INFLUENCE OF DIFFERENT PLANTING DATES, NITROGEN AND BORON FERTILIZATION ON GROWTH AND YIELD OF CAULIFLOWER (*Brassica oleracea* var. *botrvtis* L.

THESIS

By

ARUN K. GUPTA

Submitted to

HIMACHAL PRADESH KRISHI VISHVAVIDYALAYA

PALAMPUR - 176062 (H.P.) INDIA

IN

Partial fulfilment of the requirements for the degree

OF

DOCTOR OF PHILOSOPHY

(VEGETABLE SCIENCE)

1996

Dedicated
to
my
beloved
Mother

Dr. Jagmohan Kumar
Associate Director (Research)
Himachal Pradesh Krishi Vishvavidyalaya
Palampur (H.P.) INDIA

CERTIFICATE I

This is to certify that the thesis entitled "**Influence of different planting dates, nitrogen and boron fertilization on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.)**" submitted in partial fulfilment for the award of the degree of **Doctor of Philosophy in Agriculture** (Vegetable Science) of Himachal Pradesh Krishi Vishvavidyalaya, Palampur, is the bonafide research work carried out by Mr. Arun K. Gupta (Admission No. A-92-40-21) under my guidance and supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of these investigations and the source of literature have been fully acknowledged.

Jagmohan Kumar

Place: Palampur
Dated: Dec 7th, 1996

(Dr. Jagmohan Kumar)
Chairman
Advisory Committee

CERTIFICATE II

This is to certify that the thesis entitled "**Influence of different planting dates, nitrogen and boron fertilization on growth and yield of cauliflower (<u>Brassica oleracea</u> var. <u>botrytis</u> L.)**" submitted by Mr. Arun K. Gupta (A-92-40-21) in partial fulfilment of the requirements for the degree of **Doctor of Philosophy in Agriculture** (Vegetable Science) has been approved by the examining committee after an oral examination of the same in collaboration with the external examiner.

30-1-97
Chairman
Advisory Committee

30.1.97
External Examiner

30.1.97
Member

30.1.97
Member

30.1.97
Member

30.1.97
Member

Jagmohan Kumar 30.1.97
Head of Department

1.2.97
Dean,
Post-Graduate Studies,
H.P. Krishi Vishva Vidyalaya,
PALAMPUR—176062

Dean,
Post Graduate Studies

ACKNOWLEDGEMENT

With limitless humility, I would like to praise and thank "God" - the almigthy, the merciful, the compassionate, who bestowed me with health and courage enough to undertake and finally accomplish this treatise.

It is with adnascent pleasure that I reiterate my indebtness to my major advisor, Dr. Jagmohan Kumar, Associate Director (Research), for his expert, invaluable and tireless guidance, methodological approach, deep scientific vision, painstaking efforts, constant encouragement, inspiration and care for my professional growth during the course of investigations. He had been a valuable mentor, who constantly pushed and inspired me as I struggled to shape my work. I 'shall always remain indebted to him.

No expression of thanks will be sufficient without recognition of intelligence and professional dextrity of Drs. P.S.Arya, Senior Vegetable Breeder, H.L.Sharma Prof.(Agro S.K.Sharma Prof.(Genetics) and S.K.Kaushal, Asstt. Scientist (Plant Physiology) members of my advisory committee for having meticulously supervised my work with their unfailing help and suggestions at every stage of its preparation.

I express my sincere gratitude to Hon'ble Vice Chancellor, SKUAST, Jammu and Kashmir for deputing me to undertake higher studies. Words fail to express the thanks to Sh. P.N.Kerni for his constant encouragement and inspiration during the critical junctures.

The Senior Research Fellowship received from ICAR is duly acknowledged.

I wish to record my special appreciation to Sh. Lal Mani Verma, Programmer, IASRI, New Delhi, for preparing the computer programme and analysing the data.

I am equally thankful to the Vice Chancellor, HPKV, Dean, Post Graduate Studies and Director of Research for providing me the necessary facilities in terms of field, laboratory and library to enable me to complete my research work in reasonable time.

I am conscious of my gratitude towards my colleagues and friends for their kind cooperation and valuable assistance, Emotions get high on me as I think of acknowledging the nice company, moral support, ever caring nature, painstaking efforts and innovative ideas of my beloved wife 'Sunita'. She has always been my source of inspiration. I would like to mention a few words in appreciation for the preservance shown by my kids Aarti and Sumeet, who spared me to complete this work at their personal comforts and against heavy odds. I am indebted to my mother and inlaws, whose inspiration will continue to guide me in trial and tranquility.

Gupta 7/11/96

(Arun K. Gupta)

LIST OF CONTENTS

LIST OF TABLES

Contd...

Contd...

Contd...

Contd...

Contd...

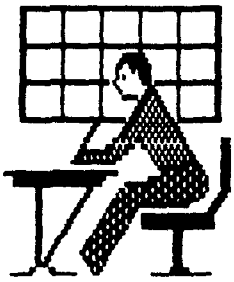
Contd...

Contd...

Contd...

Contd...

Contd...



INTRODUCTION

Chapter 1

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*, L.) is one of the most important vegetable crops grown throughout the World. Among cole crops, it is next to cabbage in importance with regard to acerage and production in the World covering an area of 42300 hectares with annual production of 700,000 metric .tonnes of which more than 25 per cent area is under snowball cauliflowers (Anonymous, 1993) and is prized for snow white attractive curds. The produce of hills is sold on premium prices as compared to the produce of plains because of special aroma.

In low hill areas of Himachal Pradesh, cultivation of early and mid season cauliflower varieties is more remunerative. In dry temperate zone, late group of cauliflower is important as off-season crop. However, in mid hills above 5000 m a.m.s.l., seed production of late group of cauliflower is very remunerative. With the improvement in living standard of public, the demand for quality vegetables is increasing. Because of these factors, the area under cauliflower is increasing gradually.

