EFFECT OF LIQUID FERTILIZER THROUGH DRIP IRRIGATION ON GROWTH, YIELD AND QUALITY OF SURU SUGARCANE CV. COM - 7714

By

ANIL JAGANNATH GITE

(Regd. No. 94177)

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI, DIST. AHMEDNAGAR, MAHARASHTRA (INDIA)

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

IRRIGATION WATER MANAGEMENT

DEPARTMENT OF IRRIGATION WATER MANAGEMENT
POST GRADUATE INSTITUTE MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI-413722
1997

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Approved by

Dr. S.H. Shinde
(Chairman and Research Guide)

Dr. B.N. Shinde
(Committee Member)

Dr. A.R. Bangar
(Committee Member)

Prof. P.S. Pol
(Committee Member)

Prof. S.D. Dahiwalkar
(Committee Member)

Prof. Mrs. S.U. Bholte
(Committee Member)

DEPARTMENT OF IRRIGATION WATER MANAGEMENT

POST GRADUATE INSTITUTE
MAHATMA PHULE K
VIDYAPEETH, RAHURI -
1997

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for Degree or Diploma

(A.J. Gite)

Place : MPKV,Rahuri

Dated : 14 / 07 /1997.

Dr. S.H. Shinde
Head,
Department of Agronomy,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar,
Maharashtra State (INDIA)

C E R T I F I C A T E

This is certify that the thesis entitled, "Effect of liquid fertilizers through drip irrigation on growth, yield and quality of suru sugarcane cv. CO-7714" submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **IRRIGATION WATER MANAGEMENT**, embodies the results of a bona fide research work carried out by Shri. **ANIL JAGANNATH GITE**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of these investigation have been duly acknowledged.

Place : Rahuri

(S.H. Shinde)

Dated : 14/07/1997.

Dr. V.M. Pawar
Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar,
Maharashtra State (INDIA)

CERTIFICATE

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Place : Rahuri

Dated : 23/07/1997.

(V.M. Pawar)

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Place : Rahuri

Date : 14/07/97

(A.J. Gite)

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ABBREVIATIONS

C.C.S.	:	Commercial cane sugar
C.D.	:	Critical difference
cm	:	Centimetre
CPE	:	Cumulative pan evaporation
^{o}C	:	Degree celcius
DAP	:	Days after planting
dSm^{-1}	:	Decisimen's per meter
et al.	:	All others
etc	:	Et cetera
Fig	:	Figures
g/cm^{3}	:	Gram per centimetre cube
ha	:	Hectare
hr	:	Hour
IW/CPE	:	Irrigation water cumulative pan evaporation ratio
kg	:	Kilograms
Kg/ha-mm	:	Kilograms per hectare milimeters
m	:	Meter
ml	:	Mililiter (s)
mm hos/mm	:	Milimohos per milimeter
Rs ha^{-1}	:	Rupees per hectare
%	:	Per cent
S.E.	:	Standard error
viz.,	:	Namely

ABSTRACT

EFFECT OF LIQUID FERTILIZER THROUGH DRIP IRRIGATION ON GROWTH, YIELD AND QUALITY OF SURU SUGARCANE CV. CO-7714

By

Gite Anil Jagannath

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

1997

Research Guide	:	Dr. S.H. Shinde
Department	:	Irrigation Water Management

A field trial was conducted to study the effects of liquid fertilizer on growth, yield and quality of suru sugarcane cv. CO-7714 during Feb. 1995 to Feb. 1996 at Water Management Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra). The experiment was laid out in randomised block design with six treatments replicated three times. The total seasonal water requirement in drip was 111.49 cm as compared with 227.43 cm in surface irrigation treatments indicating 50.97 per cent water saving. Field water use efficiency was maximum in drip (1581.94 kg/ha-cm) than in surface irrigation (599.74 kg/ha-cm).

Among the liquid fertilizer, levels the yield of cane decreased substantially with decrease in the levels of

Abstract contd.... Gite A.J.

fertilizers. The cane yield obtained due to liquid fertilizer levels (125 to 75 % per cent of RD) were at par with each other and significantly more than the yield obtained due to 50 per cent liquid fertilizer level. The yield obtained in 75 % liquid fertilizer level was also on par with the treatment 100 % recommended dose (N through drip). This indicate 25 % saving in fertilizer material. The application of 50 per cent recommended dose in liquid from was also almost equal in respect of yield with control treatment which indicates 50 per cent saving in fertilizer. The fertilizer use efficiency was highest in 50 per cent level of liquid fertilizer and minimum in 100 per cent solid fertilizer with surface irrigation.

Drip method of irrigation offered more gross returns per hactare, but the net return per hectare, Benefit : cost and net return per mm of water used was highest in drip irrigation and only N through drip and was low in drip irrigation with liquid fertilizer. Drip method of irrigation offered better juice quality as compared to surface method of irrigation.

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INTRODUCTION

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is one of the most important cash crops of India, in general and Maharashtra in particular. The area under sugarcane in India during 1996 was 3.61 million hactares, with production of 230.83 million tonnes and average productivily was 63.8 t/ha. In Maharashtra during the same year, the area under sugarcane was 5.80 lakh hacters, with production of 46.65 million tonnes and the average productivity was 80.0 t/ha (Anonymous, 1996). These figures indicate that sugarcane industry in Maharashtra is of prime importance.

The high income obtianed through its cultivation has made sugarcane, the most favourable cash crop under irrigated agriculture. However, among top ten sugarcane growing countries of the world, India does not occupy an enviable position so far as production per unit area is concerned. Dutt (1950) a renowed Indian authority on sugarcane while analysing the possible causes of this low yield, stated that lack of proper manurial, irrigational and cultural practices are mainly responsible for miserably low yields in India.

The area under sugarcane is hardly 2 to 3 per cent of the total cropped area, but it consumes about 60 per cent of the available water resource in the India. Yield of cane and sugar are quite high where adequate attention has been paid towards fertilizer and water requirments. However, more application of water is just not enough, adequate quantity and appropriate time of application are also important.

Fertilizer is costly input and every efforts need to be made to improve the efficiency of applied fertilizer. Judicious use of fertilizer provides one of the quickest means of increasing sugarcane production without deteriorating the soil health. Inadequate supply of fertilizer results in low cane and sugar yields, per hactare while excessive application results in poor quality of cane. Hence, proper balance and efficient use of nitrogen is also necessary for maximising production and profit from sugarcane (Salunkhe et al., 1980).

Sugarcane, which is long duration crop requires heavy fertilizers and its proper management is very important to increase fertilizer use efficiency. By adopting fertigation practices it is plausible to reduce fertilizer dose specially for N (Rudich et al. 1982).

Lack of knowledge among the farmers about efficient water application results in over application of water to the fields. The limited supply of available water is not being used judiciously through flow method of irrigation as, there are more losses of water during transit. Prolonged application of excess water deteriorates productive lands. Further expansion of irrigated area may depend upon adoption of new systems such as pressurized irrigation systems viz., drip and sprinkler irrigation systems.

The use of drip irrigation system has become widespread in recent years, especially in areas of water scarcity. Among the sophisticated methods of irrigation, drip has proved its superiority over flow method of irrigation due to direct and frequent application of water to the vicinity of rootzone. The application of water through drip system minimises the conveyance losses and deep percolation losses. Water saving by the use of drip is 80 per cent in orchard crop (Patel and Patel, 1977) and 40-50 per cent for vegetables crops (Sivannapan and Rajgopal, 1978).

Drip irrigation research in the State is being carried out with the major emphasis on water saving, increasing yield, efficient fertilizer application for crop such as cotton, pomegranate, mango, cabbage, etc, (Bangal et al., 1986), sugarcane (Magar et al. 1987), Bhendi, Bitter gourd, Ridge gourd (Mane et al., 1987) and Tomato (Kadam, 1990). In drip irrigated sugarcane, there was water saving to the extent of 40 to 70 per cent (Magar et al., 1984) and 19.9 per cent increase in yield with 25 per cent saving in applied nitrogen without any reduction in yield (Shinde et al., 1992).

The application of fertilizer or agrochemicals through irrigation system with irrigation water, a new technique recently introduced in agriculture, is gaining momentum. The most efficient way to use water and plant nutrients effectively is fertigation as it offers

i. an opportunity for placement of fertilizer in liquid form at the vicinity of rootzone of the crop along with irrigation water which increase water and fertilizer use efficiency,

ii. deeper penetration into the soil,

iii. Avoids nitrogen volatization from soil surface,

iv. easy co-ordination with specific crop demand,

v. Convenience and labour saving,

vi. improves the availability of nutrients and their uptake by roots,

vii. trace elements can also be applied along with major elements and

viii. saving of fertilizers.

Fertigation is a recent practice introduced in agriculture, needs to be evaluated in proper way for profit maximization with optimum resource utilization. Very meagre research work has been reported on this aspect in sugarcane agriculture and hence present study is undertaken with the following objectives :

1. To study the effect of application of liquid fertilizer through drip irrigation on growth and yield of sugarcane,
2. To determine the extent of water and fertilizer saving under drip irrigation system,
3. To determine the optimum doses of liquid fertilizer for sugarcane under drip irrigation methods and
4. To assesses the drip irrigation method vis-a-vis surface method of irrigation on the basis of monetory returns.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Water and fertilizer being the limited and costly inputs, are to be used carefully and in a judiciously planned manner. The cane yield can by increased by effective combination of water, nitrogen, phosphorus and potassium fertilizers. However, this accompanied with various difficulties, as the N,P,K fertilizers are subjected to various losses when applied to soil and actual utilization by the crop is very less. A very scanty information is available on the utilization of N, P, K by sugarcane when applied through drip irrigation. In this chapter an attempt is made to review the available literature on the subject under the following headings.

2.1 Effect of methods of irrigation

2.1.1 Growth, yield and water saving

Bernstein and Francois (1973) conducted a experiment on comparis on of drip, furrow and sprinklers irrigation. They recorded 30 per cent increase in yield in addition to saving of water due to drip irrigation when compared to furrow or sprinkler irrigation. They stated the reasons that this was mainly due to small controlled amounts of irrigation at frequent intervals to root system.

Donald (1974) conducted a trial on drip irrigation to sugarcane at Hawaiian sugar planters experiment station and observed an increase in cane and sugar yields per unit area and a 30 per cent improvement in water use efficiency.

Warren Gibson (1974) converted furrow irrigated lands to drip irrigation at Hawaiin sugar industry. He observed that the gross water applications are considerbly less for drip than furrow irrigation and some what less than sprinkler irrigation.

Phulare and Upadhyay (1978) reported maximum cane yield (112.96 t/ha) and the total seasonal consumptive use of sugarane was worked out to be 1903.75 mm with 59.34 kg/ha-mm water use efficiency. The total water requirement of seasonal crop of sugarcane was 253.83 cm when irrigations were applied at 75 mm CPE under Parbhani conditious.

Chavan et al. (1979) conducted an experiment with the seasonal sugarcane cvs. CO-419, CO-1163 and CO-740 at 75, 125, 175 and 225 mm CPE irrigation levels and reported that the maximum yield of 112 t/ha was obtained when irrigation scheduled at 75 mm CPE. The total consumptive use of water was 210.3 mm with 53 kg/ha-mm water use efficiency. They also reported higher values of yield contributing characters such as height (232.4 cm), number of tillers (1.9 per plant), mean diameter of middle internode (38.75 mm) and number of internodes (26 per cane) when irrigation was applied at 75 mm CPE to sugarcane crop as compared with other irrigation treatments (125, 175 and 225 mm CPE).

Haung *et al*. (1983) compared drip irrigation with furrow irrigation on sand and sandy loam soils in Taiwan. On drip irrigated plots, water was applied at intervals of 3 days based on pan ratio (PR) 0.4, 0.6, 0.7, 0.8 and 1.0. They reported that in sandy soil, cane and sugar yields/ha were increassed with the increase of PR treatment, ranging from 0.4 to 1.0. While in sandy loam soil with well distributed rainfall, number significant yield response to higher PR treatment was observed. Water use efficiency decreased with increasing rate of PR on both two soil types regardless of dry or wet weather condition. The drip irrigation of pan ratio 0.4 on sandy soils showed a significant increase in cane and sugar yields over the adjoining conventional furrow irrigation plots.

Mane *et al*. (1983) compared drip irrigation with traditional furrow method of irrigation for sugarcane (Var. CO-7219) at M.P.K.V., Rahuri. They observed that the saving in irrigation water was to the extent of 30 per cent and increase in yield by 20 per cent under drip when compared with traditional furrow method of irrigation. Under limiting water resources drip method of irrigation gave significantly more yield than the tradtiional irrigation system. They further observed the higher values of average height of cane (3.758 cm), average weight (1.845 kg), average number of internode/plant (36.08) average number of tillers/hill (8.3) under drip irrigation as comapred with furrow irrigation (cane height 3.419 cm), average weight of cane (1.359 kg), average number of internode per cane (27.36) and average number of tillers per hill (7.6).

Prasada et al. (1983) conducted an experiment on different irrigation methods and reported higher germination (72.20 %), cane yield (216.40 kg/plot) in drip irrigation as compared with normal furrow irrigation germination (70.11 %), cane yield (200.85 kg/plot). They further stated lower irrigation water requirement of 92.10 cm in drip irrigation as compared with furrow method (136.00 cm).

Godoy et al. (1985) conducted a comparative trial of drip vs furrow irrigation in Venezuela and recorded 120 t/ha and 80 t/ha cane production under drip and furrow irrigation system, with sugar production of 8.5 t/ha and 6.0 t/ha a respectively. They also found an improved control of amount of water applied, reduced losses from evaporation and more efficient use of nutrient supplied through the irrigation directly to the root systems.

Magar (1985) conducted the experiment on drip irrigation for sugarcane with major objectives of adaptibility. Water saving and reduction in the cost at

M.P.K.V., Rahuri, and reported 65 per cent water saving along with 10 to 15 per cent increase in yield.

Mane et al. (1985) have evaluated drip method of irrigation for suru sugarcane crop (CO-7219) in respect of water ecomony and crop response in comparis on with furrow method at M.P.K.V., Rahuri during the year 1984-85. The study revealed that the drip method recorded maximum cane yield (167.27 t/ha) and utilized only 78.47 cm of irrigation water. It resulted in saving of irrigation water by 59.8 per cent and increase in cane yield by 5.7 per cent when compared with normal furrow method of irrigaiton.

Deshmukh et al. (1988) stuided both surface drip and sub surface drip with daily and alternate day irrigation and paired row planting for sugarcane variety CO-7219 and compared with conventional planting and furrow method of irrigation. The water saving to the extent of 50 to 55 per cent, considerably higher yield, and 2.7 times more water use efficiency were recorded for both surface and sub surface method and paired row planting than the control.

Patil (1988) conducted a comparative trial on biwall and traditional furrow irrigation at Shahada Co-operative Sugar Factory for sugarcane and stated higher values of total height (442.33 mm), millable height (296.22 mm), number of internodes (27.22), length of internode (15.65 cm), girth of internode (10.85 cm) in biwall irrigation system. The corresponding values under traditional furrow method were 421.0, 277.20, 26.10, 14.10 and 9.20.

Hapse (1989) conducted an experiment on technoeconomic feasibility of micro-irrigation for sugarcane at V.S.I., Pune. He recorded higher average height, millable height, number of matured canes per hill number of internodes per cane, girth and weight per cane in surface and drip with paired row method of planting and daily irrigation as compared with troditional furrow irrigation. He further noted lower irrigation water applied (107.56 ha-cm), higher yield (175.5 t/ha) and WUE of 1.631 t/ha-cm in drip as against traditional furrow method.

Bankar et al. (1992) conducted the comparative trial of drip vs. conventional systems of irrigation for sugarcane (CO-7219) at M.P.K.V., Rahuri. Their data revealed that the maximum cane yield (136.3 t/ha) of suru sugarcane was obtained in drip with pit method of planting followed by paired row planting with drip method (128.18 t/ha). The increase in cane yield due to drip with pit method was 18 per cent over conventional normal furrow method of irrigation. The water saving due to drip with pit method was 68 per cent over conventional method of irrigation.

2.1.2 Nutrient concentration, uptake and dry matter accumulation

Mukharjee and Verma (1950) reported that in India, an average crop of sugarcane yielding 100.0 tonnes per hactare removed 150 kg nitrogen, 63 kg P_2O_5 and 313 kg K_2O. As such application of these major nutrients through fertilizer is absolutely essential for getting economic yield.

Zende et al. (1972) reported that there was wide variability in the uptake of nutrients in different seasons. According to them, one tone of crop of sugarcane on an average removed 1.4 kg N, 1.6 kg P_2O_5 and 3.5 kg K_2O from the soil.

Kadam (1986) conducted an experiment on effect of levels of irrigation on growth, dry matter accumulation and uptake of nitrogen by sugarcane (CO-7219) and concluded that the dry matter production and N uptake at all stages were higher in the plots where irrigation were scheduled at 75 mm CPE with 8 cm depth throughout growth period as compared with canal rotations.

The experiment on feasibility of drip irrigation method for ratoon sugarcane (CO-7219) was conducted at MPKV, Rahuri and it revealed higher N (166.1 kg/ha), P (69.1 kg/ha) and K (285.0 kg/ha) uptake under alternate dry drip as compared with normal furrow irrigation (152.0 N, 54.9 kg P and 248.5 kg K per hectare) (Anonymous, 1988).

Shih (1988) conducted an experiment to compare the differences in sugarcane yield, biomass and water use efficiency between micro-irrigation and sub irrigation. The results showed that sugarcane required about 220 to 275 kg of water to produce kg of sugarcane dry biomass and about 520 to 620 kg water to produce 1 kg of sugar.

2.1.3 Quality of juice

Phulare and Upadhyay (1979) compared four irrigation levels viz., 75, 175 and 225 mm CPE for seasonal sugarcane and found that irrigation scheduled at 75 mm CPE significantly increased the sucrose percentage of juice.

Prasada et al. (1983) conducted an experiment on evaluation of irrigation methods for its economy in sugarcane and reported higher values of sucrose (16.21 %) and CCS (24.16 kg/plot) under drip irrigation as against 15.62 per cent surcose and 21.05 kg CCS/plot in normal furrow method.

Results of a trial on drip and furrow irrigation conducted at Water Management Project, Rahuri to assess the feasibility of drip irrigation for seasonal sugarcane revealed high value of brix (19.78 %), sucrose content in juice (18.31 %), CCS yield (14.54 t/ha), purity (92.57 %), CCS in cane (13.11 %) under drip as compared with normal furrow irrigation [brix (19.18 %), sucrose content in juice (17.30 %), CCS yield (11.83 t/ha) and purity (90.20 %)] (Anonysmous, 1988).

Patil (1988) conducted a comparative trial on biwall and traditional furrow irrigation methods and reported higher values of brix (20.94 %), Pol (18.84 %), Purity (89.87 %), CCS (13.32 %) in biwal irrigation system as compared with traditional furrow method [brix (19.8 %), pol (16.86 %), purity (85.20 %), CCS (11.60 %)].

Dodsworth et al. (1990) conducted a trial to assess drip irrigation for sugarcane as compare with well managed flood irrigation. They observed 12.82 and 12.50 per cent sucrose content in drip and furrow irrigations, respectively in plant cane and 13.36 and 12.99 per cent sucrose under drip and flood irrigations, respectively in first ratoon.

2.1.4 Emission uniformity and uniformity coefficient

Mycis and Bucks (1972) had proposed a system having low operating pressure and relatively higher diameter of emitter which would eliminate the problem of clogging and reduce the cost of operation. He attained application uniformity by varying emitters sizes along the lateral to compensate for the attendant pressure drop.

Karmeli and Keller (1975) stated that uniformity less than 94 per cent within the sub unit is likely to lower down the performance of over all drip system due to problem of clogging. They suggested that uniformity should be above 90 per cent. Spacing of micro-tubes along the lateral has the direct relationship with uniformity coefficient.

Nakayama et al. (1979) compared the emitter flow rate by estimating average flow rate for a spcified subgroup of enitre emitter population design. Coefficient of uniformity for emitters was obtained that included the number of emitter per plant.

Bralts et al. (1981) conducted the study and showed that hydraulie and manufacturing variation could be statistically combined and included in the design of evaluation for uniformity of single chamber drip irrigation laterals lines. The variation of emitter flow rate due to water temperature, emitter clogging and emitter spacing can also be statistically included in the uniformity and emitter flow variation equations.

Bourne (1987) reported that the emission uniformity of water distribution and proper control of soil moisture regime in drip irrigation are very much dependent on the efficiency of emitter discharge. The attempt has been made to analyse the operating variables to emitter discharge and comparing the results to theoritical accepted values of emission uniformities.

2.2 Fertilizer management

2.2.1 Growth and yield

Gahlot (1954) observed at Shahajahanpur that the highest number of tillers per plant was found under 227 kg additional nitrogen per hectare but increase in tiller number per plant over the 114 kg levels was not so marked.

