			71.13	132.66	148.02			64.21	107.32	110.89			72.97	101.30	104.16		
	Mean	77.20	120.20	135.84	111.08		72.53	133.74	148.02	118.10		65.63	108.11	125.80	99.85		73.74	103.94	107.50	98.06	
Grand mean for N levels		74.55	111.75	128.41			69.32	126.67	139.24			62.48	102.16	119.95			71.77	100.03	104.50		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	1.659	4.604	Yes	1.620	3.497	Yes	2.084	5.788	Yes	2.113	5.865
Between two levels of Potassium means (K)	Yes	1.167	2.368	Yes	1.549	3.144	Yes	1.871	3.796	Yes	1.722	3.465
Between two times of Potassium application means (T)	Yes	1.429	2.900	Yes	1.898	3.850	Yes	2.291	4.649	No	2.109	-
Between two N means at the same level of K	No	2.297	-	No	2.335	-	No	3.212	-	No	3.107	-
Between two K means at the same level of N	No	2.022	-	No	2.684	-	No	3.240	-	No	2.982	-
Between two K means at the same level of T	No	2.022	-	No	2.684	-	No	3.240	-	No	2.982	-
Between two T means at the same level of K	No	2.022	-	No	2.684	-	No	3.240	-	No	2.982	-
Control Vs other K treatments	Yes	1.544	3.132	Yes	2.049	4.158	Yes	2.474	5.021	Yes	2.278	4.622

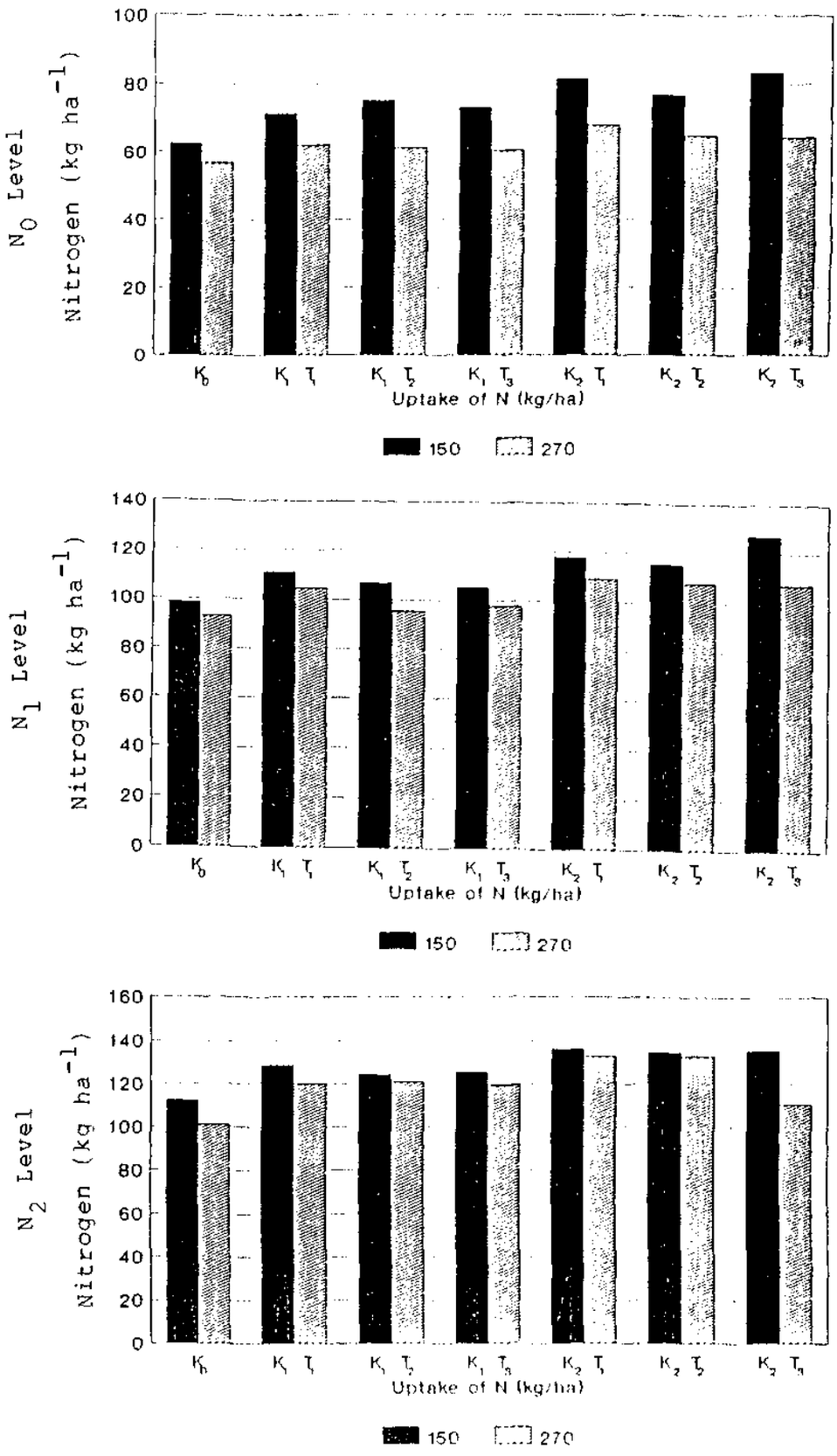


Fig.15: Uptake of N (Kg ha^{-1}) at different crop growth stages (Plant crop)

Table 28. Uptake of N (Kg ha^{-1}) in whole plant at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		150 DAR					210 DAR					270 DAR					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		46.28	61.43	98.66	68.79		31.55	55.10	91.72	59.46		37.28	65.69	99.28	67.42		36.22	56.60	93.32	62.05	
112	T_1	51.98	70.62	128.50		88.34	46.20	70.14	108.92		79.38	50.89	75.12	108.23		82.05	43.36	78.02	94.30		78.50
	T_1^1	50.12	68.61	119.49		82.34	43.76	67.24	105.54		76.59	43.25	72.44	104.63		78.00	42.19	74.52	99.01		76.28
	T_2^2	51.24	69.95	115.39		82.79	43.82	67.45	102.81		75.55	46.70	73.38	105.47		78.64	43.45	70.51	98.24		74.12
	T_3 Mean	51.11	69.73	121.13	80.66		44.59	68.28	105.76	72.88		47.61	73.65	106.11	75.79		43.00	74.35	97.18	71.51	
224	T_1	58.90	82.56	137.49			50.75	76.32	123.94			53.95	82.06	122.04			50.19	85.57	119.54		
	T_1^1	54.72	68.73	132.32			49.19	74.17	119.62			52.39	78.68	116.61			47.72	81.56	112.67		
	T_2^2	53.60	79.54	127.03			47.74	73.58	117.92			49.67	78.12	116.51			46.43	76.66	109.44		
	T_3 Mean	55.74	76.94	132.38	88.32		49.23	74.69	120.49	81.47		52.00	79.61	118.39	83.33		48.11	81.26	113.88	81.09	
Grand mean for N levels		52.41	71.63	122.70			44.72	69.14	110.07			48.02	75.07	110.39			44.22	74.78	103.79		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	2.435	6.759	Yes	1.946	5.402	Yes	2.249	6.775	Yes	2.382	6.614
Between two levels of Potassium means (K)	Yes	1.107	2.245	Yes	1.518	3.087	Yes	1.543	3.084	Yes	1.657	3.362
Between two times of Potassium application means (T)	Yes	2.355	4.709	No	1.990	-	No	2.164	-	Yes	2.029	4.117
Between two N means at the same level of K	No	2.958	-	Yes	2.800	6.483	No	3.286	-	No	3.277	-
Between two K means at the same level of N	No	1.917	-	Yes	2.630	5.377	No	2.644	-	No	2.870	-
Between two K means at the same level of T	No	1.917	-	No	2.630	-	No	2.644	-	No	2.870	-
Between two T means at the same level of K	No	1.917	-	No	2.630	-	No	2.644	-	No	2.870	-
Control Vs other K treatments	Yes	1.464	2.970	Yes	2.009	4.076	Yes	2.152	4.302	Yes	2.192	4.446

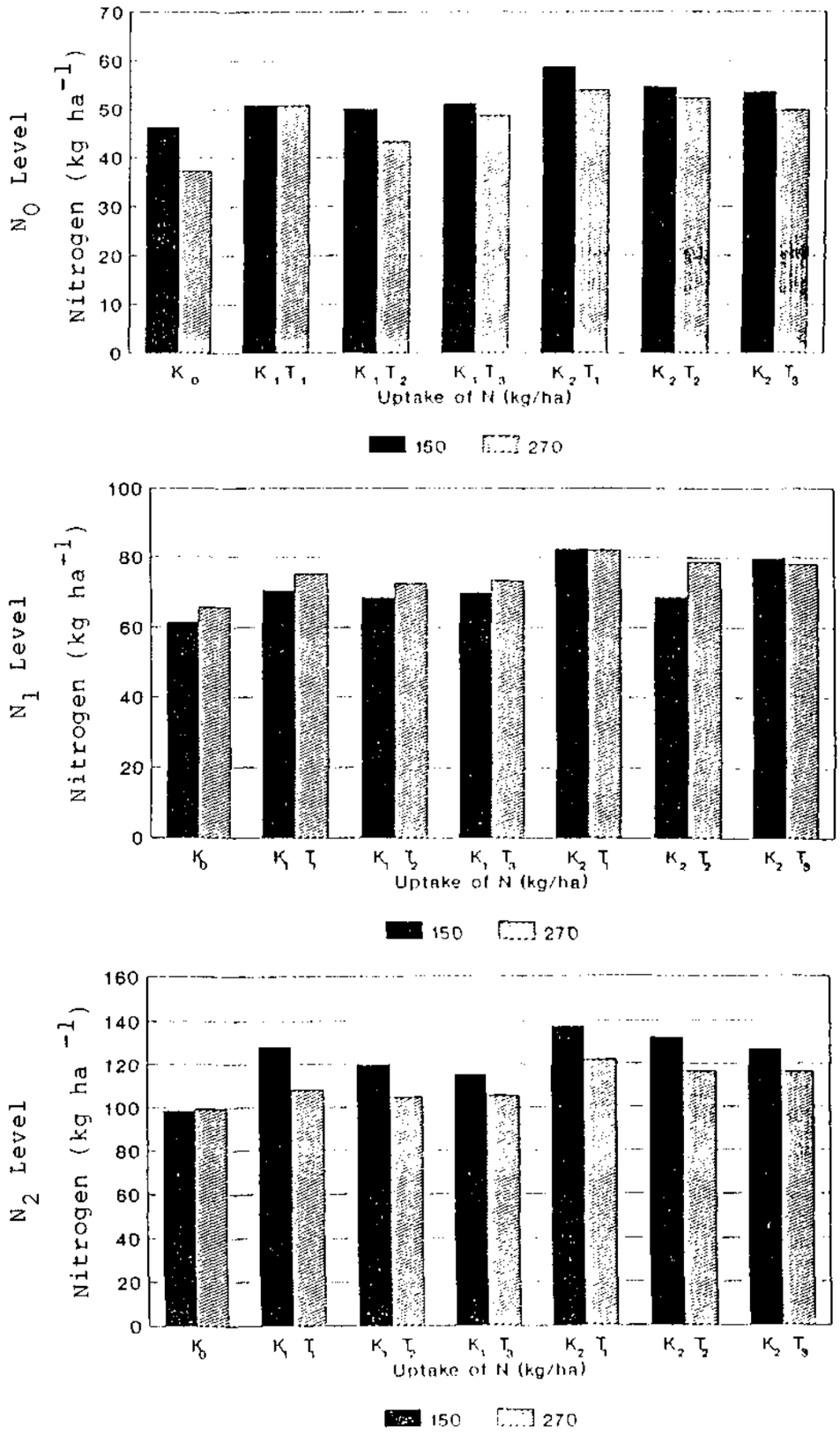


Fig.16: Uptake of N (Kg ha^{-1}) at different crop growth stages (Ratoon crop)

application at all the stages of crop growth compared to control (K_o). Similarly N uptake was significantly higher with k_2 compared to K_1 at all the stages of sampling. Basal application of K (T_1) significantly enhanced the N uptake over delayed application (T_2 and T_3) at 150 DAR. At harvest, T_1 was superior to T_3. The interaction between N and K was significant only at 210 DAR. At any given level of N there was increase in N uptake with the application of Potassium compared to no application. However, between K_1 and K_2 levels there was no significant difference at any N level. Increase in N uptake with every increase in N application was significant at all K levels.

Nitrogen uptake (Kg ha^{-1}) at 210 DAR

N level	K level			CD (P=0.05)
	K_o	K_1	K_2	
N_o	31.55	44.59	49.23	A. 4.830
N_1	55.10	68.28	74.69	B. 5.377
N_2	91.72	105.76	120.49	

A = Between two N means at the same level of K
B = Between two K means at the same level of N

4.9 POTASSIUM CONTENT AND UPTAKE IN WHOLE PLANT

Potassium content and its uptake in whole plant was estimated in both plant and ratoon crops at 150, 210 and 270 DAP/DAR and at harvest.

4.9.1 Potassium Content in Whole Plant

4.9.1.1 Plant crop

The K content in whole plant (Table 21) was highest at 150 DAP followed by sharp decline at later stages of observation. Application of N at 224 Kg ha^{-1} significantly increased the K content over control (N_o) at all the stages of sampling except at harvest. At 210 and 270 DAP, application of 224 Kg N ha^{-1} showed a significant increase in whole plant K content over 112 kg N ha^{-1}. The differences in K content in whole plant due to 112 and 224 kg K_2O ha^{-1} was significant at all the stages of crop growth except at 150 DAP. Similarly the differences in K content in whole plant due to 0 and 112 kg K_2O ha^{-1} was significant at all the stages except at harvest. Time of K application had no significant effect on whole plant K content at any stage of crop growth. None of the interaction effects were significant.

4.9.1.2 Ratoon crop

Similar to that of plant crop, the K content in whole plant was higher at 150 DAR followed by sharp decline at later stages of crop growth (Table 22). At 224 kg N ha^{-1} (N_2) level there was significant improvement in K content in whole plant over N_o level at all the stages of crop growth. There was no significant difference in K content in whole

Table 21. Potassium (%)in whole plant at different crop growth stages of Plant crop as influenced by N, K and time of K application.

Treatment		150 DAP					210 DAP					270 DAP					At harvest				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.212	1.247	1.256	1.242		0.764	0.784	0.896	0.815		0.548	0.608	0.696	0.617		0.532	0.568	0.576	0.559	
112	T_1	1.344	1.582	1.582		1.504	0.824	0.852	0.984		0.905	0.604	0.648	0.748		0.687	0.576	0.632	0.642		0.630
	T_2	1.345	1.584	1.589		1.508	0.820	0.840	0.984		0.899	0.602	0.642	0.744		0.687	0.577	0.635	0.644		0.632
	T_3	1.346	1.586	1.588		1.509	0.828	0.858	0.978		0.906	0.604	0.640	0.742		0.686	0.576	0.638	0.645		0.633
	Mean	1.345	1.584	1.586	1.503		0.824	0.815	0.982	0.885		0.603	0.643	0.745	0.664		0.576	0.635	0.644	0.618	
224	T_1	1.354	1.574	1.588			0.848	0.892	1.028			0.648	0.672	0.808			0.608	0.656	0.666		
	T_2	1.355	1.584	1.589			0.863	0.894	1.020			0.647	0.678	0.808			0.607	0.658	0.669		
	T_3	1.358	1.586	1.588			0.808	0.888	1.072			0.648	0.673	0.806			0.609	0.658	0.668		
	Mean	1.356	1.585	1.588	1.508		0.839	0.891	1.040	0.921		0.648	0.674	0.807	0.709		0.608	0.657	0.668	0.644	
Grand mean for N levels		1.306	1.535	1.540			0.818	0.858	0.995			0.614	0.652	0.765			0.584	0.635	0.644		
		r = 3					n = 63														

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitroger means (N)	Yes	0.051	0.164	Yes	0.021	0.066	Yes	0.014	0.044	Yes	0.016	0.066
Between two levels of Potassium means (K)	No	0.043	-	Yes	0.017	0.034	Yes	0.011	0.023	Yes	0.011	0.023
Between two times of Potassium application means (T)	No	0.048	-	No	0.019	-	No	0.016	-	No	0.010	-
Between two N means at the same level of K	No	0.089	-	No	0.046	-	No	0.028	-	No	0.028	-
Between two K means at the same level of N	No	0.073	-	No	0.039	-	No	0.023	-	No	0.024	-
Between two K means at the same level of T	No	0.073	-	No	0.039	-	No	0.023	-	No	0.024	-
Between two T means at the same level of K	No	0.073	-	No	0.039	-	No	0.023	-	No	0.024	-
Control Vs other K treatments	Yes	0.048	0.102	Yes	0.018	0.036	Yes	0.019	0.041	Yes	0.018	0.038

Table 22. Potassium (%) in whole plant at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		150 DAR					210 DAR					270 DAR					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen levies (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		1.122	1.134	1.174	1.143		0.644	0.689	0.708	0.680		0.564	0.607	0.654	0.608		0.380	0.421	0.464	0.422	
112	T_1	1.314	1.352	1.377		1.353	0.812	0.843	0.874		0.851	0.716	0.745	0.777		0.751	0.566	0.590	0.635		0.600
	T_2	1.313	1.354	1.382		1.357	0.814	0.844	0.871		0.851	0.714	0.748	0.776		0.751	0.566	0.592	0.634		0.601
	T_3	1.315	1.355	1.374		1.355	0.816	0.840	0.872		0.851	0.714	0.749	0.778		0.752	0.564	0.595	0.636		0.601
	Mean	1.314	1.353	1.377	1.348		0.814	0.842	0.872	0.843		0.715	0.747	0.777	0.746		0.565	0.592	0.635	0.597	
224	T_1	1.323	1.362	1.394			0.824	0.854	0.896			0.724	0.748	0.795			0.572	0.601	0.633		
	T_2	1.324	1.373	1.397			0.825	0.858	0.894			0.726	0.745	0.797			0.574	0.604	0.635		
	T_3	1.322	1.375	1.394			0.826	0.854	0.896			0.726	0.747	0.794			0.576	0.602	0.632		
	Mean	1.323	1.370	1.395	1.362		0.825	0.855	0.895	0.859		0.725	0.747	0.795	0.756		0.574	0.602	0.633	0.603	
Grand mean for N levels		1.290	1.329	1.355			0.794	0.826	0.859			0.698	0.727	0.767			0.543	0.572	0.610		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.019	0.059	Yes	0.016	0.050	Yes	0.016	0.050	Yes	0.018	0.057
Between two levels of Potassium means (K)	No	0.016	-	No	0.012	-	No	0.014	-	No	0.016	-
Between two times of Potassium application means (T)	No	0.018	-	No	0.015	-	No	0.017	-	No	0.019	-
Between two N means at the same level of K	No	0.039	-	No	0.023	-	No	0.025	-	No	0.026	-
Between two K means at the same level of N	No	0.036	-	No	0.021	-	No	0.023	-	No	0.022	-
Between two K means at the same level of T	No	0.036	-	No	0.021	-	No	0.023	-	No	0.022	-
Between two T means at the same level of K	No	0.036	-	No	0.021	-	No	0.023	-	No	0.022	-
Control Vs other K treatments	Yes	0.020	0.042	Yes	0.025	0.054	Yes	0.028	0.060	Yes	0.031	0.066

plant between N_o and N_1 levels at all the stages of crop growth except at 270 DAR. At 112 and 224 kg K_2O ha^{-1} (k_1 and k_2) levels, there was no significant difference of K content in whole plant at all the stages of crop growth. However, these two levels (K_1 and K_2) significantly increased the K content in whole plant over no K application (K_o). Time of application of K has no significant influence on K content. The interaction effects between N and K or K and its time of application were not significant.

4.9.2 Potassium Uptake

Potassium uptake of plant and ratoon crops was estimated at 150, 210 and 270 DAP/DAR and at harvest.

4.9.2.1 Plant crop

With every increase in the level of N from 0 to 224 kg ha^{-1} there was significant increase in the K uptake at all the stages of investigation (Table 23 Fig.17). There was significant increase in K uptake with K application compared to no application. Within the two application levels, K_2 had higher uptake than that in K_1. Basal application of K (T_1) significantly enhanced the K uptake over delayed application at 120 DAP (T_3) at all the stages of observation except at 270 DAP. Application of K at 60 (T_2) and 120 (T_3) DAP did not differ significantly with regard to K uptake. None of the interaction effects had significant effect on K uptake.

Table 23. Uptake of K (Kg ha^{-1}) in whole plant at different crop growth stages of Plant crop as influenced by N, K and time of K application.