Being heavy feeder, it needs application of large quantities of macronutrients. Micronutrient deficiencies have started appearing in different vegetables including cauliflower in some pockets as a result of intensive cultivation. Nitrogen is known to have vital role in the formation and synthesis of proteins, enzymes and chlorophyll etc. An adequate supply of nitrogen is associated with vigorous vegetative growth and a deep green colour to the plants. Excessive quantities of nitrogen can prolong the growing period and delay crop maturity. Similarly boron has vital role to play in plant activities like translocation of sugars across membranes,modification of equilibrium in phosphate ester metabolism, regulatory effect on oxidation by polyphenolase activity, influencing inhibition of indole-acetic acid oxidation and possibly promoting pyridine nucleotide quinone reductase activity which is especially high in roots. Its deficiency causes browning and hollowness of curds, thus lowers the market value and farmers suffer huge losses.

In high rainfall areas like Palampur, the soils are acidic in nature. Due to acidic conditions, deficiency of micronutrients like boron is likely to be more acute. Balanced application of macro and micro nutrients is essential to have proper vegetative growth and ultimately optimum quality yield.

During January, February, cauliflower produce from plains causes glut in the markets of hills, but in the month of March, April, the produce from hills gets very good price. If through cultural practices, crop maturity is delayed upto first fort—night of March, the farmers are bound to get much higher returns.

Not much work on these aspects seems to have been carried out under mid hill conditions of Himachal Pradesh on cauliflower crop, although, it is commercial crop of the area. The present studies involving graded doses of nitrogen, boron and transplanting dates, were planned with the following objectives:-

1. To find out suitable planting dates for prolonging availability of marketable produce,
2. to assess optimum nitrogen and boron doses for getting quality marketable produce,
3. to assess the effect of different fertilizer treatments on physiological characters of plants, and
4. to work out economics of different fertilizer treatments.

REVIEW OF LITERATURE

Chapter 2

REVIEW OF LITERATURE

The role of macro and micro nutrients has been widely recognised in many crops. Micro nutrient defeciencies have been observed by many workers in cauliflower. Micronutrient like boron check browning, the physiological disorder of cauliflower. The use of micro-nutrients needs very careful consideration on account of their narrow range between deficiency and toxicity limits. Available literature on influence of transplanting dates, nitrogen and boron nutrition on growth and curd production of cauliflower is reviewed as under.

2.1 Effect of transplanting dates on growth and yield characters

Vaidya and Patil (1965) tried different dates of transplantings (4.11.61, 14.11.61 and 24.11.61) and different ages of seedlings in cabbage cv. Drum Head and observed that different age of seedlings at transplanting had no effect on yield and quality of cabbage except on period required for maturity. Seedlings transplanted on 4.11.61 and 14.11.61 gave heavier shoots and heavier heads with bigger size as compared to those transplanted on 24.11.61. Seedlings transplanted on 4.11.61 required maximum period for maturity.

Singh *et al*. (1978) observed that exact time of transplanting seedlings in field is essential for obtaining maximum yield alongwith quality increase of cauliflower cv. SB-16. Transplanting of seedlings on 15th October proved beneficial over other dates of transplantings with respect to height of plant, diameter of main stem, plant spread, number of leaves per plant yield per hectare and also from economic~~s~~ point of view. Similar findings have been given by Pandey et al. (1981) who reported that days taken to marketable maturity, marketable curd yield, curd leaf ratio, net curd weight ~~were~~ increased with third week of September (22nd) transplanting date in mid season cv. Hissar-1. Wurr and Fellows (1990) in their studies suggested that there is relationship between the time of transplanting, curd initiation and maturity in cauliflower cv. White Fox. They showed that time taken from curd initiation to maturity was related with date of transplanting.

Mishra (1989) studied the response of sowing dates on cauliflower. He observed that sowing of cauliflower seeds on 25th June is found to be most beneficial for cauliflower cv. Early Patna with respect to vegetative parameters and seed production. Similar are the findings of Sharma et al. (1994) who reported that 30th September transplanting and 250 kg nitrogen per hectare were found to be optimum for seed yield and other attributes in cauliflower cv. PSB-1 under Solan conditions of Himachal Pradesh.

Singh et al. (1994) tried different levels of nitrogen (100, 150 and 200 kg ha^{-1}) and different transplanting dates (20the Sept., 5th Oct. and 20th Oct.) on cauliflower cv.

Narendra Gobhi-1 and Pant Subhra. They observed that number of leaves per plant, plant height, gross weight per plant, net curd weight, dry matter (%) and net curd yield increased with 200 kg N ha^{-1} and 20th September transplanting in both the cultivars tried.

2.3 Effect of nitrogen on growth characters

Cultural practices determine greatly the growth of the cauliflower and among the .various inputs nitrogen, phosphorous and potash applications have been reported to exert a great influence on growth. (Pimpini et al., 1971, Mathur and Vashishta, 1976 and Pandey et al., 1979).

Arora et al. (1970) tried different levels of nitrogen (0, 75, 150 kg/ha) with basal dressing of phosphorous at the rate of 60 kg and Potassium @ 40 kg/ha and observed that maximum plant weight (948.1 g) could be obtained by highest nitrogen dose. The increase in nitrogen rate had no influence on the per cent marketable curd formation or the leaves and curd ratio but nitrogen content in the plant increased (Genkov et al., 1972).

Gill et al. (1975) observed that 500 kg of N and 250 kg of phosphorus per hectare, respectively increased number of leaves, curd size, number of branches, numbers of seeds per pod and plant height, resulting in increased curd and seed yields. They also observed increased marketable maturity due to higher nitrogen application. Increase in number of leaves and plant height as a result of higher dose of nitrogen (180 kg/ha) gave positive response. (Randhawa and

Bhail 1976). Similar results were reported by Singh et al. (1976) that with increase in the dose of nitrogen, there was increase in the number of leaves and plant height but this increase was statistically non-significant.