Sastry and Venkatachari (1960) while working at Rodrur in Andhra Pradesh, indicated that application of nitrogen had improved shoot population and height of cane plant over no nitrogen but difference between 170 and 340 kg N/ha were slight in both these attributes.

Gahlot (1961) observed maximum green leaves with 120 lb N per acre followed by 80, 40 lb and no nitrogen. Significant positive corelation between number of leaves and yield was also observed higher the number greater is the yield. On the contrary, deficiency of nitrogen lowered leaf area in sugarcane.

Kirtikar and Anang Nath (1964) observed that in Eastern U.P. increase in levels of nitrogen from 0 to 227 kg/ha increased the number of tiller per plant and thereafter, there was a depression effect on tillering (i.e. at higher level).

Srinivasan and Mariakulandai (1969) reported that the increasing dose of nitrogen from 170 to 340 kg N per hectare increased early vigour in terms of plant height, dry matter accumulation and cane attributes.

Cheema and Moolani (1970) opined that application of nitrogen at both the rates (112 and 168 kg N/ha) at tillering period, significantly increased milleable cane length and length of internode and weight per cane.

Srinivasan et al. (1977) observed that under Cauvery delta area (Tamil Nadu), application of nitrogen increased the yield of cane for variety CO-419 a 12 months crop of sugarcane and optimum dose could be fixed at 280 kg/ha.

Shinde et al. (1981) reported that under Kolhapur conditions for a seasonal (12 months) crop of sugarcane 250 kg nitrogen per hectare was optimum dose for obtaining higher sugar yields.

Bharad et al. (1991) conducted field trails in 1971-73 on clay loam soil. The effects of 100, 200 and 300 kg N per hectare on shoot number leaf area, height and yield of sugarcane were favourable. Whereas results showed there had no effect on shoot number, leaf area and height of cane when N dose was increased, the 100, 200 and 300 kg N/ha gave average cane yield of 72.9, 74.9 and 76.1 tonnes per hectare, respectively.

2.2.2 **Uptake and dry matter accumulation**

Arakeri (1956) stated that the nitrogen uptake was increased with increased dose of nitrogen which resulted in low uptake of P_2O_5 and K_2O leading to imbalanced nitrogen.

Lakshikanthm et al. (1964) conducted experiment on nitrogen fertilization at Coimbtore and observed progressive increase in dry matter with increase in levels of nitrogen.

Takahashi (1964) conducted an experiment on nitrogen field studies with sugarcane at Hawaii, He confirmed progressive increase in dry matter production with added levels of nitrogen and pointed out that lower doses of nitrogen were more effective in this aspects.

At Anakapalle in an experiment of 12 months crop of sugarcane (variety CO-419), it was observed that there was an increase in the uptake of nitrogen upto 210 days after planting and thereafter showed a gradual decline upto harvest. With manurtal schedule for this tract viz., 111.15 kg N/ha, 130.9 tonnes of sugarcane crop was noted to remove 106.21 kg Nitrogen, 30 kg phosphorus and 212 kg potassium per hectare (Anonysmous, 1965).

Reddy (1977) studied the effect of nitrogen on yield of sugarcane at APAU, Rajendranagar and confirmed the earlier findings that dry matter production progressively increased with increase in levels of nitrogen upto 300 kg/ha.

2.2.3 Quality of juice

Gahlot (1954) conducted an experiment on nitrogenous manures in sugarcane and observed that application of nitrogen at the rate of 114 and 228 kg per hectare decreased sucrose per cent and purity co-efficient.

Ojha et al. (1954) conducted anexperiment to assess the effect of application of NPK on juice quality of sugarcane at Shahajahanpur and reported that application of 224 kg N per hectare increased the cane yield significantly, however, increased dose exerted adverse effect on juice quality.

Kiritkar and Anang Nath (1964) conducted a experiment on nitrogen response of sugarcane in Eastern U.P. They reprоted that the sucrose percent in juice was markedly influenced by nitrogen dose (114, 228 and 342 kg/ha). Higher the dose, lower was the sucrose per cent and purity coefficient.

Kunarajah (1969) conducted two years fertilizers trials with sugarcane var. CO-775 and applied N at levels upto 300, P_2O_5 upto 120 and K_2O upto 200 lb/acre. The results indicated that NPK application at 200:120:50 or 200:60:100 lb/acre gave the best results in respect of yield and juice quality of cane.

Chiranjiri et al. (1974) conducted an experiment on rates of nitrogen fertilizer to sugarcane at Coimbtore. They found that among the various doses tried (0, 200, 250 and 300 kg N/ha), the dose of 250 kg N/ha gave the highest values of juice parameters, however, 300 kg N/ha proved detoterious for juice quality.

Patil et al. (1977) conducted an experiment on response of sugarcane to rates of nitrogen fertilization at Kolhapur. They observed that the application of 250 kg nitrogen per hectare for sugarcane was optimum to increase the sucrose percentage of juice.

2.3 Fertigation and liquid fertilizer

The application of liquid fertilizer through drip irrigation system was more efficient than conventional method of fertilizer application, since it confines nutrient placement to the area of greatest root concentration (Anonymous, 1978).

Staduts et al. (1984) reported that by supplying the crop with nutrients and water at the same time through irrigation system (fertigation) presents number of advantages such as saving in labour and fertilizer, higher efficiency of the two factors of production (water and fertilizer) reduction of ground water pollution.

Asokan (1988) reported that the nutrients can be injected into irrigation system to improve production, reduce fertilizer requirements, improve efficiency and reduce labour. Divided seasonal requirements into weekly applications at proportionally reduced rates increase the productivity.

Krishna Sastry (1991) stated that fertigation is a new concept developed with advent of new irrigation system. Under drip irrigation it was possible to provide fertilizers in liquid form so that irrigation and fertilizers could be applied at same time to the crop in the most efficient manner.

Clark et al. (1991) reported that improved water and fertilizer management by using tensiometer and fertigation on sandy loam soils could result in reduced water and fertilizers application as compared with those associated with seepage irrigation.

Shinde et al. (1992) conducted a experiment on effect of different levels of nitrogen through drip irrigation on yield of sugarcane at V.S.I., Pune during 1988-89 to 1991-92. The nitrogen levels used were 125 per cent (T_1), 100 per cent (T_2), 75 per cent (T_3) and 50 per cent (T_4) of recomended dose (250 kg/ha) with drip method of irrigation, where as 100 per cent N (T_5) with conventional method of irrigation. The results revealed that treatment T_3 (75 % N) recorded the highest yield (68.68 to 80.18 t/ha) among the treatments. The results thus indicated that 25 per cent reduction in nitrogen dose under drip did not affect the yield and sugar recovery.

Rakh (1992) conducted the experiment on cabbage crop to assess the effect of liquid fertilizer through drip at M.P.K.V.,Rahuri. The results revealed that liquid fertilizer were superior in respect of yield, yield contributing characters and water use efficiency.

Suryawanshi (1992) conducted experiment on different levels of fertilizer through drip to sugarcane. The results revealed that 20 per cent saving of fertilizers without any reduction in yield of sugarcane.

Deshmukh et al. (1993) conducted the experiment on drip irrigation to sugarcane with nutri-drip levels 100 per cent, 85 per cent, 70 per cent and 55 per cent of recommended dose for sugarcane CO-740 in adsali at V.S.I. Pune. The results indicated that cane yield (168.99 t/ha) and CCS (28.30 t/ha) was found the highest in treatment with 85 per cent NPK which was superior to control in cane yield (132.73 t/ha) and CCS (22.4 t/ha).

2.4 Economic studies

Among commercial crops, the production cost of sugarcane is relatively much higher than other crops. Mathur and Tripathi (1975) reported that the most economic level of nitrogen was 250 kg/ha although the highest cane yield was obtained with 300 kg/ha.

Pande (1976) stated that in the case of sugarcane, the cost of fertilizer including organics rarely exceeds 40 to 50 per cent, on a very liberal estimate of the total cost of cultivation.

Sastry and Ramana (1978) worked out cost per tonne of sugarcane production to Rs. 74.04 and Rs. 69.22 for planted and ratoon crops, respectively. With general hike of 25 to 30 per cent in cost of fertilizer and chemicals, a further increase in production costs could be anticipated which will further reduce the net returns per rupee invested.

Hapse (1978) laid down particular emphasis on reducing cost on inputs which could be brought through reduction of nitrogen dose based on research data at Padegaon and kolhapur, it was found that the dose of 400 and 250 kg N/ha for _adsali_ and _suru_ crops could be brought down at 300 and 150 kg N/ha, respectively, by adopting nitrogen economy measures.

Narwal and Behal (1979) reported the highest net income of Rs. 6266/ha from 150 kg N/ha, followed by 100 kg N/ha to CO-1148 and S-37-61 sugarcane varieties.

MATERIALS AND METHODS

3. MATERIAL AND METHODS

The present investigation on the "Effect of liquid fertilizer through drip irrigation on growth, yield and quality of sugarcane (cv. CO-7714) was conducted at Water Management Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra) during the year 1995-96. The details of the material used and methods employed during the course of investigation are described in this chapter under the following heads.

3.1 Details of experimental material

3.1.1 Experimental site

This field trial was conducted in survey No. 133/1 of Water Management Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar. The plot used for the experiment was fairly uniform in topography and fairly well drained.

3.1.2 Soils

The soils of experimental field was medium black with a average depth of 0.75 metre. The composite samples were drawn from 0 to 30 cm depth from eighteen location of the field. The samples were then prepared and stored in cool and dry place in laboratory. Physical and chemical properties of soil with the methods adopted are given in Table 3.1.

Table 3.1 Physical and chemical characteristics of soil with methods of determination

Sr. No.	Characteristic	Composition	Method adopted	Reference
I.	**Physical properties**			
1.	Soil texture	Clay laom	International pipette method	Piper, (1966)
	Coarse sand (%)	15.6		
	Fine (%)	10.8		
	Silt (%)	35.3		
	Clay (%)	38.3		
2.	Bulk density (g/cm^3)	1.22	Core sampler method	Klute et al., (1986)
3.	Field capacity (%)	36.76	Pressure plate apparatus	Black, (1965)
4.	Permanant wilting point (%)	17.85	---- " -----	---- " -----
5.	Hydraulic conductivity	1.20	Bruce and klute method	Bruce and Klute, (1956)
6.	Available soil moisture	14.0	By difference	
II.	**Chemical properties**			
1.	Available N (kg/ha)	116.7	Alkaline potassium permagnate method	Subbiah and Asija, (1956)
2.	Available P (kg/ha)	18.47	Olsen's method	Olsen (1954)
3.	Available K (kg/ha)	492.8	Flame photometer method	Page et al., (1982)
4.	Soil pH	8.3	Potentiometric	Piper (1966)
5.	Electrical conductivity (mmhos/cm at 25°C)	0.204	Conductometric	Jackson, (1973)
6.	Organic carbon (%)	0.542	Walkely and black method	-
7.	Calcium carbonate (%)	9.0	Rapid titration method	F [illegible]

3.1.3 Source of water

Water used for irrigating sugarcane crop during the period of investigation was from the tube well. The electrical conductivity of water used was 0.7 dSm^{-1}.

3.1.4 Climatic conditions

3.1.4.1 General

Climatically this area falls in the semi-arid subtropical zone. This tracts lies in the Eastern side of the Western Ghats and comes in rain shadow area receiving most of the rainfall from South West mansoon. Agro-climatically, the area falls in scarcity zone of Maharashtra State. The annual rainfall ranges from 307 to 619 mm with an average of 520 mm. About 80 per cent rainfall is received in June and September, from south west monsoon. The distribution is erratic and dry spells are common.

The annual average maximum temperature of the tract is 37.9°C, which ranges from 33°C to 43°C and the average minimum temperature being 17.2°C with range of 3°C to 18°C. The mean relative humidity at 8.00 and 14.00 hours is 59 and 35 per cent, respectively. The mean pan evaporation ranged from 5.3 to 12.1 mm.

3.1.4.2 Nature of season during the experimental period

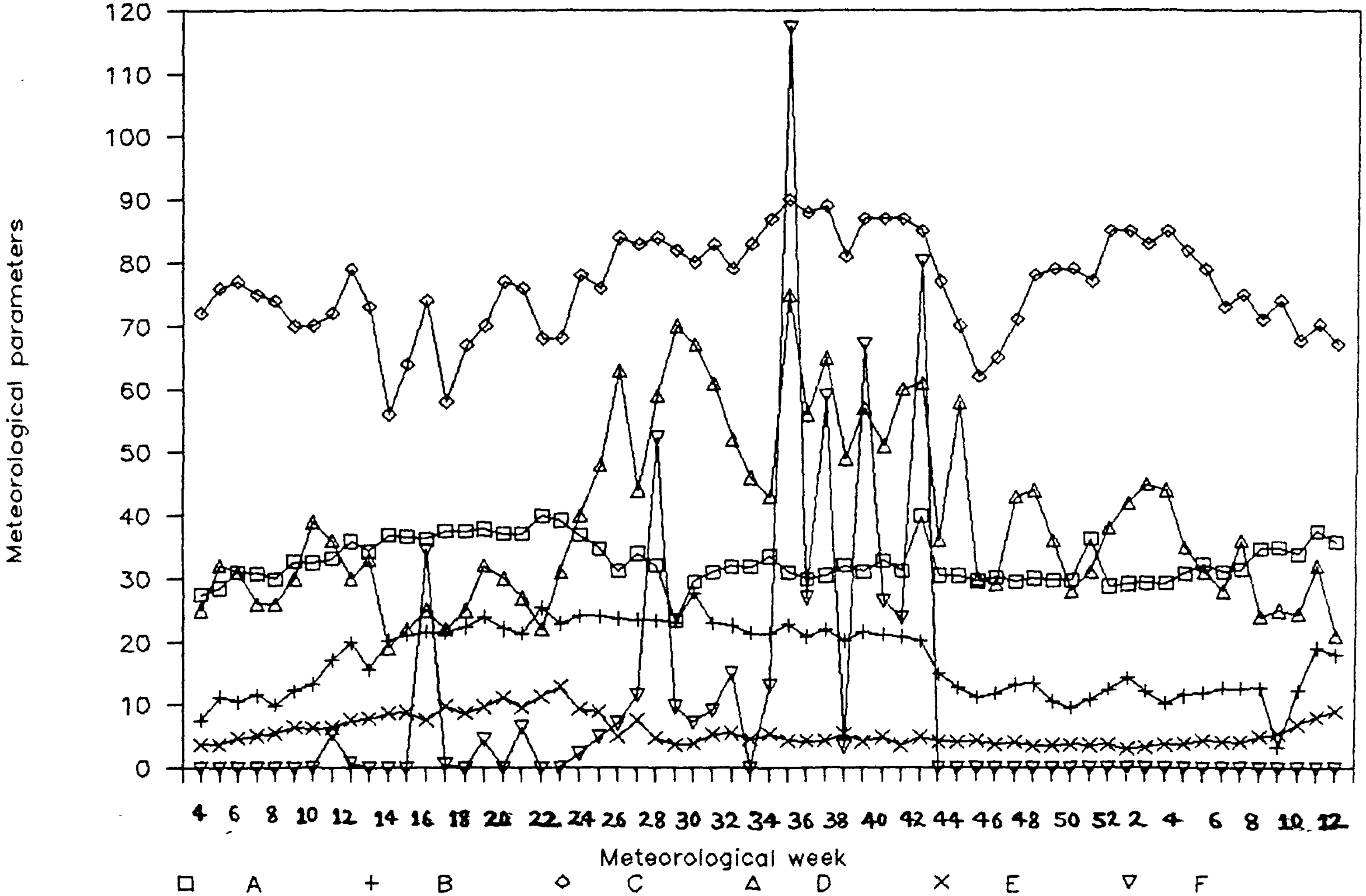
The weekly data regarding the different meteorological parameters are presented in Table 3.2 and graphically depicted Fig. 3.1.

Table 3.2 Details of Meterological data during the experimental period

Metero-logical week	Date	Mean temperature °C		Mean relative humidity		Wind velocity km/hr	Total sunshine hr/day	Mean pan evaporation mm/day	Rainfall (mm)	No.of rainy days
		Maximum	Minimum	Morning (%)	Evening (%)					
	February									
6.	5-11	31.1	10.5	77	31	2.5	10.1	4.7	-	-
7.	12-18	30.8	11.6	75	26	3.1	9.9	5.6	-	-
8.	19-25	29.9	10.0	74	26	2.9	10.6	5.3	-	-
9.	26-4	32.7	12.3	70	30	3.4	10.5	6.9	-	-
	March									
10.	5-11	32.4	13.2	70	39	3.5	10.1	6.9	-	-
11.	12-18	33.2	17.1	72	36	3.5	9.6	6.6	5.4	1
12.	19-25	35.9	19.9	79	30	3.5	9.4	8.7	0.8	-
13.	29-1	34.3	15.5	73	33	4.0	10.3	8.7	-	-
	April									
14.	2-8	36.9	20.3	56	19	3.6	10.8	9.8	-	-
15.	9-15	36.7	21.2	64	22	4.4	10.0	10.3	-	-
16.	16-22	36.3	21.6	74	25	3.5	10.0	9.5	34.5	-
17.	23-29	37.5	21.5	58	22	4.5	9.6	10.6	0.6	-
18.	30-6	37.5	22.4	67	25	4.6	8.3	10.0	-	-
	May									
19.	7-13	37.9	23.9	70	32	6.2	8.3	10.7	4.5	1
20.	14-20	37.1	22.2	77	30	11.3	9.5	11.3	-	-
21	21-27	37.1	21.4	76	27	6.8	10.0	11.2	6.5	1
22.	28-3	40.0	25.4	68	22	8.0	9.0	12.6	-	-
	June									
23.	4-10	39.2	22.8	68	31	11.4	11.3	13.9	-	-
24	11-17	36.9	24.1	78	40	8.3	10.2	10.8	2.3	-
25.	18-24	34.7	24.1	76	48	9.1	7.6	9.7	5.0	1
26.	25-1	31.2	23.7	84	63	6.7	3.5	5.3	7.1	2
	July									
27.	2-8	34.0	23.5	83	44	8.7	7.6	7.5	11.6	2
28.	9-15	32.1	23.4	84	59	7.8	3.9	5.5	52.3	1
29.	16-22	28.3	23.1	82	70	10.9	1.0	3.7	9.7	2
30.	23-29	29.5	22.7	80	67	7.7	-	4.3	7.2	1
31.	30-6	31.1	23.0	83	61	9.0	-	5.0	9.2	2
	August									
32.	7-13	31.9	22.6	79	52	8.0	-	6.4	15.0	1
33.	14-20	31.8	21.4	83	46	7.7	-	7.0	-	-
34.	21-27	33.5	21.3	87	43	5.4	-	6.6	13.1	1
35.	28-2	31.0	22.7	90	75	5.7	-	5.6	117.4	1

Table 2 continued....

Meterological week	Date	Mean temperature °C		Mean relative humidity		Wind velocity km/hr	Total sunshine hr/day	Mean pan evaporation mm/day	Rainfall (mm)	No.of rainy days
		Maximum	Minimum	Morning (%)	Evening (%)					
	September									
36.	3-9	29.9	20.8	88	56	6.7	7.2	5.1	27.0	3
37.	10-16	30.5	21.9	89	65	4.3	6.6	5.1	58.9	2
38.	17-23	32.1	20.2	81	49	5.1	9.3	6.2	3.4	1
39.	24-30	31.1	21.5	87	57	2.6	6.7	4.3	67.0	3
	October									
40.	1-7	32.8	21.2	87	51	3.2	8.7	6.1	26.4	3
41.	8-14	31.3	20.8	87	60	3.0	6.7	4.1	23.7	3
42.	15-21	29.9	20.1	85	61	3.5	8.1	4.4	80.2	4
43.	22-28	30.5	14.9	77	36	3.4	9.9	4.0	-	-
44.	29-4	30.5	12.7	70	28	1.9	10.2	3.9	-	-
	November									
45.	5-11	29.6	11.2	62	30	2.1	10.1	4.3	-	-
46.	12-18	30.2	11.7	65	29	2.3	9.9	4.3	-	-
47.	19-25	29.5	13.3	71	43	2.6	9.2	3.8	-	-
48.	26-2	30.0	13.4	78	44	2.0	7.2	3.7	-	-
	December									
49.	3-9	29.7	10.6	79	36	1.9	9.4	3.9	-	-
50.	10-16	29.7	9.6	79	28	2.1	9.9	3.8		
51.	17-23	36.2	10.8	77	31	2.2	9.7	3.7	-	-
52.	24-31	28.7	12.4	85	38	3.6	8.5	4.1	-	-
	January-1996									
1.	1-7	29.1	14.2	85	42	2.6	7.0	3.3	-	-
2.	8-14	29.3	12.2	83	45	2.2	8.8	3.7	-	-
3.	15-21	29.2	10.2	85	44	3.0	9.7	4.5	-	-
4.	22-28	30.8	11.6	82	35	2.1	9.8	4.4		
5.	29-4	32.3	11.9	76	31	1.9	9.8	5.2		



A maximum temperature °C B minimum temperature °C C morning humidity

D evening humidity E pan evaporation mm day^{-1} F Rainfall mm.