Treatment		150 DAP					210 DAP					270 DAP					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		134.05	199.27	219.55	184.29		142.33	192.63	230.00	188.32		130.42	195.65	219.98	182.01		155.72	213.91	220.09	196.57	
112	T_1	181.44	264.67	285.70		248.22	172.63	218.11	263.02		222.54	149.37	226.22	263.89		224.33	182.94	244.14	258.66		237.67
	T_2	172.97	257.08	285.07		242.78	162.20	209.41	256.82		217.37	147.07	212.50	261.07		220.62	179.50	244.98	260.37		233.77
	T_3	171.61	255.02	282.35		240.85	160.63	211.67	248.03		217.26	145.44	212.80	256.29		217.95	167.33	242.57	248.84		226.55
	Mean	175.34	258.92	284.37	239.55		165.15	213.06	255.96	209.74		147.29	217.17	260.42	208.19		176.59	243.90	255.96	225.48	
224	T_1	189.29	267.42	300.76			182.26	235.93	278.18			171.33	239.03	296.13			195.59	268.69	275.99		
	T_2	181.16	266.43	293.96			165.36	232.89	277.54			166.86	241.23	295.89			189.26	259.25	269.27		
	T_3	170.29	266.29	299.50			161.52	230.52	291.15			165.11	238.38	289.68			187.51	252.47	260.59		
	Mean	180.25	266.71	298.07	248.34		169.71	233.11	282.24	228.37		167.77	239.55	293.90	233.74		190.79	260.14	268.62	239.85	
Grand mean for N levels		171.54	253.74	280.98			163.85	218.74	263.53			153.66	223.69	268.99			179.69	246.57	256.26		
			r = 3					n = 63													

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	1.975	5.483	Yes	1.091	3.028	Yes	1.743	4.838	Yes	3.031	9.020
Between two levels of Potassium means (K)	Yes	2.566	5.206	Yes	1.861	3.777	Yes	2.731	5.540	Yes	2.763	5.607
Between two times of Potassium application means (T)	Yes	3.142	6.376	Yes	2.156	4.342	No	3.344	-	Yes	3.385	6.867
Between two N means at the same level of K	No	3.798	-	No	2.566	-	No	3.838	-	No	5.163	-
Between two K means at the same level of N	No	4.444	-	No	3.224	-	No	4.729	-	No	4.786	-
Between two K means at the same level of T	No	4.444	-	No	3.224	-	No	4.729	-	No	4.786	-
Between two T means at the same level of K	No	4.444	-	No	3.224	-	No	4.729	-	No	4.786	-
Control Vs other K treatments	Yes	3.394	6.880	Yes	2.462	4.995	Yes	3.612	7.328	Yes	3.655	7.416

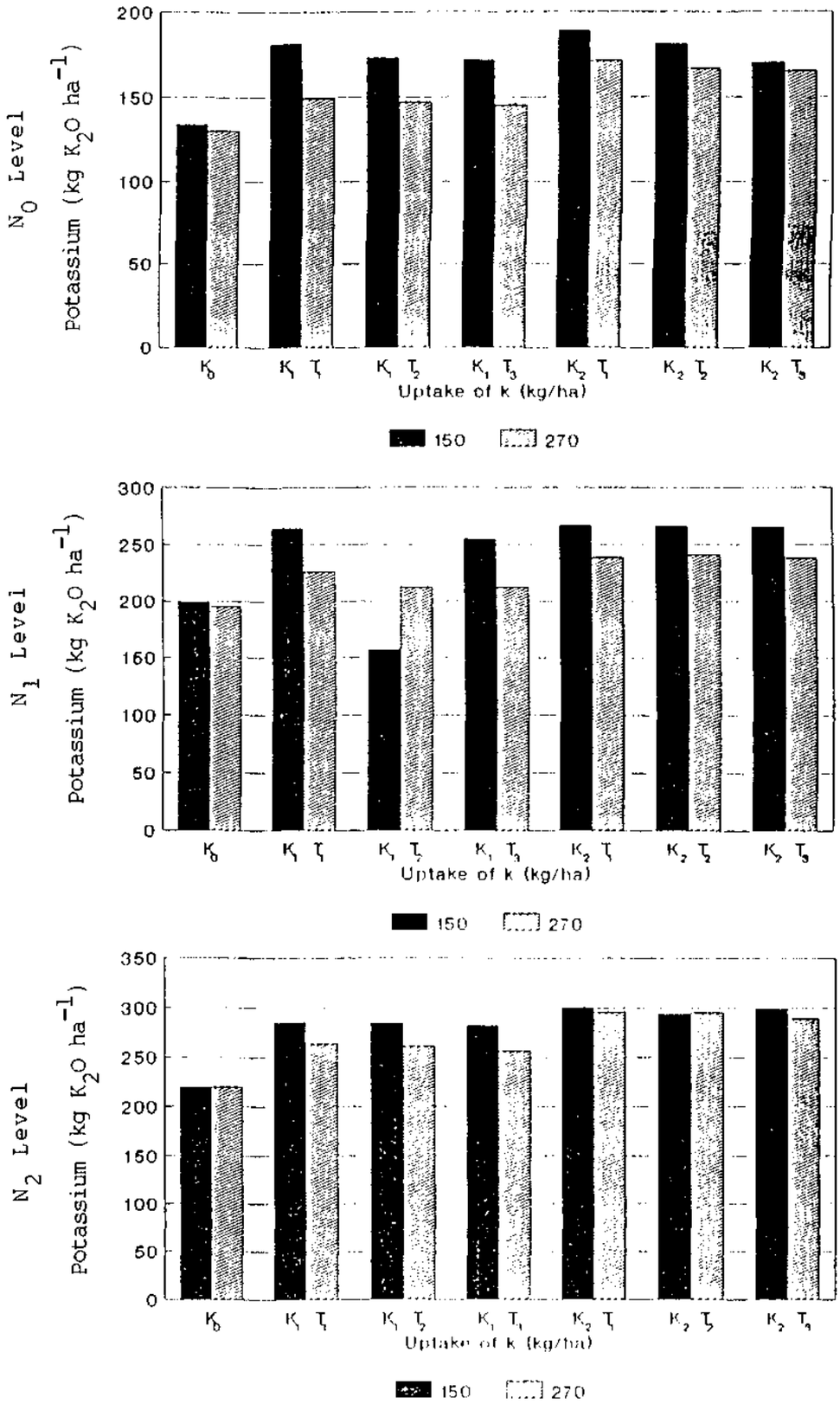


Fig.17: Uptake of K (Kg ha^{-1}) at different crop growth stages (Plant crop)

4.9.2.2 Ratoon crop

Uptake of K by the ratoon crop (Table 24 Fig.18) was much less than that in plant crop. Every increase in the N level from 0 to 224 kg ha^{-1} at all the stages increased the K uptake significantly. There was similar significant increase in K uptake due to K application compared to no application. There was significant increase in K uptake with K_2 compared to K_1 at all the stages of crop growth. Significant differences in K uptake due to time of K application were observed at 150 DAR. Basal application of K (T_1) had a significant effect in increasing the K uptake over late application (60 and 120 DAR). Interaction between N and K was significant at 150 days only. There was significant increase in K uptake with every increase in N application at all K levels. Similarly significant increase in K uptake was observed with the increase in K application at all N levels.

Potassium uptake (kg ha^{-1}) at 150 DAR

N level	K level			CD at (P=0.05)
	K_0	K_1	K_2	
N_o	102.98	120.94	130.52	A. 6.245
N_1	129.70	151.69	172.19	B. 7.642
N_2	188.82	250.42	268.78	

A = Between two N levels at the same level of K

B = Between two K levels at the same level of N

Table 24. Uptake of K (Kg ha^{-1}) in whole plant at different crop growth stages of Ratoon crop as influenced by N, K and time of K application.

Treatment		150 DAR					210 DAR					270 DAR					At harvest				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224			0	112	224		
0		102.98	129.70	188.82	140.50		80.95	116.09	167.37	121.47		91.82	139.42	192.66	141.30		68.48	106.39	152.52	109.13	
112	T_1	122.80	158.94	266.58		190.20	113.35	152.99	209.45		168.02	126.94	182.89	242.34		193.34	105.33	173.04	226.82		171.75
	T_2	118.71	138.82	244.43		178.15	106.96	146.26	209.39		162.60	125.52	177.65	234.66		86.36	102.04	165.23	220.45		168.08
	T_3	121.32	157.20	240.24		178.92	107.38	146.41	204.22		159.50	121.16	179.61	235.11		184.98	104.73	157.14	221.71		163.92
	Mean	120.94	151.69	250.42	174.34		109.23	148.55	207.69	155.16		124.54	180.05	237.37	180.66		104.03	165.14	222.99	164.05	
224	T_1	136.01	176.22	280.62			121.21	165.42	245.68			134.22	197.99	275.62			117.66	179.67	227.94		
	T_2	127.28	170.73	268.90			117.24	160.70	235.03			129.37	188.41	262.53			113.19	173.47	224.98		
	T_3	128.28	169.62	256.83			112.99	158.67	227.32			123.49	187.65	262.81			109.61	164.22	226.14		
	Mean	130.52	172.19	268.78	190.50		117.15	161.60	236.01	171.59		129.02	191.35	266.99	195.79		113.49	172.45	226.35	171.78	
Grand mean for N levels		122.48	157.32	249.49			108.58	149.51	214.07			121.78	179.09	243.68			88.43	159.88	214.37		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	5.093	14.138	Yes	4.943	13.722	Yes	4.834	14.508	Yes	4.433	12.305
Between two levels of Potassium means (K)	Yes	2.175	4.412	Yes	3.615	7.334	Yes	3.436	6.868	Yes	3.271	6.637
Between two times of Potassium application means (T)	Yes	2.663	5.504	No	4.427	-	No	4.358	-	No	4.006	-
Between two N means at the same level of K	Yes	6.112	6.245	No	6.936	-	No	6.770	-	No	6.243	-
Between two K means at the same level of N	Yes	3.776	7.642	No	6.261	-	No	6.125	-	No	5.666	-
Between two K means at the same level of T	No	3.776	-	No	6.261	-	No	6.125	-	No	5.666	-
Between two T means at the same level of K	No	3.776	-	No	6.261	-	No	6.125	-	No	5.666	-
Control Vs other K treatments	Yes	2.876	5.836	Yes	4.781	9.701	Yes	4.674	9.339	Yes	4.327	8.779

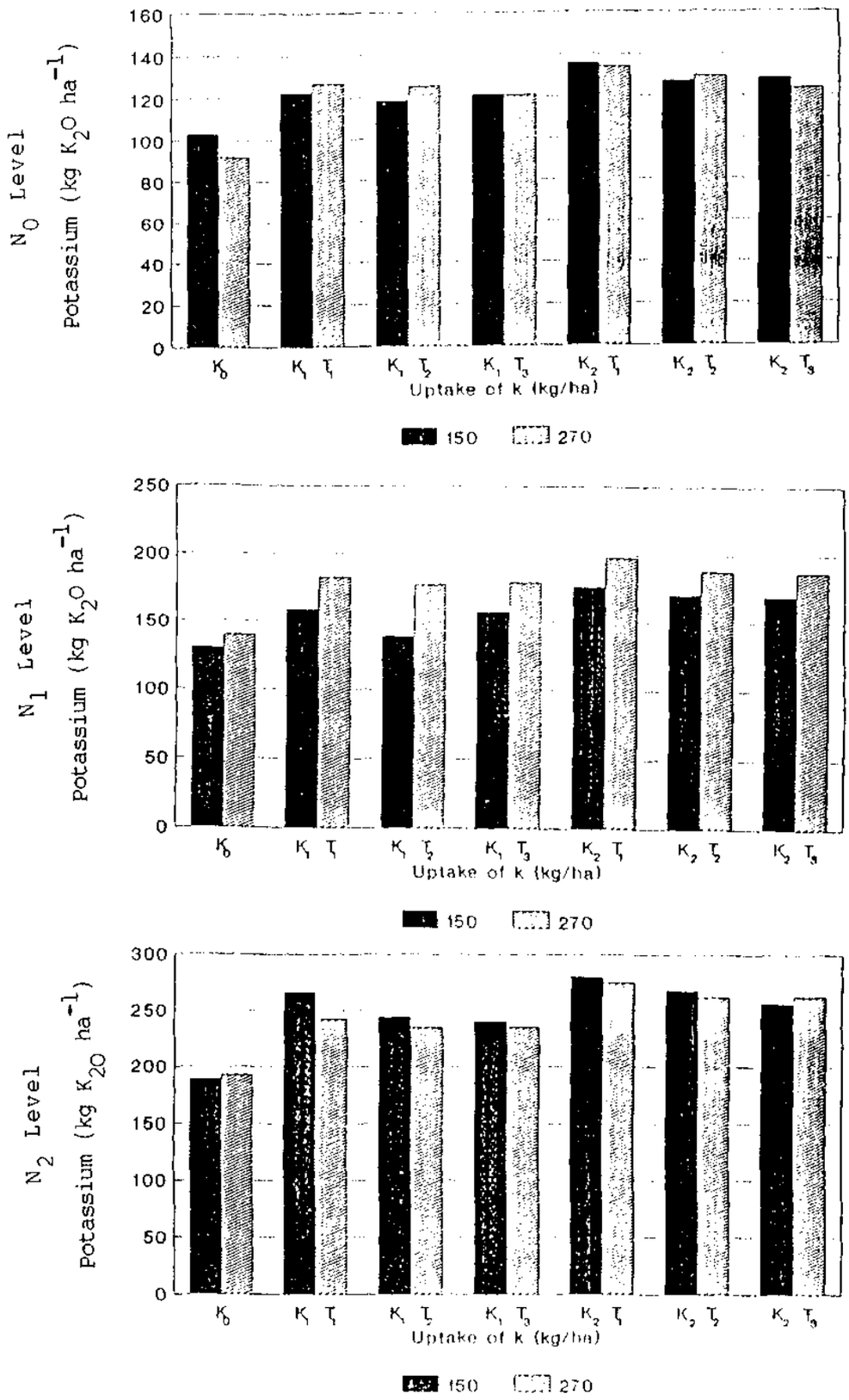


Fig.18: Uptake of K (Kg ha^{-1}) at different crop growth stages (Ratoon crop)

4.10 JUICE QUALITY IN MATURITY PHASE

The progress of maturity of plant and ratoon crops was judged by per cent sucrose and purity of juice from Novemeber to January.

4.10.1 Juice Sucrose

4.10.1.1 Plant crop

There was continuous improvement in juice sucrose per cent from November to harvest (January) due to different treatments (Table 25 Fig.19). Application of N had a significant influence on the per cent juice sucrose at all the stages of sampling. Significantly higher juice sucrose content was recorded with the application of N at 112 Kg ha^{-1} (14.55%) compared to 224 kg N ha^{-1} (14.29%) but it was on par with no N application during November. The sucrose content during December was highest with N_o (17.26%) and it was significantly superior to N_1 (17.05%) and N_2 (16.86%). During January, N_o (18.40%) and N_1 (18.26%) were at par but had significantly higher sucrose content than N_2 (17.51%). Highest N level (224 kg ha^{-1}) depressed the juice sucrose content in all the months of sampling. Application of K significantly improved the juice sucrose over no K application. However, between K levels (K_1 and K_2) there was no significant difference in juice sucrose at all the stages of sampling. Delayed application of K at 120 DAP (T_3)

Table 25. Sucrose (%) in juice during maturity phase of plant crop as influenced by N, K and time of K application.

Treatment		November					December					January (At harvest)				
Potassium levels ($Kg\ K_2O\ ha^{-1}$) and time of application		Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T	Nitrogen Levles ($Kg\ ha^{-1}$)			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		13.65	14.37	14.00	14.01		17.09	16.67	16.44	16.73		17.85	17.43	17.08	17.45	
112	T	14.26	14.39	14.12		14.32	17.13	16.86	16.66		16.94	18.15	18.11	17.60		18.03
	T_1	14.36	14.50	14.26		14.42	17.20	17.05	16.96		17.17	18.56	18.53	17.30		18.13
	T_2	14.58	14.68	14.42		14.71	17.33	17.05	16.92		17.22	18.72	18.62	17.55		18.32
	T_3 Mean	14.40	14.52	14.27	14.40		17.22	16.99	16.85	17.02		18.48	18.42	17.48	18.13	
224	T	14.39	14.51	14.22			17.22	16.92	16.85			18.31	18.28	17.72		
	T_1	14.64	14.48	14.30			17.39	17.46	16.96			18.54	18.25	17.57		
	T_2	14.96	14.90	14.72			17.48	17.31	17.24			18.69	18.59	17.75		
	T_3 Mean	14.66	14.63	14.41	14.56		17.36	17.23	17.02	17.20		18.51	18.37	17.68	18.19	
Grand mean for N levels		14.41	14.45	14.29			17.26	17.05	16.86			18.40	18.26	17.51		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.057	0.172	Yes	0.067	0.185	Yes	0.098	0.273
Between two levels of Potassium means (K)	No	0.093	-	No	0.104	-	No	0.054	-
Between two times of Potassium application means (T)	Yes	0.098	0.197	Yes	0.114	0.231	Yes	0.066	0.133
Between two N means at the same level of K	Yes	0.103	0.219	No	0.128	-	No	0.125	-
Between two K means at the same level of N	Yes	0.110	0.223	No	0.136	-	No	0.093	-
Between two K means at the same level of T	No	0.110	-	No	0.136	-	No	0.093	-
Between two T means at the same level of K	No	0.110	-	No	0.136	-	No	0.093	-
Control Vs other K treatments	Yes	0.084	0.170	Yes	0.123	0.248	Yes	0.071	0.144

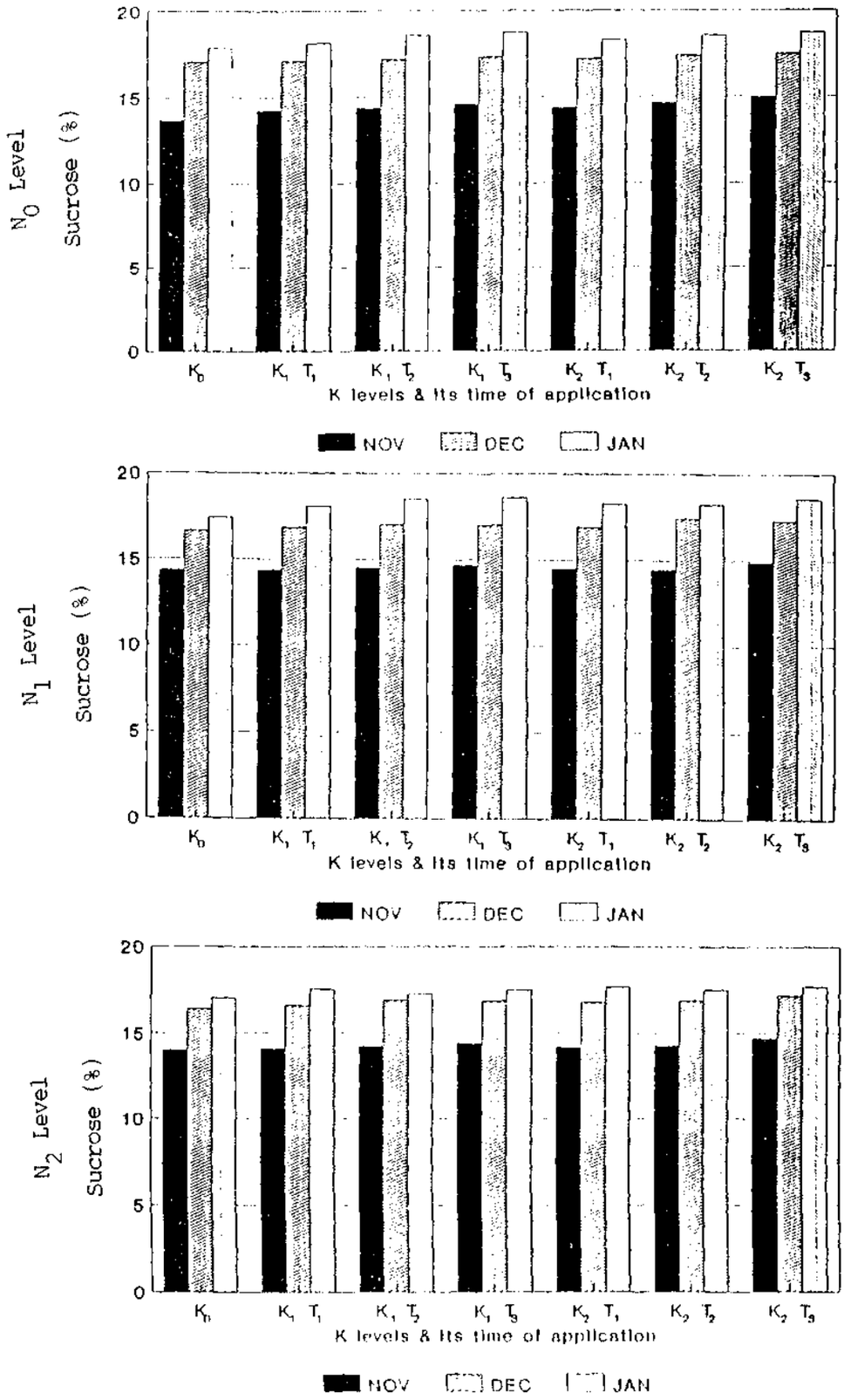


Fig.19: Sucrose (%) in maturity phase (Plant crop)

significantly improved the juice sucrose content over its application at planting (T_1) or at 60 DAP (T_2) during November and January while it was on par with T_2 during December. The per cent juice sucrose values were at par when K was applied either at basal (T_1) or at 60 DAP (T_2) during all the months of sampling. Interaction of N and K or k and its time of application had no significant influence on juice sucrose content except during November where N and K interaction was significant.