Roy (1981) recorded an increase in curd diameter (18.70 and 20.20) and yield (208.80 to 261.41 q ha^{-1}) with increase in application of nitrogen from 50 to 200 kg/ha. The leaf area index, curd depth, diameter of curd and dry matter content increased significantly in Snowball-16 variety of cauliflower with every increment in the dose of nitrogen from 60 kg to 120 kg per hectare (Sharma and Parashar, 1982).

Sharma and Arora (1984) observed the effect of four nitrogen levels (0,60, 120 and 180 kg/ha), two dates of N application (all at transplanting or half at transplanting and half 40 days later) on cauliflower cv. Improved Japanese. Dry matter yield per plant and curd yield per hectare increased progressively with increased nitrogen rate. Split application on an average produced 9.2 and 7.9 per cent higher dry matter and curd yield. The highest curd mean yield was 205.5 q/ha.

Balyan et al. (1988) studied different levels of nitrogen application (0, 40, 80, 120 and 160 kg). They observed increase in number of leaves and leaf size with increase in the rate of nitrogen application. Nitrogen application up to 120 kg/ha improved compactness and marketable yields. However, increase in nitrogen level delayed curd initiation. Similar are the findings of Thakur *et al*. (1991). They reported that with increasing rates of nitrogen from 80 to 240 kg ha^{-1} curd maturity was delayed but there was significant increase in dry matter content, gross plant weight, stalk length, number of leaves per plant, leaf area in cauliflower cv. Pusa Snowball-1.

2.4 Effect of nitrogen on curd yield

Arora *et al*. (1970) reported maximum yield of 275.5 q/ha with the application of N 150 kg, P_2O_5 60 kg and K_2O 40 kg/ha. With the increasing rates of N from 0 to 250 kg/ha there was significant increase in curd yield of cauliflower, and highest was with 250 kg N + 100 kg P_2O_5 + 80 kg K_2O/ha. Similar results were obtained by Pirovski and Dyankova (1975) when they applied 240 kg N, 210 kg P_2O_5 and 240 kg K_2O per hectare. Geissler *et al*. (1974) recommended higher doses of N viz., 320 kg/ha, 45 kg P_2O_5/ha and 320 kg K_2O/ha to obtain 350 q/ha curd yield of cauliflower.

Rajput and Singh (1975) obtained the maximum yield, when they applied N 60 kg/ha as basal dose followed by top dressing of 30 kg/ha each at 30 and 45 days after transplanting. They further reported that results were not better by foliar application of N as compared to soil application.

Cauliflower is a heavy feeder of mineral nutrients. A yield of 50 t/ha removes approximately 200 kg N, 85 kg P_2O_5 and 270 kg K_2O (Chaudhary 1977).

Roy (1981) studied the effect of 5 levels of N viz; 0, 50, 100, 150 and 200 kg N per hectare on curd yield of cauliflower and found 100 kg N, the most economical dose in combination with 75 kg of P_2O_5 and 50 kg of K_2O per hectare. This gave 251.1 q/ha curd yield with 20 cm curd diameter. Singh et al. (1983) recorded the highest yield of 382 q/ha which was obtained from the cauliflower crop receiving N and P_2O_5 at the rate of 150 and 60 kg/ha, respectively. There was significant increase in curd yield which was to the tune of 117 per cent when the cauliflower plants received 125 kg nitrogen per hectare. The overall increase in yield was 299.4 per cent over control with the treatment combination 125 kg N + 275 kg S/ha (Nagda and Chauhan, 1987). A highest curd yield of (227.4 - 250.2 q/ha) has been recorded with the mid season cultivar of cauliflower when the plants were spaced at 60 x 40 cm and received nitrogen and phosphorus at the rate of 100 and 60 kg/ha, respectively (Khurana et al., 1987).

Balyan et al. (1988) while studying the different levels of nitrogen application (0-160 kg/ha, P_2O_5 0-50 kg/ha and $ZnSO_4$ 0-30 kg/ha) reported that with the increase in nitrogen application, there was significant increase in yield. A maximum curd yield of 238 q/ha was obtained with 160 kg N + 50 kg P_2O_5 + 20 kg Zn per hectare in the cv. SnowBall-16. Similar are the observations of Yadav and Palival (1990) who reported that curd yield generally increased with the increasing rate of nitrogen application. A curd yield of 11.7 kg per plot (2 x 2 mts) was recorded with 200 kg N/ha in cv. SnowBall-16 compared with 3.4 kg per plot at 0 kg N/ha.

Singh and Naik (1990) recorded similar observations. The curd size, weight and curd yield increased with the increase in rates of nitrogen from 50 to 200 kg per hectare. However, the highest curd yield was recorded with 200 kg N/ha.

2.5 Effect of boron on growth characters

In a review on boron, nutrition, Gupta and Cutcliffe (1976) concluded that the role of boron in plants is poorly understood. Nason and McElory (1963) observed that boron plays a key role in many metabolic processes such as cell differentiation, cell development, N metabolism, fertilization, fat metabolism, hormone metabolism, active salt absorption and photosynthesis. There are indications that it is involved in elongation of root and shoot growing points (Epstein 1972), in carbohydrate metabolism and translocation of sugars (Sisler _et_ _al_., 1956). Higher concentration of B occurs in certain plant organs such as anthers, stigma and ovary where levels may be twice as high as stems (Johri and Vasil, 1961; Hewitt, 1983) stated that floral and fruiting organs are particularly sensitive to B deficiency.

Boron deficiency causes stunted growth, stiff stem with hollow core, leaves stiff, curled leathery and less in number and curd formation is delayed. Death of apical bud may occur resulting in no curd formation (Mehrotra and

Mishra, 1974). The roots become rough and dwarfed, lesion appear in the pith and a loose curd is produced (Bergmann, 1976).