FIG-3.1 Average weather situation prevailed during experimental period

Rainfall received during the period of investigation was 634.9 mm in 40 rainy days. The mean maximum temperature ranged between 28.3°C and 40.0°C, while mean minimum temperature ranged between 9.6°C and 25.4°C. The relative humidity during morning and evening ranged between 56.0 to 90.0 per cent and 19.0 to 75.0 per cent, respectively. The wind velocity ranged between 1.1 to 11.4 km hr^{-1}. The maximum pan evaporation of 13.9 mm day^{-1} was recorded in 23rd meterological week while minimum pan evaporation of 3.3 mm was observed in 1st meterological week of year 1996.

3.1.5 Cropping history of the experimental field

The details of the cropping history of the experimental field for past three years is presented in Table 3.3

3.1.6 Fertilizer

In solid fertilizer treatments the recommended dose of 250 kg N + 125 kg P_2O_5 + 125 kg K_2O per hectare was applied through urea, single super phosphate and muriate of potash, respectively.

Table 3.3 Cropping history of experimental plot

Sr. No.	Year	Kharif	Rabi	Summer
1.	1991-92	Pearl millet	Wheat (HD-2189)	Fallow
2.	1992-93	Groundnut (JL-24)	Chickpea (PG-12)	Fallow
3.	1993-94	Sunflower (morden)	Chickpea (PG-12)	Maize (fodder)
4.	1994-95	-	Fallow	Sugarcane (present investigation

In liquid fertilizer treatments, liquid fertilizer of 12:6:6 grades viz., 12 g N : 6 g P_2O_5 : 6 g K_2O per 100 g fertilizer material was used.

3.1.7 Planting material

The planting sets of the sugarcane variety Com-7714 was obtained from D-block of Director Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.2 Details of experimental methods

3.2.1 Experimental details

The plan of layout of experiment is shown in Fig. 3.2 (a).

The experimental details of field are as fallows.

1. Desing : Randomised block design
2. Number of treatments : Six (given in Table 3.4)

3.	Number of replications	:	Three
4.	Total number of plot	:	Eighteen
5.	Spacing	:	$0.9 \times 0.3\ m^2$
6.	Plot size		
	a. Gross	:	$12 \times 8.1\ m^2$
	b. Net	:	$9.6 \times 4.5\ m^2$
7.	Planting technique	:	One row skipped after every four rows

3.2.2 Fertilizer application

The quantity of fertilizer to be applied to each plot was calculated as per treatments.

In solid fertilizer treatments, the recommended dose of fertilizer of 250 kg N + 125 kg P_2O_5 + 125 kg K_2O per hectare were applied through urea (46.0 % N), Single super phosphate (16.0 % P_2O_5) and muriate of potash (58.0 %, K_2O), respectively. Whole dose of P_2O_5 and K_2O was applied as basal dose by band placement in T_1 and T_2 treatments. N was applied in four splits viz., 10 per cent; 40 per cent; 10 per cent, 40 per cent at the time of planting, 60 DAP, 105 DAP and 135 DAP, respectively. In treatment T_1 N was applied by band placement and in treatment T_2, N was applied through drip irrigation.

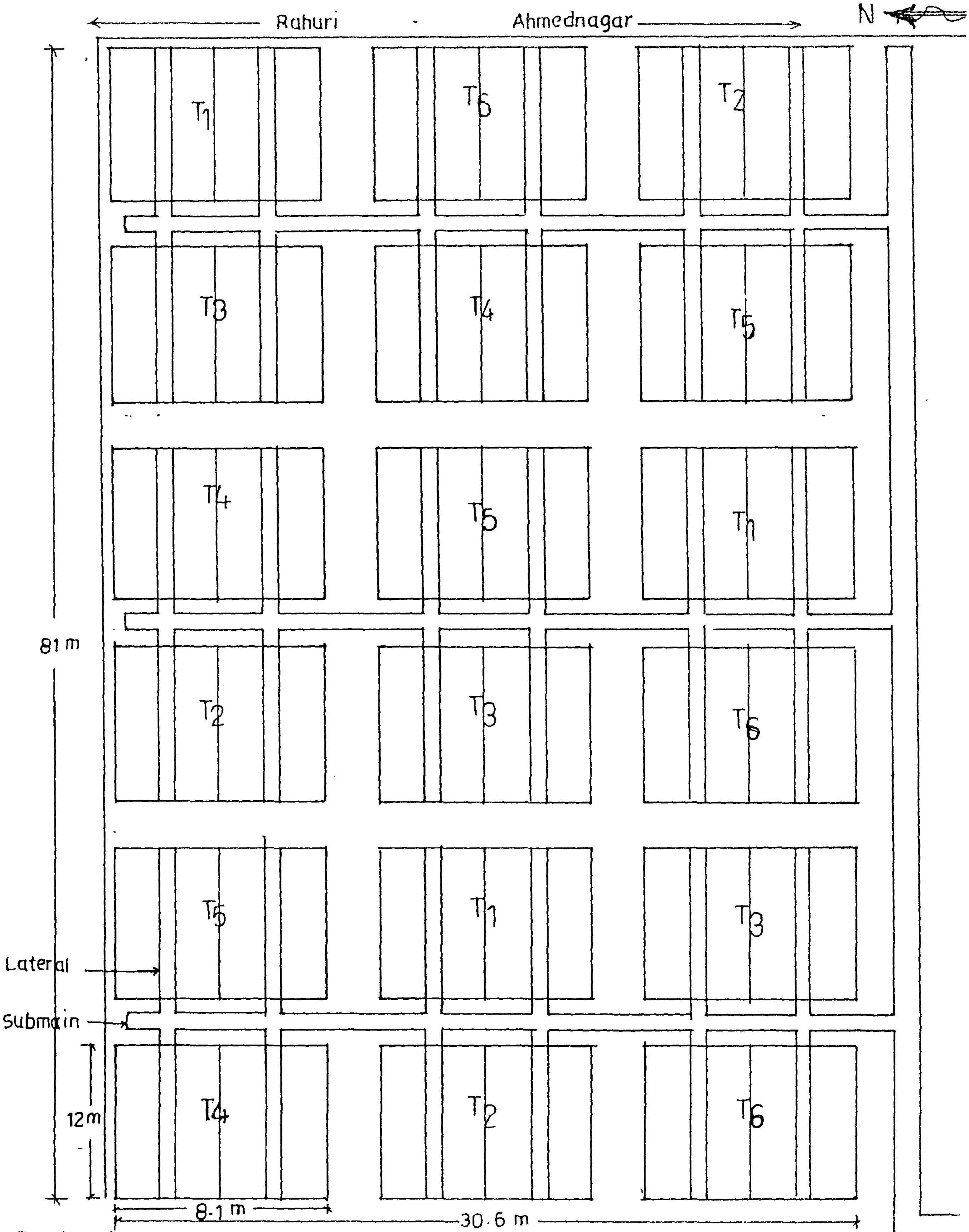
In case of treatments T_3 to T_6, 125 per cent, 100 per cent, 75 per cent and 50 per cent of the recommended dose, respectively was applied through drip by using liquid fertilizer having grade 12:6:6. The details of spliting of fertilizer followed during experimentation are given in Table 3.5.

3.2.3 Layout of the experiment

The exeperiment was laid out in radomised block design with three replication and six treatments. Treatments details with symbol used are given in Table 3.4.

Table 3.4. Details of the treatments and symbol used in experiment

Sr. No.	Symbol used	Tretment details
1.	T_1	Recomended dose of solid fertilizer by band plancement method with surface irrigation (250:125:125 NPK kg/ha).
2.	T_2	Recommended dose of solid fertilizer, P and K by band placement and N through drip only.
3.	T_3	125 per cent recommended dose in the form of liquid fertilizer through drip irrigation.
4.	T_4	100 per cent recommended dose in the form of liquid fertilizer through drip irrigation.
5.	T_5	75 per cent recommended dose in the form of liquid fertilizer through drip irrigation.
6.	T_6	50 per cent recommended dose in the form of liquid fertilizer through drip irrigation.



Treatments :- T_1 = RD + SI T_2 = RD + ND T_3 = 125% L.F.

T_4 = 100% L.F. T_5 = 75% L.F. T_6 = 50% L.F.

Sugarcane Layout - One skip after four rows

Table 3.5 Fertilizer schedulings

A. Solid fertilizer (250 + 125 + 125 kg NPK/ha)

Sr No.	Split for treatment T_1 and T_2	Time of application	Quantity of fertilizer per hectare (kg)		
			Urea	S.S.P.	M.O.P.
1.	Basal dose	At the time of planting	54.34	781.25	208.33
	a. 10 % nitrogen				
	b. 100 % P_2O_5				
	c. 100 % K_2O				
2.	40 % Nitrogen	60 days after planting	217.20		
3.	10 % Nitrogen	105 days after planting	54.34		
4.	40 % Nitrogen	135 days after planting	217.20		
		Total	543.50	781.25	208.33

B. Liquid fertilizers

Sr. No.	Splits for treatment T_3, T_4, T_5 & T_6	Time of application	Quantity of liquid fertilizer (12:6:6) per ha (litres)			
			T_3-125 %	T_4-100 %	T_5-75 %	T_6-50 %
1.	10 %	30 days after planting	217.0	173.61	130.20	86.80
2.	10 %	45 DAP	217.0	173.61	130.20	86.80
3.	10 %	60 DAP	217.0	173.61	130.20	86.80
4.	10 %	75 DAP	217.0	173.61	130.20	86.80
5.	10 %	90 DAP	217.0	173.61	130.20	86.80
6.	10 %	105 DAP	217.0	173.61	130.20	86.80
7.	10 %	120 DAP	217.0	173.61	130.20	86.60
8.	10 %	135 DAP	217.0	173.61	130.20	86.80
9.	10 %	150 DAP	217.0	173.61	130.20	86.80
10.	10 %	165 DAP	217.0	173.61	130.20	86.80
		Total	2170.10	1736.10	1302.08	868.05

3.2.4 Cultural operations

The details of the important cultural operations carried out in experimental field during the crop growth period are presented in Table 3.6.

3.2.4.1 Preparatory tillage and other preliminary operations

The soil of the experimental plot was prepared to a fine tilth by cross wise ploughing followed by two harrowing with disk harrow. Field was made free from organic residues of previous crop or weeds. After making of all boundries 90 cm ridges and furrow were opened in East-West direction. The compost was mixed well in soil.

3.2.4.2 Planting

The planting was done on 8th February, 1995. Single eye bud setts planting technique was followed. Planting was done in the furrows with 90 cm width and at 30 cm spacing. In each plot there were nine furrows, out of that, planting was done in adjacent four furrows and one furrow was skipped off and again four furrows were planted.

3.2.4.3 Earthing up

Loose soil in the skipped ridges and furrows was directed manually towards both sides to give mechanical supports to plant.

Table 3.6. Cultural operations followed during experimentation

Sr. No.	Field operations	Frequency	Date
A.	Preparatory tillage and other preliminary operations		
1.	Ploughing (cross-wise)	2	25.11.94, 28.11.94
2.	Harrowing (disk harrow)	2	5.12.94, 8.12.94
3.	Collection of stubbles	1	15.12.94
4.	Preparation of layout	1	10.1.95
5.	Application of compost and mixing	1	15.1.95
6.	Installation of drip irrigation system (Except laterals and emitters)	1	23.1.95
B.	Planting	1	8.2.95
C.	Irrigation		
1.	Common irrigation after planting (7 cm each)	3	9.2.95, 14.2.95
2.	Subsequent irrigation	-	As per treatment
D.	Interculturing		
1.	Weeding	3	28.2.95, 27.3.95 22.4.95
2.	Earthing up	1	17.4.95
3.	Wrapping and propping	2	14.9.95, 19.9.95
E.	Fertilizer	-	As per the fertilizer schedule given in Table 3.4 A & B
F.	Plant protection		
1.	Application of thimate	1	17.5.95
2.	Endosulphan spraying @ 2ml/liter	2	9.5.95, 18.5.95
G.	Harvesting	1	5.2.96, 7.2.96

3.2.4.4 Irrigation scheduling

As per the treatments, the respective method of irrigation was used. In case of surface irrigation 1 IW/CPE ratio was used to schedule the irrigations and 5 cm of water was applied at 50 mm CPE.

3.2.4.5 Plant protection measures

The crop was infested with early shoot borer at early stage of growth. This pests initially feeds on leaves and later enter into the young shoot and tunnel downwards. Thus, the central shoot dries up causing `dead heart'. Incidence of this pest was noticed at 4 months age of the crop. The control measures adopted against this pest were as below :

i. Removal of dead hearts

ii. Two sprayings of 0.05 per cent endouslfan at an inerval of 15 days were undertaken.

3.3 Details of drip system

Drip unit installed at the experimental farm was run with the help of bye pass flow obtained from a 7.5 Hp submersible motor installed in the tube well. The drip unit used in this experiment was categorised under liner low density polythene (LLDPE) lateral with drippers. Digramatic view of main submain and manifold layout is shown in Fig. 3.3 (a). Details of drip design are as follows.

i.	Type of dripper	:	Turbo key
ii.	Discharge of dripper	:	8 LPH
iii.	Dripper spacing along the lateral	:	0.75 m
iv.	Lateral size	:	16 mm
v.	Lateral spacing	:	2.25 m
vi.	Laterallength	:	12 m
vii.	Number of laterals/ treatment plot	:	4
viii.	Mainfold size	:	40 mm
ix.	Mainfold length	:	6 m
x.	Submain pipe size	:	50 mm
xi.	Submain length	:	20 m
xii.	Main pipe size	:	63 mm
xiii.	Length of main	:	100 m
xiv.	Number of emitter/ lateral	:	16
xv.	Operating pressure	:	1.0 kg/cm^2

3.3.1 Flushing system

To avoid the clogging of drippers due to physical impurities in water, both sand and screen filters were used. As the irrigation water source was from tube well and the organic residues were almost nil. The back flueshing arrangement was provided and it was operated as and when required. Sedimented material in the laterals and submains was flushed out by removing end plug and end cap occasionally.

3.3.2 Performance of drip system

In drip irrigation, it is necessary to apply water, at least to meet the ET demand of crop. To ensure the minimum essential water application from each dripper, emission uniformity of the system was worked out so that gross quantity of water was determined by dividing the net amount by emmission uniformity.

For computing emission four laterals were selected from each replication. Out of four, two were selected from middle and two from outside. These laterals were divided into four sections along the lateral length. Thus, the whole system was divided into 16 parts. Two emitters from each were selected in each replication to measure the discharge. The average value of the two sucessive emitters were taken. The emission uniformity was calculated by following formula given by Nakayama and Bucks (1986).

$$EU = 100 \left(\frac{q\ min}{q\ av.} + \frac{q\ av.}{q\ x} \right) \times \frac{1}{2}$$

Where,

EU = Emission uniformity

qmin = Minimum emitter flow rate, lph.

qav = Average emitter flow rate, lph.

qx = Average of the highest 1/8th of the emitter flow rate

3.4 Water management

3.4.1 Water requirement in surface treatments irrigation

The water requirement of the crop was determined by the procedure de ribed by Michael (1978). The formula used was,

$$WR = IR + ER + S$$

Where,

WR = Water requirement, cm

IR = Irrigation requirement, cm

ER = Effective rainfall, cm

S = Soil moisture contribution, cm.

Soil moisture contribution was considered nil, as the water table was deep enough.

3.4.1.1 Net depth of irrigation

The net depth of irrigation was determined with the help of formula suggested by Dastane (1972).

$$d = MAD \% \times AWHC$$

Where,

d = Depth of irrigation, cm

MAD = Maximum allowable depletion

AWHC = Average water holding capacity, cm

50 per cent depletion was considered. AWHC was calculated by.

$$AWHC = \frac{FC - PWP}{100} \times B.D. \times \text{Effective root zone depth, cm}$$

Where,

FC = Field capacity (%)

PWP = Permanant wilting point

BD = Bulk density g/cm^3.

Effective root zone depth was considered upto 0.6 m. AWHC of soil is 15.0 cm, so .5 cm depth of irrigation was given at every turn. Depletion is coordinated with CPE and 1 IW/CPE ratio was selected as a criteria for irrigation shceduling. Hence irrigation was scheduled at 50 CPE. Any rain received was deducted from the CPE. The rainfall equal to or less than cumulative evaporation to the day of rainfall was considered as effective (Hegde and Shrinivas, 1991).

Total water applied per turn per plot was calculated by following formula.

$$\text{Total amount of water applied per plot in liters} = \frac{A \times D}{Ea}$$

Where,

A = Total area of a plot, m^2

D = Net depth of water in mm

Ea = Application efficiency (90 %)

Time of application was calculated as,

$$T = \frac{\text{Amount of water to be applied}}{\text{Discharge of pipe (lit/hr)}}$$

Where,

T = Time in hrs.

3.4.2 Water requirement in drip irrigated treatments

The irrigation was scheduled at alternate day basis by using the pan evaporation data. depth of water application in mm was calculated by the following formula, indicated in FAO paper 36 (Vermerin and Jobling, 1980).

$$ETc = Ep \times Kp \times Kc$$

Where,

ETc = Evapotranspiration of crop (mm/two days)

Ep = Sum of two days pan evaporation (mm)

Kp = Pan factor (0.7)

Kc = Crop factor as per growth stages (FAO,33,1979)

$$ETCa = ETc \times WA$$ (Karmeli and Keller, 1975).

Where,

ETCa = Actual crop evapotranspiration of crop for drip irrigation mm/2 days

WA = Wetted area (60 %) (Karmeli and Keller, 1975)

Net alternate day water requirement in liters per plot was calculated as fallows.

$$V = Ep \times Kp \times Kc \times Aw \times S_1 \times S_2$$

Where,

V = Volume of water applied, lit/dripper/alternate day

Ep = Pan evaporation for two days mm

Kp = Pan factor (0.7)

Kc = Crop coefficient

AW = Wetted area factor (0.6)

S_1 = Lateral spacing (m)

S_2 = Dripper spacing (m)

$$\text{Actual volume of water to be applied} = \frac{V}{Eu}$$

$$= \frac{V}{0.9}$$

Where,

EU = 0.9

Time of operation of drip system was calculated by following formula,

$$\text{Operation time (hrs)} = \frac{\text{Volume of water applied lit/dripper/alternate day}}{\text{Average dripper discharge lph}}$$

The rainfall equal to or less than cumulative evaporation to the day of rainfall was considered as effective rainfall (Hegde and Srinivas, 1991).

3.4.3 Field water use efficiency

Field water use efficiency is the ratio of economic yield of crop to total water applied during its life period. It is given by equation,

$$\text{FWUE (kg/ha-cm)} = \frac{\text{Total yield (kg/ha)}}{\text{Total water use (cm)}}$$

3.5 Biometric observations

3.5.1 Sampling technique

For recording various growth observations, 5 sample plants were selected randomly from each plot. The sample plants were tagged for the observations viz., height, number of tillers, number of leaves, leaf area, number of internode, girth of internode, were recorded with an interval of one and half month till harvesting.

3.5.2 Growth studies

3.5.2.1 Emergence count and emergence percentage

The emergence count of mother shoots in each net plot was taken at 45 days after planting in the field. The emergence percentage of the respective treatments was calculated from the emergence count and the actual number of buds planted per net plot.

3.5.2.2 Number of tillers

Number of tillers from each of the five plant selected was seperately noted at one and half month interval from emergence.

3.5.2.3 Number of green leaves per plant

Number of green leaves from each of the five selected plants was noted separately at interval of one and half month.

3.5.2.4 Height of plant

The height of selected five plants from each plot was measured from ground level to the last legule of the leaf at interval of one and half month.

3.5.2.5 Leaf area

Leaf area was calculated by recording the maximum length and breadth of the green leaves of five selected observation canes by using a factor worked out by Bhan and Pandey (1966). The formula used for estimation of leaf area in sugarcane is given below :

$$\text{Leaf area} = \text{Maximum length} \times \text{Maximum breadth} \times 0.75$$

3.5.2.6 Number of internodes

The number of internodes of selected five pl in each plots was noted at interval of one and half month.

3.5.2.7 Girth of cane

The girth of internode in cm of selected five plants in each plot was noted at an interval of one and half month.

3.6.3 Weights of green tops per plots

The weight of all green tops from each net plot was recorded.

3.6.4 Height of millable canes

A day before harvesting, two plants from each plots were cut close to ground their millable heights were recorded. Length of millable canes was measured from bottom to highest visible transverse mark of last internode of the top portion of cane.