At N_0 level there was significant increase in sucrose (%) content at K_1 and K_2 compared to K_o and also at K_2 over K_1. At N_1 level, significant increase in juice sucrose content was observed with K_2 over K_o. At N_2 level both K_1 and K_2 had significantly higher sucrose compared to K_o. Similarly at K_o there was significant increase in sucrose content at N_1 and also superior to N_o. At K_1 level N_1 had higher sucrose content over N_2, but at K_2 level N_o had significantly higher sucrose content over N_2.

Juice sucrose (%) in November

N level	K level			CD at (P=0.05)
	K_0	K_1	K_2	
N_o	13.65	14.40	14.66	A. 0.219
N_1	14.37	14.52	14.63	B. 0.223
N_2	14.00	14.27	14.41	

A = Between two N levels at the same level of K
B = Between two K levels at the same level of N

4.10.1.2 Ratoon crop

The sucrose content at maturity phase was higher in ratoon crop compared to plant crop (Table 26 Fig.20). Juice sucrose content progressively increased from November to harvest (January). The Juice sucrose values did not vary significantly due to N levels at all the stages of sampling. Further, the depressing effect of 224 Kg N^{-1} observed in plant crop was not observed in ratoon crop. Application of K significantly increased the juice sucrose content over no K application at all the months of sampling, while K_2 had significantly higher sucrose content than K_1. Application of K at 120 DAR (T_3) significantly increased the juice sucrose content than basal (T_1) or 60 DAR (T_2) at all the sampling dates. The interaction between the factors studied were not significant at any stage of the crop.

4.10.2 Purity of Juice

The per cent purity of juice was estimated during November, December and January for both Plant and Ratoon crops.

4.10.2.1 Plant crop

Nitrogen application had a significant influence on juice purity (Table 27) at all the sampling dates. The purity of juice was significantly high with No compared to

Table 26. Sucrose (%) in Juice during maturity phase of Ratoon crop as influenced by N, K and time of K application.

Treatment		November					December					Jamurary (at harvest)				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		15.30	15.25	15.15	15.23		17.05	16.86	16.72	16.88		18.93	19.03	18.80	18.92	
112	T_1	15.65	15.50	15.50		15.67	17.45	17.34	17.22		17.53	19.13	19.15	19.06		19.20
	T_2	15.95	15.85	15.80		16.05	18.00	17.88	17.86		17.83	19.28	19.25	19.16		19.33
	T_3	16.45	16.30	16.25		16.43	18.20	18.00	17.90		18.13	19.41	19.36	19.25		19.45
	Mean	16.02	15.88	15.85	15.92		17.88	17.74	17.66	17.76		19.27	19.25	19.16	19.23	
224	T_1	15.85	15.80	15.70			17.76	17.68	17.69			19.31	19.30	19.25		
	T_2	16.30	16.20	16.20			17.80	17.76	17.70			19.47	19.45	19.35		
	T_3	16.65	16.50	16.40			18.30	18.20	18.16			19.64	19.50	19.51		
	Mean	16.27	16.17	16.10	16.18		17.95	17.88	17.85	17.89		19.47	19.42	19.37	19.42	
Grand mean for N levels		16.02	15.87	15.86			17.79	17.67	17.62			19.31	19.29	19.20		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	No	0.059	-	No	0.062	-	No	0.066	-
Between two levels of Potassium means (K)	Yes	0.069	0.153	Yes	0.050	0.107	Yes	0.054	0.115
Between two times of Potassium application means (T)	Yes	0.060	0.128	Yes	0.058	0.124	Yes	0.061	0.130
Between two N means at the same level of K	No	0.094	-	No	0.072	-	No	0.076	-
Between two K means at the same level of N	No	0.085	-	No	0.064	-	No	0.069	-
Between two K means at the same level of T	No	0.085	-	No	0.064	-	No	0.069	-
Between two T means at the same level of K	No	0.085	-	No	0.064	-	No	0.069	-
Control Vs other K treatments	Yes	0.069	0.153	Yes	0.061	0.098	Yes	0.065	0.139

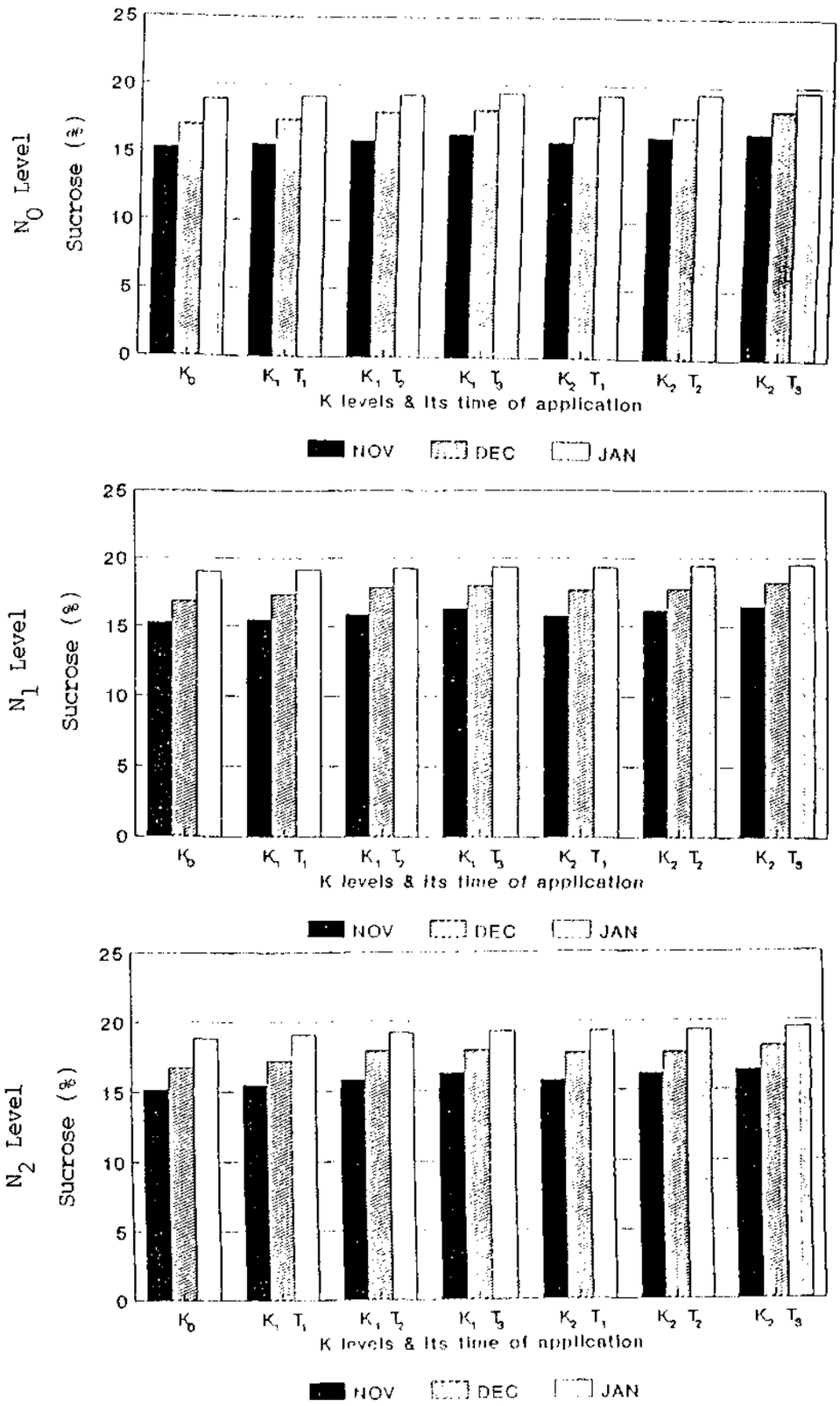


Fig.20: Sucrose (%) in maturity phase (Ratoon crop)

N_2 at all the months of analysis. There was significantly higher purity with N_1 compared to N_o during November, but both the N levels were at par during December and January. In January the purity of juice with N_1 was significantly high over N_2, but during December both N_1 and N_2 levels were at par. K application significantly improved the juice purity compared to no k application, while K levels (k_1 and K_2) did not reach the level of significance at all the dates of analysis. Application of K at 120 DAP (T_3) significantly improved the purity of juice compared to basal (T_1) and 60 DAP (T_2) at all the three samplings. During December, application of K at 60 DAP (T_2) had significantly higher purity than applied at basal (T_1), but in November and January they were at par. Interaction between N and K on purity was significant in November only.

At N_o level there was significant increase in purity (%) with every increase in the level of K application which was not observed at N_1 level. At N_2 level, the purity was significantly high with K_1 and K_2 compared to K_o. At a given level of K_o, highest purity was observed with N_1 which was significantly superior to N_o which was inturn superior to N_2. While at K_1 and K_2 levels N_1 and N_o were at par but had significantly higher purity values compared to N_2.

Table 27. Purity (%) in juice during maturity phase of plant crop as influenced by N, K and time of K application.

Treatment		November					December					January (At harvest)				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		82.41	83.40	81.22	82.34		85.65	84.70	82.89	84.41		87.56	86.55	85.67	86.59	
112	T_1	82.45	83.33	82.14		82.64	87.68	86.78	85.65		87.10	90.15	89.88	88.44		89.31
	T_2	83.46	83.63	81.21		82.80	88.20	87.10	85.90		87.67	91.22	91.50	86.44		89.41
	T_3	83.37	83.09	82.80		83.28	89.62	87.90	86.65		88.32	91.58	91.35	87.53		90.22
	Mean	83.09	83.35	82.05	82.72		88.50	87.26	85.97	87.24		90.98	90.91	87.47	89.79	
224	T_1	83.13	83.07	81.69			88.75	87.65	86.10			90.48	89.51	87.37		
	T_2	83.49	83.28	81.75			89.15	88.20	87.45			90.88	88.28	88.10		
	T_3	84.30	83.67	82.44			89.45	88.65	87.90			91.18	91.00	88.68		
	Mean	83.64	83.34	81.96	82.99		89.12	88.17	87.15	88.15		90.85	89.60	88.05	89.50	
Grand mean for N levels		83.09	83.35	81.61			88.36	87.28	86.03			90.44	89.72	87.47		
		r = 3					n = 63									

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	Yes	0.091	0.250	Yes	0.438	1.318	Yes	0.469	1.301
Between two levels of Potassium means (K)	No	0.153	-	No	0.214	-	No	0.224	-
Between two times of Potassium application means (T)	Yes	0.187	0.405	Yes	0.262	0.528	Yes	0.275	0.568
Between two N means at the same level of K	Yes	0.212	0.416	No	0.548	-	No	0.576	-
Between two K means at the same level of N	Yes	0.265	0.538	No	0.375	-	No	0.388	-
Between two K means at the same level of T	No	0.265	-	No	0.375	-	No	0.388	-
Between two T means at the same level of K	No	0.265	-	No	0.375	-	No	0.388	-
Control Vs other K treatments	Yes	0.202	0.415	Yes	0.284	0.571	Yes	0.296	0.602

Juice Purity (%) in November

N level	K level			CD at (P=0.05)
	K_0	K_1	K_2	
N_o	82.41	83.09	83.64	A. 0.416
N_1	83.40	83.35	83.34	B. 0.538
N_2	81.22	82.05	81.96	

A = Between two N levels at the same level of K
B = Between two K levels at the same level of N

4.10.2.2 Ratoon crop

Similar to plant crop there was progressive improvement in juice purity from November to harvest (January) time (Table 28). Application of N had no significant effect on cane juice purity. Nitrogen levels did not had any significant effect on juice purity at any stage of sampling. Application of K had a profound influence on purity of cane juice. There was significant increase in purity due to K application compared to control (K_o). Increase in the level of K application from 112 to 224 kg K_2O ha^{-1} increased the purity of juice at all the stages of sampling. Time of application of K had significant effect on juice purity at all the times of sampling. During November, application of K at 120 DAR (T_3) significantly improved the juice purity (88.02%) over its basal (T_1) application

Table 28. Purity (%) of Juice during maturity phase of Ratoon crop as influenced by N, K and time of K application.

Treatment		November					December					January (at harvest)				
Potassium levels (Kg K_2O ha^{-1}) and time of application		Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T	Nitrogen Levles (Kg ha^{-1})			Grand mean for K levels	Grand mean for T
		0	112	224			0	112	224			0	112	224		
0		85.65	85.46	85.21	85.44		88.94	88.92	88.56	88.81		89.65	89.00	88.98	89.21	
112	T_1	86.94	86.85	86.48		87.31	89.37	89.32	88.93		89.64	90.44	90.11	89.86		90.70
	T_2	87.38	87.10	86.96		87.67	90.10	89.92	89.72		90.06	90.90	90.84	90.67		91.61
	T_3	87.72	87.60	87.12		88.02	90.30	89.90	89.93		90.25	91.42	91.20	90.98		91.94
	Mean	87.35	87.18	86.85	87.13		89.92	89.71	89.53	89.92		90.92	90.72	90.50	90.71	
224	T_1	88.01	87.96	87.58			90.31	90.00	89.91			91.58	91.20	91.00		
	T_2	88.45	88.20	87.92			90.53	90.20	89.90			92.76	92.47	92.00		
	T_3	88.80	88.64	88.25			90.75	90.40	90.20			92.83	92.52	92.67		
	Mean	88.42	88.27	87.92	88.20		90.53	90.20	90.00¢	90.24		92.39	92.06	91.89	92.11	
Grand mean for N levels		87.56	87.40	87.07			90.04	89.81	89.59			91.37	91.05	90.88		

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)	Significant or not	SEd	CD (P=0.05)
Between two levels of Nitrogen means (N)	No	0.259	-	No	0.264	-	No	0.374	-
Between two levels of Potassium means (K)	Yes	0.238	0.479	Yes	0.218	0.463	Yes	0.265	0.537
Between two times of Potassium application means (T)	yes	0.242	0.487	Yes	0.245	0.528	Yes	0.324	0.658
Between two N means at the same level of K	No	0.392	-	No	0.429	-	No	0.518	-
Between two K means at the same level of N	No	0.365	-	No	0.404	-	No	0.459	-
Between two K means at the same level of T	No	0.365	-	No	0.404	-	No	0.459	-
Between two T means at the same level of K	No	0.365	-	No	0.404	-	No	0.459	-
Control Vs other K treatments	Yes	0.244	0.504	Yes	0.256	0.546	Yes	0.350	0.711

(87.31%) but it was at par with T_2 (87.67%). Similar results were observed in December and January samplings. None of the interaction effects were significant.

4.10.3 Glucose Content in Juice

4.10.3.1 Plant crop

The glucose content in juice at harvest (Table 29 Fig.21) increased significantly due to N application. Maximum glucose content was recorded at 224 Kg N ha^{-1} (1.066%) which was significantly higher than at 112 kg N ha^{-1} (0.87%). Glucose content due to no N application (0.733%) was significantly lower than that due to application of N at 112 kg ha^{-1} (0.871%). Application of K significantly reduced the glucose content (0.846%) in juice over no K application (1.015%). However, application of K at 112 kg ha^{-1} (0.855%) did not differ significantly than K application at 224 kg K_2O ha^{-1} (0.846%). None of the interactions had significant effect on glucose content in juice.

4.10.3.2 Ratoon crop

Ratoon crop had lower glucose content in juice than plant crop (Table 30 Fig.22). Application of N at 224 kg ha^{-1} (N_2) significantly increased the glucose content (0.629%) compared to N_o (0.586%) and N_1 (0.594%) while the

Table 29. Glucose (%) in juice at harvest of plant crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		0.903	0.966	1.176	1.015	1.015	
112	T_1	0.796	0.836	1.122	0.918		0.889
	T_2	0.616	0.935	0.994	0.848		0.844
	T_3	0.674	0.821	0.901	0.799		0.819
	Mean	0.695	0.864	1.006		0.855	
224	T_1	0.852	0.908	1.008	0.859		
	T_2	0.653	0.901	0.983	0.850		
	T_3	0.589	0.732	1.200	0.840		
	Mean	0.602	0.874	1.090		0.846	
Grand mean for N levels		0.733	0.871	1.066			
		r = 3		n = 63			

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.018	0.051
Between two levels of potassium means (K)	No	0.038	-
Between two times of potassium application means (T)	No	0.046	-
Between two N means at the same level of K	No	0.050	-
Between two K means at the same level of N	No	0.065	-
Between two K means at the same level of T	No	0.065	-
Between two T means at the same level of K	No	0.065	-
Control Vs other K treatments	Yes	0.050	0.101

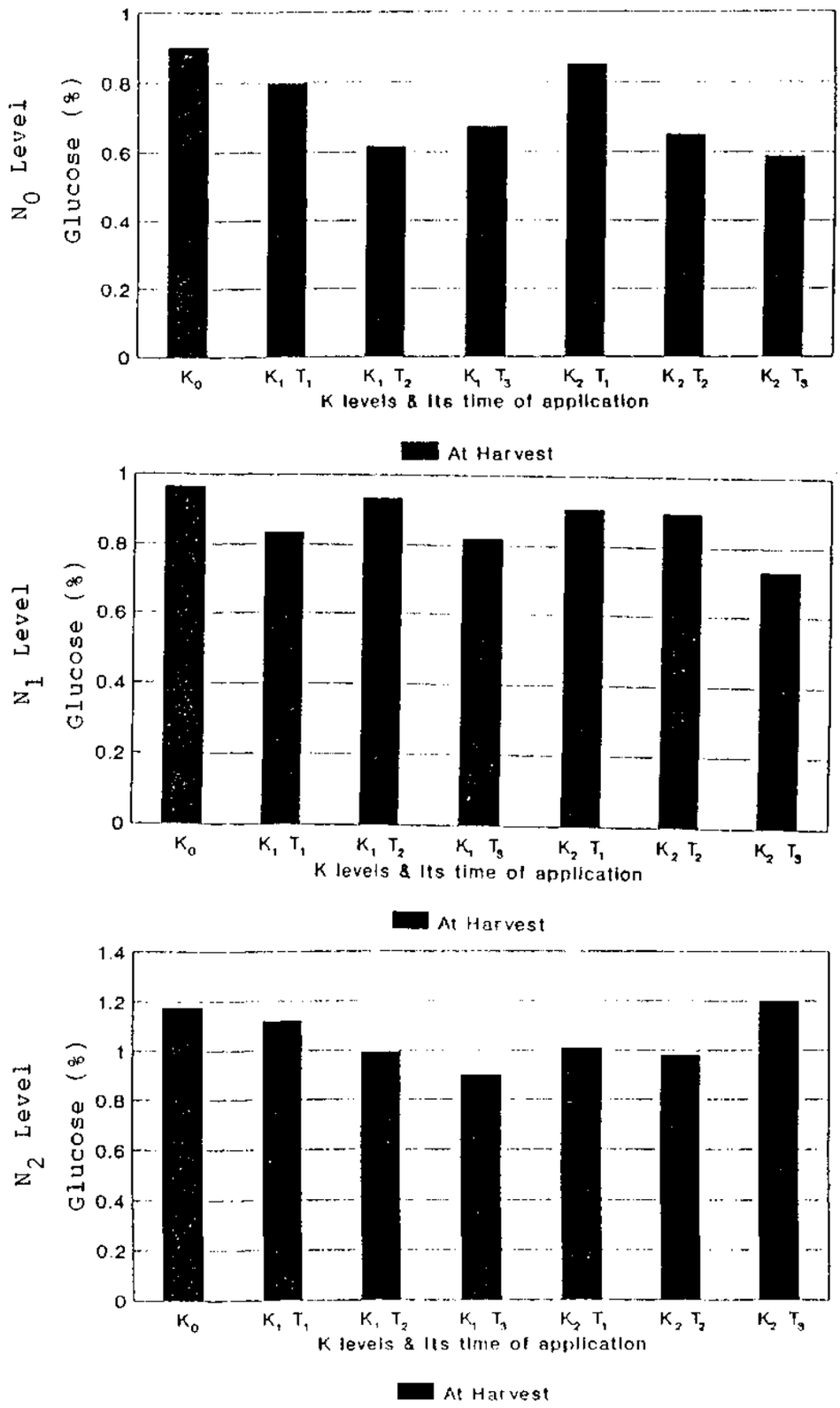


Fig.21: Glucose (%) at harvest (plant crop)

glucose content in N_o and N_1 were at par. Application of K significantly decreased the glucose content in juice over no K application. Higher dose of K application at 224 Kg K_2O ha^{-1} reduced the glucose content in juice (0.580%) compared to K application at 112 kg K_2O ha^{-1} (0.613%) Time of K application had a significant influence on glucose content of juice. Application of K at 120 DAR (T_3) recorded significantly lower glucose content (0.581%) compared to K applied at 60 DAR (0.594%) or applied at basal (0.614%). Interaction between N and K levels was significant.