Kuramoto et al. (1970) supplied the cauliflower seedlings with complete solutions of nutrients, B, Cu, Fe, Mn and Mo and observed that B deficiency had most marked effects on the growth. A hot water soluble B content of 0.34 to 0.49 ppm. in soil was.sufficient for optimum growth in cauliflower and found no boron toxicity even at highest rate of application (4.48 kg/ha) (Gupta and Cutcliffe, 1976).

The growth and elemental composition of various parts of cauliflower cv. white top plants were investigated under green-house condition. The B was added at a concentration of 0, 0.25, 1.0, 2.5 and 12.5 mg/litre. Optimal plant and head yield and maximum fresh weight and harvest index were found at 1.0 mg/litre (Reynolds etal, 1987).

2.6 Effect of boron on curd yield

Nieuwhof (1969) recommended that the application of 20 kg borax/ha applied directly to the soil is useful, though small amounts can also suffice. Too heavy doses of borax may have a toxic effect. Acute shortage can be controlled by spraying with 0.25 to 0.50 per cent solution of borax @ 1-2 kg/ha. The yield of cauliflower was doubled by the application of 0.5 ppm. B application and also the boron content in the meristematic tissues ranged from 3-4 ppm. Gupta (1971).

Chokrabarty (1976) observed no deformed curd in B treated plots even at 18.125 kg/ha. According to his findings, the application of half of B in soil and half through foliar application are the best for obtaining maximum curd yield in cauliflower under field conditions. The yield of cauliflower increased from 20735 to 25532 kg/ha when the soil pH was 6.6 and the borax was applied @2.24 kg/ha Gupta and Cutcliffee (1976).

Parsad and Singh (1988) screened eight genotypes of cauliflower against boron deficiency. The boron was applied in the form of boric acid at the rate of 15 kg/ha. Application of B significantly increased the curd yield, curd weight, curd diameter, number of marketable curds and total plant weight. A highest yield of 15.4 t/ha was recorded in cv. Pusa snowball K1 which was followed by Sel-5 and the lowest yield of 8.8 t/ha was recorded in Kt-9 cv. Kotur and Kumar (1989) studied the response of cv. Pusa snowball-1 to boron application. The boron was applied to the plants at 10 rates ranging from 0 to 6.4 kg/ha. A highest yield of 9.1 t/ha was recorded with plants receiving 1.6 kg B/ha as compared to 0.4 t/ha in control.

2.7 Effect of nitrogen and boron on curd yield

Mishra (1972) observed that cauliflower yield was increased from 4.2 to 13 tonnes/ha with application of N, P_2O_5 and K_2O @ 250 kg, 150 kg and 80 kg/ha, respectively alongwith 17 kg borax/ha. The curd size, curd weight and ascorbic acid content was increased when the boron was applied through soil and foliar spray to the cauliflower crop (Mehrotra *et al.*, 1975).

Randhawa and Bhail (1976) obtained highest curd yield of 163 q/ha by the application of 120 kg N, 40 kg P_2O_5 and 15 kg borax per hectare but when the concentration of boron was increased, it had toxic effect and decreased yield in cv. SnowBall-16. When in the soil, the boron concentration was 2.64 ppm. a highest yield of 504 q/ha was recorded by the application of 20kg $ZnSO_4$, 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare as compared to 20 kg/ha borax alone in which 124.09 q/ha curd yield was recorded (Pandey *et al.*, 1978).

Medhi (1987) studied the combined effect of nitrogen, Mg, B and Mo on curd yield and disease incidence. N @ 125 kg, Mg 15 kg, B 15 kg and Mo 0.05 per cent foliar spray per hectare produced highest curd yield and disease free curds. Similarly Chakrabarty (1987) observed considerable decrease in the incidence of curd rot of cauliflower with the application of boron (borax 20 kg/ha) Thakur *et al.* (1991) observed that borax at 20 kg/ha not only increased the curd yield of cauliflower along with N 240 kg and P_2O_5 250 kg per hectare but also reduced the incidence of stalk rot disease under Solan conditions. The highest net curd weight, curd size, curd yield and less incidence of browning and stalk rot has been recorded by the application of 150 kg N +60 kg P_2O_5 + 20 kg B per hectare in cv. Selection-4 of cauliflower (Bhagat 1994).

2.8 Economics

Pandey and Singh (1984) obtained highest average yield of 277.89 q/ha and a maximum profit to the tune of Rs. 4560/- over control when the crop was applied 40 kg N at transplanting + 40 kg N as top dressing + 10 kg N as foliar application 60 days after transplanting.

Singh and Srivastava (1987) worked out the economics of cauliflower with different fertility levels. The cv. SnowBall 16 gave a gross income of Rs. 15258.00 and net profit to the tune of Rs. 10399.20 per hectare with 175 kg N. Similarly N 150 kg + P_2O_5 60 kg + B 20 kg per hectare showed an edge over all other treatments involving an expenditure of Rs. 13,031.80 and net returns worth Rs. 44,845.70 per hectare (Bhagat, 1994).

Singh and Singh (1994) worked out the economics of nitrogen and spacing on seed production of mid season cauliflower. Application of 120 kg N and 60 x 40 cm. spacing gave net profit of Rs. 35931.00 ha^{-1} and cost benefit ratio of 3.15 with Improved Japanese cv. of cauliflower.

2.9 Uptake of nitrogen and boron

Sharma and Parashar (1982) studied the periodical accumulation of dry matter and N and P uptake by cauliflower plants. The results indicated that dry matter production increased with increasing levels of N and P. Nitrogen and phosphorus uptake also increased with levels of N and P at the rate of 120 kg and 100 kg ha^{-1}, respectively.