3.7 Juice quality stuides

3.7.1 Pol reading

The juice was clarified by adding 2 to 3 g of monobasic unhydrous lead acetate powder to about 100 ml juice to precipitate the inpurities and tannins in the juice. It was then filtered through whatman No.1 filter paper. The filtered juice was transfered to the pol tube and readings were taken on polaroscope as decribed by Spencer and Meade (1964).

3.7.2 Sucrose percent

The sucrose percentage in juice was calculated from Schmitz table for Horne's Dry Lead Acetate Method as explained by Spencer and Meade (1964).

3.7.3 Purity percentage

The purity percentage of juice was calculated by using the following formula, suggested by Spencer and Meade (1964).

$$\text{Purity (\%)} = \frac{\text{Sucrose percentage}}{\text{Corrected brix}} \times 100$$

3.7.4 Corrected brix

The reading of freshly extracted juice was recorded by brix hydrometer along with room tempreture. These reading were corrected at 27.5^{o}C as described by Spencer and Meade (1964).

3.8 Chemical analysis

3.8.1 Soil analysis

Soil samples from 0-15, 15-30 and 30-45 depth from each plots were collected after havrvest of the crop. They were ground in wooden pestal and morter after air drying and passed through 2 mm sieve and used for chemical analysis to determine the available NPK in the soil after harvest. The methods used for soil NPK analysis are indicated in Table 3.1.

3.8.2 Plant analysis

1. Nitrogen was estimated by modified Micro-Kjeldhal's method.
2. Phosphorus was determined in an aliquat of the acid extract by measuring the intensity of the vandophospho-molybdate yellow colour on spectronic-20.
3. Potassium concentration in the plant was determined on help of flame photometer.

The NPK uptake of sugarcane plant was calculated at harvest from concentration of NPK and weight of cane per plot at harvest.

3.9 Fertilizer saving

The fertilizer saving was calculated from the total yield of net plot of different treatments. The yield of different treatments were compared and saving of fertilizer was calculated.

3.10 Fertilizer use efficiency

The fertilizer use efficiency was calculated by the following formula.

$$\text{Fertilizer use efficiency} = \frac{\text{Yield in kg/ha}}{\text{Fertilizer dose (kg)}}$$

Fertilizer dose take as the NPK total in kg.

3.11 Cost of cultivation

The cost of cultivation was calculated for drip irrigation treatments and surface irrigation treatments. The cost of cultivation includes all the items and operation from preliminery operation upto transport of produce, and also includes the supervision charges, interest on capital and rental value of land.

3.12 Gross return

The gross return was calculated by multiplying the yield of produce with their selling price. The gross return of each treatments was calculated by multiplying the selling price with their respective yield.

3.13 Net return

The net return was the difference in income produce and seasonal total cost. The seasonal total cost was subtracted from the income from respective treatments.

Net return = Income from produce - Seasonal total cost

3.14 Net return/mm of water used

The net return/mm of water used was calculated by dividing the net return of each treatment with total water used in milimeter in that treatment.

3.15 Cost benefit ratio

Cost of sugarcane production and monetory returns in different treatments in the drip irrigation and surface method plots and economy in planting material and total inputs was worked out by considering the prices of inputs and sugarcane.

3.16 Statistical analysis

The data relating to the each character was statistically analysed by randomised block design. A standard method of `Analysis of variance' as described by Panse and Sukhatme, (1957) was used.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The results obtained from the present investigation are presented in the tables in appropriate form, after the necessary statistical analysis. The results obtained are interpreted in an integrated manner to draw the broad conclusions in forgoing chapter, under the following heads.

4.1 Biometric observations

4.2 Yield and yield attributes

4.3 Water balance studies

4.4 Quality stuides

4.5 Leaf NPK concentration at harvest

4.6 NPK uptake

4.7 Fertilizer saving and fertilizer use efficiency

4.8 Economic studies

4.1 **Biometric observations**

Periodical observations were recorded with an interval of 45 days, on major growth contributing characters viz., plant height, number of functional leaves and leaf area, Perodical data of all these parameters are given under respective heading. In general, each parameters exhibited linear increase during grand growth period followed by sharp decline thereafter.

4.1.1 **Emergence percentage**

The mean emergence percentage of cane was 94.07 (Table 4.1). The differences in the emergence percentage due

Table 4.1 Mean plant count and emergence percentage as influenced by different treatments.

Treatment	Plant count		Emergence percentage
	Therotical count	Initial count	
T_1 i.e. RDSF + SI	32922.00	30940.00	93.98
T_2 i.e. RDSF + ND	32922.00	31005.10	94.18
T_3 125 RDLF + DI	32922.00	31154.10	94.63
T_4 100 RDLF + DI	32922.00	31068.50	94.37
T_5 75 RDLF + DI	32922.00	30887.42	93.82
T_6 50 RDLF + DI	32922.00	30768.90	93.46
'F' test			N.S.
S.E. ±			0.412
C.D. at 5 %			-
General mean	32922.00	30970.67	94.07

N.S.: Not Significant

to treatments were not significant indicating a common and uniform plant population existed in all the plots and thus the treatments were compared unbiassed and uniform seat of comparis on giving equal chance for expressing their merits.

4.1.2 Plant height

The periodical data in respect of the plant height as influenced by different treatments are presented in Table 4.2 and graphically depicted in Fig. 4.1. The average plant height was 40.11 cm at 45 DAS which increased to its maximum (394.13 cm) at harvest.

The plant height differed significantly with different levels of fertilizer throughout the growth period of the crop. Application of 125 per cent recommended dose of fertilizer in the form of liqud fertilizer through drip registered maximum plant height which was significantlly more than those obtained from other levels of nitrogen at all the days of observations.

Amongst the liquid fertilizer treatments, the plant height decreased with every sucessive reduction in the fertilizer level at all the observations dates. The maximum height was recorded in treatment T_3 (125 %, RD) which might be due to the effect of higher fertilizer dose. Heights in T_2 i.e. RDSF + ND, T_4 i.e. 100 per cent L.F. and T_5 i.e. 75 per

Table 4.2 Mean height of plant as influenced by different treatments cm

Treatment	Days after planting							
	45	90	135	180	225	270	315	At harvest
T_1 i.e. RDSF + SI	38.97	134.45	228.42	325.01	344.68	361.03	367.82	391.73
T_2 i.e. RDSF + ND	40.40	139.79	235.60	335.22	355.48	372.36	379.39	395.40
T_3 125 RDLF + DI	41.30	143.66	242.09	344.42	365.24	382.61	389.84	398.13
T_4 100 RDLF + DI	40.49	140.72	237.30	337.30	357.68	374.81	382.13	395.86
T_5 75 RDLF + DI	40.16	139.59	235.40	334.62	354.84	371.71	379.06	394.73
T_6 50 RDLF + DI	39.36	136.79	230.68	328.21	348.05	364.58	371.46	393.53
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.106	0.365	0.621	0.861	0.913	0.975	0.99	0.34
C.D. at 5 %	0.333	1.15	1.955	2.712	2.87	3.070	3.11	1.05
General mean	40.11	139.32	234.91	334.13	354.32	371.18	378.28	394.93

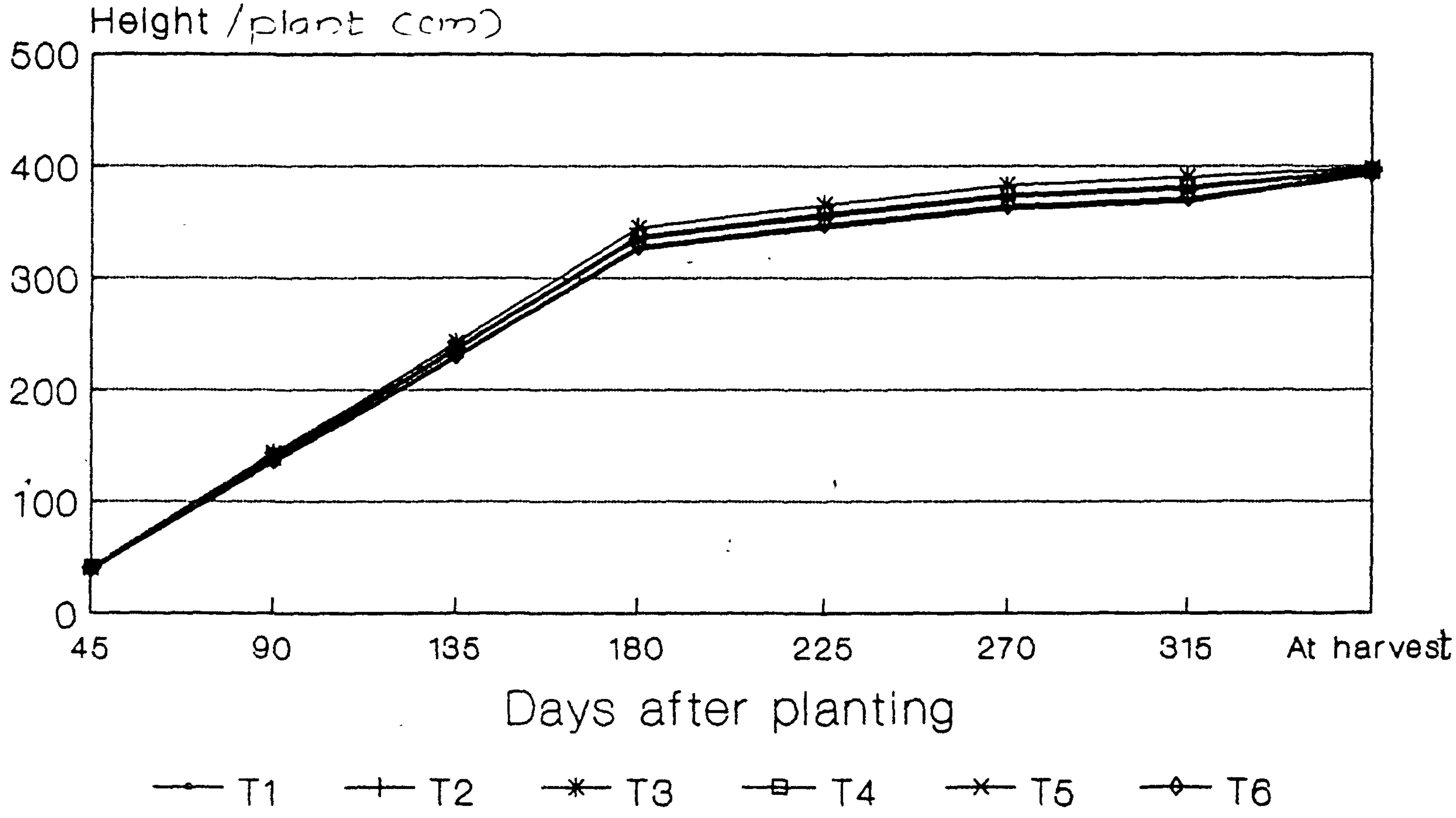


Fig.4.1 Mean height of plant as influenced by different treatments (cm)

cent L.F. were at par with each other. It indicated the superiority of liquid fertilizers over solid fertilizer. The, minimum plant height was observed in conventional method of irrigation with recommended dose of solid fertilizers (T_1) throughout the growth period which was significantly less than that observed in 50 per cent level of liquid fertilizer (T_6) with during impatern at all the days of observations. This may be attributed to the moisture stress experienced by the crop in surface irrigation compared with the alternate day application of water through drip and also the fertilizer applied in minimum splits in T_1 compared with the ten splits of fertilizer in drip irrigation system. These observations are in agreement with the observations of Patil (1988) and Hapse (1989).

4.1.2 Number of functional leaves

The data relating to the mean number of functional leaves per plant as influenced periodically by the different treatments are presented in Table 4.3 and graphically depicted in Fig. 4.2. The mean number of functional leaves increased with advancement in the age of the crop upto 135 DAS, thereafter, it was slowly declined upto 225 DAS and remained unaffected upto harvest indicating that the number of funcational leaves/plants were at higher magnitude during the grand growth phase of the crop and thereafter due to

Table 4.3 Mean number of functional leaves per plant as influenced by different treatments

Treatment	Days after planting							
	45	90	135	180	225	270	315	At harvest
T_1 i.e. RDSF + SI	8.68	12.20	15.21	14.14	10.11	11.56	11.76	11.33
T_2 i.e. RDSF + ND	8.95	12.38	15.69	14.58	10.21	11.92	11.12	13.20
T_3 125 RDLF + DI	9.19	12.77	16.32	14.99	10.41	12.25	12.45	13.90
T_4 100 RDLF + DI	9.01	12.42	15.80	14.78	10.43	12.01	12.20	13.20
T_5 75 RDLF + DI	8.94	12.36	15.66	14.55	10.50	11.92	12.10	13.00
T_6 50 RDLF + DI	8.76	12.12	15.36	14.28	10.73	11.67	11.86	12.33
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. $\pm$	0.024	0.094	0.096	0.134	0.028	0.032	0.034	0.301
C.D. at 5 %	0.075	0.297	0.301	0.421	0.089	0.100	0.106	0.948
General mean	8.92	12.37	15.67	14.55	10.39	11.88	12.08	12.82

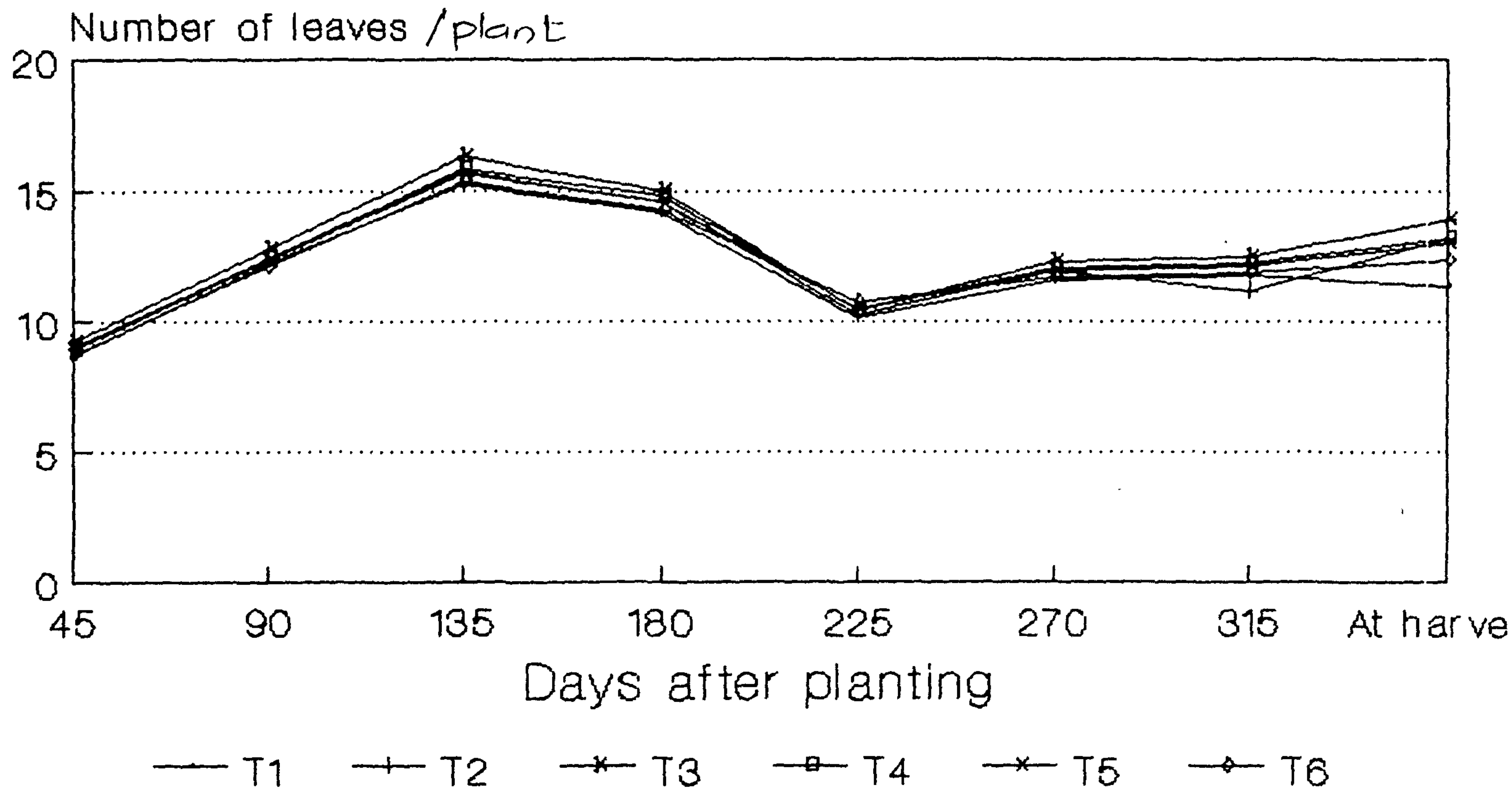


Fig.4.2 Mean number of functional leaves per plant as influenced by different treatments

senescence, the number of functional leaves reduced substantially as age advanced. The maximum number of functional leaves per plant were recorded at 135 DAs.

The data in Table 4.3 revealed that the differences in number of functional leaves/plant differed significantly due to different treatments at all the days of observations. The treatment T_3 i.e. 125 per cent liquid fertilizer of recommended dose through drip irrigation registered significantly more number of functional leaves than other treatments at all stages, except at 180, 225 and at harvest which was at par with T_4 (100 % LF). At 90, 135 and 180 DAP the treatments T_1, T_2, T_4, T_5 and T_6 did not show any significant effect on number of functional leaves per plant.

4.1.3 **Leaf area/plant**

The data pertaining to the mean leaf area per plant as influenced periodically by the different treatments are presented in Table 4.4 and graphically depicted in Fig. 4.3. The mean leaf area per plant increased with the advancement of the age of the crop till harvest. The mean values of the leaf area/plant were 1.78, 3.21, 4.10, 5.21, 5.94, 6.99, 7.40 and 8.35 m^2/plant at various stages of observation, respectively.

The leaf area/plant registered maximum in T_3 i.e. 125 per cent liquid fertilizer of recommended dose which was

Table 4.4 Mean leaf area per plant as influenced by different (m^2/plant)

Treatment	Days after planting							
	45	90	135	180	225	270	315	At harvest
T_1 i.e. RDSF + SI	1.65	2.97	3.79	4.80	5.56	6.47	6.83	7.72
T_2 i.e. RDSF + ND	1.77	3.19	4.07	5.29	5.98	7.16	7.54	8.28
T_3 125 RDLF + DI	2.01	3.61	4.62	5.66	6.39	7.45	7.77	9.39
T_4 100 RDLF + DI	1.83	3.29	4.21	5.32	6.06	7.19	7.72	8.55
T_5 75 RDLF + DI	1.76	3.15	4.03	5.23	5.95	6.99	7.48	8.19
T_6 50 RDLF + DI	1.71	3.07	3.92	5.00	5.72	6.54	7.08	7.98
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.020	0.037	0.047	0.037	0.034	0.062	0.084	0.092
C.D. at 5 %	0.061	0.117	0.150	0.116	0.109	0.197	0.267	0.306
General mean	1.78	3.21	4.10	5.21	5.94	6.99	7.40	8.35

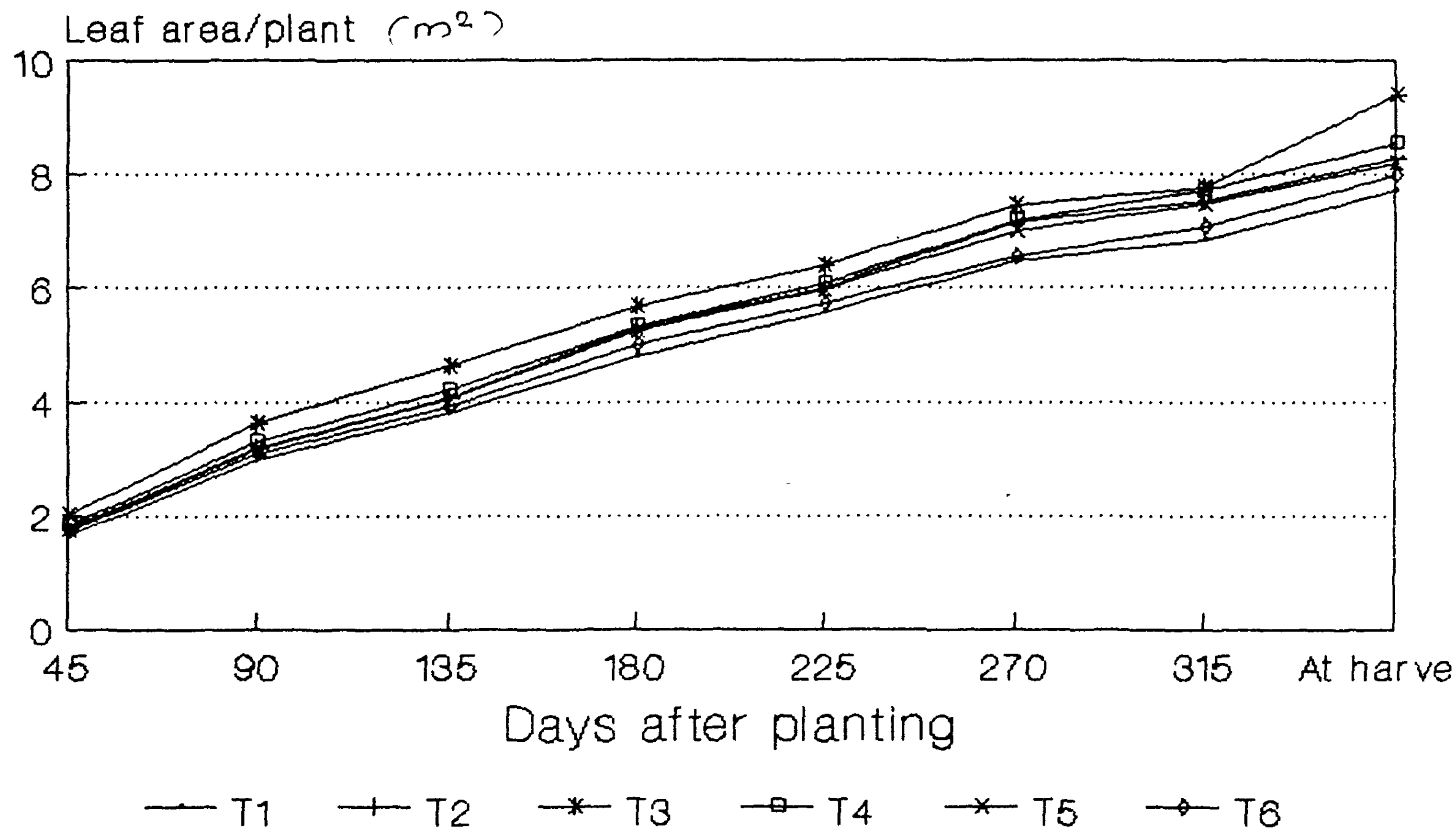


Fig.4.3 Mean leaf area per plant as
as influenced by different (m /plant)

significantly more than that obtained in rest of the treatments throughout the growth period. Amongst the liquid fertilizers, the leaf area decreased with decrease in levels of nitrogen L.F. being minimum at 50 per cent liquid fertilizer of recommended dose through drip which was at par with 100 per cent recommended dose of solid fertilizer with surface irrgation at all the days of observations except 180 and 225 DAS.