The glucose content in juice significantly decreased with every increase in K application at all the levels of N. The glucose content with N_1 and N_o was not significantly different but both had lesser glucose content at K_o level compared to N_2. But at K_1 level the glucose content in N_1 and N_o was significantly lower than that of N_2 while at K_2 level there was significant increase in glucose content with every addition of N.

Glucose (%) at Harvest

N level	K level			CD at (P=0.05)
	K_0	K_1	K_2	
N_o	0.628	0.607	0.550	A. 0.0196
N_1	0.628	0.598	0.578	B. 0.0212
N_2	0.667	0.634	0.612	

A = Between two N levels at the same level of K
B = Between two K levels at the same level of N

Table 30. Glucose (%) in juice at harvest of Ratoon crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		0.628	0.628	0.667	0.642	0.642	
112	T_1	0.622	0.595	0.650	0.622		0.614
	T_2	0.603	0.600	0.636	0.613		0.594
	T_3	0.596	0.598	0.614	0.603		0.581
	Mean	0.607	0.598	0.634		0.613	
224	T_1	0.589	0.599	0.628	0.605		
	T_2	0.553	0.565	0.606	0.576		
	T_3	0.505	0.571	0.601	0.559		
	Mean	0.550	0.578	0.612		0.580	
Grand mean for N levels		0.586	0.594	0.629			
		r = 3		n = 63			

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.0045	0.0124
Between two levels of potassium means (K)	Yes	0.0060	0.0122
Between two times of potassium application means (T)	Yes	0.0074	0.0150
Between two N means at the same level of K	Yes	0.0088	0.0196
Between two K means at the same level of N	Yes	0.0105	0.0212
Between two K means at the same level of T	No	0.0105	-
Between two T means at the same level of K	No	0.0105	-
Control Vs other K treatments	Yes	0.0080	0.0162

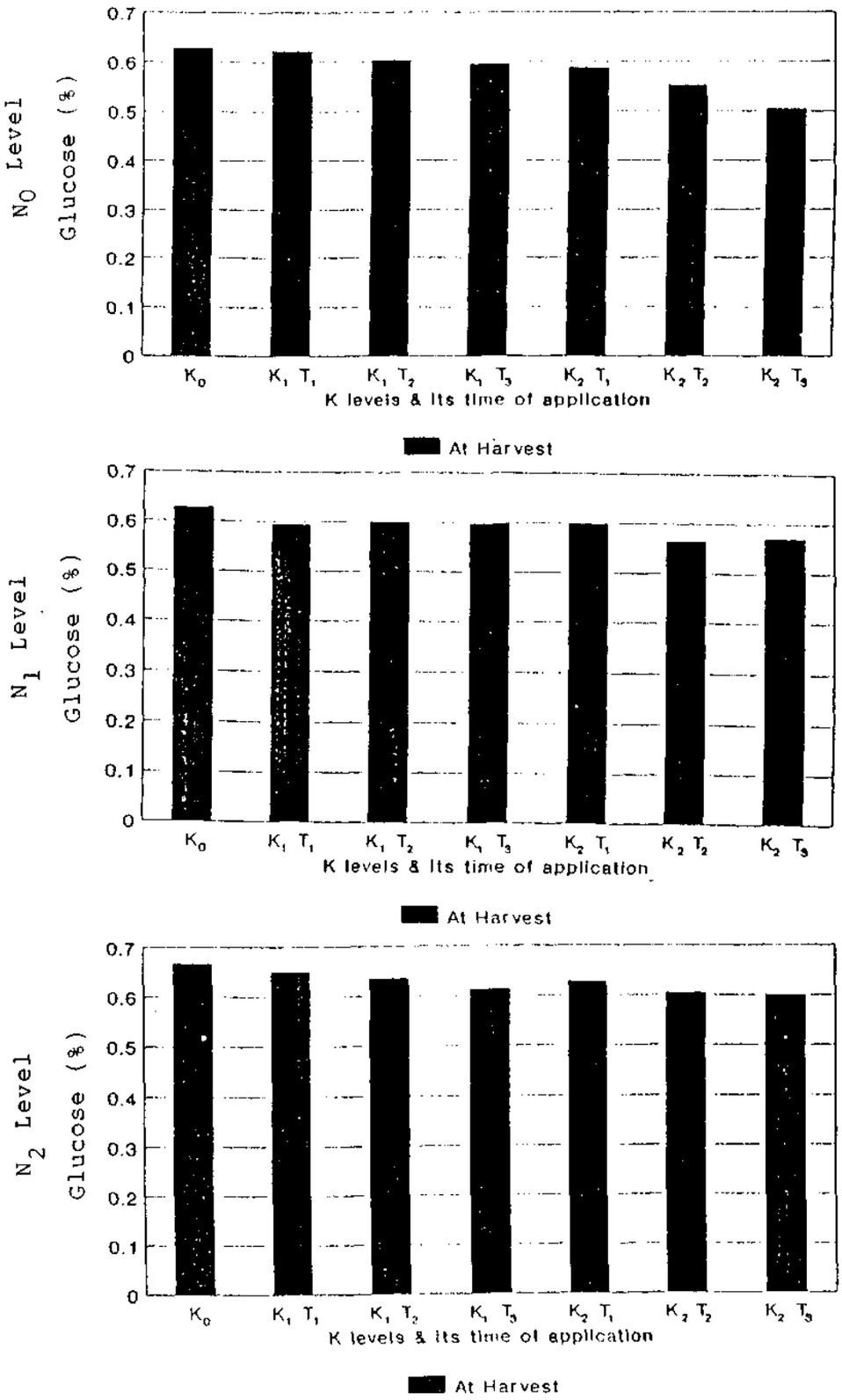


Fig.22: Glucose (%) at harvest (ratoon crop)

4.11 STALK CHARACTERS AT HARVEST

4.11.1 Millable Stalk Population

4.11.1.1 Plant crop

Nitrogen levels had a significant influence on millable stalk population at harvest (Table 31). Application of nitrogen at 112 kg ha^{-1} significantly increased the millable stalk population (78,455 ha^{-1}) over no N application (70,399 ha^{-1}) but the differences between 112 (78,455 ha^{-1}) and 224 kg N ha^{-1} (80,163 ha^{-1}) was not significant. In respect of millable stalk population the levels of K i.e., K_1 (75,068 ha^{-1}) and K_2 (77,291 ha^{-1}) did not differ significantly among themselves, but significantly superior over control (72,245 ha^{-1}). Significant differences in millable stalk population was noticed due to time of application of K. Basal application of K (T_1) significantly increased the millable stalk population at harvest (78,187 ha^{-1}) compared to K application at 120 DAP (75,730 ha^{-1}). However, significant differences were not observed in millable stalk population between K application at basal (78,187 ha^{-1}) and at 60 DAP (77,147 ha^{-1}) or at 60 DAP (77,147 ha^{-1}) and 120 DAP (75,730 ha^{-1}).

None of the interaction effects were found to be significant.

Table 31. Millable Stalk Population (000's ha^{-1}) at harvest of Plant crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1}) 0	112	224	Mean	Grand mean for K levels	Grand mean for time of K application
Potassium levels (Kg,K_2O, ha^{-1}) and time of application							
0		65.560	74.088	77.088	72.245	72.245	
112	T_1	72.601	79.288	82.166	78.018		78.187
	T_2	70.814	79.799	80.889	77.167		77.147
	T_3	69.383	76.438	79.384	75.068		75.730
	Mean	70.933	78.508	80.813		75.068	
224	T_1	72.954	80.456	81.659	78.356		
	T_2	71.635	79.758	79.984	77.126		
	T_3	69.845	79.356	79.971	76.391		
	Mean	71.478	79.857	80.538		77.291	
Grand mean for N levels		70.399	78.455	80.163			
		r = 3		n = 63			

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.642	1.784
Between two levels of potassium means (K)	No	0.821	-
Between two times of potassium application means (T)	Yes	1.004	2.037
Between two N means at the same level of K	No	1.217	-
Between two K means at the same level of N	No	1.416	-
Between two K means at the same level of T	No	1.416	-
Between two T means at the same level of K	No	1.416	-
Control Vs other K treatments	Yes	1.082	2.193

4.11.1.2 Ratoon crop

Levels of N had a significant effect on millable stalk number (Table 32). There was significant increase in the millable stalk population with every increase in the level of nitrogen from 0 (63,681 ha^{-1}) to 112 (74,367 ha^{-1}) and from 112 to 224 kg ha^{-1} (82,910 ha^{-1}). Application of potassium significantly increased the millable stalk population (75,094 ha^{-1}) compared to no application of K (69,835 ha^{-1}). However, significant differences in stalk population were not observed between the levels of K i.e., K_1 (73,533 ha^{-1}) and K_2 (75,094 ha^{-1}). Time of application of K did not have any significant influence on millable stalk population at harvest.

The interaction effects between N and K or K and its time of application were not significant.

4.11.2 Length of Millable Cane (LMC)

4.11.2.1 Plant crop

Nitrogen levels had a significant influence on length of millable cane (Table 33). There was significant increase in millable cane lenth with increase in N dose from 0 (262.3 cm) to 112 kg ha^{-1} (327.7 cm). Further increase in the N level from 112 kg ha^{-1} to 224 kg ha^{-1} (330.5 cm) had no significant effect. Both levels of potassium i.e., 112 kg

Table 32. Millable Stalk Population (000's ha^{-1}) at harvest of Ratoon crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O, ha^{-1}) and time of application							
0		60.611	69.857	79.037	69.835	69.835	
112	T_1	64.908	76.693	85.092	75.569		76.562
	T_2						
	T_3	61.523	71.939	80.142	71.202		72.113
	Mean	63.238	74.653	82.704		73.533	
224	T_1	66.992	78.060	87.630	77.561		
	T_2	65.104	74.869	84.115	74.696		
	T_3	63.346	73.828	81.900	73.025		
	Mean	65.148	75.586	84.549		75.094	
Grand mean for N levels		63.681	74.367	82.970			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.838	2.327
Between two levels of potassium means (K)	No	1.445	-
Between two times of potassium application means (T)	No	2.290	-
Between two N means at the same level of K	No	2.988	-
Between two K means at the same level of N	No	2.504	-
Between two K means at the same level of T	No	2.504	-
Between two T means at the same level of K	No	2.504	-
Control Vs other K treatments	Yes	1.912	3.879

K_2O ha^{-1} (309.8 cm) and 224 kg K_2O ha^{-1} (306.8 cm) were at par, but significantly increased the millable cane length over no K application (297.8 cm). Significant increase in length of millable cane was observed due to time of K application. Basal application of K (T_1) significantly increased the length of millable cane (315.1 cm) over its delayed application at 120 DAP (299.9 cm). However, basal application of K (T_1) and at 60 DAP (310.0 cm) were at par in respect of length of millable cane at harvest. Interaction between N and K levels or K and its time of application did not effect the millable cane length.

4.11.2.2 Ratoon crop

Significant influence on millable cane length due to N and K application was recorded. (Table 34). Increase in the level of N from 0 (244.3 cm) to 112 kg ha^{-1} (265.9 cm) and from 112 to 224 Kg ha^{-1} (279.4 cm) significantly increased the length of millable cane at harvest. There was significant improvement in length of millable cane due to K application over no K application, but the differences between K_1 (262.5 cm) and K_2 (266.3 cm) were not significant. Time of K application and all the interactions had no significant effect on millable stalk length at harvest.

Table 33. Length of Millable Cane (cm) at harvest of plant crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O,ha^{-1}) and time of application							
0		256.0	315.7	321.7	297.8	297.8	
112	T_1	270.3	338.3	342.3	317.0		315.1
	T_2	268.3	336.3	334.3	313.0		310.0
	T_3	251.0	320.7	327.0	299.6		299.9
	Mean	263.2	331.8	334.5		309.8	
224	T_1	274.3	333.7	331.7	313.2		
	T_2	260.7	329.7	330.3	306.9		
	T_3	255.3	319.3	326.0	300.2		
	Mean	263.4	327.6	329.3		306.8	
Grand mean for N levels		262.3	327.7	330.5			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	4.03	11.18
Between two levels of potassium means (K)	No	2.12	-
Between two times of potassium application means (T)	Yes	2.60	5.28
Between two N means at the same level of K	No	3.58	-
Between two K means at the same level of N	No	3.68	-
Between two K means at the same level of T	No	3.68	-
Between two T means at the same level of K	No	3.68	-
Control Vs other K treatments	No	2.81	5.70

Table 34. Length of Millable Cane (cm) at harvest of Ratoon crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O,ha^{-1}) and time of application							
0		232.7	263.4	271.5	255.9	255.9	
112	T_1	248.1	267.7	278.7	264.8		267.5
	T_2	241.2	263.3	280.1	261.5		262.8
	T_3	244.0	261.6	217.1	261.2		262.9
	Mean	244.4	264.2	279.0		262.5	
224	T_1	251.3	270.1	289.2	270.2		
	T_2	248.2	264.8	279.4	264.1		
	T_3	244.9	270.1	278.5	264.5		
	Mean	248.1	268.3	282.4		266.3	
Grand mean for N levels		244.3	265.9	279.4			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	2.08	5.77
Between two levels of potassium means (K)	No	2.09	-
Between two times of potassium application means (T)	No	3.56	-
Between two N means at the same level of K	No	3.40	-
Between two K means at the same level of N	No	3.62	-
Between two K means at the same level of T	No	3.62	-
Between two T means at the same level of K	No	3.62	-
Control Vs other K treatments	Yes	2.77	5.61

4.11.3 Number of Internodes Per Cane

4.11.3.1 Plant crop

Levels of nitrogen only had a significant influence on number of internodes per cane (Table 35).

Increase in the level of N from 0 (28.19) to 112 kg ha^{-1} (30.55) significantly enhanced the number of internodes per cane. Further increase in the N level upto 224 kg ha^{-1} (30.76) failed to increase the number of internodes significantly. Different K levels or time of K application had no significant influence on the number of internodes. Interaction between N and K doses or K and its time of application had no significant influence on internode number.

4.11.3.2 Ratoon crop

Significant differences in internode number was recorded only in N levels (Table 36).

Nitrogen at 224 kg ha^{-1} significantly enhanced the number of internodes per cane (29.18) at harvest compared to N_o (26.69) and N_1 (27.19). The differences due to N_o and N_1 (112 kg N ha^{-1}) was not significant in this respect. Either the rate or time of application of K had no significant effect on the number of internodes per cane. None of the interaction effects were significant.

Table 35. Number of internodes per cane at harvest of Plant crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O,ha^{-1}) and time of application							
0		28.91	29.89	30.29	29.70	29.70	
112	T_1	28.97	30.88	31.00	30.28		30.11
	T_2	27.87	30.13	30.60	29.53		29.78
	T_3	27.32	30.64	30.72	29.56		29.69
	Mean	28.05	30.55	30.77		29.79	
224	T_1	27.71	31.00	31.12	29.94		
	T_2	28.75	30.52	30.84	30.03		
	T_3	27.83	30.84	30.77	29.81		
	Mean	28.10	30.79	30.91		29.93	
Grand mean for N levels		28.19	30.55	30.76			
		r = 3		n = 63			

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.230	0.638
Between two levels of potassium means (K)	No	0.220	-
Between two times of potassium application means (T)	No	0.274	-
Between two N means at the same level of K	No	0.366	-
Between two K means at the same level of N	No	0.381	-
Between two K means at the same level of T	No	0.381	-
Between two T means at the same level of K	No	0.381	-
Control Vs other K treatments	No	0.291	-

Table 36. Number of internodes per cane at harvest of Ratoon crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		26.35	26.38	28.13	26.96	26.96	
112	T_1	25.80	27.70	29.52	27.67		27.75
	T_2	27.88	27.17	29.92	28.32		27.82
	T_3	26.78	26.83	29.48	27.70		27.81
	Mean	26.82	27.23	29.64		27.90	
224	T_1	26.82	27.40	29.28	27.83		
	T_2	26.15	27.20	28.60	27.32		
	T_3	27.07	27.63	29.32	28.01		
	Mean	26.68	27.41	29.07		27.72	
Grand mean for N levels		26.69	27.19	29.18			
		r = 3		n = 63			

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.523	1.452
Between two levels of potassium means (K)	No	0.232	-
Between two times of potassium application means (T)	No	0.284	-
Between two N means at the same level of K	No	0.633	-
Between two K means at the same level of N	No	0.402	-
Between two K means at the same level of T	No	0.402	-
Between two T means at the same level of K	No	0.402	-
Control Vs other K treatments	No	0.387	-

4.11.4 Diameter of Cane

4.11.4.1 Plant crop

Application of N at 112 kg ha^{-1} significantly increased the diameter of cane (2.52 cm) over no N application (2.34 cm). Further increase in the level of nitrogen to 224 kg ha^{-1} (2.58 cm) had no significant effect on cane diameter (Table 37). Application of K significantly increased the cane diameter (2.51 cm) over K_o application (2.43 cm). However, potassium levels i.e., K_1 (2.50 cm) and K_2 (2.51 cm) had no significant effect on cane diameter. Time of application of K had no significant effect in this regard.

Interaction between N and K levels or K and its time of application were not significant.

4.11.4.2 Ratoon crop

Nitrogen and potassium levels had significant effect on diameter of cane (Table 38). There was significant increase in diameter of cane with every increase in the level of N from 0 (2.34 cm) to 112 kg ha^{-1} (2.42 cm) and from 112 to 224 kg ha^{-1} (2.50 cm). Application of k had similar positive effect on the cane diameter compared to no K application. The diameter of cane with K_2 (2.47 cm) was significantly higher than with K_1 (2.41 cm). None of the interaction effects were significant.

Table 37. Diameter of cane (cm) at harvest of plant crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O, ha^{-1}) and time of application							
0		2.21	2.45	2.51	2.43	2.43	
112	T_1	2.32	2.52	2.58	2.54		2.52
	T_2	2.36	2.49	2.60	2.49		2.51
	T_3	2.30	2.52	2.59	2.48		2.49
	Mean	2.33	2.51	2.59		2.50	
224	T_1	2.42	2.55	2.59	2.50		
	T_2	2.40	2.56	2.60	2.52		
	T_3	2.38	2.53	2.56	2.51		
	Mean	2.40	2.55	2.58		2.51	
Grand mean for N levels		2.34	2.52	2.58			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.037	0.112
Between two levels of potassium means (K)	No	0.021	-
Between two times of potassium application means (T)	No	0.026	-
Between two N means at the same level of K	No	0.057	-
Between two K means at the same level of N	No	0.036	-
Between two K means at the same level of T	No	0.036	-
Between two T means at the same level of K	No	0.036	-
Control Vs other K treatments	Yes	0.028	0.056

Table 38. Diameter of cane (cm) at harvest of ratoon crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		2.16	2.32	2.39	2.29	2.29	
112	T_1	2.33	2.42	2.48	2.41		2.45
	T_2	2.34	2.42	2.50	2.42		2.46
	T_3	2.35	2.44	2.44	2.41		2.42
	Mean	2.34	2.43	2.47		2.41	
224	T_1	2.43	2.47	2.59	2.50		
	T_2	2.40	2.44	2.56	2.47		
	T_3	2.36	2.43	2.53	2.44		
	Mean	2.40	2.45	2.56		2.47	
Grand mean for N levels		2.34	2.42	2.50			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.015	0.041
Between two levels of potassium means (K)	Yes	0.016	0.032
Between two times of potassium application means (T)	No	0.019	-
Between two N means at the same level of K	No	0.025	-
Between two K means at the same level of N	No	0.027	-
Between two K means at the same level of T	No	0.027	-
Between two T means at the same level of K	No	0.027	-
Control Vs other K treatments	Yes	0.021	0.043

4.11.5 Single Cane Weight

4.11.5.1 Plant crop

Nitrogen and potassium had significant effect on single cane weight (Table 39). Application of 112 kg N ha^{-1} significantly increased the single cane weight (1.606 kg) over no N application (1.280 kg). Significant increase in single cane weight was not observed when the level of N increased upto 224 kg ha^{-1} (1.627 kg). Between the levels of K i.e., 112 kg K_2O ha^{-1} (1.496 kg) and 224 kg K_2O ha^{-1} (1.531 kg) there was no significant difference in cane weight. However, K application resulted in significantly more cane weight over no K application. Basal application of K significantly increased the cane weight (1.569 kg) over late application at 120 DAP (1.428 kg). All the interaction effects except the interaction between N and K levels were not significant.

At N_o level, there was significant increase in cane weight with every increase in K application. At N_1 and N_2 levels, K_1 and K_2 were at par but had significantly higher cane weight compared to K_o. At a given level of K, there was increase in cane weight at N_1 and N_2 levels compared to N_o but both N_1 and N_2 were at par at all the K levels.