Kathan (1986) applied different doses of nitrogen to cauliflower cv. Markanta on various dates between late February and mid April. Leaf nitrate content increased by 30 per cent after the first manuring with 75 kg N/ha; by 50 per cent after 100 kg N/ha and by 120 per cent after 200 kg N/ha.

Reynolds et al. (1987) conducted a pot experiment in glass house to investigate if nitrogen supplied to cauliflower can affect its boron uptake via soil pH changes. They concluded that nitrogen had a small but very important influence on final soil pH and total amount of boron in the mature leaves. The boron concentration in young leaves and stem were less clearly related. Boron levels in the old leaves and the young tissues particularly the head are, respectively the most reliable indicator of boron toxicity and deficiency. Optimal plant and head yield, and maximum fresh weight and harvest index were recorded at 1.0 mg boron/litre. Boron levels in the head, the old and young leaves were 41, 543 and 145 mug g^{-1} DM, respectively. Above and below 1.0 mg boron/litre, foliar symptoms of toxicity and deficiency were evident. However, indirect assessment of element retranslocation, based on the ratio of its concentration in young leaves, old leaves or heads showed that boron is remobilised under boron deficiency. The boron concentration of the nutrient solution also caused changes in the retranslocation of other elements particularly the largely phloem - immobile elements to young leaves (Shelp and Shattuck, 1987).

To get a optimal yield of cauliflower, the soil inorganic N level should be 300-345 kg/ha at the time of planting, reduced to 90 kg/ha in the soil by harvest time. With little removal of N via the curds, the amount of N added to the soil via plant foliage left in situ should be considered while calculating the subsequent season's N - fertilizer requirement in order to minimise nitrate leaching following excessive building in soil (Weier and Scharpf (1988).

Gunadi and Asandhi (1988) applied nitrogen to cauliflower plants in the form of urea 135 kg N/ha, Chilean sodium nitrate 67 kg N/ha and Chilean potassium nitrate 135 kg N/ha. There was little difference in plant N uptake from different N sources. However, uptake of P, B and Na were greatest when 135 kg N/ha was applied as Chilean sodium nitrate but N sources had no significant effect on cauliflower quality in terms of fibre and total soluble solids contents.

Parsad et al. (1988) screened eight genotypes of cauliflower for B deficiency. Ca : B ratio in leaf samples were determined prior to harvest. Reduction in yield due to B deficiency ranged from 43.8 per cent in snowball to 63.4 per cent in Kt-16. Generally a higher tolerance of B deficiency was associated with high B content (highest observed in Pusa SnowBall 19.7 mg/g) and lower Ca : B ratio in leaf tissue. The mechanism of tolerance appeared to be related to efficient uptake of B from the soil. The boron imbalance enhances susceptibility to black rot disease in cauliflower (Kumar and Kotur, 1991).

Markovic and Djusovoka (1990) recommended that with the increase in rates of nitrogen from 0 to 200 kg/ha, there was significant increase in dry matter, proteins, vitamins, nitrates, nitrites and N, P, K, Ca, Mg and Fe accumulation in all above ground parts. The nitrogen dose of 200 kg/ha was found to be more suitable one. The three micro nutrient anions (B, Mo and Se) are consistently higher in leaves and lowest in the stem. (Gupta, 1991).

Malewar and Indulkar (1993) reported that despite the presence of adequate amount of total phosphorous and boron in Maharashtra soils, their availability is very low to the crops. They recorded maximum yield and uptake of phosphorous and boron in plants by the application of boronated super phosphate to soil.

2.10 Correlation studies

Correlation coefficient is a measure of the degree of association between the two traits worked out at the same time.

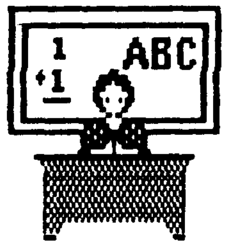
Gulshan Lal (1973) studied the correlation coefficients among different characters in the F_2 in both intra and inter-group varieties of Indian cauliflower. He observed that curd weight was significantly associated with curd size index, leaf size and plant spread.

Thamburaj *et al*. (1982) obtained positive correlation of plant weight with foliage weight (0.89) and between number of leaves and leaf area (0.56); curd length and curd girth had significant positive association with number of leaves and leaf area. Sharma et al. (1982) in a two year study concluded that the correlation coefficients of curd yield with curd diameter, dry matter production, leaf number and leaf area index were highly significant, thus suggesting that yield can be increased with the manifestation of these simple traits in cauliflower.

Pandey and Naik (1985) reported that yield in cauliflower was affected by most of characters viz; days to curd initiation, curd weight, weight of leaves and plant height. Positive correlation of net curd weight with number of leaves was recorded. Highly significant and positive association of curd weight with days to curd maturity, number of leaves per plant and weight of leaves per plant was obtained, where as days to curd initiation and curd maturity had negative but non-significant association with sugar contents (Pandey and Naik 1991).

Dutta and Korla (1991) while studying correlation and regression in advanced generations of late cauliflower observed that net curd weight was positively and significantly correlated with days to marketable maturity, curd initiation, curd depth, curd diameter, gross weight of the plant and harvest index where as days to curd initiation had negative and significant correlation with net curd weight.

Kher (1995) reported high phenotypic coefficient for marketable yield per plant and gross weight per plant. The higher marketable yield can be obtained by increasing gross weight per plant, curd size index and harvest index, while moderate correlation coefficient was obtained for number of leaves per plant, leaf area and curd size index.



MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

The present investigations were carried out during Rabi seasons of 1993-94 and 1994-95 at the experimental farm of the Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur. The details of the materials used and the experimental methods employed during the course of investigations have been detailed in this chapter.

3.1 EXPERIMENTAL SITE

The experimental farm is located at $32^{o}6'$N latitude and $76^{o}3'$ E longitude at an elevation of 1290.8 meters above mean sea level.