It was obviously due to beneficial effect of liquid fertilizer on leaf area per plant which increased with increase in levels of liquid fertilizer. Due to constant availability of soil moisture maintained in drip irrigaiton treatments they recorded higher leaf area per plant than surface irrigation treatment throughout the crop growth period. The treatment T_1 i.e. surface irrigation + solid fertilizer, registered less leaf area than other treatments at all growth stages, it might be due to less availability of fertilizer and soil moisture. The results are in conformity with those reported by Dukre (1991) and Maher (1991).

4.1.4 **Dry matter accumulation**

The data pertaining to the mean dry matter per plant as influenced periodically by the different treatments are presented in Table 4.5 and graphically depicted in Fig. 4.4. From the data in Table 4.5, it could be observed that the

Table 4.5 Mean dry matter per plant as influenced by different treatment (gm/plant)

Treatment	Days after planting			
	90	180	270	At harvest
T_1 i.e. RDSF + SI	20.74	118.91	467.41	714.21
T_2 i.e. RDSF + ND	21.50	123.29	484.63	740.21
T_3 125 RDLF + DI	21.90	125.56	493.17	754.13
T_4 100 RDLF + DI	21.59	123.79	486.59	743.73
T_5 75 RDLF + DI	21.46	123.06	483.71	739.19
T_6 50 RDLF + DI	20.88	119.73	470.78	719.16
'F' test	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.055	0.318	1.176	1.975
C.D. at 5 %	0.172	1.001	3.704	6.220
General mean	21.34	123.39	481.04	735.10

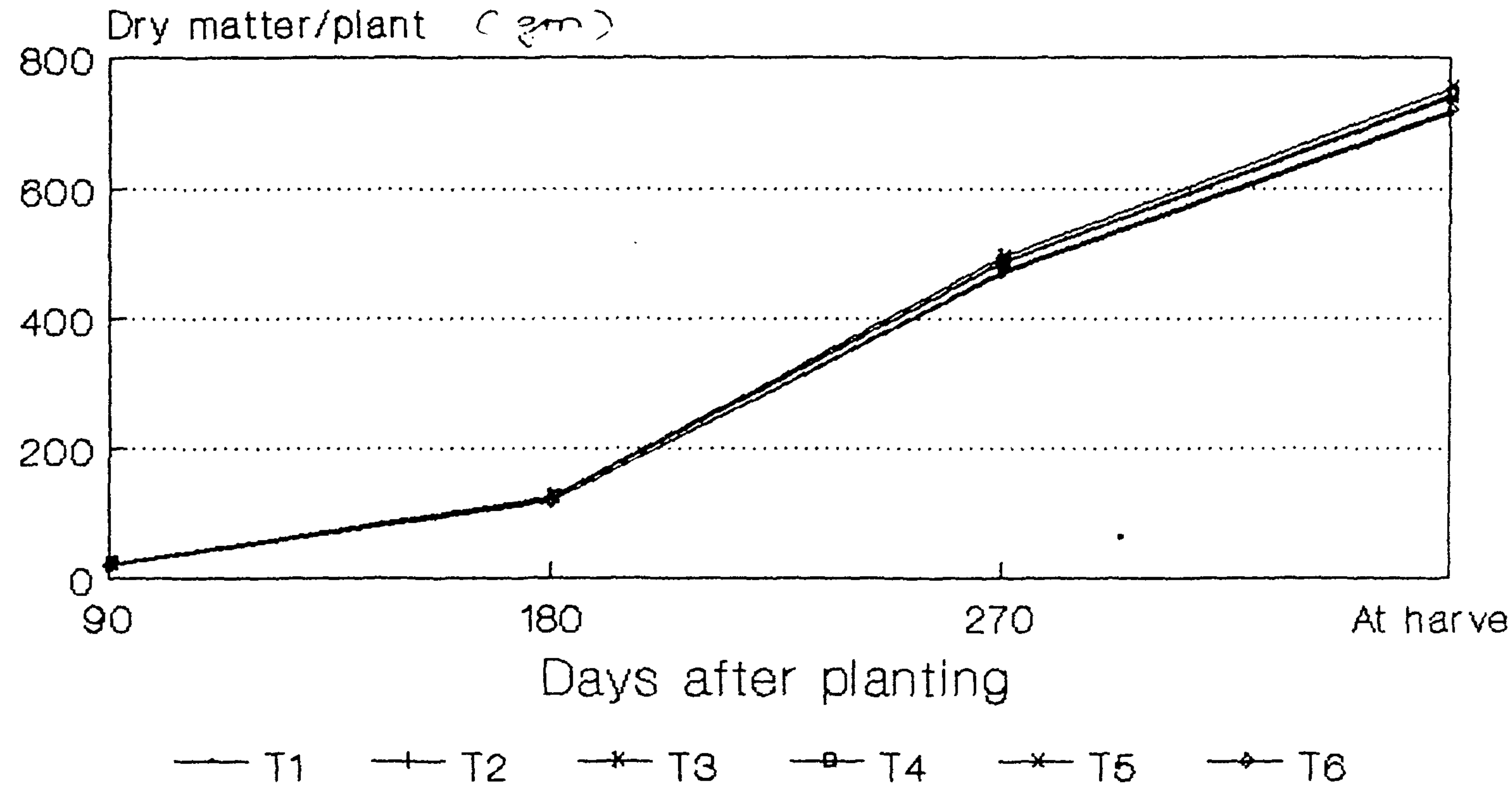


Fig.4.4 Mean dry matter per plant as influenced by different treatment (g/plant)

mean dry matter accumulations per plant was increased with increase in the rate of liquid fertilizer upto 270 DAP. The rate of increase in total dry matter production per plant was maximum at harvest (735.10 g/plant) inoculation. The further critical study revealed that the dry matter accumulation per plant was more in drip irrigated treatments compared with the surface irrigation treatment throughout the growth period. There was vigorous growth due to more availability of fertilizer and moisture.

The treatment T_3 i.e. 125 per cent liquid fertilizer registered significantly more mean dry matter/plant than rest of treatments at all growth stages of crop. This was closely followed by application of 75 per cent liquid fertilizer of R.D. through drip at all the days of observations. Amongst the level of liquid fertilizers tested, the dry matter accumulation per plant decreased with every sucessive decrease in the levels of nitrogen, it being minimum with 50 per cent liquid fertilizer of R.D. applied though drip which was at par with 100 per cent recommended dose of solid fertilizers with surface irrigation (T_1) at all the days of observations. The dry matter production in treatment T_1 was less compared with rest of the treatments because there was less spliting of fertilizers and less availability of soil moisture compared with drip irrigation.

These results are in agreement with those reported by Lakshimikanthm et al. (1964).

4.2 Yield and yield contributing characters

4.2.1 Number of tillers

The data relating to the mean number of tillers as influenced periodically by the different treatments are presented in Table 4.6 and graphically depicted in Fig. 4.5. The mean number of tillers/plant increased with the advancement in the age of the crop. The values were 6.36, 10.60 and 14.97 at 45, 90 DAP and at harvest respectively. From the data it could be seen that treatment T_3 i.e. 125 per cent of liquid fertilizer, recorded significantly more number of tillers per plant than observed in any other treatments tried at 45, 90 DAS and at harvest. The number of tillers/plant reduced substantially with every sucessive reduction in the levels of liquid fertilizer it being minimum with 50 per cent liquid fertilizer applied through drip. However, application of 100 per cent recommended dose of solid fertilizer with surface irrigation it was the lowest in respect of number of tillers/plant and was at par with T_6 i.e. 50 per cent liquid fertilizer aplication throughout the crop growth period. Hapse (1989) also recorded the same trend in respect of number of tillers/plant due to levels of nitrogen.

Table 4.6 Mean dry matter per plant as influenced by different treatment (gm/plant)

Treatment	Days after planting		
	45	90	At harvest
T_1 i.e. RDSF + SI	5.70	9.49	13.40
T_2 i.e. RDSF + ND	6.35	10.58	14.93
T_3 125 RDLF + DI	7.40	12.32	17.40
T_4 100 RDLF + DI	6.46	10.77	15.20
T_5 75 RDLF + DI	6.29	10.47	14.80
T_6 50 RDLF + DI	6.01	10.01	14.13
'F' test	Sig.	Sig.	Sig.
S.E. ±	0.197	0.329	0.473
C.D. at 5 %	0.621	1.037	1.489
General mean	6.36	10.60	14.97

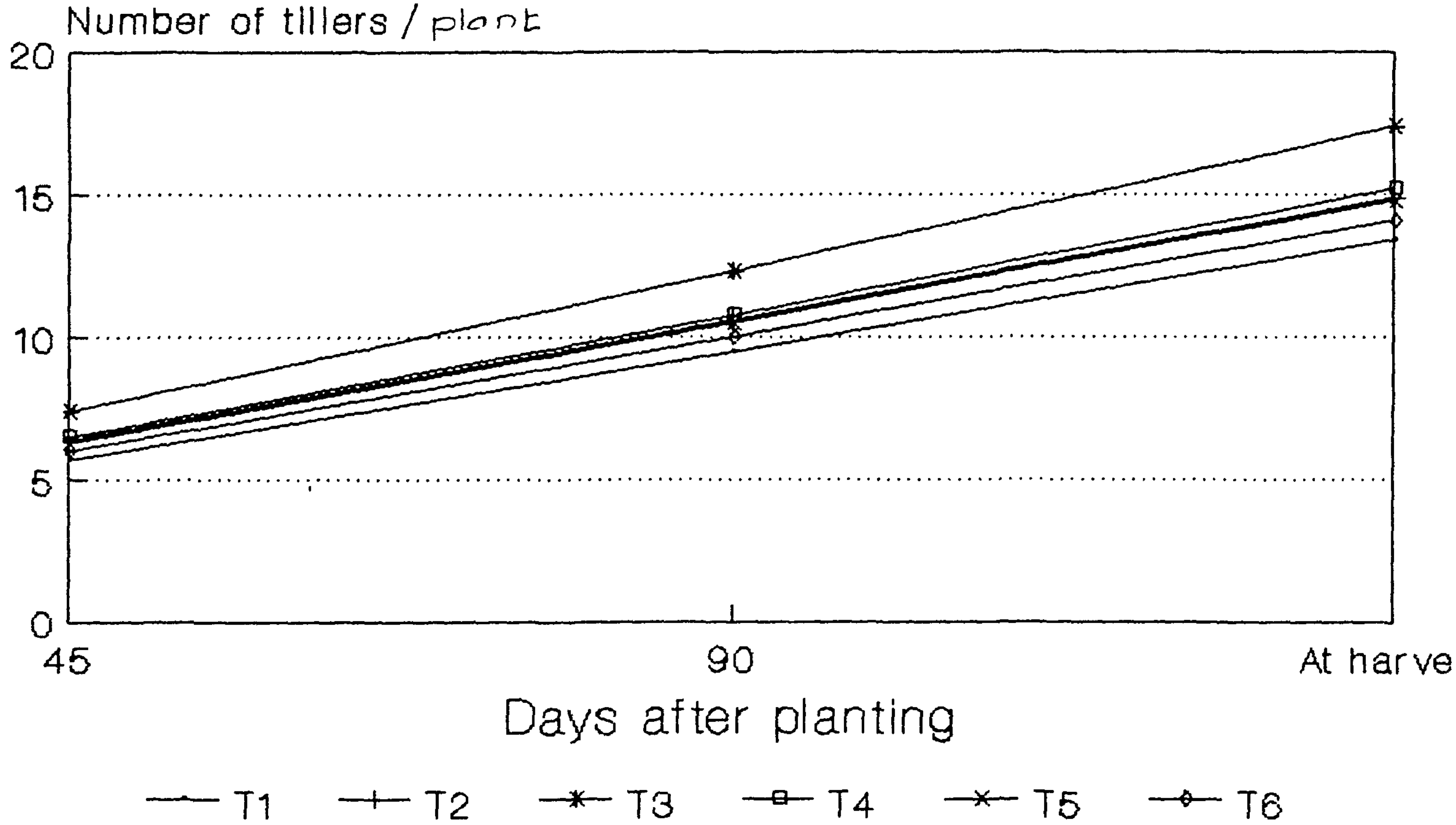


Fig.4.5 Mean number of tillers as influenced by different treatment

4.2.2 Number of internodes

The data pertaining to the mean number of internodues per cane as influenced by the different treatments are presented in Table 4.7 and graphically depicted in Fig. 4.6. The mean number of internodes per cane was 6.90, 10.2, 12.19, 17.19, 21.08 at 180, 225, 230, 315 DAS and at harvest, respectively.

From the data it was observed that treatment T_3 i.e. 125 per cent liquid fertilizer, registered maximum and significantly more number of internodes than those obained in the rest of the treatments. Amongst the liquid fertilizer treatments, the number of internodes per cane decreased with decrease in the levels of nitrogen. The 100 per cent recommended dose in the solid fertilizer form with surface irrigation registered less number of tillers at all the days of observations, however, it was at par with 50 per cent liquid fertilizer of R.D. with drip irrigation at all stages of growth i.e. at 180, 225, 270, 315 and 360 DAP. The treatment T_1, T_2, T_4, T_5 and T_6 did not differ significantly in respect of mean number of internode at harvest. It indicated that number of internodes were not significantly influenced by irrigation methods as reported earlier by Hegde and Srinivas (1991).

Table 4.7 Mean number of internode per plant as influenced by different treatment

Treatment	Days after planting				
	180	225	270	315	At harvest
T_1 i.e. RDSF + SI	6.72	9.84	12.55	17.42	20.20
T_2 i.e. RDSF + ND	6.93	10.21	13.02	17.97	21.13
T_3 125 RDLF + DI	7.12	10.39	13.25	18.46	22.33
T_4 100 RDLF + DI	6.96	10.24	13.06	18.08	21.33
T_5 75 RDLF + DI	6.92	10.18	12.99	17.95	20.86
T_6 50 RDLF + DI	6.79	9.91	12.64	17.59	20.66
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.018	0.025	0.032	0.047	0.47
C.D. at 5 %	0.057	0.079	0.100	0.148	1.42
General mean	6.90	10.12	12.91	17.91	21.08

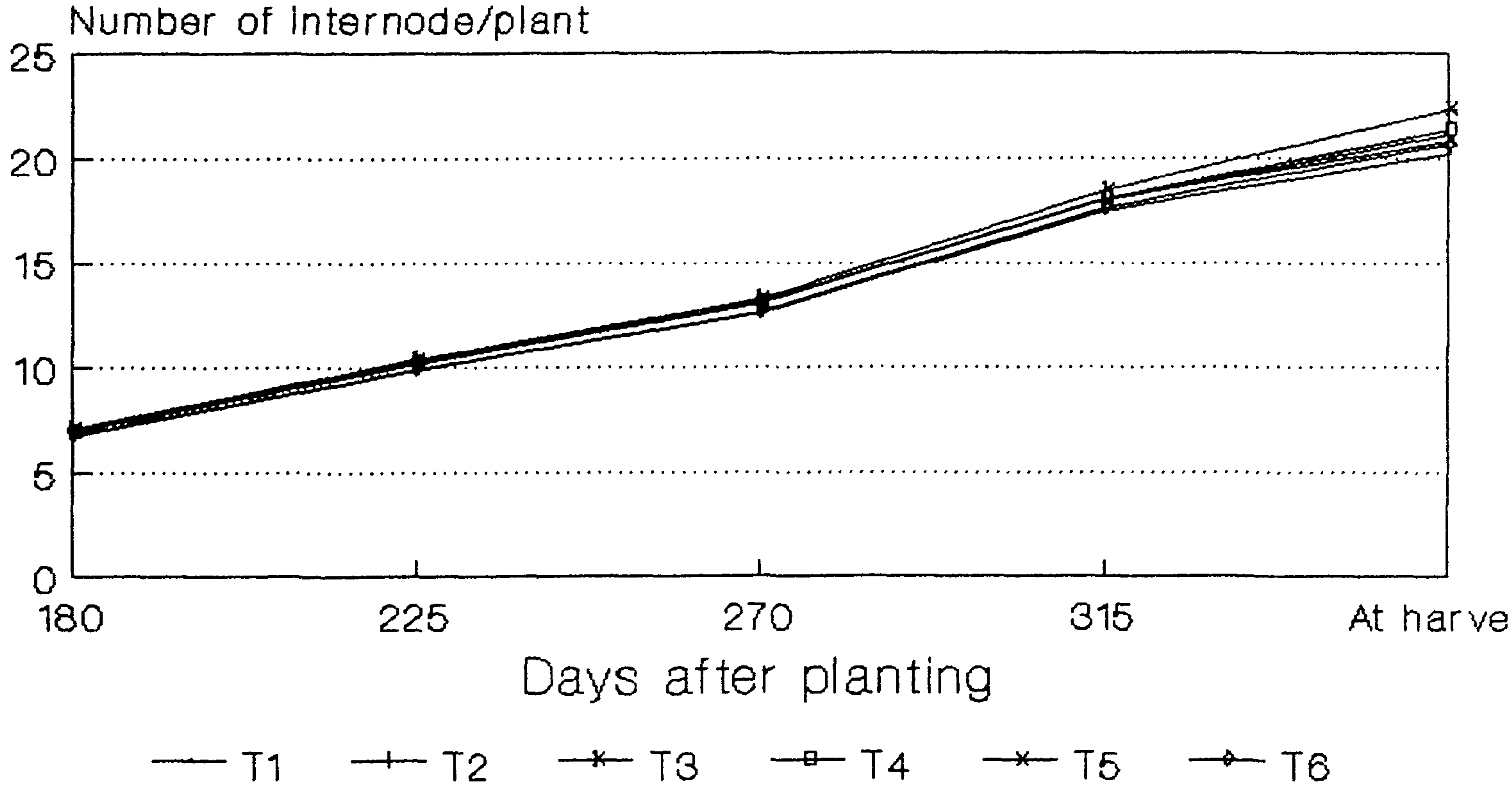


Fig.4.6 Mean number of internode per plant as influenced by different treatments

4.2.3 Girth of internode

The data relating to mean girth of internode as influenced perodically by the different treatments are presented in Table 4.8 and graphically depicted in Fig. 4.7. The mean girth of internodes are 9.11, 9.64, 10.0, 10.98 and 11.12 cm at 180, 225, 270, 315 DAP and at harvest, respectively. From the data it was observed that treatment T_3 i.e. 125 per cent liquid fertilizer registared significantly more mean girth of internode than any other treatments tried. The mean girth of internode in Treatments T_2, T_4 and T_5 were at par with each other at all stages of growth. The treatment T_6 i.e. 50 per cent liquid fertilizer, also registared significantly more girth of internode than that observed in treatment T_1. The girth of internode in treatment T_3 was the highest due to 125 per cent liquid fertilizer dose and was decreased with decreasing levels of fertilizer. These results are in conformity with those reported by Patil et al. and More et al. 1983.