Table 39. Single cane weight (Kg) at harvest of plant crop as influenced by N, K and time of K applicatiion.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels ($Kg,K_2O/ha^{-1}$) and time of application							
0		1.251	1.534	1.552	1.446	1.446	
112	T_1	1.353	1.682	1.665	1.567		1.569
	T_2	1.237	1.639	1.670	1.515		1.544
	T_3	1.131	1.510	1.580	1.407		1.428
	Mean	1.290	1.610	1.639		1.496	
224	T_1	1.357	1.678	1.678	1.571		
	T_2	1.373	1.681	1.655	1.573		
	T_3	1.257	1.516	1.575	1.449		
	Mean	1.329	1.625	1.639		1.531	
Grand mean for N levels		1.280	1.606	1.627			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.009	0.024
Between two levels of potassium means (K)	No	0.018	-
Between two times of potassium application means (T)	Yes	0.016	0.033
Between two N means at the same level of K	Yes	0.018	0.036
Between two K means at the same level of N	Yes	0.023	0.046
Between two K means at the same level of T	No	0.023	-
Between two T means at the same level of K	No	0.023	-
Control Vs other K treatments	Yes	0.017	0.036

Single cane weight (Kg)

N level	K level			CD at (P=0.05)
	K_0	K_1	K_2	
N_o	1.251	1.290	1.329	A. 0.036
N_1	1.534	1.610	1.625	B. 0.046
N_2	1.552	1.639	1.639	

A = Between two N levels at the same level of K
B = Between two K levels at the same level of N

4.11.5.2 Ratoon crop

Application of N and K significantly influenced the single cane weight (Table 40). Highest single cane weight was recorded with 224 kg N ha^{-1} (1.420 kg) which was significantly superior to no N application (1.202 kg) and 112 kg N ha^{-1} (1.302 kg). The increase in cane weight with 112 kg N ha^{-1} over no N was also significant. Similar significant differences in single cane weight were observed due to K application. Application of K at 224 kg K_2O ha^{-1} significantly increaed the cane weight (1.325 kg) over application of K at 112 kg K_2O ha^{-1} (1.288 kg). Similarly both the levels of K i.e.,K_1 and K_2 significantly increased the single cane weight over no K application. Time of application of K had no significant effect on the single cane weight. None of the interactions had significant influence on the single cane weight.

Table 40. Single cane weight (Kg) at harvest of Ratoon crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1})			Mean	Grand mean for K levels	Grand mean for time of K application
		0	112	224			
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		1.125	1.256	1.363	1.248	1.248	
112	T_1	1.209	1.303	1.421	1.311		1.334
	T_2	1.208	1.274	1.413	1.298		1.310
	T_3	1.207	1.275	1.413	1.298		1.310
	Mean	1.208	1.284	1.416		1.288	
224	T_1	1.249	1.347	1.477	1.358		
	T_2	1.210	1.329	1.426	1.322		
	T_3	1.211	1.328	1.427	1.322		
	Mean	1.223	1.335	1.443		1.325	
Grand mean for N levels		1.202	1.302	1.420			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.019	0.053
Between two levels of potassium means (K)	Yes	0.010	0.020
Between two times of potassium application means (T)	No	0.012	-
Between two N means at the same level of K	No	0.024	-
Between two K means at the same level of N	No	0.017	-
Between two K means at the same level of T	No	0.017	-
Between two T means at the same level of K	No	0.017	-
Control Vs other K treatments	Yes	0.013	0.027

4.12 YIELD OF CANE AND COMMERCIAL CANE SUGAR (CCS) AT HARVEST

4.12.1 Cane Yield

4.12.1.1 Plant crop

Cane yield varied significantly due to N and K levels (Table 41 Fig.23). Highest cane yield of 109.69 t ha^{-1} was obtained with N_2 (224 kg N ha^{-1}) but it was on par with N_1 (107.01 t ha^{-1}). Application of 112 kg N ha^{-1} (N_1) significantly increased the cane yield (107.01 t ha^{-1}) over N_o (77.92 t ha^{-1}). The percentage increase in cane yield due to 112 and 224 kg N ha^{-1} over no N was 27.18 and 29.60 respectively. Application of K significantly improved the cane yield over no K application. However, the difference in cane yield due to 112 (98.67 t ha^{-1}) and 224 (100.46 t ha^{-1}) kg K_2O ha^{-1} was not significant. The per cent increase in cane yield at 112 kg K_2O ha^{-1} over no K was 9.69. Time of K application had significant influence on cane yield. Delayed application of K at 120 DAP (T_3) significantly decreased the cane yield by 4.54 t ha^{-1} compared to basal application of K (T_1). However, the cane yield differences due to basal application of K (T_1) and at 60 DAP (T_2) and between 60 and 120 DAP (T_3) were not significant. The interaction effects between N and K or K and its time of application were not significant.

Table 41. Cane yield (t ha^{-1}) at harvest of plant crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1}) 0	112	224	Mean	Grand mean for K levels	Grand mean for time of K application
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		68.16	97.60	101.64	89.13	89.13	
112	T_1	82.29	109.96	112.40	100.69		101.72
	T_2	78.06	101.76	109.83	99.22		99.81
	T_3	76.76	103.35	108.20	96.10		97.18
	Mean	79.04	107.69	111.39		98.67	
224	T_1	82.68	110.58	114.97	102.74		
	T_2	80.60	109.57	111.00	100.39		
	T_3	76.89	108.27	109.63	98.26		
	Mean	80.06	109.47	110.62	100.05	100.46	
Grand mean for N levels		77.92	107.01	109.67			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	3.62	10.05
Between two levels of potassium means (K)	No	1.30	-
Between two times of potassium application means (T)	Yes	1.59	3.22
Between two N means at the same level of K	No	4.22	-
Between two K means at the same level of N	No	2.24	-
Between two K means at the same level of T	No	2.24	-
Between two T means at the same level of K	No	2.24	-
Control Vs other K treatments	Yes	1.71	3.48

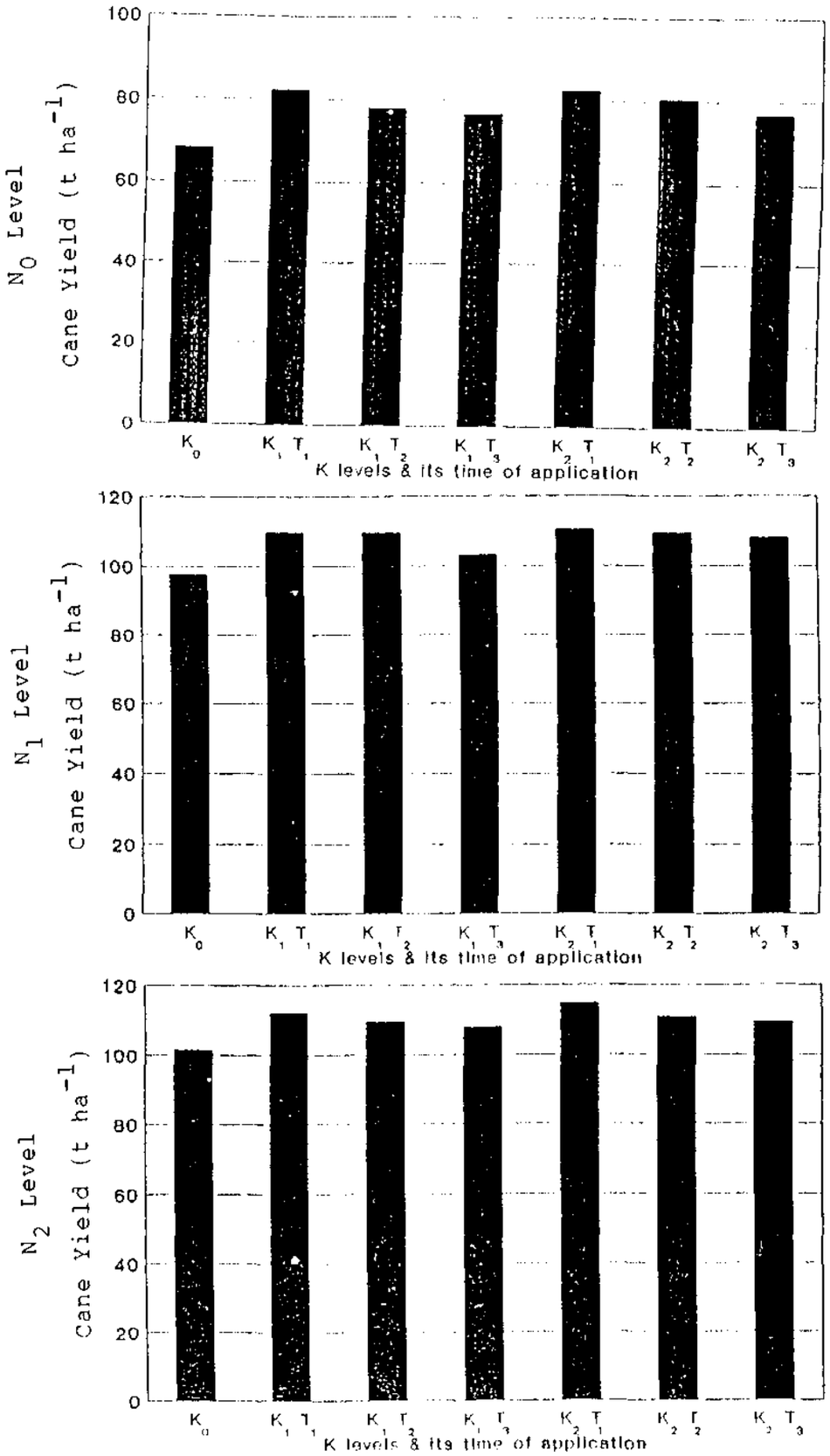


Fig.23: Cane yield (t ha^{-1}) at harvest (Plant crop)

4.12.1.2 Ratoon crop

In general the cane yield of ratoon crop was much lower than the plant crop. Every increase in the level of N from 0 to 224 kg ha^{-1} significantly increased the cane yield (Table 42 Fig.24). The cane yields due to 0, 112 and 224 kg N ha^{-1} were 56.58, 78.74 and 90.26 t ha^{-1} respectively.

The per cent increase in cane yield due to 112 and 224 kg N ha^{-1} over control was 28.14 and 37.31 respectively. The per cent increase in cane yield at 224 kg N ha^{-1} over 112 kg N ha^{-1} was 12.76. Between the two levels of K application (K_1 and K_2) there was no significant difference in cane yield. However, application of K significantly increased the cane yield over no K application. The per cent increase in cane yield at 112 kg K_2O ha^{-1} over no K application was 14.83. There was no significant influence due to time of K application on cane yield. Interaction between N and K levels or K levels and its time of application had no significant effect.

4.12.2 Yield of Commercial Cane Sugar (CCS)

4.12.2.1 Plant crop

Levels of N had significant effect on the CCS yield (Table 43 Fig.25). The CCS yield (13.82 t ha^{-1}) due to 112 kg N ha^{-1} was significantly superior over no N application

Table 42. Cane yield (t ha^{-1}) at harvest of Ratoon crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1}) 0	112	224	Mean	Grand mean for K levels	Grand mean for time of K application
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		46.56	62.77	74.13	63.82	63.82	
112	T_1	58.40	80.44	93.98	77.60		78.30
	T_2	56.93	77.64	89.84	74.80		75.60
	T_3	53.78	75.62	87.76	72.38		73.37
	Mean	56.37	77.90	90.53		74.93	
224	T_1	59.44	82.55	94.99	78.99		
	T_2	57.94	80.37	90.85	76.39		
	T_3	55.01	79.82	88.25	74.36		
	Mean	57.47	80.91	91.36		76.58	
Grand mean for N levels		55.44	77.03	88.54			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	1.05	2.92
Between two levels of potassium means (K)	No	1.54	-
Between two times of potassium application means (T)	No	2.76	-
Between two N means at the same level of K	No	2.39	-
Between two K means at the same level of N	No	2.98	-
Between two K means at the same level of T	No	2.98	-
Between two T means at the same level of K	No	2.98	-
Control Vs other K treatments	Yes	2.01	4.07

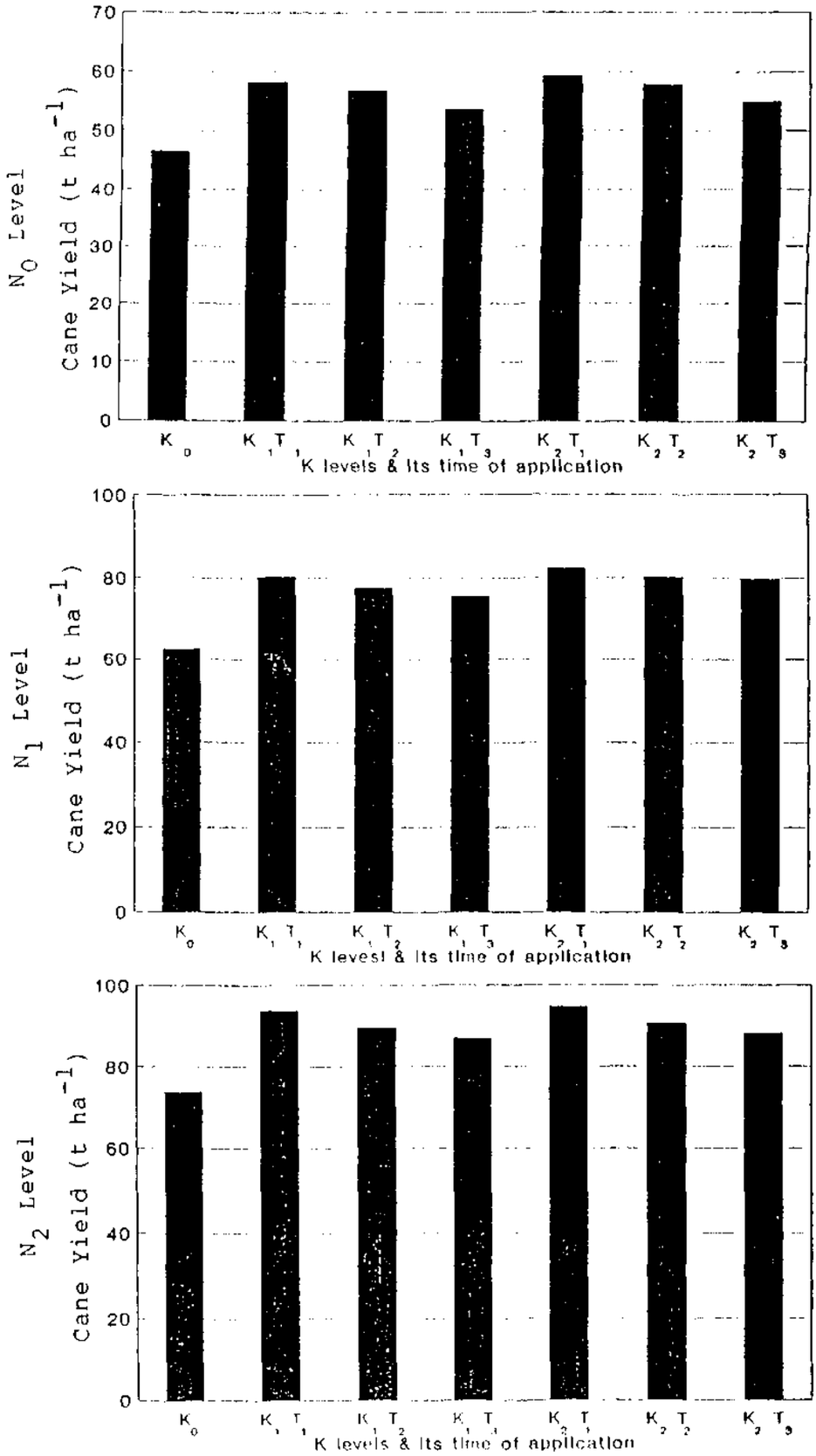


Fig.24: Cane yield (t ha^{-1}) at harvest (Ratoon crop)

(10.43 t ha^{-1}). Further increase in the N level upto 224 kg ha^{-1} (13.55 t ha^{-1}) did not improve the CCS yield significantly, but slight reduction in CCS yield (0.27 t ha^{-1}) was recorded at 224 Kg N level. There was no significant difference in CCS yield due to K levels (k_1 and K_2). However, application of K significantly increased the CCS yield over no K application. Significant increase in CCS yields were recorded with basal application of K (12.98 t ha^{-1}) over its late application at 120 DAP (12.49 t ha^{-1}). However, the differences between basal application of K (T_1) and application at 60 DAP (T_2) and between 60 and 120 DAP (T_3) were not significant.

None of the interaction effects were significant.

4.12.2.2 Ratoon crop

Ratoon crop gave relatively lower CCS yield compared to plant crop. Every increase in the level of N from 0 to 112 and 112 to 224 kg ha^{-1} significantly enhanced the CCS yield (Table 44 Fig.26). Increase in CCS yield due to 112 and 224 kg N ha^{-1} was 2.97 and 4.49 t ha^{-1} over no application of N respectivley. The CCS yield due to 112 (10.38 t ha^{-1}) and 224 kg K_2O ha^{-1} (10.73 t ha^{-1}) was not significant. However, application of K resulted in significantly higher CCS yield over no K application (8.34 t ha^{-1}). Basal application of K significantly increased the

Table 43. Commercial cane sugar (ccs) yield (t ha^{-1}) of plant crop as influenced by N,K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1}) 0	112	224	Mean	Grand mean for K levels	Grand mean for time of K application
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		9.37	13.10	12.90	11.79	11.79	
112	T_1	10.66	13.90	13.72	12.76		12.98
	T_2	10.58	13.72	13.45	12.58		12.74
	T_3	10.40	13.61	13.16	12.39		12.49
	Mean	10.55	13.74	13.44		12.58	
224	T_1	10.88	14.42	14.26	13.19		
	T_2	10.71	14.21	13.75	12.89		
	T_3	10.42	13.76	13.60	12.59		
	Mean	10.67	14.13	13.87		12.89	
Grand mean for N levels		10.43	13.82	13.55			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.409	1.134
Between two levels of potassium means (K)	No	0.173	-
Between two times of potassium application means (T)	Yes	0.211	0.429
Between two N means at the same level of K	No	0.489	-
Between two K means at the same level of N	No	0.299	-
Between two K means at the same level of T	No	0.299	-
Between two T means at the same level of K	No	0.299	-
Control Vs other K treatments	Yes	0.228	0.463

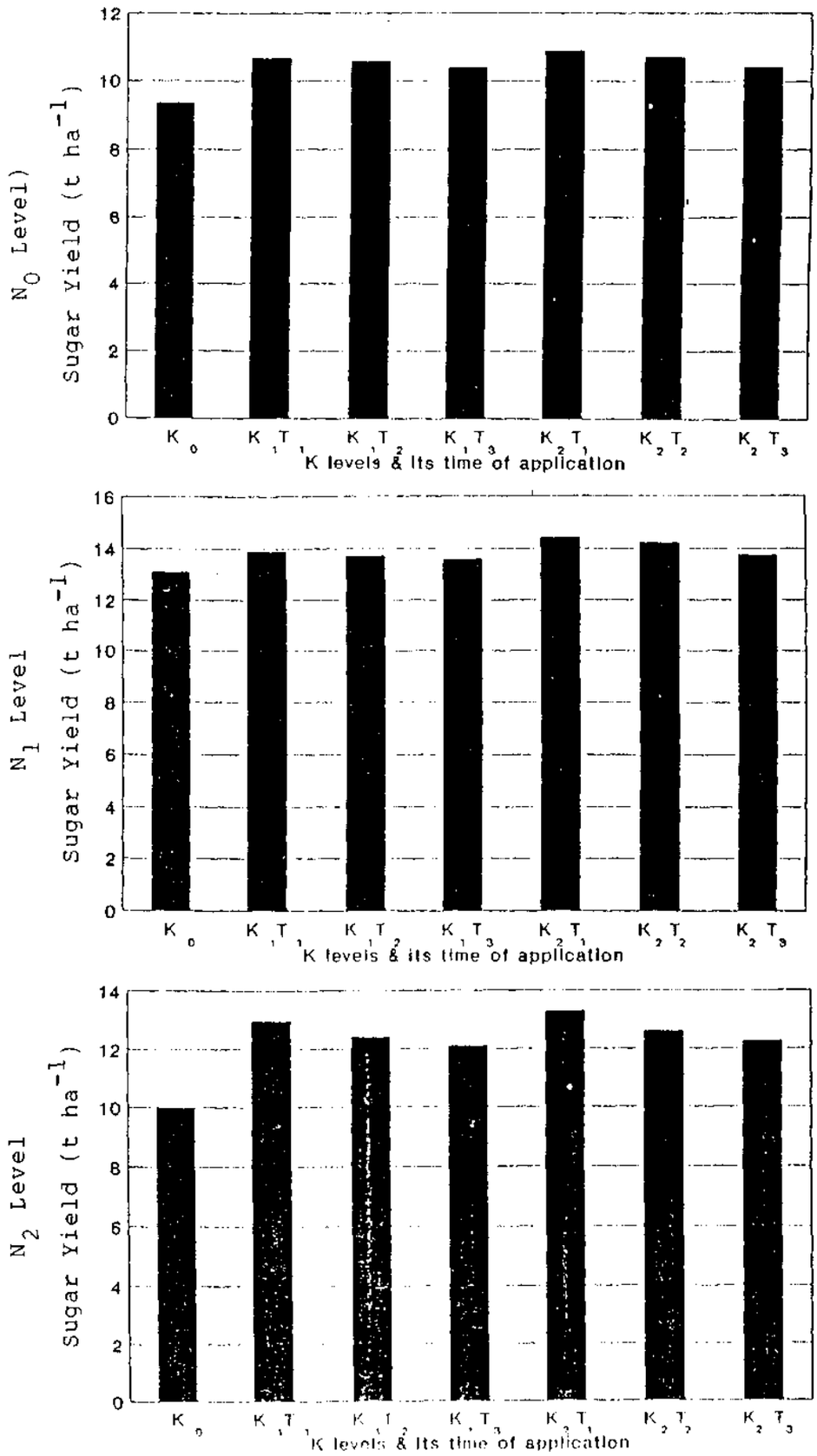


Fig.25: Sugar yield (t ha^{-1}) at harvest (Plant crop)

CCS yield (10.95 t ha^{-1}) over delayed application at 120 DAR (10.20 t ha^{-1}). The difference in CCS yield due to application of K at 60 days (10.51 t ha^{-1}) and further delayed application at 120 DAR (10.20 t ha^{-1}) did not differ significantly. Interaction between N and K doses or K doses and its time of application had no significant effect on CCS yield.