3.2 CLIMATE AND WEATHER

Agroclimatically, the region is characterized as sub temperate humid zone (Verma, 1979) with severe winter and mild summers. The annual rainfall is more than 2500 mm out of which about 75 per cent is received during June to September, whereas May, October and November are mostly the months of least rainfall. May and August are the hottest months, whereas, December and January are the coldest. The mean weekly meteorological data recorded at Meteorological Observatory of the Department of Agronomy and Agrometeorology, Himachal Pradesh Krishi Vishvavidyalaya, Palampur have been depicted in Table 3.1.

A brief perusal of weekly meteorological data revealed

Table 3.1 Mean weekly meteorological data during experimental period

Standard week	Date	Temperature (°C) Maximum 1993-94	Temperature (°C) Maximum 1994-95	Temperature (°C) Minimum 1993-94	Temperature (°C) Minimum 1994-95	Relative humidity (%) 1993-94	Relative humidity (%) 1994-95	Rainfall (mm) 1993-94	Rainfall (mm) 1994-95	Sunshine (hrs) 1993-94	Sunshine (hrs) 1994-95
41	8-14 Oct.	27.0	25.9	16.3	14.0	40	34	-	3.3	10.3	10.1
42	15-21	25.3	24.4	13.6	12.7	44	38	-	-	10.4	10.0
43	22-28	23.6	24.0	11.9	14.0	33	46	-	1.0	9.8	8.4
44	29-4 Nov.	22.7	23.0	11.8	11.8	45	33	-	-	9.2	9.1
45	5-11	21.7	22.5	11.5	11.6	42	43	21.5	-	7.7	9.0
46	12-18	20.9	21.5	10.1	10.1	44	38	-	-	7.9	9.3
47	19-25	20.6	20.8	8.7	9.5	35	44	-	-	9.2	8.7
48	26-2 Dec.	21.3	19.6	10.0	9.2	30	55	-	-	7.8	7.3
49	3-9	21.6	18.1	9.5	9.8	26	55	-	13.0	9.2	2.2
50	10-16	17.7	16.3	6.1	6.4	37	47	-	5.5	8.9	7.9
51	17-23	16.1	16.5	5.9	6.2	37	43	-	0.9	7.5	7.1
52	24-31	18.1	13.5	7.7	6.7	30	65	-	42.0	8.1	3.2
1	1-7 Jan.	17.7	13.9	7.8	4.2	33	43	-	-	6.9	8.6
2	8-14	15.7	12.6	7.3	4.1	49	56	30.6	14.0	4.1	5.1
3	15-21	11.6	11.4	4.7	3.8	48	59	8.1	34.3	4.4	3.1
4	22-28	18.3	13.7	9.1	4.4	40	42	3.0	-	3.9	7.6
5	29-4 Feb.	14.9	16.4	3.6	5.7	42	48	8.4	0.8	6.3	8.5
6	5-11	14.9	19.2	6.6	8.6	50	42	25.3	-	6.2	6.2
7	12-18	14.1	14.5	5.5	6.8	44	60	3.6	62.8	6.3	3.9
8	19-25	14.7	13.0	5.5	4.3	47	52	43.1	6.5	6.5	5.2
9	26-4 March	18.7	15.5	9.2	6.6	38	53	0.8	12.7	7.8	6.7
10	5-11	21.3	17.5	9.1	6.5	41	42	-	0.7	9.2	8.6
11	12-18	23.4	20.2	13.6	9.5	36	36	1.1	1.8	8.1	7.5
12	19-25	24.0	24.7	13.8	14.5	40	40	6.9	-	6.9	5.8
13	26-1 April	24.9	19.2	14.3	9.2	37	53	-	50.6	7.9	4.6

Source: Meteorological Observatory Deptt. of Agronomy, HPKV, Palampur that mean maximum temperature was recorded 27^{o}c during crop season of 1993-94 and 25.4^{o}c during 1994-95. The minimum temperature remained 3.6^{o}c and 3.8^{o}c during the two consecutive years of the experimentation. Similarly the total annual rainfall received was 1875.9 mm and 2048.3 mm. and the rain received during the crop seasons of 1993-94 and 1994-95 was 152.4 mm and 249.9 mm, respectively. The relative humidity ranged between 26 to 50 per cent and 33 to 69 per cent and sunshine hours ranged between 4 to 10.4 hrs. and 1.8 hrs to 10.1 hrs. in 1993-94 and 1994-95, respectively.

3.3 Physico chemical properties of the soil

Soil samples were obtained from 0-15 cm. depth from different spots before planting the crop during both the years, so as to know true nutrient status of the soil before manuring the field. The samples were composited and subjected to physico-chemical analysis. The results of the analysis have been depicted in Table 3.2.

The results of the chemical analysis presented in Table 3.2 revealed that the soil of experimental fields was clay loam in texture and acidic in reaction. The soil was rated as medium in available Nitrogen, Phosphorus and Potassium and low in available Boron.

3.4 CROPPING HISTORY

The fields selected for the experiment were under potato and bhindi crops during the preceding season for both the years.