4.2.4 Height of millable cane

The data pertaining to the height of millable cane at harvest as influenced by different treatments are presented in Table 4.9. The mean height of millable cane was 148.13 cm. From the data (Table 4.9) if could be seen that the treatment T_3 i.e. 125 per cent liquid fertilizer registered significantly more height of millable cane than that observed

Table 4.8 Mean girth of internode as influenced by different treatment (cm/plant)

Treatment	Days after planting				
	180	225	270	315	At harvest
T_1 i.e. RDSF + SI	8.86	9.36	9.72	10.68	10.82
T_2 i.e. RDSF + ND	9.14	9.65	10.03	11.01	11.16
T_3 125 RDLF + DI	9.39	10.04	10.31	11.32	11.47
T_4 100 RDLF + DI	9.20	9.72	10.10	11.09	11.24
T_5 75 RDLF + DI	9.13	9.65	10.02	11.00	11.15
T_6 50 RDLF + DI	8.95	9.45	9.82	10.78	10.93
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.E. ±	0.024	0.025	0.026	0.029	0.029
C.D. at 5 %	0.075	0.08	0.083	0.091	0.091
General mean	9.11	9.64	10.00	10.98	11.12

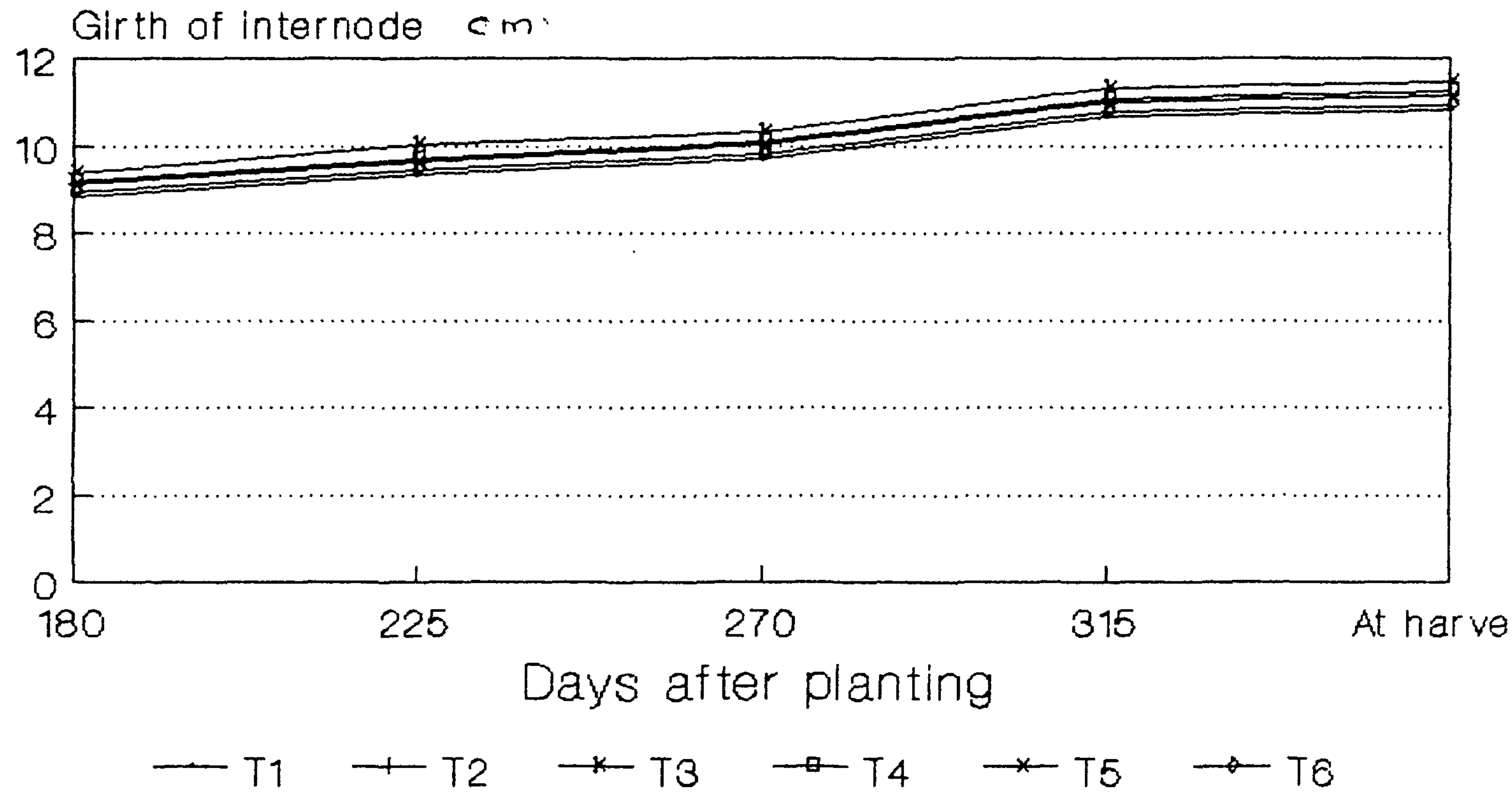


Fig.4.7 Mean girth of internode as influenced by different treatments (cm/plant)

in rest of treatments studied (152.71 cm). The treatments T_2 (148.627 cm), T_4 (149.49 cm) and T_5 (148.36) were at par with each other. The treatment T_6 registered more height millable cane (145.52 cm) which was signifiantly more than treatment T_1 (144.103 cm). The treatment T_3 recorded maximum height of millable cane because of higher liquid fertilizer dose compared with other treatments. The treatment T_1 registered less millable height which might be due to less fertilizer spliting coupled with moisture stress experienced by the crop.

4.2.5 **Number of millable canes**

The data relating to mean number of millable canes per hactare as influenced by different treatments are presented in Table 4.9. The mean number of millable canes/ha was . From the data in table 4.9 it could be observed that the differences in number of millable cane/ha due to different treatments were significant. Application of 125 per cent liquid fertilizer registered significantly more number of millable canes than those obtained in rest of treatments. The treatment T_2, T_4 and T_5 were at par with each other. However, expression of this character declined substantially with successive reduction in fertilizer dose. The treatment T_1 registered less number of millable canes than treatment T_6 i.e. 50 per cent liquid fertilizer.

Table 4.9 Number of millable canes, height of milleable canes and weight of green tops as influenced by different treatments

Treatment	No.of milleable canes	Height of milleable canes (cm)	Weight of green tops (t/ha)
T_1 i.e. RDSF + SI		144.10	37.48
T_2 i.e. RDSF + ND		148.62	38.65
T_3 125 RDLF + DI		152.71	39.71
T_4 100 RDLF + DI		149.49	38.83
T_5 75 RDLF + DI		148.36	38.57
T_6 50 RDLF + DI		145.52	37.84
'F' test		Sig.	Sig.
S.E. ±		0.390	0.10
C.D. at 5 %		1.228	0.315
General mean		148.13	38.51

4.2.5 Weight of green tops

The data in respect of weight of green tops as influenced by different treatments are presented in Table 4.9. The mean weight of green tops of cane was 38.51 t/ha. It could be observed (Table 4.9) that treatment T_3 i.e. 125 per cent liquid fertilizer, registered significantly more (39.717 t/ha) weight of green tops than those observed in any other treatments studied. The treatments T_2 (38.653 t/ha), T_4 (38.83 t/ha) and T_5 (38.57 t/ha) were at par with each other. The treatment T_1 (37.48 t/ha) registered signifiantly less weight of green tops than treatment T_6 (37.84 t/ha) i.e. 50 per cent liquid fertilizer, it might be due to less fertilizer and soil moisture stress.

4.2.6 Yield

The data relating to yield of cane (t ha^{-1}) as influenced by different treatments are presented in Table 4.10 and graphically depicted in Fig. 4.8. The mean yield of cane was 159.70 t ha^{-1}. The differences in mean cane yield due to different levels of fertilizer and method of irrigation were significant.

From the data, it could be observed that treatment T_3 (176.37 t ha^{-1}), application of 125 per cent liquid fertilizer of recomended dose registered maximum yield, which was significantly more than those obtained from T_1 (136.4 t

Table 4.10 Yield of cane as influenced by different treatments

Treatment	Yield of cane (t/ha)
T_1 i.e. RDSF + SI	136.40
T_2 i.e. RDSF + ND	166.21
T_3 125 RDLF + DI	176.37
T_4 100 RDLF + DI	172.37
T_5 75 RDLF + DI	167.08
T_6 50 RDLF + DI	139.80
'F' test	Sig.
S.E. ±	9.214
C.D. at 5 %	29.929
General mean	159.70

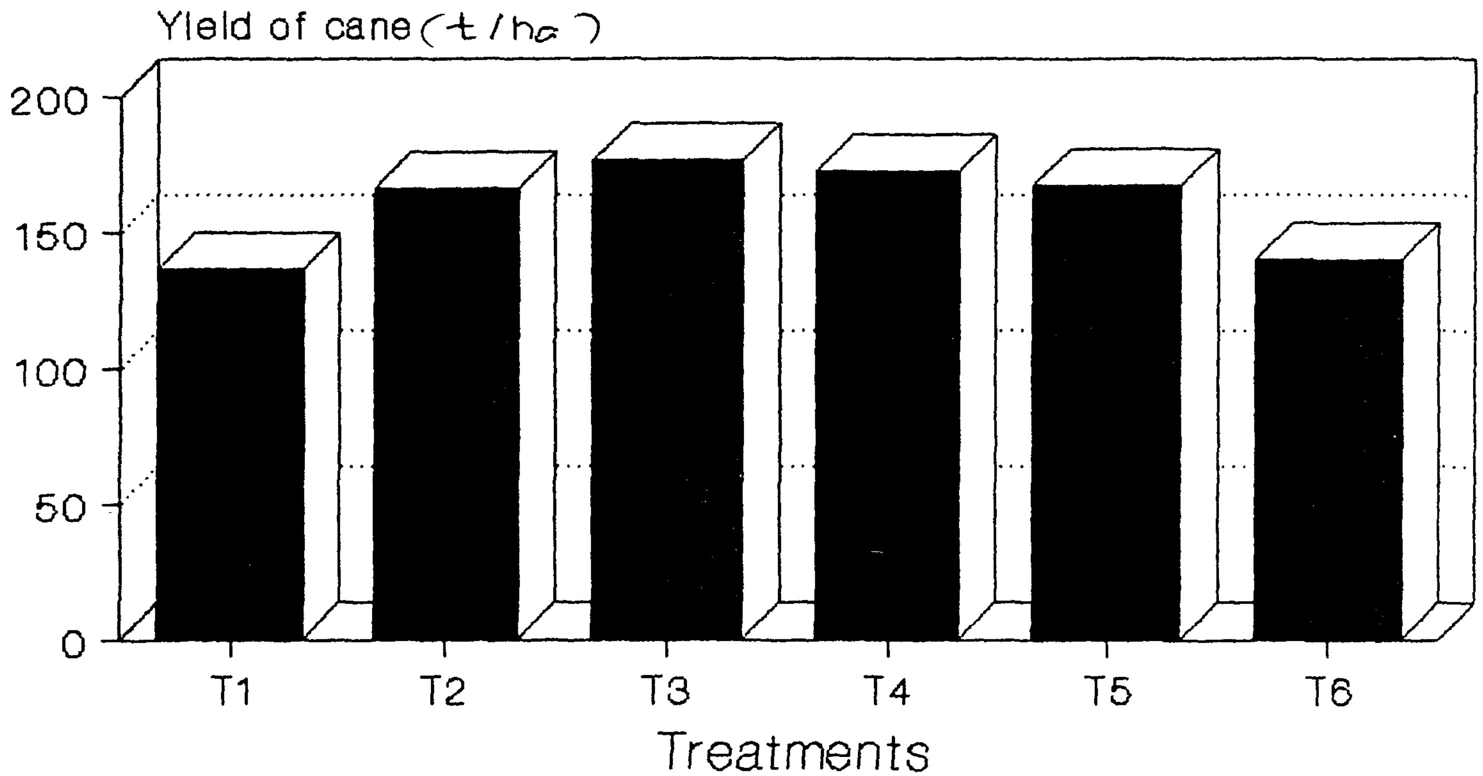


Fig.4.8 Yield of cane as influenced by different treatments

ha^{-1}) and T_6 (139.83 t ha^{-1}), but was at par with treatment T_2 (166.21 t ha^{-1}), T_4 (172.37 t ha^{-1}) and T_5 (167.09 t ha^{-1}).

Among the liquid fertilizer treatments, the yield of cane decreased substantialy with decrease in the levels of liquid fertilizer. The cane yields obtained due to liquid fertilizer levels range from 125 to 75 per cent were at par with each other and significantly more than the yield obtained due to 50 per cent level of liquid fertilizer, this would indicate that the performance of liquid fertilizer with 75 per cent recommended dose was almost equal to that of 100 and 125 per cent of recommended dose of liquid fertilizer, there by resulting in saving of fertilizer to the extent of 25 per cent. The further critical studies revealed that application of 50 per cent recommended dose of fertilizer in liquid form registered the cane yield of 139.8 t ha^{-1}, which was at par with 100 per cent recommended dose of solid fertilizer (136.4 t/ha) with surface irrigation. This would indicate that fertilizer saving was to the extent of 50 per cent. Further it was observed that application of 100 per cent recommended dose of fertilizer only N through drip treatment registered 166.21 t/ha which was at par with 75 per cent recommended dose of liquid fertilizer, thereby indicating that if liquid fertilizer are not available in the market or available at high rates, it could be possible to switch over to solid fertilizer with 100 per cent recommended dose of which `N' be applied through drip.

The yield obtained due to liquid fertilizer with drip irrigation was at higher magnitude compared with that obtained from recommended dose of solid fertilizer with surface irrigation. This might be due to efficient utilization of liquid fertilizer applied in 10 splits coupled with optimum soil moisture maintained throughout crop growth period by applying desired quantity of water at every alternate day through drip irrigation. These results are in conformity with those reported by Mane et al. (1985), Bernstain and Francois (1983) and Magar and Bhapkar (1990).

4.3 Water balance studies

The total seasonal water requirement of the crop for both conventional and drip system was worked out for total crop period. The irrigation was stopped a weak earlier to harvest of the crop. Details about irrigation scheduling followed during the crop period are given in Appendix-I.

The data regarding the water applied, effective rainfall, seasonal water requirement, water saving and water use efficiency are presented in Table 4.11.

From the data in Table 4.11, it could be observed that water applied in drip system throughout the growth period

Table 4.11. Details of water applied, effective rainfall, seasonal water requirement water saving and water use efficiency as influenced by different treatments.

Treatments	Water applied (cm)	Effective rainfall (cm)	Seasonal water requirement (cm)	Water saving (%)	Yield t/ha	Water use efficiency (at field level) (kg/ha-cm)
T_1	180.96	46.47	227.43	-	136.40	599.74
T_2	85.95	25.54	111.49	50.97	166.21	1490.80
T_3	85.95	25.54	111.49	50.97	176.37	1581.94
T_4	85.95	25.54	111.49	50.97	172.37	1546.06
T_5	85.95	25.54	111.49	50.97	167.08	1497.89
T_6	85.95	25.54	111.49	50.97	139.83	1253.92

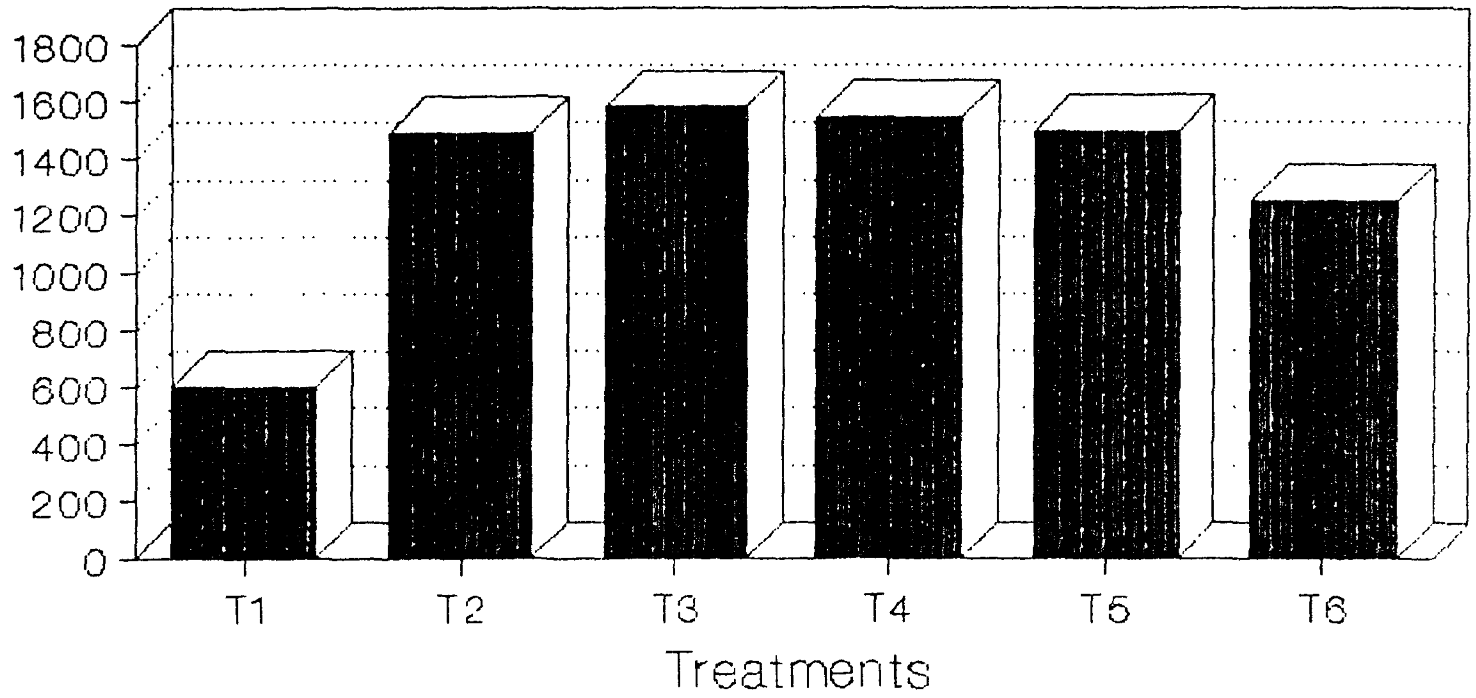


Fig. 4.9. Water use efficiency as influenced by different treatments (kg/ha-cm)

of cane (85.95 cm) was very much less as compared with the surface method of irrigation T_1 (180.96 cm), because unlike conventional treatment T_1, in drip only root zone of crop was wetted and the water was applied as per the crop requirement. Losses due to runoff and deep percolation were also checked by delivering the water with safer discharge. Effective rainfall in drip was also less (25.54 cm) as compared with conventional (46.47 cm) method because in drip saturation deficit of soil was less continuously throughout the life period. Total seasonal water requirement of the sugarcane crop was 111.49 cm in the drip irrigation, while it was 227.43 cm in surface method of irrigation resulting 50.97 per cent water saving due to drip when compared with conventional method of irrigation. The simillar results were also obtained by Deshmukh *et al*. (1988). The advantage of drip system over conventional was more clearly and precisely reflected in field water use efficiency expressed in kg yield produced per cm of water applied.

The water use efficiency was the highest in treatment T_3 i.e. 125 per cent fertilizer dose of liquid fertilizer applied through drip (1581.94 kg/ha-cm) and the lowest in surface method of irrigation treatment T_1 (599.74 kg/ha-cm). The water use efficiency was decreased with successive decrease in levels of liquid fertilizer.

4.4 Quality studies

4.4.1 C.C.S. (%)

The data relating to mean C.C.S. % as influenced by different treatments are presented in Table 4.12. The mean C.C.S. % was 12.34, the quality parameter, Commercial Cane Sugar percent was not affected significantly in various treatments studied, however, the maximum C.C.S. % was observed in treatment T_3 where 125 per cent liquid fertilizer dose was applied (13.09) through drip. The C.C.S. % was gradually decreased with decrease in fertilizer levels. The C.C.S. % was better in drip irrigated plots as compared to surface irrigated plots. The C.C.S. % was varied from 12.34 to 13.09 in drip irrigated plots and 11.69 in surface irrigated plots.