14.13 RESPONSE FUNCTIONS FOR N AND K APPLICATION

Response functions to applied N and K fertilisers in terms of cane and CCS yield have been worked out for both for plant and ratoon crops.

14.13.1 Plant Crop

Response to N

Cane yield : $77.73 + 0.3881\ N - 0.0011\ N^2$ ($R^2 = 0.8569$)

CCS yield : $10.2069 + 0.0587\ N - 0.002\ N^2$ ($R^2 = 0.9972$)

Response to K

Cane yield : $89.1651 + 0.1178\ K - 0.0003\ K^2$ ($R^2 = 0.9964$)

CCS yield : $11.7853 + 0.0094\ K - 0.0002\ K^2$ ($R^2 = 0.9967$)

The response functions of both cane and CCS yields (Fig.27) were quadratic with a coefficient of multiple determination of over 85 per cent. It was also quadratic with a much higher multiple determination coefficient over 99 per cent. Further, the linear response coefficients for K

Table 44. Commercial cane sugar (ccs) yield (t ha^{-1}) of Ratoon crop as influenced by N, K and time of K application.

Treatment		Nitrogen levels (kg ha^{-1}) 0	112	224	Mean	Grand mean for K levels	Grand mean for time of K application
Potassium levels (Kg,K_2O ha^{-1}) and time of application							
0		6.38	8.66	9.98	8.34	8.34	
112	T_1	8.18	11.18	12.99	10.78		10.95
	T_2	7.93	10.68	12.41	10.34		10.51
	T_3	7.46	10.50	12.11	10.02		10.20
	Mean	7.86	10.79	12.50		10.38	
224	T_1	8.43	11.61	13.31	11.12		
	T_2	8.16	11.25	12.62	10.68		
	T_3	7.71	11.18	12.26	10.38		
	Mean	8.10	11.35	12.73	10.73	10.73	
Grand mean for N levels		7.75	10.72	12.24			

r = 3 n = 63

Conclusions:

Particulars	Significant or not	SEd	CD(P=0.05)
Between two levels of nitrogen means (N)	Yes	0.158	0.439
Between two levels of potassium means (K)	No	0.240	-
Between two times of potassium application means (T)	Yes	0.294	0.597
Between two N means at the same level of K	No	0.340	-
Between two K means at the same level of N	No	0.416	-
Between two K means at the same level of T	No	0.416	-
Between two T means at the same level of K	No	0.416	-
Control Vs other K treatments	Yes	0.318	0.645

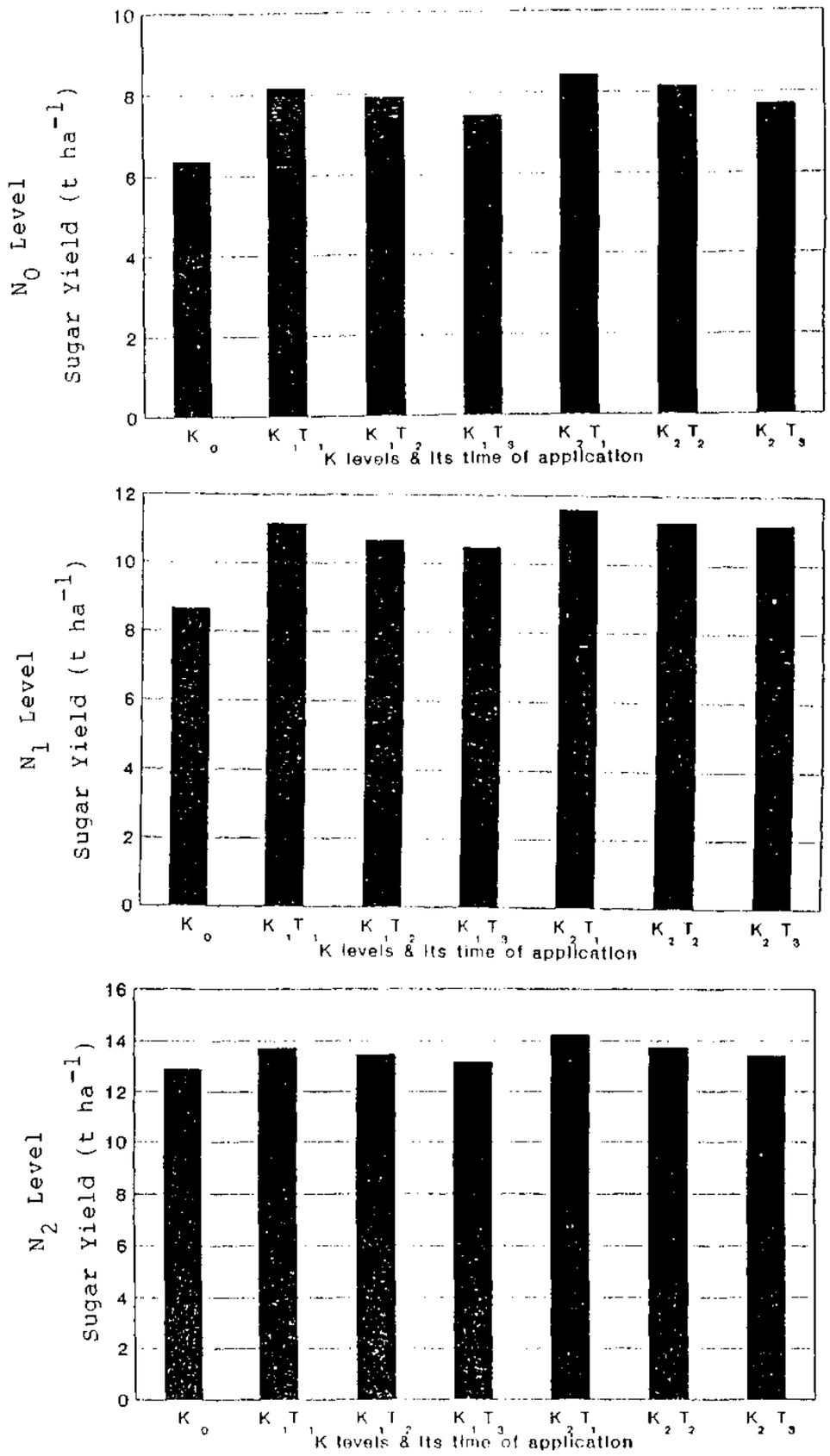


Fig.26: Sugar yield (t ha^{-1}) at harvest (Ratoon crop)

were of a lower order than for N indicating that the increase of cane and CCS yield per unit N in the linear part of response was much higher than that per unit of K applied.

14.13.2 Ratoon Crop

Response to N

Cane Yield = 58.3485 + 0.1504 N (R^2 = 0.9681)

CCS yield = 8.1619 + 0.0204 N (R^2 = 0.9654)

Response to K

Cane yield = 63.7201 + 0.1466 - 0.0004 K^2 (R^2 = 0.9945)

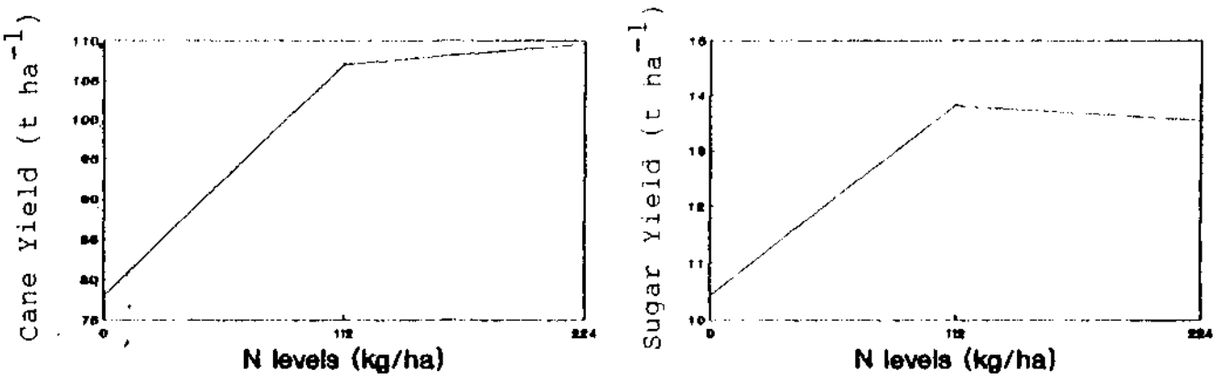
CCS yield = 8.3345 + 0.0263 K - 0.0007 K^2 (R^2 = 0.9924)

The response (Fig.28) of both cane and CCS yields to N application was linear upto the highest dose of 224 kg N ha^{-1} where as it was quadratic for K. The functions accounted for over 96 per cent cane and CCS yield variation with regards to N and over 99 per cent with regard to K response.

4.14 INTER-RELATIONSHIP OF STALK CHARACTERS AMONG THEMSELVES AND WITH CANE YIELD

Simple correlation co-efficients (r) were worked out to study the association of different stalk characters viz., stalk population, length of millable cane, single cane weight and diameter of cane at harvest among themselves for plant and ratoon crops.

RESPONSE TO NITROGEN



RESPONSE TO POTASSIUM

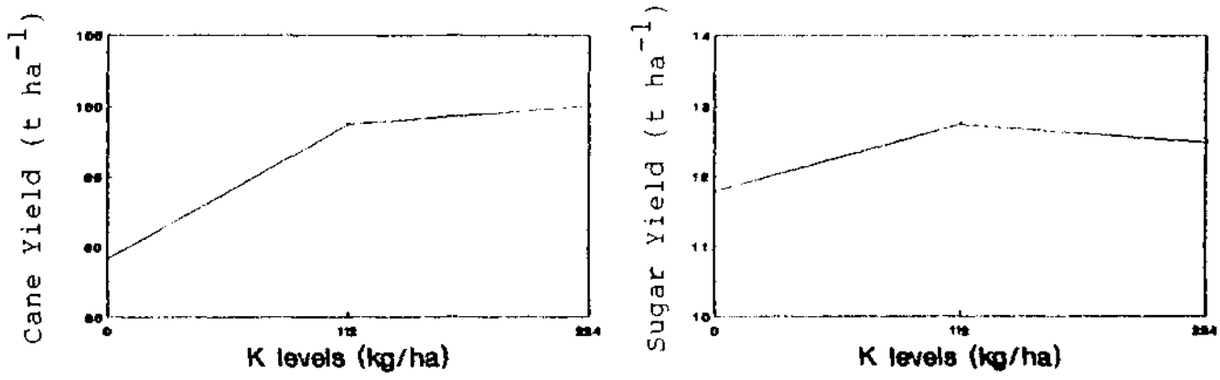
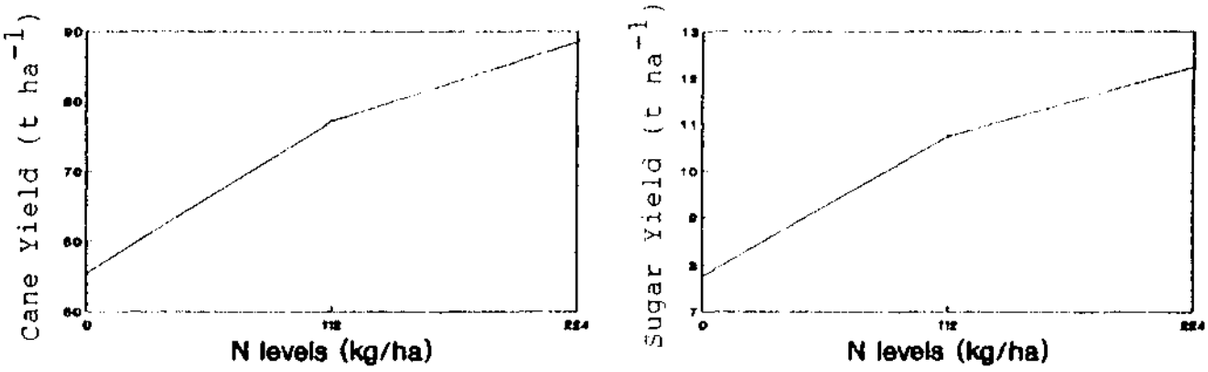


Fig.27: Response of Cane and Sugar yields to N and K (plant crop)

RESPONSE TO NITROGEN



RESPONSE TO POTASSIUM

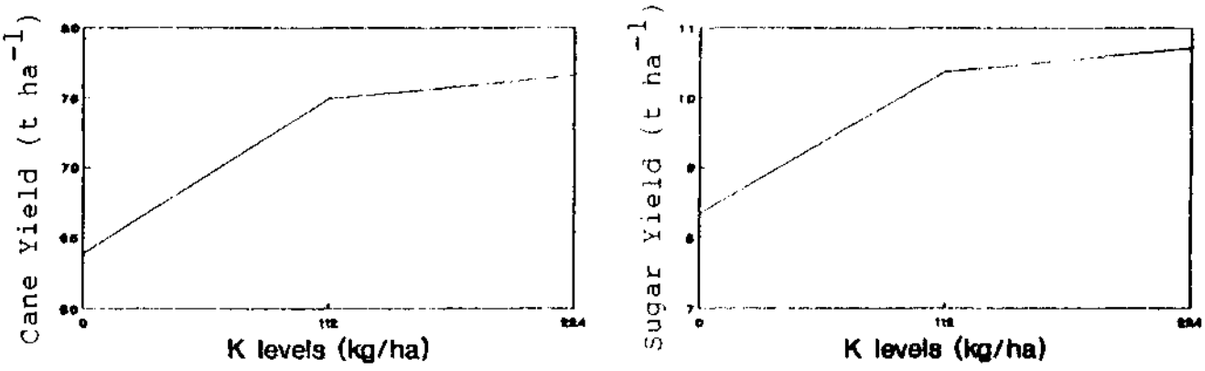


Fig.28: Response of Cane and Sugar yields to N and K (ratoon crop)

4.14.1 Inter-relationships of Stalk Character Among Themselves And Cane Yield of Plant And Ratoon Crops

4.14.1.1 Plant crop

Significant and positive association between stalk population and length of millable cane was observed (Table 45) at all N levels. The association between stalk population and single cane weight was not significant. There was no significant relationship between stalk population and diameter of cane at N levels. The association between length of millable cane and single cane weight was positive and significant at 112 kg N ha^{-1}. There was no relationship between length of millable cane and diameter of cane at all the other N levels. Single cane weight had a positive and significant association with cane diameter irrespective of N levels.

Stalk population exhibited a significant correlation with length of millable cane and single cane weight at both 112 and 224 kg ha^{-1} K levels only. A non significant negative association was observed between stalk population and diameter of cane at all the K levels. The relation between length of millable cane and single cane weight was positive. There was significant negative association between length of millable cane and diameter of cane at 112 and 224 kg K_2O ha^{-1}. Similarly, single cane weight exhibited a

Table 45. Simple correlations of stalk characters among themselves at harvest of plat crop

Particulars		Millable stalk population (x_1)	Length of millable cane (x_2)	Single cane weight (x_3)	Diameter of cane (x_4)
Nitrogen levels					
Millable stalk population (x_1):	N_o	-	0.5550*	0.0708	-0.0694
	N_{112}	-	0.7018*	0.4097	0.2137
	N_{224}	-	0.4438*	0.3263	-0.2668
Lenth of millable cane (x_2):	N_o	-	-	0.3072	-0.2106
	N_{112}	-	-	0.6144*	-0.1498
	N_{224}	-	-	0.4008	-0.4591*
Single cane weight (x_3):	N_o	-	-	-	0.5874*
	N_{112}	-	-	-	0.5281*
	N_{224}	-	-	-	0.5314*
Potassium levels					
Millable stalk population (x_1):	K_o	-	0.4526	0.5212	-0.4329
	K_{112}	-	0.8797*	0.7434*	-0.3646
	K_{224}	-	0.8574*	0.7852*	-0.0780
Length of millable cane (x_2):	K_o	-	-	0.4634	-0.4068
	K_{112}	-	-	0.9314*	-0.6395
	K_{224}	-	-	0.9261*	-0.6715*
Single cane weight (x_3):	K_o	-	-	-	0.4142
	K_{112}	-	-	-	0.7019*
	K_{224}	-	-	-	0.6289

strong positive relation with diameter of cane at 112 and 224 kg K_2O ha^{-1}.

4.14.1.2 Ratoon crop

The relationship between stalk population and length of millable cane (Table 46) was positive and significant at 112 and 224 kg N ha^{-1} only. Irrespective of the level of N, the association of stalk population with single cane weight was positive, while it was non significant and negative with diameter of the cane. Length of millable cane exhibited significant positive association with single cane weight and negative association with diameter. On the other hand, single cane weight had positive and significant association with diameter of cane, irrespective of N application.

The association of stalk population at K_o level was positive with length of millable cane and single cane weight and negative with diameter of the cane. However, this character had significant positive association with length of millable cane and single cane weight at 112 and 224 kg K_2O ha^{-1} and negative and non significant association with diameter of cane. There was similar relation between length of millable cane and the single cane weight or diameter of the cane. The single cane weight had a positive and significant association with diameter of the cane at the two K levels.

Table 46. Simple correlations of stalk characters among themselves at harvest of Ratoon crop

Particulars		Millable stalk population (x_1)	Length of millable cane (x_2)	Single cane weight (x_3)	Diameter of cane (x_4)
Nitrogen levels					
Millable stalk population (x_1):	N_o	-	0.1742	0.3737	-0.2539
	N_{112}	-	0.6589*	0.1474	-0.2761
	N_{224}	-	0.5422*	0.2529	-0.1790
Length of millable cane (x_2):	N_o	-	-	0.6645*	-0.3453
	N_{112}	-	-	0.6328*	-0.2740
	N_{224}	-	-	0.5217*	-0.3672
Single cane weight (x_3):	N_o	-	-	-	0.4750*
	N_{112}	-	-	-	0.6807*
	N_{224}	-	-	-	0.6558*
Potassium levels					
Millable stalk population (x_1):	K_o	-	0.5845	0.4551	-0.3459
	K_{112}	-	0.8409*	0.7276*	-0.3780
	K_{224}	-	0.7502*	0.8072*	-0.3342
Length of millable cane (x_2):	K_o	-	-	0.4019	-0.4153
	K_{112}	-	-	0.8316*	-0.3893
	K_{224}	-	-	0.8882*	-0.2457
Single cane weight (x_3):	K_o	-	-	-	0.5262
	K_{112}	-	-	-	0.8139*
	K_{224}	-	-	-	0.8688*

4.15 RELATIONSHIP OF STALK CHARACTERS WITH CANE YIELD (SIMPLE CORRELATIONS)

4.15.1 Plant Crop

Irrespective of N or K levels, stalk population exhibited strong and positive association with cane yield (Table 47). Similarly, length of the millable cane and single cane weight had a significant positive association with cane yield at 112 and 224 kg N ha^{-1}. Significant and positive association between single cane weight and the diameter of cane was observed at all the levels of N and K.

4.15.2 Ratoon Crop

Stalk population had a significant and positive association with the cane yield due to N and K application (Table 47). Similar association was observed between length of millable cane and cane yield at 112 and 224 kg N and K_2O ha^{-1} respectively. The association between these parameters was negative with N_o and positive with K_o but did not attain the level of significance. Single cane weight and diameter exhibited significant positive association at 112 and 224 kg N and K_2O ha^{-1} respectively. Diameter of the cane had positive significant relation with cane yield, irrespective of N and K lelvels.