Table 3.2 Mechanical and chemical analysis of the soil of experimental site

Particulars	Year 1993-94	Year 1994-95	Methods employed
A. Mechanical analysis:			
1. Sand (%)	18.9	18.9	International pipette method (Piper, 1966)
2. Silt (%)	41.3	41.3	
3. Clay (%)	39.6	39.6	
Texture	Clay loam		
B. Chemical analysis:			
1. pH	5.5	5.48	Determined in 1:2.5 soil water suspension glass electrode pH meter (Jackson, 1973)
2. Organic carbon (%)	0.85	0.86	Walkely and Black's rapid titration method (Piper, 1966)
3. Available nitrogen (kg ha^{-1})	386	390	Alkali potassium permanganate method (Subbiah and Asija, 1956)
4. Available phosphorus (kg ha^{-1})	15.5	13.4	Olsen's method of extraction with 0.5N $NaHCO_3$ at pH 8.5 (Olsen *et al.*, 1954)
5. Available potassium (kg ha^{-1})	198.6	235.8	Neutral N ammonium acetate extraction using flame photometer (Merwin and Peech, 1951)
6. Available Boron (ppm)	0.43	0.44	Extracted in hot water (Wear, 1965) and determined by Carmine method (Hatcher and Wilcox, 1950)

3.4.1 EXPERIMENTAL DETAILS

Pusa Snowball K-1 a variety of late cauliflower commercially grown for curd and seed crop in Himachal Pradesh was used as plant material. The experiment was laid out in 3^3 factorial and partially confounded design. The details were as follows:-

Treatments : There were three factors each having three different levels as under:-

A. Different transplanting dates

D1 = 12th October

D2 = 26th October

D3 = 10th November

B. Nitrogen

N1 = 100 kg ha^{-1}

N2 = 150 kg ha^{-1}

N3 = 200 kg ha^{-1}

C. Boron

B1 = 15 kg ha^{-1}

B2 = 20 kg ha^{-1}

B3 = 25 kg ha^{-1}

Treatment combinations

1. D1 N1 B1	10. D1 N2 B1	19. D1 N3 B1
2. D1 N1 B2	11. D1 N2 B2	20. D1 N3 B2
3. D1 N1 B3	12. D1 N2 B3	21. D1 N3 B3
4. D2 N1 B1	13. D2 N2 B1	22. D2 N3 B1
5. D2 N1 B2	14. D2 N2 B2	23. D2 N3 B2
6. D2 N1 B3	15. D2 N2 B3	24. D2 N3 B3

7. D3 N1 B1	16. D3 N2 B1	25. D3 N3 B1
8. D3 N1 B2	17. D3 N2 B2	26. D3 N3 B2
9. D3 N1 B3	18. D3 N2 B3	27. D3 N3 B3

3.5 TECHNIQUES OF CONFOUNDING IN 3^3 EXPERIMENT

Each level of each of the factor, D, N and B are denoted as under:

Dates of transplanting (D) - 1,2,3

Nitrogen (N) - 1,2,3

Boron (B) - 1,2,3

Thus 111 denotes the treatment combination D1 N1 B1 similarly, 123 will denote the treatment combination D1 N2 B3, respectively.

Design = 3^3 factorial partially confounded

Replications = Four

Total number of plots = 108

Plot size = 4.20 x 2.25 mts.

Variety = Pusa SnowBall K-1

Spacing = (i) Row to row - 60 cm

(ii) Plant to Plant - 45 cm.

The full dose of phosphorus and potassium @ 100 kg ha^{-1} and 50 kg ha^{-1}, respectively were added in soil before transplanting while nitrogen was applied in three equal splits:

i) Half at the time of transplanting

ii) Half in two equal splits at Ist earthing up and curd initiation stage.

Boron was applied in the soil in the form of borax before transplanting.

3.6 SOURCE OF NUTRIENTS:

Source of nitrogen, phosphorus, potassium were urea (46% N), single super phosphate (16% P_2O_5), muriate of potash (60% K_2O) and Borax (Sodium tetraborate) containing 14% boron, respectively.

3.7 NURSERY RAISING AND TRANSPLANTING:

The raised seed beds were prepared thoroughly by working the soil into fine tilth. Well rotten farmyard manure was mixed in each bed. The seed of cauliflower (PSB K-1) was sown on 10-9-93, 25-9-93, 10-10-93 during 1993-94 and 10-9-94, 25-9-94, 10-10-94 during 1994-95, respectively. Proper care was taken of timely irrigation and weeding during the entire period of nursery raising. Seedlings of almost equal size and vigour were transplanted on 12-10-93, 26-10-93, 10-11-93 and 12-10-94, 26-10-94 and 10-11-94 during both the years 1993-94 and 1994-95. All the necessary steps were undertaken to ensure uniform crop stand during both the years.

3.8 FIELD OPERATIONS:

The fields were ploughed thrice before transplanting of seedlings. Well rotten FYM @10 tonnes/ha was incorporated in the fields two weeks before transplanting. A buffer of one meter size was maintained between adjacent plots. Irrigation was applied when needed and the crop kept weed free by manual weeding. The plants were harvested at curd maturity stage. All the necessary cultural practices required were carried out from time to time during the growth period.

3.9 RECORDING OF DATA

The data were recorded on 10 randomly selected plants in each plot and the observations were recorded on following characters:

Time taken from transplanting to marketable size:

The number of days taken from transplanting to the day when the 50% curds attained marketable maturity were counted. The curd maturity was judged when younger inner leaves covering the curd just began to separate and the curd had attained optimum size.

Number of leaves/plant:

At curd maturity, all full grown leaves were counted while the small leaves attached inside the whorl were not taken into consideration.

Leaf size (cm^2):

Length and breadth of 10 randomly marked leaves were measured in cms. at the time of marketable curd maturity and averages worked out. Leaf size was estimated by multiplying both the parameters and expressed in cm^2.

Leaf area index:

The leaf area index was calculated by the following formula:

$$LAI = \frac{\text{Leaf size} \times \text{No. of leaves per plant} \times \text{No. of plants } (ha^{-1})}{100 \times 10{,}000}$$

Curd size index(cm^2):

Polar and equatorial diameters of the curd were measured and multiplied to obtain curd size index.

Gross curd weight per plant (kg):

The weight of curd along with leaves and stalk at marketable maturity was recorded and expressed in kg per plant.

Net curd weight per plant (kg):

The curds excluding stalk upto first leaf and leaves upto line to curd were weighed at marketable maturity and weight was recorded in kg/plant.