4.4.2 Pol (%)

The data relating to Pol % as influenced by different treatments are presented in Table 4.12. The mean pol per cent was 17.75. The pol per cent was not affected significantly due to various treatments studied, however the maximum pol per cent was observed in T_3 (18.66) where 125 per cent liquid fertilizer dose was applied though drip. The pol per cent was gradually decreased with decrease in fertilizer levels. The pol per cent was better in drip irrigated plots as compared to surface irrigated plots. The pol per cent was varied from 17.55 to 18.66 in drip irrigated plots and was

Table 4.12 Mean of quality parameters as influenced by different treatment

Treatment	Quality parameters			
	C.C.S.	Pol	Brix	Purity
T_1 i.e. RDSF + SI	11.49	17.15	19.55	85.33
T_2 i.e. RDSF + ND	12.37	17.60	20.13	88.65
T_3 125 RDLF + DI	13.09	18.63	20.95	88.97
T_4 100 RDLF + DI	12.71	18.08	20.35	88.85
T_5 75 RDLF + DI	12.34	17.55	20.01	87.62
T_6 50 RDLF + DI	11.84	17.50	19.79	86.92
'F' test	N.S.	N.S.	N.S.	N.S.
S.E. ±	0.767	0.999	0.95	1.161
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
General mean	12.34	17.75	20.13	87.72

N.S : Not Significant

17.15 in surface irrigated plots. These results are in conformity with those reported by Kirtikar and Anang Nath (1964).

4.4.3 Brix reading

The data relating to Brix as influenced by different treatments are presented in Table 4.12. The mean brix reading was 20.13. The differences in brix reading due to levels of fertilizer were not significant; however, the maximum Brix was recorded in treatment T_3 (20.95) where 125 per cent liquid fertilizer were applied through drip. The Brix was gradually decreased with decrease in fertilizer levels. The Brix reading was better in drip irrigated plots. The Brix reading was varied from 20.01 to 20.95 in drip irrigated plots and was 19.55 in surface irrigated plots.

4.4.4 Purity percentage

The data relating to purity percentage as affected by different treatments are presented in Table 4.12. The mean purity percentage was 87.72. The purity percentage was not affected significantly due to treatments under study; however, purity percentage was at higher magnitude in treatment T_3 i.e. 125 per cent liquid fertilizer through drip (88.97). Though the differences in purity percentage were not significant, it was better under drip method of irrigation as compared to surface irrigation and there was decline in purity percentage with increase in levels of fertilizer. Kirtikar and Anang Nath (1964) also reported similar trend.

4.5 Leaf NPK concentration at harvest

4.5.1 Leaf nitrogen

The data relating to the concentration of leaf nitrogen as influenced by different treatments are presented in Table 4.13. The mean leaf nitrogen per cent was 1.64. It could be observed from data that leaf nitrogen was the highest in treatment T_3 i.e. 125 per cent liquid fertilizer through drip (1.84); it was significantly superior to rest of treatments. The leaf nitrogen in treatment T_2 was at par with T_4 and T_1 was at par with T_5. This might be due to T_5 was of liquid fertilizer treatment. Per cent N in leaf was observed to be increased with increasing fertilizer levels and moisture availability. Some favorable results of increased fertilizer and moisture on nitrogen content in leaf were also reported by Roy et al. (1988) and Daree et al. (1990). The lowest nitrogen content in leaf in T_6 (1.42 %) might be due to less fertilizer dose (50 % of the recommended dose).

4.5.2 Leaf phosphorus

The data relating to per cent leaf `P' content at harvest as influenced by different treatments are presented in Table 4.13. The mean leaf phosphorus per cent was 0.556. From the data it could be observed that per cent leaf `P' was

Table 4.13 Leaf NPK concentration of harvest as influenced by different treatments

Treatment	Leaf N %	Leaf P %	Leaf K %
T_1 i.e. RDSF + SI	1.617	0.570	1.357
T_2 i.e. RDSF + ND	1.700	0.580	1.447
T_3 125 RDLF + DI	1.840	0.640	1.527
T_4 100 RDLF + DI	1.730	0.590	1.467
T_5 75 RDLF + DI	1.570	0.517	1.307
T_6 50 RDLF + DI	1.420	0.493	1.197
S.E. ±	0.013	0.014	0.009
C.D. at 5 %	0.041	0.044	0.030
General mean	1.64	0.556	1.36

gradually increased with successive increase in levels of fertilizer. The leaf `P' content was significantly higher in treatment T_3 than the rest of the treatments. The solid fertilizer treatments T_1 (0.52 %) was at par with liquid fertilizer treatment T_5 (0.517 %) and T_6 (0.493 %) this might be due to better utilization of liquid fertilizer through drip irrigation.

4.5.3 Leaf potassium

The data relating to the leaf potassium content as influenced by different treatments are presented in Table 4.13. The mean leaf potassium per cent was 1.38. From the data it could be seen that treatment T_3 i.e. 125 per cent liquid fertilizer through drip (1.527 %) recorded the highest per cent of `K' content which was significantly more than rest of treatments. This might be due to higher fertilizer dose. The `K' content was the lowest in treatment T_6 (1.197 %) this might be due to lower (50 %) liquid fertilizer dose.

4.6 Uptake of Nutrients (NPK)

4.6.1 Nitrogen

Nitrogen uptake by the crop as influenced by different treatments are presented in Table 4.14. The mean nitrogen uptake was 278.07 kg ha^{-1}. The uptake of nitrogen was the highest in treatment T_3 i.e. 125 per cent liquid fertilizer through drip (319.14 kg ha^{-1}) which was

Table 4.14 Uptake of NPK

Treatment	Nitrogen kg ha^{-1}	Phosphorus kg ha^{-1}	Potassium kg ha^{-1}
T_1 i.e. RDSF + SI	265.563	85.413	222.857
T_2 i.e. RDSF + ND	286.040	98.783	246.390
T_3 125 RDLF + DI	319.140	110.997	264.800
T_4 100 RDLF + DI	295.807	100.800	250.783
T_5 75 RDLF + DI	266.920	87.840	222.150
T_6 50 RDLF + DI	234.957	81.633	198.013
S.E. ±	2.616	2.422	1.790
C.D. at 5 %	8.241	7.628	5.638
General mean	278.07	94.25	234.16

significantly more than rest of treatments. This might be due to application of higher liquid fertilizer dose through drip. This treatment was followed by treatment T_4 (295.807 kg ha^{-1}) which was at par with T_2 (286.04 kg ha^{-1}), T_5 (266.92 kg ha^{-1}) and T_1 (265.563 kg ha^{-1}). The nitrogen uptake in T_6 (234.937 kg ha^{-1}) was the lowest because of lower (50 %) fertilizer dose.

4.6.2 Phosphorus

The phosphorus uptake by crop as influenced by different treatments are presented in Table 4.14. The mean phosphorus uptake was 94.25 kg ha^{-1}. The data indicated that maximum phosphorus uptake was observed in treatment T_3 i.e. 125 per cent liquid fertilizer through drip (110.997 kg ha^{-1}) which was significantly superior to rest of the treatments. Uptake in treatment T_4 (100.88 kg ha^{-1}) was next in order and was at par with T_2 (98.783 kg ha^{-1}). Uptake in T_5 (87.84 kg ha^{-1}), T_1 (85.413 kg ha^{-1}) and T_6 (81.633 kg ha^{-1}) were at par with each other. By and large, at lower levels of fertilizer applied, the uptake of nutrients was low.

4.6.3 Potassium

The differences in potassium uptake by crop was influenced significantly due to differents treatments (Table 4.14). The mean potassium uptake was 234.16 kg ha^{-1}. Potassium uptake in T_3 i.e. 125 per cent liquid fertilizer (264.8 kg ha^{-1}) was at higher magnitude and significantly more than rest of the treatments. Uptake in T_4 (250.783 kg ha^{-1}) and T_2 (246.39 kg ha^{-1}) was at par with each other and also in T_1 (222.857 kg ha^{-1}) and T_5 (222.15 kg ha^{-1}). Uptake was the lowest in T_6 (198.613 kg ha^{-1}).

4.7 Fertilizer saving and fertilizer use efficiency

4.7.1 Fertilizer saving

The yield of treatment T_3 i.e. 125 per cent liquid fertilizer through drip (176.37 t ha^{-1}) was maximum but it was at par with treatment T_2 i.e. RDSF + SI (166.21 t ha^{-1}), T_4 i.e. 100 per cent liquid fertilizer (172.37 t ha^{-1}) and T_5 i.e. 75 per cent liquid fertilizer (167.09 t ha^{-1}). By comparing yield of different treatments, the treatment T_5 i.e. 75 per cent liquid fertilizer produced statistically equal yield as that of treatment T_2, T_3 and T_4 and was significantly more than T_1 and T_6 i.e. 50 per cent liquid fertilizer. This comparis on showed that there was 25 per cent fertilizer saving in treatment T_5 i.e. 75 per cent liquid fertilizer, without any loss in yield of cane.

4.7.2 Fertilizer use efficiency

The data relating to fertilizer use efficiency as influenced by different treatments are presented in Table 4.15. The highest FUE was recorded in treatment T_6 (599.32) it might be due to 50 per cent liquid fertilizer dose. The lowest

Table 4.15 Fertilizer use efficiency as influenced by different treatments

Treatment	Yield (kg/ha)	Fertilizer dose (kg/ha)	Fertilizer use efficiency
T_1 i.e. RDSF + SI	136400	500	272.80
T_2 i.e. RDSF + ND	166210	500	332.42
T_3 125 RDLF + DI	176370	625	281.93
T_4 100 RDLF + DI	172370	500	344.74
T_5 75 RDLF + DI	167080	375	445.54
T_6 50 RDLF + DI	139830	250	559.32

FUE was recorded in treatment T_1 (272.8), it might be due to less yield as compared to other treatments. The FUE of treatments T_2, T_3, T_4 and T_5 were 332.42, 281.93, 344.74 and 445.54, respectively.

4.8 Economic studies

4.8.1 Gross return

The data relating to mean gross returns per hectare are presented in Table 4.16. It was noticed that, the gross returns were the highest in T_3 i.e. 125 per cent liquid fertilizer through drip (1, 23, 459.0 Rs ha^{-1}). There was no significant difference due to various treatment studied in gross returns. The lowest gross returns was obtained in treatment T_1 i.e. RDSF + SI (95480.0 Rs ha^{-1}).

4.8.2 Cost of cultivation

The data relating to cost of cultivation as influenced by different treatments are presented in Table 4.16. From the data, it could be observed that treatment T_3 i.e. 125 per cent liquid fertilizer through drip, required significantly more (64409.94 Rs ha^{-1}) cost of cultivation as compared with rest of treatments. The treatment T_4 (58694.03) also required significantly more cost of cultivation than T_1, T_2 and T_5 and T_6 treatment. The treatment T_5 also required significantly more cost of cultivation than T_1, T_2 and T_6. The treatment T_1, T_2 and T_6 were at par with each other in respect of cost of cultivation. The treatments T_3, T_4 and T_5 required high cost of cultivation (Rs ha^{-1}), it might be due to high prices of liquid fertilizer and seasonal cost of drip irrigation methods.

4.8.3 Net returns

The data relating to net returns (Rs ha^{-1}) as influenced by different treatments are presented in Table 4.16. It was noticed that the net returns received from treatment T_2 (53691.74 Rs ha^{-1}) were the highest; but were at par with treatments T_1 (48488.18 Rs ha^{-1}) and T_5 (45392.48 Rs ha^{-1}). The non significant differences between T_1, T_2 and T_5 might be due to high seasonal cost of drip system. The treatment T_4 was at par with T_3 and T_6 treatments. This had indicated that besides 25 per cent fertilizer saving in treatments T_5, it also registered equal net returns per hectare with 100 per cent solid and liquid fertilizer treatments. Low net returns per hectare in liquid fertilizer treatments could mainly be attributed to the high cost of liquid fertilizer over that of solid fertilizer. Due to this reason and due to high seasonal cost of drip system, through T_3, T_4 treatments produced more yields (176.37 t ha^{-1} and 172.37 t ha^{-1}) than T_1 (136.40 t ha^{-1}), they registered less net returns than T_1 treatment.

Table 4.16 Economics of crop cultivation as influenced by different treatments

Treatment	Gross returns Rs/ha	Cost of cultivation Rs/ha	Net returns per ha Rs/ha	B:C ratio	Net returns per mm of water used
T_1	95480.34	45626.83	48488.18	2.03	21.32
T_2	116344.70	47305.27	53691.74	1.85	48.15
T_3	123459.00	64409.94	38699.06	1.45	34.73
T_4	120659.00	58694.03	41614.97	1.52	37.32
T_5	116900.00	52890.19	45392.48	1.59	39.16
T_6	97860.00	45602.10	31907.90	1.48	28.61
F test	N.S.	Sig.	Sig.	Sig.	Sig.
S.E. ±	13387.210	1290.834	3799.91	0.045	0.856
C.D. at 5 %	-	4065.616	11968.23	0.142	2.697

N.S : Not Significant

4.8.4 Benefit : cost ratio

The data pertaining to the benefit : cost ratio as influenced by different treatments are presented in Table 4.16. From the data it could be observed that treatment T_1 where recommended fertilizer dose was applied with surface irrigation (2.03) has recorded the widest benefit : cost ratio (2.03) and was significantly more than those obtained due to other treatments, it could be attributed mainly to less total seasonal cost as compared with drip irrigation treatments. The treatment T_2 also recorded significantly wider benefit : cost ratio than treatments T_3, T_4, T_5 and T_6. The treatments T_3, T_4, T_5 and T_6 were at par with each other, it might be due to high costs of liquid fertilizer which increase the total seasonal cost.

4.8.5 Net return per mm of water used

The data relating the net returns per mm of water used are presented in Table 4.16. From the data it was clear that treatment T_2 (48.15) registered significantly maximum net returns than rest of treatments, it was obviously due to high yield and low cost of solid fertilizer than liquid fertilizer. The liquid fertilizer treatment T_5 (39.167 Rs/mm) was at par with treatment T_4 (37.323 Rs/mm) which was at par with T_3 (34.733 Rs/mm) treatment. The treament T_6 (28.61 Rs/mm) registered significantly maximum net returns per mm of water

4.8.4 Benefit : cost ratio

The data pertaining to the benefit : cost ratio as influenced by different treatments are presented in Table 4.16. From the data it could be observed that treatment T_1 where recommended fertilizer dose was applied with surface irrigation (2.03) has recorded the widest benefit : cost ratio (2.03) and was significantly more than those obtained due to other treatments, it could be attributed mainly to less total seasonal cost as compared with drip irrigation treatments. The treatment T_2 also recorded significantly wider benefit : cost ratio than treatments T_3, T_4, T_5 and T_6. The treatments T_3, T_4, T_5 and T_6 were at par with each other, it might be due to high costs of liquid fertilizer which increase the total seasonal cost.

4.8.5 Net return per mm of water used

The data relating the net returns per mm of water used are presented in Table 4.16. From the data it was clear that treatment T_2 (48.15) registered significantly maximum net returns than rest of treatments, it was obviously due to high yield and low cost of solid fertilizer than liquid fertilizer. The liquid fertilizer treatment T_5 (39.167 Rs/mm) was at par with treatment T_4 (37.323 Rs/mm) which was at par with T_3 (34.733 Rs/mm) treatment. The treament T_6 (28.61 Rs/mm) registered significantly maximum net returns per mm of water used than treatment T_1 (21.323 Rs/mm), it might be due to less yield in treatment and drip system.

4.7.4 Economics of added levels of liquid fertilizer

The data pertaining to the economics of added levels of liquid fertilizer on mean values are presented in Table 4.17. From table it could be seen that benefit cost ratio obtained from T_5 was the highest (4.30), further increase in fertilizer dose decreased the returns per rupee invested drastically. It indicated that T_5 (75 %) liquid fertilizer dose was an optimum dose as compared to T_4 (100 % *RDLF*) and T_3 (125 % *RDLF*) and clearly brought out that there could be a saving of fertilizer to the tune of 25 per cent. If resorted to liquid fertilizers and irrigation thorugh drip.

Table 4.17. Economics of added levels of liquid fertilizers

Treatment	Additional cost of fertilizer over T_6 (50 % RDLF)	Additional gain over T_6 (50 % RDLF)	B:C ratio
T_6	-	-	-
T_5	4427.00	19040.00	4.30
T_4	8854.15	22799.00	2.57
T_3	13281.23	25599.00	1.92

SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The field experiment entitled "Effect of liquid fertilizer through drip irrigation on growth, yield and quality of suru sugarcane cv. CO-7714" was conducted during the period Feb, 1995 to Feb. 1996 at Water Management Research Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar. The experiment was laid out in Randomised Block Design with six treatments, replicated three times. Treatments comprised of two fertilizer sources viz. Liquid with 4 levels of recomeded dose of fertilizer (RDLF) viz., 125, 100, 75 and 50 per cent and solid with 100 per cent recomeded dose (RDSF). Five treatments are of drip irrigation methods (DI) and one of surface irrigation method (SI) forming six treatments.

The liquid fertilizer were given in ten equal splits (at 30, 45, 60, 75, 90, 105, 120, 135, 150 and 165 DAP) whereas solid fertilizers were given in four splits (at planting 60, 105 and 135 DAP). In surface irrigated treatments irrigations were scheduled at 1 IW/CPE ratio i.e. 50 mm irrigation dpeth at 50 CPE. In drip irrigated treatments irrigation was scheduled at every alternate day on the basis of pan evaporation data. In the drip irrigated treatments emmission uniformity was considered 99.00 per cent while calculating the irrigation requirement in drip. Other field operations were carried out as per the requirement.

5.1.2 Soil and climate

The soil of the experiment field was medium black and clay loam in texture with average 75 cm soil depth. The AWHC of soil was 24.10 cm/m. The soil was well drained. It was low in available N (116.7 kg ha^{-1}), medium in available P (18.47 kg ha^{-1}) and rich in potassium (492.8 kg ha^{-1}).

The climatic conditions during the crop growth period was good with rainfall of 778.6 mm (as against an average of 520 mm) which favored the growth of crop.

5.1.3 Water balance studies

Considering the effective rainfall and quantum of water applied at 50 mm CPE throughout the crop growth period, the total seasonal water required in surface irrigation was 227.43 cm of which effective rainfall was 46.47 cm and the water applied was 180.96 cm. While in case of drip irrigation the total seasonal water requirement was 111.49 cm, which comprised of 25.54 cm of effective rainfall. The total water requirement of the crop was 50.97 per cent less due to drip irrigation as compared with surface irrigation method. The water use efficiency in drip was almost double in drip irrigated treatments as compared with surface irrigated treatment. The highest field water use efficiency was observed in Treatment T_3 (1581.94 kg/ha-cm) i.e. 125 % RD through L.F. drip.

5.1.4 Growth parameter

The increase in height reached its maximum upto 90 DAP in drip and 135 DAP in surface irrigation treatments. The rate of increase in number of functional leaves in treatment T_1 (surface irrigation) was the highest during 45-90 DAP. Leaf area increased with higher rate upto 180 DAP. The dry matter increased with increasing rate upto 270 DAP. All these major growth parameters were increased with levels of fertilizers and moisture availability. Maximum height, number of functional leaves, leaf area and dry matter per plant was recorded in treatment T_3 and the lowest in treatment T_1.

5.1.5 Yield and yield attributes

The yield attributes viz., number of internode, number of tillers, girth of internode, number of millable canes and height of millable canes were increased with increasing levels of fertilizer. Liquid fertilizer exhibited their superiority over solid fertilizers. The number of tillers/sett internode/cane, girth of internode, number of millable canes and height of millable canes were registered maximum in treatment T_3 where 125 per cent recommended dose of liquid fertilizer was applied through drip. The treatments T_2, T_4 and T_5 were at par with each other with regards to above parameters.

The yield of cane was maximum in treatment T_3 (176.37 t ha^{-1}), and was significantly more than treatments T_1 (136.40 t ha^{-1}) and T_6 (139.8 t ha^{-1}) but was at par with treatments T_2 (166.21 t ha^{-1}), T_4 (172.37 t ha^{-1}) and T_5 (167.09 t ha^{-1}). Saving fertilizer to the tune of 25 per cent was observed in T_5 treatment as it was on par with treatment T_2, T_3 and T_4 in respect of yield.

5.1.6 Juice quality

Quality of juice was improved by increasing levels of liquid fertilizers as compared to solid fertilizer. Drip irrigation system also exhibited beneficial effects on juice quality than surface irrigated treatment. The measures of juice quality such as C.C.S. per cent, Pol per cent, Brix and Purity percentage were not affected significantly. The C.C.S. per cent, Pol per cent, Brix and Purity percentage were maximum in treatment T_3 (13.09, 18.63, 20.95 and 88.977 %, respectively) and were minimum in T_1 (11.69, 17.15, 19.55 and 85.333 %, respectively).

5.1.7 NPK concentration in leaf

Plant nitrogen, phosphorus and potassium was maximum *in T_3 treatment (1.84, 0.64 and 1.527 % respectively)* and was minimum in T_6 treatment (1.42, 0.493 and 1.197 %, respectively).