Table47. Simple correlations of stalk characters with cane yield of plant and Ratoon crops

Particulars	Nitrogen levels			Potassium levels		
	N_o	N_{112}	N_{224}	K_o	K_{112}	K_{224}
Plant crop:						
Millable stalk population:	0.6669	0.6555	0.5379	0.8316	0.8939	0.8319
Length of millable cane:	0.3517	0.5109	0.5333	0.4265	0.9198	0.9371
Single cane weight:	0.2310	0.5171	0.5802	0.3491	0.8857	0.8773
Diameter of cane:	0.6395	0.6611	0.4825	0.7714	0.6654	0.7165
Ratoon Crop						
Millable stalk population:	0.9178	0.8486	0.9630	0.9646	0.9742	0.9486
Length of millable cane:	-0.0197	0.4720	0.6457	0.5627	0.8651	0.7549
Single cane weight:	0.1982	0.5690	0.4633	0.4035	0.8010	0.8663
Diameter of cane:	0.5072	0.6243	0.6235	0.8590	0.8641	0.8706

4.16 RELATIONSHIP OF N AND K UPTAKE WITH CANE AND SUGAR YIELDS

4.16.1 Uptake of N

Uptake of N with cane and sugar yields at 112 and 224 kg N ha^{-1} had positive and significant association (Table 48) both in plant and ratoon crops except with cane yield at 112 kg N ha^{-1}. Uptake of N at N_o level had non significant positive relationship with cane and sugar yields of both plant and ratoon crops. The N uptake at K levels was positive and significant with cane and sugar yields in both plant and ratoon crops, but its asssociation with sugar yields at K_o level was not significant.

4.16.2 Uptake of K

Irrespective of levels of N or K, Potassium uptake exhibited significant positive association with cane and sugar yields of plant and ratoon crops (Table 48).

4.16.3 Multiple Regression of Stalk Characters on Cane Yield

Multiple regression (R^2) of the foregoing four stalk characters on cane yield have been worked out separately for plant and ratoon crops without and with the application of N and K fertilisers.

Table 48. Simple correlations of nutrient uptake (N and K) at 210 days wtih cane and sugar yields of Plant and Ratoon crops

Particulars	Plant crop		Ratoon crop	
	cane yield	sugar yield	cane yield	sugar yield
N uptake				
N_o	0.3099	0.2404	0.4074	0.3598
N_{112}	0.4581*	0.5718*	0.4307*	0.4799*
N_{224}	0.7361*	0.8080*	0.6793*	0.4706*
K_o	0.9143*	0.5170*	0.9151*	0.4016
K_{112}	0.9283*	0.8713*	0.8666*	0.8743*
K_{224}	0.9317*	0.8836*	0.8124*	0.8181*
K uptake				
N_o	0.5310*	0.4511	0.5092*	0.5658*
N_{112}	0.5898*	0.5040	0.4960	0.5186
N_{224}	0.5211	0.4538	0.6992*	0.4402
K_o	0.9287*	0.8466*	0.8549*	0.8434*
K_{112}	0.6492*	0.6080*	0.8922*	0.8990*
K_{224}	0.6226*	0.5825*	0.8504*	0.8442*

4.16.3.1 Plant crop

The multiple regression equation of stalk characters viz. number of canes (X_1); length (X_2); weight (X_3) and diameter (X_4) on cane yield (y) are presented hereunder.

N_o : $Y = -237.4127 + 0.6007\ X_1 + 0.733\ X_2 - 83.0901\ X_3 + 144.1616\ X_4$ ($R^2 = 0.8036$)

N_{112} : $Y = 169.3353 + 0.1831\ X_1 + 0.3512\ X_2 + 62.8225\ X_3 + 38.2845\ X_4$ ($R^2 = 0.7349$)

N_{224} : $Y = 52.5943 + 0.7818\ X_1 - 0.9825\ X_2 + 137.6064\ X_3 + 116.9824\ X_4$ ($R^2 = 0.5472$)

K_o : $Y = -237.4127 + 0.6007\ X_1 + 0.7333\ X_2 - 83.0901\ X_3 + 144.1616\ X_4$ ($R^2 = 0.8036$)

K_{112} : $Y = 613.8052 + 1.4730\ X_1 + 0.3739\ X_2 + 87.6028\ X_3 + 126.7000\ X_4$ ($R^2 = 0.9105$)

K_{224} : $Y = - 465.9360 + 0.4497\ X_1 + 1.3984\ X_2 + 33.7465\ X_3 + 128.2808\ X_4$ ($R^2 = 0.9005$)

N and K combined : $Y = -445.2168 + 0.6022\ X_1 + 1.1512\ X_2 + 69.1713\ X_3 + 106.4358\ X_4$ ($R^2 = 0.8858$)

The multiple determination co-efficient contribution of stalk characters to cane yield (R^2) in plant crop was as high as 88 per cent. These values were higher for potassium fertiliser than for nitrogen. Among the stalk characters, diameter followed by weight of cane and to some extent, stalk population appears to be important for cane yield.

4.16.3.2 Ratoon crop

The multiple regression equation of stalk characters on cane yield of ratoon crop are given here under.

N_o : $Y = 6.9092 + 1.1355\ X_1 - 0.4093\ X_2 - 46.3215\ X_3 + 28.4375\ X_4$ ($R^2 = 0.8826$)

N_{112} : $Y = 37.6556 + 0.9418\ X_1 - 0.1626\ X_2 + 15.9562\ X_3 + 12.5105\ X_4$ (R^2 0.7228)

N_{224} : $Y = 38.9883 + 1.1674\ X_1 - 0.4002\ X_2 + 74.6673\ X_3 - 23.8203\ X_4$ ($R^2 = 0.9423$)

K_o : $Y = 6.9092 + 1.1355\ X_1 - 0.4093\ X_2 - 46.3215\ X_3 + 28.4375\ X_4$ ($R^2 = 0.8826$)

K_{112} : $Y = -480.8051 + 1.2044\ X_1 + 0.0087\ X_2 + 52.8780\ X_3 + 132.9072\ X_4$ ($R^2 = 0.9793$)

K_{224} : $Y = -450.1580 + 1.1643\ X_1 - 0.8994\ X_2 + 189.7988\ X_3 + 145.3035\ X_4$ ($R^2 = 0.9377$)

N and K Combined : $Y = -6.89998 + 1.0793\ X_1 - 0.1816\ X_2 + 76.3483\ X_3 + 17.4415\ X_4$ ($R^2 = 0.8803$)

Almost similar trend as in the plant crop was observed even in ratoon crop with the four stalk characters giving again a multiple determination coefficient (R^2) of 88 per cent. Both N and K fertilisers effected these parameters in influencing the yield. The same trend as in the plant crop, viz. cane diameter and weight followed by stalk population being important in yield production, was noticed in the ratoon crop.

Thus, the multiple regression of stalk characters on cane yield of both plant and ratoon crops not only brought out the high contribution of these characters to cane yield (multiple* determination coefficient) but also followed the trends;indicated by simple correlation of the same.

DISCUSSION

CHAPTER V

DISCUSSION

Investigations were carried out on sandy loam soils at Regional Agricultural Research Station, Anakapalle to study the effect of nitrogen and potassium at three levels each and time of application of potassium at basal, 60 and 120 days after Planting/Ratooning on plant and first ratoon crops of sugarcane var. Co T 8201 under moisture stress conditions during formative phase (April and May). Treatmental effects on growth parameters, nutrient (N and K) contents in index tissues and their uptake, juice quality, yield of cane and CCS in plant and ratoon crop of sugarcane presented in the preceding chapter are evaluated and discussed in this chapter.

There was not much variation in weather parameters during the two years of experimentation as compared with normal weather at Anakapalle except the amount of rainfall. Plant crop of sugarcane received about 110 mm of more rainfall as compared with ratoon crop with no variation in total number of rainy days. An insight into the rainfall distribution, however, indicate that the ratoon crop was subjected to relatively more stress as compared to plant crop especially during the formative phase (April and May). Ingeneral, weather during the crop period of both plant and ratoon crops was within the optimum requirements.

5.1 GROWTH PARAMETERS

There was no significant variation in germination per cent of setts in plant crop due to treatments indicating the sufficiency of reserved food in the setts for optimum germination under field conditons. Mean plant height and shoot population of plant crop was higher than the ratoon crop under corresponding treatments at all stages of observation. There was steep increase in plant height during grand growth phase (120 to 240 days) followed by marginal increase during maturity phase (240 to 300 days) in both plant and ratoon crops. Shoot population of both plant and ratoon crops was highest at 120 days and gradually declined as crop age advanced. These trends are in accordance with the general growth pattern of sugarcane crop (Dillewijn, 1952; Evans, 1975; Lakshmikantham, 1982 and Parameswaran et al., 1988).

Mean plant height and shoot population of plant crop was higher than the ratoon crop under corresponding treatments at all stages of investigation. Application of N had significant effect on plant height and shoot population of both plant and ratoon crops at all stages, the former being responsive at 112 kg N ha^{-1} while the latter being responsive at 224 kg N ha^{-1}. Higher responsiveness of ratoon crop to applied N is an usual phenomena because of less fertiliser use efficiency of the ratoon crop (Evans, 1935;

Humbert, 1953; Hardy and Smith, 1954 and Lakshmikantham, 1982). Application of K had significant improvement in plant height and shoot population at 112 kg K_2O ha^{-1} in both plant and ratoon crops, except the shoot population of ratoon crop, where significant increase at the highest dose of 224 kg K_2O ha^{-1} at 240 days. Response of ratoon crop in increasing the shoot population upto 224 kg K_2O ha^{-1} can be attributed to its favourable effect on increasing the capacity of the plant in tolerating the soil moisture stress. Rainfall during the plant and ratoon crop period indicated relatively high soil moisture stress conditions in ratoon crop. These results confirm the importance of K for favourable soil moisture relations (Naidu and Srinivasan, 1982; Perumal and Pasupati, 1984 and Yadav et al., 1986).

Importance of leaf area index (LAI) and its positive relation with photosynthesis has been well documented. Ingeneral, plant crop recorded higher LAI than the ratoon crop all through the crop growth period. Nitrogen application upto 112 kg ha^{-1} significantly increased the LAI of plant crop, while the LAI increase was upto 224 kg N ha^{-1} in case of ratoon crop. The influence of K either in terms of rate of application or its time of application had no significant effect on LAI. This can be attributed due to the fact that N has more profound effect on LAI than K or P. There was gradual increase in LAI as the crop grew upto 210

days followed by a decline upto harvest mainly due to senescence of old leaves. (Bull and Glasziou, 1980; Venkataraman et al., 1984 and Ramachandra Rao, 1988).

5.2 CONCENTRATION AND UPTAKE OF N AND K IN PLANT

The importance of N for growth, cane yield and juice quality of sugarcane has been stressed through out the world (Clements, 1951; Dillewijn, 1952; Humbert, 1968; Barnes, 1974; Parthasarathy and Perumal, 1975; Lakshmikantham, 1982 and Curtes et al., 1985). Application of K increased the response of sugarcane to N besides its role in synthesis and accumulation of sugars (Dillewijn, 1952; Humbert, 1968; Husz, 1972; Kadian et al., 1981; Martinex et al., 1983 and Narasimham, 1989). Leaf sheaths of 3-6 leaves for moisture and K status and 3-6 leaves for N status in sugarcane plant have been identified as index tissues (Clements, 1972 and Lakshmikantham, 1976). Using these index tissue, the moisture, N and K status of the plant was assessed.

Plant crop had relatively higher sheath moisture content than the ratoon crop at all the stages of observation. There was gradual increase in sheath moisture in both the crops from 120 to 180 days followed by a decline beyond this stage. Decline in sheath moisture values during maturity phase was reported by several workers

(Lakshmikantham et al., 1976; Mohan Naidu, 1976: Clements, 1982 and Agarwal, 1985). Application of N significantly increased the sheath moisture upto 112 Kg ha^{-1} in plant crop and upto 224 kg ha^{-1} in ratoon crop. Increase in sheath moisture following N application was reported by Lakshmikantham et al. (1963): Parthasarathy and Perumal (1975); Asokan (1981); Perumal, (1981); Agarwal (1985) and Ramakrishna Rao et al. (1988). Application of 112 kg K_2O ha^{-1} recorded significantly higher sheath moisture content at 180 days age of the plant crop. There was significant increase in sheath moisture content upto 224 kg K_2O ha^{-1} at all the stages of observation. As indicated earlier, relatively higher sheath moisture content was due to the influence of K in better maintaining the water balance. (Sivalingam et al., 1984 Ramalingaswamy, 1990). In general, application of K at planting and at 60 days significantly increased the sheath moisture content over late application at 120 days. However, ratoon crop had significantly higher sheath moisture content due to K application as basal over later applications at 60 and 120 days as evident from the findings of Narasimham (1988 and 1989).

Plant crop had higher leaf N content over ratoon crop and the same trend continued even in N uptake by whole plant. Nitrogen content of both plant and ratoon crops were highest at 120 days with subsequent gradual decline during

later stages. Application of N at 112 kg ha^{-1} recorded significantly higher leaf N content of both plant and ratoon crops at all stages of crop growth. Further increase upto 224 kg N ha^{-1} had no significant influence in leaf N content. This indicate sufficiency of 112 kg N ha^{-1} for maintaining adequate N content in plant for optimum growth as evident from the findings (Mohan Rao and Narsimham, 1956; Bavaskar et al., 1978 and Singh 1978). There was significant increase in nitrogen. This indicates there is no relation between N content and N uptake. When once the plant registers optimum N content in the plant, drymatter production continuously increases as long as the plant maintains optimum N content, uptake of N was highest at 120 days which remained almost constant from 150 to 210 days followed by a marginal decline in plant crop. In the case of ratoon crop, N uptake gradually declined from 150 to 270 days. Relatively higher decline of N uptake by ratoon crop as compared with plant crop might have been due to the difference in root activity for the absorption of N, the former being more effective than the latter. These trends are in accordance with the results of Bavaskar et al. (1978); Singh (1978) and Yadav and Sharma (1980). The trend in leaf N content at all the stages of crop growth and the N uptake by the crop due to 112 and 224 kg K_2O ha^{-1} was similar that of 112 and 224 kg N ha^{-1} from the two crops,

except that N uptake was highest due to 224 kg K_2O ha^{-1} in the case of ratoon crop. The total uptake of N was less by the ratoon crop as compared to plant crop. The plant crop attained maximum N uptake at 112 kg K_2O ha^{-1} while the ratoon crop attained its highest uptake at 224 kg K_2O ha^{-1}. This differencial uptake indicate lesser potassic fertiliser use efficiency of the ratoon crop as compared to plant crop. The complementary role of K fertiliser application on N uptake by the crop was well documented from the results of Husz (1972); Dagade (1978); Hunsigi (1981); Fon Seca and Felipe (1983) and Narasimham (1988 and 1989). Time of K application had no appreciable effect on N content of both crops. However, there was decrease in N uptake when K application was delayed. Ratoon crop showed beneficial effect to basal application of K. Plant crop could use the available K as its content in the soil would be higher as compared with that in the soil for a ratoon crop because of depletion of K from the soil by the plant crop (Narasimham 1988 and 1989).

Potassium content in leaf sheath remained almost constant for both the crops all through the crop period. Similarly uptake of K was similar at all the stages of sampling. Uptake of K by plant crop was higher than that of the ratoon crop. Higher uptake of K by plant crop over ratoon crop was due to higher dry matter production in the

case of plant crop. There was significant increase in sheath K content due to 112 kg N ha^{-1} without further increase in the case of plant crop. Sheath K content significantly increased with increase in applied N upto 224 kg ha^{-1} in ratoon crop. This difference in K concentration was due to the differences in utilising the applied N by both the crops. This gain suggest the low fertiliser use efficiency by the ratoon crop. Uptake of K by both the crops increased significantly with increased level of applied N upto 224 kg ha^{-1}. This suggest the beneficial effects of N for effecient use of applied K. Sheath K content and its uptake by the crop varied significantly all through the crop period. There was no significant difference in sheath k content of both the crops at any stage of growth. However, uptake of K by plant crop was higher over ratoon crop mainly due to higher accumulation of dry mater as evident from higher yield. Ratoon crop significantly increased sheath K content upto 224 kg N ha^{-1} while there was no difference between 112 and 224 kg N ha^{-1} in plant crop. The uptake of K by both the crops significantly increased with increasing levels of N. Higher N needs for a ratoon crop to maintain optimum sheath K and uptake by the crop as compared with plant crop has been stressed by many workers (Jafri and Alam, 1983; Sivalingam et al., 1984 and Rakkiyappan, 1987).

Application of K varied the sheath K content significantly. Plant crop had similar sheath K content due to application of 112 and 224 kg K_2O ha^{-1} while the ratoon crop showed significant differences between these two levels. This again emphasises the need for higher levels of K for ratoon crop to maintain required sheath K content and uptake as compared with plant crop.

Altaf Ahmed et al. (1975), Hunsigi (1981), Sundara, (1980), Nageswara Rao (1985), Yadav et al. (1986) and Narsimham (1989 and 1990) Stressed the importance of K in sugar cane nutrition. Basal application of K significantly increased sheath K content and uptake by the plant over late application at 60 and 120 days. This suggest the necessity for adequate K at early stages for maintaining better water relations in the plant leading to high content of K and uptake by the plant. These results are in conformity with the earlier results at Anakapalle (Narasimham 1984) and other places (Jafri and Alam 1983 and Rakkiyappan 1987).

5.3 JUICE QUALITY IN MATURITY PHASE

The ultimate yield of sugar or Jaggery largely depends on juice quality interms of sucrose and purity. In addition to these two quality characters, Glucose content of juice was also estimated at harvest.

There was progresive increase in sucrose and purity per cent of juice from November to harvest. At maturity, the ratoon crop recorded higher values of quality characters than that of the plant crop. Addition of N upto 224 kg ha^{-1} significantly decrease the sucrose and purity as compared to 112 kg N ha^{-1}. There was no significant difference in these two quality characters due to no N and 112 kg N ha^{-1} in the case of plant crop. There was significant improvement in quality of juice due to application of N even upto 224 kg ha^{-1} in ratoon crop. Adverse effect of higher rates of N application at the cost of juice quality characters (Sucrose, purity and Glucose) has been reported by many workers (Clements 1951; Mohan rao and Narasimham 1956; Srinivasan and Morachan, 1980; Hatam and Pazir 1984; Kumar et al. 1985; Jayabal, 1989 and Kannappan et al., 1990). Improvement in the quality characters of ratoon crop can be attributed to low nitrogen use effeciency by the crop as indicated from the low yield even at the highest level of N.

Contrary to the depressing effect of juice quality due to N, application of K had beneficial effect in the quality characters of both the crops. There was significant improvemnt in the quality characters due to application of 112 kg K_2O ha^{-1}. High dose of 224 kg K_2O ha^{-1} had no depressing effect on these quality characters unlike N application upto 224 kg ha^{-1}. The beneficial effect of

increase in juice quality can be attributed to the role of K in reducing the adverse effect of higher rates of N application. (Patil et al. 1966; Mahamuni et al. 1973; Fritz 1974; Raut et al., 1974; Jafri 1985 and Narasimham 1991). Late application of K significantly improved the quality of juice as compared with basal application. Adequate availability of K to the plant due to late application when the juice quality is determined might have contributed to this beneficail effect of late application of k (Narasimham 1988 and 1989).

5.4 STALK CHARACTERS AND YIELD OF CANE AND CCS AT HARVEST

Cane yield is a function of number of millable canes, length, diameter and the weight of the cane which depends on crop management practices. Sugar output is a function of cane yield, juice quality and per cent juice extraction which also varies according to management practices to a limited extent.

5.4.1 Stalk Characters

The stalk characters (Millable stalk population, length, number of internodes, diameter and single cane weight) of plant crop varied significantly due to no N and 112 kg N ha^{-1}. Further addition of N had no significant effect in these stalk characterstics. However, there was

significant increase in the stalk characters with increasing levels of N upto 224 kg ha^{-1} in the case of ratoon crop. Improvemnt in these stalk characters due to 112 and 224 kg N ha^{-1} of plant and ratoon crops respectively was due to favourable effect of respective levels of N on growth parameters such as plant height, LAI and shoot population. Favourable effect of N for improving the growth and development of sugar cane leading to improvement in yield attributes has been reported by several workers (Lal and Lal, 1978; Venkataraman et al., 1978; Kadian et al., 1981; Srivastava et al., 1986; Rao et al., 1990 and Singh et al., 1991).

There was signficant improvement in all the stalk characters except number of internodes due to 112 kg K_2O ha^{-1} with no further significant difference at higher level 224 kg K_2O ha^{-1} in case of plant crop. Application of K on the other hand significantly improved the stalk characters with increase in the level of K upto 224 kg ha^{-1} except in the case of number of millable stalk population, length of millable cane where the significant influence upto 112 kg K_2O ha^{-1} in ratoon crop. Improvement in the stalk characters (Diameter and signle cane weight) upto 224 kg K_2O ha^{-1} can be attributed to its favourable effect on growth characters leading to improvement in stalk characters because of the beneficial effect of K in imparting the tolerance to soil

moisture stress which the ratoon crop experienced during the formative phase. Several authors (Dilliwijn 1951; Humbert 1968; Mathur and Tripathi 1975; Narwal and Behel 1979; Srivastava et al., 1986 and Jayabal et al., 1989) stressed the importance of K for reducing the adverse effects of stress an crop growth.

5.4.2 Yield of Cane and CCS

The ultimate economic criteria for judging the profitability of crop production whether in terms of variety, management practices, resistance to pests and diseases and other adverse conditions is the yield ultimately. In the case of sugarcane both yield of cane and sugar/jaggery are to be considered as they are differentially influenced by all aspects of cultivation including fertiliser use as is the case in this investigation. From this angle, there are interesting trends in the yield of cane and CCS for the plant and ratoon crops. As is generally the case with most of the varieties, the plant crop gave higher yield of cane and CCS as compared to those from ratoon crop. When the agronomic role of the fertiliser treatments on yield are considered the yield trends represented a clear blue-print of the summation effects of the treatments on growth parameters, nutrient uptake and stalk characters which have been discussed so far.