5.1.8 **NPK uptake**

Nitrogen, phosphorus and potassium uptake was maximum in treatment T_3 (319.14, 110.997 and 264.30 kg/ha, respectively) and was minimum in T_6 treatment (234.957, 81.633 and 198.013 kg/ha, respectively).

5.1.9 **Economic studies**

The gross returns, net returns, Benefit : Cost ratio and net returns per mm of water used indicated that the gross return was maximum in treatment T_3 (1,23,459.00 Rs/ha) and was minimum in T_1 (95480.34 Rs/ha), the other treatments did not showed any significant difference. The net returns were maximum in treatment T_2 (53691.74 Rs ha^{-1}) and was minimum in treatment T_3 (38699.06 Rs ha^{-1}). The treatments T_3,T_4 and T_6 were at par with each other. The Benefit : cost ratio was maximum in treatment T_1 (2.03) and minimum in treatment T_3 (1.45). The treatments T_3, T_4, T_5 and T_6 were at par with each other.

The net returns per mm of water used was maximum in treatment T_2 (48.15) and was minimum in T_1 (21.32). The treatments T_3, T_4 and T_5 were at par with each other and treatment T_6 was significantly more than treatment T_1. In the case of cost of cultivation, treatment T_3 required significantly more expeniture (64409.94 Rs ha^{-1}) as compared to other treatments. The treatments T_1, T_2 and T_6 were at par with each other in the case of cost of cultivation.

liquid fertilizer was applied. The yield increase was 26.37 per cent, 22.49 per cent where 100 per cent and 75 per cent liquid fertilizer was applied, respectiely.

5. Drip method of irrigation offered better juice quality as compared with surface method of irrigation.

All above findings of the present investigation have revitalised the beneficial effect of drip irrigation system and liquid fertilizer. These results need repetation for their confirmation as they are based on only one cropping season.

Future line of research work

1. Appropriate spliting of fertilizer in more splits may be weekly or even daily.
2. Different NPK proportions as per the requirement be studied.
3. Planting technique be studied to avoid lodging.
4. Combination of liquid fertilizer with organic manures be studied.

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6. LITERATURE CITED

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Appendices

Appindix-I. Irrigation schedule for drip irrigation

Date of Irrigation	Cumulative pan evaporation (mm)	Net depth of water applied (mm)	Effective rainfall (mm)
4.2.95	-	50.0 (Presowing)	-
8.2.95	-	50.0 (Surface irrigation)	-
10.2.95	10.2	2.88	-
12.2.95	7.1	1.98	-
14.2.95	10.1	2.85	-
16.2.95	9.6	2.68	-
18.2.95	11.1	3.16	-
20.2.95	11.0	3.08	-
22.2.95	12.0	3.36	-
24.2.95	12.0	3.36	-
26.2.95	10.2	2.85	-
28.2.95	13.2	3.69	-
2.3.95	12.6	3.53	-
4.3.95	13.6	3.81	-
6.3.95	14.6	4.08	-
8.3.95	11.8	3.33	-
10.3.95	11.8	3.33	-
12.3.95	12.3	3.44	-
14.3.95	11.8	3.33	-
16.3.95	11.9	3.36	1.8
18.3.95	12.8	3.44	-
20.3.95	12.3	3.44	-
22.3.95	15.4	4.34	-
24.3.95	16.7	4.67	0.8
26.3.95	16.5	4.62	-
28.3.95	15.4	4.62	-
30.3.95	15.1	4.23	
1.4.95	16.2	6.42	
3.4.95	14.9	5.94	-
5.4.95	18.2	7.22	-
7.4.95	18.2	7.22	-
9.4.95	19.3	7.65	-
11.4.95	15.9	6.34	-
13.4.95	16.3	6.46	-
15.4.95	19.9	7.89	-
17.4.95	18.7	7.42	-
19.4.95	17.1	6.77	-
21.4.95	-	-	10.0
23.4.95	16.7	6.67	-

Continued.....

Date of Irrigation	Cumulative pan evaporation (mm)	Net depth of water applied (mm)	Effective rainfall (mm)
25.4.95	20.1	7.93	-
27.4.95	20.0	7.93	-
29.4.95	19.2	7.64	0.2
1.5.95	12.5	4.95	0.6
3.5.95	14.6	5.78	2.8
5.5.95	20.3	8.08	-
7.5.95	21.6	8.56	-
9.5.95	19.9	7.89	0.8
11.5.95	16.0	6.33	1.2
13.5.95	17.9	7.13	-
15.5.95	20.3	8.05	-
17.5.95	23.0	9.12	-
19.5.95	23.7	9.46	-
21.5.95	20.7	8.24	-
23.5.95	17.3	6.86	1.2
25.5.95	20.0	7.93	-
27.5.95	11.7	4.64	7.0
29.5.95	17.2	6.82	-
31.5.95	20.0	7.93	-
2.6.95	27.0	12.6	-
4.6.95	30.0	14.06	-
6.6.95	26.5	12.39	-
8.6.95	25.2	11.75	-
10.6.95	23.0	10.73	-
12.6.95	21.3	9.94	-
14.6.95	8.7	4.08	7.4
16.6.95	17.7	8.16	-
18.6.95	18.2	8.48	-
20.6.95	21.0	9.8	-
22.6.95	17.7	8.28	-
25.6.95	11.4	5.32	0.6
27.6.95	4.0	1.86	0.8
29.6.95	8.8	4.14	1.2
2.7.95	10.1	4.74	0.2
4.7.95	17.6	8.21	-
6.7.95	12.1	5.64	5.6
8.7.95	6.5	3.06	5.4
10.7.95	-	-	10.0
12.7.95	8.7	4.08	-
14.7.95	11.4	5.32	-
16.7.95	5.2	2.42	1.6
18.7.95	7.5	3.50	2.6
20.7.95	3.8	1.77	3.2
22.7.95	3.4	1.58	2.6

Continued.....

Date of Irrigation	Cumulative pan evaporation (mm)	Net depth of water applied (mm)	Effective rainfall (mm)
24.7.95	2.0	0.93	4.4
26.7.95	3.3	1.54	2.4
28.7.95	5.0	2.33	4.2
28.7.95	-	-	11.6
1.8.95	10.9	5.84	0.6
3.8.95	11.9	6.38	-
5.8.95	8.9	4.77	-
7.8.95	13.0	6.97	-
9.8.95	10.8	5.86	-
11.8.95	10.6	5.68	-
-	-	-	8.8
15.8.95	11.8	6.33	-
17.8.95	7.2	3.86	2.0
19.8.95	9.9	5.31	-
21.8.95	5.3	2.84	4.0
23.8.95	10.6	5.68	-
25.8.95	12.5	6.74	-
27.8.95	12.2	6.54	-
29.8.95	-	-	6.3
31.8.95	-	-	10.0
2.9.95	-	-	7.9
4.9.95	-	-	6.2
6.9.95	11.8	6.33	-
8.9.95	-	-	7.6
10.9.95	9.0	4.83	-
12.9.95	8.9	4.78	0.6
14.9.95	-	-	6.6
16.9.95	9.4	5.24	4.8
18.9.95	9.0	4.83	-
20.9.95	11.0	5.96	-
22.9.95	11.50	6.19	-
24.9.95	-	-	9.9
26.9.95	-	-	9.1
28.9.95	5.50	2.98	1.8
30.9.95	8.50	4.59	-
2.10.95	8.50	4.59	-
4.10.95	8.50	4.59	0.6
6.10.95	-	-	11.7
8.10.95	4.0	2.19	5.4
10.10.95	-	-	9.4
12.10.95	0.3	0.16	5.4
14.10.95	5.6	3.16	-
16.10.95	-	-	13.5
18.10.95	-	-	9.1
20.10.95	-	-	8.1

Continued.....

Date of Irrigation	Cumulative pan evaporation (mm)	Net depth of water applied (mm)	Effective rainfall (mm)
22.10.95	8.6	4.64	-
23.10.95	8.2	4.40	-
25.10.95	8.6	4.61	-
27.10.95	9.1	4.66	-
29.10.95	7.6	4.07	-
31.10.95	7.2	2.85	-
2.11.95	6.8	2.76	-
4.11.95	7.0	2.78	-
6.11.95	6.8	2.76	-
8.11.95	6.9	2.73	-
10.11.95	6.5	2.58	-
12.11.95	7.5	2.98	-
14.11.95	7.8	3.08	-
16.11.95	7.4	2.93	-
18.11.95	7.1	2.87	-
20.11.95	5.4	2.19	-
22.11.95	6.7	2.66	-
24.11.95	6.2	2.46	-
26.11.95	7.0	2.78	-
28.11.95	6.8	2.76	-
30.11.95	6.6	2.62	-
2.12.95	7.3	2.96	-
4.12.95	7.3	2.96	-
6.12.95	7.8	3.08	-
8.12.95	6.7	2.66	-
10.12.95	7.6	3.07	-
12.12.95	7.1	2.87	-
14.12.95	7.6	3.07	-
16.12.95	7.1	2.87	-
18.12.95	7.2	2.85	-
20.12.95	6.9	2.73	-
22.12.95	6.8	2.76	-
24.12.95	8.0	3.18	-
26.12.95	6.2	2.46	-
28.12.95	6.8	2.76	-
30.12.95	8.3	3.29	-
1.1.96	6.0	1.85	-
3.1.96	6.1	1.85	-
5.1.96	6.9	2.08	-
7.1.96	6.0	1.85	-
9.1.96	6.3	1.94	-
11.1.96	7.2	2.19	-
13.1.96	5.9	1.79	-
15.1.96	8.6	2.64	-

Continued.....

Date of Irrigation	Cumulative pan evaporation (mm)	Net depth of water applied (mm)	Effective rainfall (mm)
17.1.96	8.9	2.76	-
19.1.96	6.9	2.08	-
21.1.96	6.4	1.94	-
23.1.96	7.1	2.15	-
25.1.96	7.4	2.24	-
27.1.96	8.5	2.58	-
29.1.96	8.3	2.54	-
31.1.96	9.9	3.06	-
2.2.96	9.4	2.86	-
4.2.96	8.3	2.52	-
		859.52 mm	255.4 mm
		85.95 cm	25.54 cm

Appendix-I. Irrigation scheduling of surface irrigation

No.of irrigation	Date of irrigation	Depth of water applied (cm)	ER (cm)	Total seasonal water applied (cm)
1	4.2.95	5.0	-	5.0
2	8.2.95	5.0	-	5.0
3	13.2.95	5.0	-	5.0
4	24.2.95	5.0	-	5.0
5	3.3.95	5.0	-	5.0
6	12.3.95	5.0	-	5.0
7	21.3.95	5.0	-	5.0
8	27.3.95	5.0	-	5.0
9	6.4.95	5.0	-	5.0
10	10.4.95	5.0	-	5.0
11	14.4.95	5.0	-	5.0
12	18.4.95	5.0	-	5.0
13	25.4.95	5.0	-	5.0
14	28.4.95	5.0	-	5.0
15	6.5.95	5.0	-	5.0
16	12.5.95	5.0	-	5.0
17	18.5.95	5.0	-	5.0
18	23.5.95	5.0	-	5.0
19	26.5.95	5.0	-	5.0
20	1.6.95	5.0	-	5.0
21	4.6.95	5.76	0.68	6.44
22	8.6.95	5.67	-	5.67
23	12.6.95	5.20	-	5.20
24	18.6.95	5.24	0.74	5.98
25	24.6.95	-	4.7	4.70
26	7.7.95	7.60	1.06	8.66
27	10.7.95	-	1.27	1.27
28	28.7.95	5.84	2.10	7.94
29	30.7.95	-	1.16	1.16
30	9.8.95	5.85	0.06	5.91
31	12.8.95	-	1.5	1.5
32	13.8 to 7.9.95	-	12.48	12.48
33	8.9 to 14.9.95	-	2.98	2.98
34	15.9 to 26.9.95	-	5.99	5.99
35	27.9 to 19.10.95	-	11.71	11.71
36	3.11.95	5.60	0.04	5.64
37	20.11.95	5.70	-	5.70
38	10.12.95	5.62	-	5.62
39	24.12.95	5.20	-	5.20
40	9.1.96	5.87	-	5.87
41	24.1.96	5.96	-	5.96
42	1.2.96	5.85	-	5.85
		180.96	46.47	227.43

APPINDIX-II. Cost of components of surface and drip irrigation system for 1 ha.

Sr. No.	Items	Skip row planting		
		Cost Rs.	Life yrs.	Depreciation D=(OC-JV)/Rs.
I.	Surface irrigation			
1.	Centrifugal pumpset (3 Hp) and acceseries	7000.00	20	315.00
2.	Interest @ 13 % p.a. Rs.	910.00		
3.	Repaire and maintainance @ 2 % p.a. Rs.	140.00		
4.	Total (for crop period)	1365.00		
II.	Drip irrigation			
1.	Centrifugal pumpset (3 Hp) and accessories	7000.00	20	315.00
2.	Sand filter with pressure guage ($10 m^3/hr$)	19630.00	20	883.35
3.	Screen filter with pressure guage	3428.30	20	154.27
4.	Fertilizer tank (90 lit)	3943.00	20	177.43
5.	PVC pipe 63 mm diameter 75 m @ Rs. 27.8/m	2085.00	12	156.37
6.	PVC pipe 50 mm diameter 200 m @ Rs. 26.55/m	5310.00	12	398.25
7.	Submain flush value (2) and main flush value (1) @ 58.6/unit (3)	175.80	12	13.18
8.	PVC Tee, 63 mm, 2 units @ Rs. 38.6/unit	77.20	12	5.79
9.	PVC reduce 63-50 mm 2 units @ Rs. 12.75/unit	25.50	12	1.91
10.	63 mm PVC ball value (3) @ Rs. 801/unit	2403.00	12	180.22

Continued......

Sr. No.	Items	Skip row planting		
		Cost Rs.	Life yrs.	Depreciation D=(OC-JV)/Rs.
11.	LDPE lateral 16 mm diameter @ Rs.6.2/m 4000 m	24800.00	6	3720.00
12.	GTO for LDPE lateral 16 mm diameter @ Rs.2.75/unit 160	440.00	6	66.00
13.	Emitters @ 2.35/unit 8 Lph 5334 emitters	12534.9	6	1880.23
14.	Miscellaneous items	400.00	6	60.00
	Total	82252.80		8012.00

'I'	Interest on total cost @ 13 % p.a. Rs.	10692.86
'R'	Repairs and maintaince charges @ 2 % p.a. on total cost of system	1645.05
	Total seasonal cost of Drip system = D + I + R	20350.00

Where,

OC = Original cost

JV = Junk value (10 % of OC)

D = Depreciation

I = Interest

R = Repairs and Maintainance

Crop duration = 12 months

L = Life period

Cost of cultivation for surface and drip system

Sr. No.	Items	One skip after four rows planting			
		Surface		Drip	
		Qty	Cost Rs.	Qty.	Cost Rs.
1.	Labour @ 30/day (8 hrs day)				
a.	Collection of stubbles and cleaning of field	6		6	
b.	Mending of ridges and furrow	2		–	
c.	Planting	20		20	
d.	Laying of drip system	–		6	
e.	Irrigation (32)	64		25	
f.	Fertilizer application	24		1	
g.	Weeding (3)	40		20	
h.	Earthing up	25		–	
i.	Spraying	2		2	
j.	Detrashing	10		10	
k.	Harvesting	40		40	
	Total	233	6990	130	3900
2.	Ploughing @ Rs. 625/ha	2	1250	2	1250
3.	Harrowing @ rs.375/ha	2	750	2	750
4.	Opening of ridges and furrows @ Rs.350/ha	1	350	1	350
5.	Planting material	–	6000	–	6000
6.	Pesticides application	–	500	–	500
7.	Electricity charges	–	900	–	900
8.	Cost of transport (50 Rs/ton)	T_1	7502	T_2 T_3 T_4 T_5 T_6	9141.55 9700.35 9480.35 9189.40 7690.65
	Working capital except fertilizer cost (WC)	T_1	24242.0	T_2 T_3 T_4 T_5 T_6	21541.55 22100.35 21880.35 21589.40 20090.65

Treatment	Fertilizer & their Qty.	Fertilizer cost Rs.	Total working capital WC + FC Rs.	Interest on working capital @ 13 % p.a. Rs.	Superwision charges 10 % of total working capital Rs.	Rental value of land 10 % of land value	Total cost of cultivation Rs.
T_1	Urea-10.86 bags S.S.P.-14.37 bags M.O.P.-3.83 bags	4722.90	28964.90	3765.43	2896.49	10000	45626.82
T_2	Urea-10.86 bags S.S.P.-14.37 bags M.O.P.-3.83 bags	4722.90	26264.45	3414.37	2626.44	10000	47305.26
T_3	125 % L.F. 2604.16 kg	22135.38	44235.73	5750.64	4423.57	10000	64409.94
T_4	100 % L.F. 2083.33 kg	17708.30	39588.65	5146.52	3958.86	10000	58694.03
T_5	75 % L.F. 1262.49 kg	13281.16	34670.56	4533.17	3487.05	10000	52890.18
T_6	50 % L.F. 1041.66 kg	8854.15	28944.80	3762.82	2894.48	10000	45602.10

Benefit cost ratio for surface and drip irrigation treatments

Sr. No.	Cost economics	T_1	T_2	T_3	T_4	T_5	T_6
		SF + SI 100 % RDSF	DI + ND 100 % RDSF	DI + 125 % L.F.	DI + 100 % L.F.	DI + 75 % L.F.	DI + 50 % L.F.
1.	Fixed cost (Rs.)						
a.	Depreciation	315.00	8012.00	8012.00	8012.00	8012.00	8012.00
b.	Interest	910.00	10692.86	10692.86	10692.86	10692.86	10692.86
c.	Repair and maintainance	140.00	1645.05	1645.05	1645.05	1645.05	1645.05
d.	Total (a+b+c)	1365.00	20350.00	20350.00	20350.00	20350.00	20350.00
2.	Cost of cultivation (Rs/ha)	45626.82	42305.26	64409.94	58694.03	52890.18	45602.10
3.	Seasonal total cost (1d + 2) Rs/ha	46991.82	62655.26	84759.94	79044.03	73240.18	65952.10
4.	Water used (mm)	2274.30	1114.90	1114.90	1114.90	1114.90	1114.90
5.	Yield of produce (t/ha)	136.40	166.21	176.37	172.37	167.00	139.80
6.	Selling price (Rs/t)	700.00	700.00	700.00	700.00	700.00	700.00
7.	Income from produce Rs/ha (5x6)	94480.00	116347.00	123459.00	120659.00	116900.00	97860.00
8.	Net seasonal income (7-3) Rs/ha	48488.18	53691.74	38699.06	41614.97	43659.82	31907.90
9.	Additional area cultivated due to saving in water (ha)	-	0.50	0.50	0.50	0.50	0.50
10.	Additional expenditure due to additional area	-	31327.63	42379.97	39522.00	36620.00	32976.00
11.	Additional income due to additional area (7x9) Rs.	-	58173.50	61729.50	60329.50	58540.00	48930.00

Continued.......

Sr. No.	Cost economics	T_1	T_2	T_3	T_4	T_5	T_6
		SF + SI 100 % RDSF	DI + ND 100 % RDSF	DI + 125 % L.F.	DI + 100 % L.F.	DI + 75 % L.F.	DI + 50 % L.F.
12.	Additional net income (11-10) Rs.	-	26845.87	19349.53	20807.50	21920.00	15954.00
13.	Gross cost of produce (3+10) Rs.	-	93983.45	127139.91	118566.03	109860.18	98928.10
14.	Gross income (7+11) Rs.	-	174520.50	185188.50	180988.50	175440.00	146790.00
15.	Net income (14-13) Rs.	-	80537.05	58048.59	62422.47	65579.82	47861.90
17.	Net extra income due to drip irrigation system over control (15 drip - 8 surface)	-	32048.87	9560.41	13934.29	17091.64	-626.28
18.	Net profit/mm water used (8/4) Rs.	21.32	48.15	34.71	37.32	39.16	28.61
19.	Benefit cost ratio (14/13)	2.03	1.85	1.45	1.52	1.59	1.48

VITA

8. VITA

ANIL JAGANNATH GITE

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

Title of the theseis	:	"Effect of liquid fertilizer through drip irrigation on growth, yield and quality of suru sugarcane, cv. COM-7714"
Major field	:	Irrigation Water Management
Biographicla information	:	
- Personal	:	Born at Moha, Tal. Jamkhed, Dist. Ahmednagar, Son of **Shri. Jagannath Shankar Gite.**
- Educational	:	Attended Primary School at Newasa, Secondary School at D.E.S., Newasa and J. M. V., Bhenda, Higher Secondary School at S. D. M., Newasa, Received B. Sc. (Agri.) degree with first class from the College of Agriculture, Pune in July 1994.
Earlier Selection	:	Selected as a Account and Finance officer Class - II through Maharashtra Public Service Commission in 1997.