In line with the crop performance and nutrient (N and K) uptake during the growth phase, the plant crop gave higher yield of cane than the ratoon under the corresponding treatments. While cane yield increase of plant crop was significant from 0 to 112 kg N ha^{-1}, but not from 112 to 224 kg N ha^{-1}, such increase for ratoon crop with each increment of N from 0 to 112 kg N ha^{-1} and from 112 to 224 kg N ha^{-1} was significant. However, for both plant and ratoon crops the dose of 112 kg K_2O ha^{-1} alone gave significantly higher cane out-turn over no potash, without any further significant change at 224 kg K_2O ha^{-1}. Again significant fall in cane yield of plant crop was obtained when K fertiliser was applied as late as 120 days compared to application at planting or at 60 days. Time of K application had no significant role in the yield of ratoon crop. Early K fertiliser application preferably at planting especially to the ratoon crop also showed a beneficial effect in enabling the crop to tolerate moisture stress to which the crop was subjected to moisture stress in the summer period.

Though the yield of CCS of plant crop at 112 kg N ha^{-1} was significantly superior over the control (0 Kg N ha^{-1}). There was actually a reduction in CCS yield at 224 kg N ha^{-1}, though this was not significant. This fall in CCS was due to the adverse effect of highest N dose of 224 kg N ha^{-1} in causing a fall in the juice sucrose level. In

the case of ratoon crop each increment in N from 0 to 112 kg ha^{-1} and from 112 to 224 kg ha^{-1} resulted in significant increase in CCS yield. This trend being in line with cane yield. The effects of K fertiliser on CCS yield of both plant and ratoon crops was similar to cane yields recording significant increase from 0 to 112 kg K_2O ha^{-1}, without further significant effect at 224 kg K_2O ha^{-1}. For both the crops late application of K at 120 days gave significantly lower CCS yield as compared to its earlier application. It can thus be concluded from an overall consideration of growth parameters, nutrient uptake and ultimate yields of cane and sugar that under the conditions of the experiment with the variety Co T 8201 the optimum doses of N and K for the plant crop are 112 kg N ha^{-1} and 112 kg K_2O ha^{-1} and for ratoon crop 224 kg N ha^{-1} and 112 kg K_2O ha^{-1}, with K fertiliser being applied preferably at planting.

The foregoing trends in cane and sugar yields are in confirmity with the individual and the integrated effects of N and K fertilisers and also time of K application on the number of canes and height variations in growth phase, uptake of these nutrients and effects on important stalk characters besides juice quality. This was evident from the work on nutrition from several workers like Srinivasan and Mariakulandai (1969); Lal and Lal (1978); Srivastava et al. (1986); Prasad Rao (1989) and Chauhan et al. (1991). The

role of K fertiliser in boosting the uptake and utilization leading to higher cane and sugar yields as is evident from this investigation has also been stressed by Rege et al. (1963) from Pugalur; Singh and Tiwari (1972) from U.P.; Dagadi (1976) from Maharastra; Srivastava and Hunsigi (1978) from Karnataka, Sundara (1985) from Tamil Nadu and Narasimham (1988, 1989 and 1990) from Andhra Pradesh. As found in this investigation, response to potash application especially applied at planting was also reported by Singh and Saini (1972), Asokan (1981); Sharma and Sharma (1981) Zende (1984) and Sundara (1985). Further, apart from the complementary effect of K fertiliser on N uptake, another role of K in boosting the cane yield especially the ratoon crop seems to be its beneficial effect on tolerance to moisture stress leading to better cane yields was evident from the report of Naidu and Srinivasan (1982); Yadav and Singh (1986); Parameswaran et al. (1988) and Tandon and Sekhan (1988).

5.4.3 Response Functions of Cane and Sugar Yields to N and K Application

Response functions of cane and sugar yields to applied doses of N (0, 112 and 224 kg ha^{-1}) and potassium (0, 112, and 224 kg ha^{-1}) have been worked out separately for plant and ratoon crops which are given hereunder.

5.3.4.1 Response to Nitrogen

Cane yield (Y_c):

Plant crop : Y_c=77.73 + 0.3881N - 0.0011 N^2 (R^2=0.8569)

Ratoon crop: Y_c=58.3485 + 0.1504 N (R^2=0.9681).

Sugar yield (Y_s):

Plant crop: Y_s=10.2069 + 0.0587 N - 0.002 N^2 (R^2=0.9972)

Ratoon crop: Y_s=8.1619 + 0.0204 N (R^2=0.9654).

5.4.3.2 Response to potassium

Cane yield (Y_c):

Plant crop : Y_c=89.1651 + 0.1178K - 0.0003 K^2 (R^2=0.9964)

Ratoon crop: Y_c=63.7201 + 0.1466 K - 0.0004 K^2 (R^2=0.9945)

Sugar yield (Y_s):

Plant crop : Y_s=11.7853 + 0.0094 K - 0.0002 K^2 (R^2=0.9967)

Ratoon crop: Y_s=8.3345 + 0.0263 K - 0.0007 K^2 (R^2=0.9924)

All the response functions had a prediction coefficient (R^2) of over 95 per cent (except response of cane yield of plant crop to N) indicating that the quadratic/linear responses as the case may be accounted for almost the entire yield variation due to the concerned nutriient. The response functions of ratoon crop to N were linear whereas those of potassium are quadratic showing continuous response to N upto 224 kg ha^{-1} and of K upto 112 kg ha^{-1}. Further the coefficients in respect of cane yield

clearly showed the linear part of the response functions (except that of ratoon crop to N) to be much higher for N as compared to K and for both nutrients to be higher in respect of the ratoon crop as compared to plant crop. This is amply supported by the effects of N and K on growth parameters, nutritional aspects and stalk characters. Response functions of cane crop to nutrients N and K at different locations have been given by Srivastava and Pandit (1970), Sanandachari (1985), Yadav et al. (1986) and Hunsigi and Srivastava (1987).

5.5 INTER-RELATIONSHIPS OF YIELD WITH NUTRIENT UPTAKE AND STALK CHARACTERS

5.5.1 Uptake of N and K with Yield of Cane and CCS

Simple correlations have been worked out in order to study the role of whole plant nutrient (N and K) uptake in later grand growth phase (210 days) on cane and CCS yields, as well as with yield of cane and CCS under different doses of N and K separately for plant and ratoon crops. Uptake of N from soil (fertiliser No-level) gave significant positive correlations with cane and CCS yields when considered with K application only. With increase in N dose there was a positive correlation of N uptake with cane and CCS yield gradually, clearly demonstrating the beneficial effect of N and various growth and yield contributing factors as stated earlier. With regard to the role of N uptake when considered

under different levels of K application this relationship was observed on cane yield and with CCS yield upto 112 kg K_2O ha^{-1}.

The correlation of K uptake under both N and K applications with both cane and CCS yields of plant and ratoon crops were positive and significant under all the three levels of N and K fertiliser. An increase in the level of correlation of K uptake with cane and CCS yields was particularly seen upto 112 kg N ha^{-1} in respect of plant crop and with CCS yield of ratoon crop upto 112 kg ha^{-1}. The foregoing trends are in confirmity with the role of N and K nutrition in growth, yield contributing stalk parameters, juice quality and the cane and CCS yields discussed in detail. They broadly agree with the results of Mahamuni et al. (1973), Wang (1976), Singh and Sinha (1978), Srinivasan and Morachan (1978), Singh and Yadav (1985) and Narasimham (1988).

5.5.2 Relation Between Stalk Characters and Cane Yield

The interrelations of yield influencing stalk characters viz., number, length, weight and diameter, among themselves and with ultimate cane yield of plant and ratoon crops under different levels of N and K fertiliser application have been worked out. These correlations gave an insight to their relative role in cane yield with and without application of N and K.

5.5.2.1 Interrelationship of stalk characters among themselves

Irrespective of dose of N and K, significant positive correlation of stalk diameter with single cane weight was obtained both for plant and ratoon crops, stressing the point that increase in diameter of cane invariably led to increase in its weight. As regards relation between length and weight of cane significant positive correlations were obtained in respect of plant and ratoon crops only under fertiliser application, at 112 kg N ha^{-1} as well as 112 and 224 kg K_2O ha^{-1}. This showed that weight of cane was influenced by length only under fertiliser application. The negative relationship between length and girth of cane is revealed by negative correlations for both plant and ratoon crops, which however reached the significance level only under K application in ratoon crop. In plant crop, the stalk population was positively correlated with length of cane as well as single cane weight only under application of N and K fertiliser; for ratoon crop, however, the stalk population was positively correlated with length of cane under N application and weight of cane under N as well as K application.

5.5.2.2 Relationship of stalk characters with cane yield

In line with the effects of different levels of N and K on individual stalk characters there was significant

positive correlation of stalk population as well as diameter with cane yield of both plant and ratoon crops, broadly underlining the fact that for this variety these stalk parameters are most important for yield. An interesting finding is that the correlations of stalk diameter with yield of plant crop at K_o (+0.7714), K_{112} (+0.654) and K_{224} (+0.7165) were higher than the corresponding values under N_o (+0.6305), N_{112} (+0.6611) and N_{224} (+0.4825). For ratoon crop, similar values were obtained for K_o (+0.8590); K_{112} (+0.8641) and K_{224} (+0.8706) as against N_o (+0.5072), N_{112} (+0.6243) and N_{224} (+0.6235). The foregoing dominant effect of K in comparison with N in improving the diameter of stalk was also stressed earlier. In contrast the effects on stalk diameter, K seemed to influence stalk population especially in plant crop giving correlations at K_o (+0.8316), K_{112} (+0.8939) and K_{224} (+0.8319) as against N_o (+0.6669), N_{112} (+0.6555) and N_{224} (+0.5379). This role of K in stalk population was less marked in case of ratoon crop. Again in tune with the nutrient effects detailed earlier, significant positive correlations of length and weight of millable cane with yield of both plant and ratoon crops were obtained under application of these nutrients. These correlation coefficients were higher under K doses as compared to the corresponding N doses. These trends again confirm the fact that, while N itself has a role on length

and weight of cane in influencing cane yield, K application had a further complementary role in boosting this role of N.

The general outcome of the relationships of individual stalk characters with cane yield were also broadly supported by their combined role were studied by working out multiple regressions of stalk number (x_1), length (x_2), weight (x_3) and diameter (x_4) of cane on cane yield (Y). The following multiple regressions were obtained for the plant and ratoon crops.

Plant crop

$$Y = -445.2108 + 0.6022\ (x_1) + 1.1515\ (x_2) + 69.1713\ (x_3) + 106.4358\ (x_4) \quad (R^2=0.8858)$$

Ratoon crop

$$Y = -6.8998 + 1.0793\ (x_1) - 0.1861\ (x_2) + 76.3483\ (x_3) + 17.4415\ (x_4) \quad (R^2 = 0.8803)$$

For both plant and ratoon crops, the four stalk characters accounted for 88 per cent of cane yield variations when the combined effects of N and K are considered together. Of these characters, cane weight and diameter with high positive regression coefficient seemed to contribute relatively more to the cane yield, followed by stalk population, with length of cane contributing least. In

the absence of N and K application diameter of stalk seemed to be the most important factor followed by cane weight to some extent. Taking individual effects of N and K, the latter (K) seemed to have a more prominant role in influencing these stalk characters of both plant and ratoon crops, while N was more dominant in its influence in the ratoon crop. Both the nutrients again influenced stalk characters, diameter, weight and number of canes as regards their role on yield of both plant and ratoon crops. Thus, for both plant and ratoon crops of this variety CoT 8201 cane diameter and weight and to some extent stalk population are found to play a key role in yield production.

The performance of plant and first ratoon crops of sugarcane variety CoT8201 was investigated under the application of 0, 112 and 224 kg N ha^{-1} in combination with 0, 112 and 224 kg K_2O ha^{-1} with potash being applied at planting/ratooning, 60 and 120 days later. In general, shoot population and cane height of plant crop increased upto 112 kg N ha^{-1} and of ratoon crop 224 kg N ha^{-1}. Such favourable influence on these attributes was felt upto a level of 112 K_2O ha^{-1}. The same trend was observed in uptake of N and K in whole plant potassium application helped in boosting of N uptake and its effects on growth parameters. Application of N and K upto 112 kg ha^{-1} was beneficial to juice quality of both crops but, this was depressed in plant crop at higher

dose of 224 kg N ha^{-1}. Nitrogen application generally helped in increasing the stalk population and length whereas potassium seemed to have in weight and diameter of cane. Cane and CCS yields of plant crop increased upto 112 kg N ha^{-1} and 112 kg K_2O ha^{-1}; while cane and CCS yields of ratoon crop showed a further increase upto 224 kg N ha^{-1}. Plant crop showed a depression in CCS yield without much change in cane yield at this higher dose of N. These trends were also reflected in the quadratic response functions of plant crop and linear function of ratoon crop as regards to N application and quadratic response of potash for both the crops. Among the stalk characters weight and diameter of cane seemed to have a dominent role in contributing cane yields. This study brought out that optimum cane and CCS yields of variety Co T 8201 can be obtained by application of 112 kg N ha^{-1} for plant crop and 224 kg N ha^{-1} for ratoon crop combined with basal application of 112 kg K_2O ha^{-1}.

SUMMARY

CHAPTER VI

SUMMARY

The effect of three levels of N (0, 112 and 224 kg ha^{-1}) in combination with three levels of K (0, 112 and 224 kg K_2O ha^{-1}) with three times of K application (Basal, 60 and 120 days after planting or ratooning) on growth parameters, N and K concentration and their uptake, juice quality, yield of cane and commercial cane sugar (CCS) in plant (1987-88) and first ratoon (1988-89) crops of sugarcane (Var., Co T 8201) was studied in sandy loam soils of Anakapalle under moisture stress conditions during formative phase.

Plant height and shoot population of plant crop was higher than that of ratoon crop at all stages of the crop growth. The plant height of both crops recorded a steep increase from 120 days to 240 days with only a marginal rise thereafter. Shoot population was highest at 120 days and gradually declined with advancement of age in both plant and ratoon crops. Plant crop showed a significant increase in plant height and shoot population at 112 kg N ha^{-1} over 0 level of N, while ratoon crop showed a further increase of these attributes at 224 kg N ha^{-1}. Early application of K at 112 kg K_2O ha^{-1} recorded more plant height and shoot population over no application in both the crops.

The leaf area index (LAI) of plant crop was higher than that of the ratoon crop. In both the crops, the leaf area index showed an increase from 150 days to 210 days and declined at harvest. Application of Nitrogen at 112 kg ha^{-1} significantly increased the LAI of plant crop, while it increased upto 224 kg N ha^{-1} in ratoon crop. Potassium levels or its time of application had no significant influence on LAI in both the crops.

The plant crop had higher concentration of N and k nutrients in the index tissues as well as their uptake than that of ratoon crop. The percentage of N in 3-6 leaves and percentage of K in 3-6 sheaths were maintained at a higher level during the growth period of plant crop, the same trend was maintained in respect of plant uptake of these nutrients. Nitrogen per cent in leaves and its uptake in whole plant increased from 0 to 112 kg N ha^{-1} in plant crop, but continuous increase was recorded upto the highest dose of 224 kg N ha^{-1} in the ratoon crop. Potash application upto 112 kg K_2O ha^{-1} for plant crop and 224 kg K_2O ha^{-1} for ratoon crop led to an increase in K per cent in sheaths as well as its uptake in whole plant during all crop growth stages. Potash application had a synergistic effect particularly on the uptake of N in whole plant at different levels of N application. Such a benefit was seen prominently

in the case of ratoon crop. The efficiency of K application was higher in respect of concentration of N and K nutrients in index tissues or their uptake by whole plant when applied at basal or 60 days after planting or ratooning in both plant and ratoon crops.

In the maturity phase, ratoon crop recorded superior juice quality in terms of higher juice sucrose, and purity with less reducing sugars than plant crop. The highest dose of 224 kg N ha^{-1} depressed the juice quality during maturity phase in plant crop. However, such depressing effect was not observed in ratoon crop. Both plant and ratoon crops showed an improvement in juice sucrose and purity with less reducing sugars with the application of potassium at 112 kg K_2O ha^{-1} than that of no application of potassium. Unlike in the case of growth attributes and nutrient uptake, late application of K fertiliser at 120 days improved the juice quality as compared to basal or 60 days of application in both the crops.

The influence of N and K fertiliser treatments on the stalk characters i.e., stalk number, length, weight, number of internodes and diameter were studied at harvest. All the stalk characters increased with N application upto 112 kg ha^{-1} for plant crop and 224 kg ha^{-1} for ratoon crop. Potassium application at 112 kg K_2O ha^{-1} significantly

influenced all the stalk characters of both plant and ratoon crops except the number of internodes. However, in ratoon crop significant improvement in stalk diameter and weight was observed at 224 kg K_2O ha^{-1}. Significantly higher values of stalk characters except number of internodes of plant crop were obtained when K fertiliser was applied as basal as compared to delayed application. Time of application of K had no apparent role on the stalk characters of ratoon crop.

Simple correlations of stalk characters among themselves under different N and K fertiliser treatments showed that weight of the cane had a significant positive correlation with diameter irrespective of fertiliser application, but such a correlation with length of cane was obtained only under N and K application. Length and diameter of cane were negatively correlated. Stalk population was positively correlated with length and single cane weight of plant crop under no K fertiliser application. In ratoon crop, there was positive correlation between length and stalk population with different levels of N and the weight of the cane was positively correlated with K application.

The yield of millable cane as influenced by the doses of N and K as well as time of K application revealed that the plant crop responded upto a dose of 112 kg each of N and K ha^{-1} confirming a quadratic function, while the ratoon

crop responded upto a dose of 224 kg N ha^{-1} with a linear function and upto only 112 kg K_2O ha^{-1} with a quadratic function. Application of K either at basal or 60 days after planting significantly increased the cane yield over late application of K at 120 days in plant crop while such differences in cane yield were not observed in ratoon crop. Multiple regression analysis of the four stalk characters on cane yield indicated that they have accounted for as much as 88 per cent of yield variation of both plant and ratoon crops with the diameter and weight of cane having a prominent role in influencing the cane yield followed by stalk population. Uptake of N during later grand growth phase (210 days) was positively correlated with cane yield of plant crop under different N applications (N_1 and N_2 only), while K uptake was positively correlated with cane yield under N_o, N_1 and N_2 levels.

The commercial cane sugar (CCS) yield of plant crop increased upto 112 kg N ha^{-1} and showed a fall at 224 kg N ha^{-1} due to adverse effect of higher doses of N on juice sucrose content. On the other hand, the CCS yield of a ratoon crop increased upto the highest dose of 224 kg N ha^{-1}, mainly due to increase in cane yield.

The CCS yield of both plant and ratoon crops increased upto 112 kg K_2O ha^{-1}. There was a reduction in CCS

yield in both plant and ratoon crops when K was applied at 120 days. The response functions of CCS yield to N and K were quadratic in plant crop, while in ratoon crop they were linear to N and quadratic for K. The CCS yield was positively correlated with N uptake in both plant and ratoon crops under N or K fertiliser application only. However, the CCS yield was positively correlated with K uptake with application of N and K or no application.

This investigation on sugarcane variety Co T 8201 has brought out several aspects of practical importance. Plant crop of this variety was found to be a superior unit in respect of growth parameters, leaf area index, uptake of nutrients (N and K), important stalk characters and ultimate cane and sugar yields over ratoon crop. The ratoon crop had better juice quality at maturity phase than plant crop. By and large, nitrogen at 112 kg ha^{-1} for plant crop and 224 kg ha^{-1} for ratoon crop significantly influenced the growth attributes, stalk characters with ultimate increase in cane and sugar yields over no application of nitrogen. Potassium had a complementary effect when applied at 112 kg K_2O ha^{-1} to both the crops in boosting the beneficial effect of N through its better uptake and utilisation in yield. The role of K is more prominent in ratoon crop than in plant crop. Nitrogen had a direct role in yield contributing stalk

characters i.e., number and length, while potassium had a dominant role in diameter and weight of cane especially when applied at planting or at ratooning. Thus with a proper combination of N and K fertiliser application to this variety higher yields of cane and CCS can be achieved.

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* Original not seen.

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I married Miss Savitri, daughter of my maternal uncle, Sri S.B.V.Raju on 19th Day of February, 1976 and we blessed with a daughter, Chaitanya, and a son, Ajay Varma.

I am at service in Andhra Pradesh Agricultural University from April 1975 till todate. I joined Ph.D programme in 1985 and worked on the "Effect of N,K and time of K application on Plant and Ratoon Crops of Sugarcane under moisture stress conditions" under the Chairmanship of Dr.G.Venkateswara Reddy, Associate Director of Research, R.A.R.S., Tirupati. I am working on sugarcane crop for the last 16 years at Regional Agricultural Research Station, Anakapalle and at present at sugarcane Research Station, Vuyyuru. I have 35 research publications to my credit.