Compactness of curd:

Compactness of curd was measured with the help of angle formed between the main axis and the extreme end of the curd. The curds having angles more than 105^{o} were catagorised as compact, between 96-104^{o} as semi compact and below 95^{o} as loose as suggested by Lal (1976).

Stalk length (cm):

Length of the stalk was measured from soil surface to position of first leaf at marketable curd stage and expressed in cms.

Gross weight per plot (kgs):

While calculating gross plant weight per plot, the plants of border rows were not taken into consideration. Based on yield of remaining 25 plants, the gross plant weight per plot was worked out.

Marketable yield per plot and per hectare:

The plants were harvested and the weight of curd excluding stalk upto first leaf and leaves upto the line of curd harvested at the marketable maturity by keeping only five petioles was recorded in each plot and average yield per hectare calculated in quintals.

Harvest index:

Harvest index was calculated as follows:

$$\frac{\text{Net weight of curd}}{\text{Gross weight of curd}} \times 100$$

Dry matter content:

Curd samples weighing 100g from each treatment were dried in forced feed air oven at 65.5^{o}c till constant weight was obtained and dry matter content recorded in per cent.

Protein content in the curd(%):

The protein content in the curd was calculated by the formula:

Protein content in curd

= Per cent nitrogen content in the curd x 6.25

3.10 PLANT ANALYSIS FOR NUTRIENT CONCENTRATION

Leaf samples were taken for the estimation of different nutrient concentrations at two growth stages, first at the time of curd initiation and next at curd maturity stage. For leaf analysis mid ribs of outer leaves of cauliflower were taken from ten randomly selected plants from each plot. Cleaning, drying, grinding and storing of samples were carried out in accordance with the procedure given by

Chapman and Pratt (1961). At sampling time 5 curds were taken at random from each treatment in each replication. From the composite sample of five curds, nutrients were estimated.

3.11 NUTRIENT/ELEMENT ESTIMATION:

For the determination of boron, dry ashing of the plant material was done at 550^{o}C for 3 hours in muffle furnace. The ash was dissolved in 10 ml. of 6 N HCl taken in distilled deionised water, filtered and volume made to 100 ml. Boron was then determined by carmine (Hatcher and Wilcox, 1950) method. For estimating the content of N, the plant material was digested in a digestion mixture having composition, K_2SO_4, $CuSO_4$, Hgo and Se powder in the ratio of 400 : 20 : 3 : 1, respectively and then estimated by micro Kjeldhal procedure (Jackson, 1973).

Uptake of nitrogen and boron:

The uptake of nitrogen and boron per hectare was calculated by the following formulae:

Uptake = per cent content x dry matter content.

3.12 ECONOMIC STUDIES:

3.12.1 Cost of cultivation:

The cost of cultivation of crop was worked out as per the procedure given by Bhagat (1994).

3.12.2 Gross returns (Rs./ha.):

The yield of the curd crop was converted into gross returns in rupees based on prevailing market price @ Rs 2/- per kg.

3.12.3 Net returns (Rs./ha.):

Net return for curd crop was calculated by deducting the cost of cultivation from the gross-return.

3.12.4 Benefit : cost ratio:

The benefit cost ratio was calculated as follows:

$$\frac{\text{Net returns (Rs ha}^{-1})}{\text{Cost of cultivation (Rs ha}^{-1})}$$

3.13 STATISTICAL ANALYSIS:

The data recorded were tabulated and analysed statistically in 3^3 factorial partially confounded design as per the procedure given by Cochran and Cox (1963) and Panse and Sukhatme (1989).

3.14 CORRELATION STUDIES:

The correlation coefficient of different economic characters viz; Days taken to marketable maturity, average number of leaves per plant, Size of leaves (cm^2), average stalk length (cm), average gross weight of curd (kg), Average marketable curd weight, average net weight of curd, compactness of curd, average marketable yield per hectare, Harvest index and dry matter content were worked out at phenotypic level.

The phenotypic correlations were calculated from variance and co-variance components according to methods given by Al-Ji-bouri *et al*. (1958) and Fisher and Yates (1963) The formulae applied in the analysis are:

$$\text{Phenotypic correlation} = r_{xy(p)} = \frac{\text{Cov. } xy(p)}{o^2x(p) \times o^2y(p)}$$

Where:

Cov. xy(p) = Phenotypic covariance of characters x and y

$o^2x(p)$ = Phenotypic variance of character x

$o^2y(p)$ = Phenotypic variance of character y.

EXPERIMENTAL RESULTS

Chapter 4

EXPERIMENTAL RESULTS

The present investigations were undertaken to study the influence of different planting dates, nitrogen and boron levels on the characters of Pusa SnowBall K-1 cultivar of cauliflower under mid-hill conditions of Himachal Pradesh. Data on different characters viz. Time taken from transplanting to marketable maturity, number of leaves per plant, leaf size, stalk length, gross weight per plant, curd size, weight of marketable curd, net curd weight, curd yield and uptake of nitrogen and boron by the plants were recorded. The economics of each treatment was also worked out. The results of these studies are presented as under:-

4.1 Days taken from transplanting to marketable maturity

The analysis of variance (Appendix-I) indicated significant differences among treatments. All the main effects of nitrogen, boron and transplanting dates significantly affected days taken to marketable maturity. Data given in Table 4.1 revealed that with the increase in nitrogen level from 100 kg N per hectare (124.8 and 125.9 days) to 200 kg N ha^{-1} (132.8 and 133.00 days) there was significant increase in days taken from transplanting to marketable maturity. In case of boron application from 15 kg ha^{-1} took (132.9 and 134.8 days) to 25 kg ha^{-1} (126.6 and 126.8 days) during both the years of study. In case of transplanting dates, the 12th October, planting date took

Table 4.1 Effect of transplanting dates, nitrogen and boron levels on days taken from transplanting to marketable maturity

Treatments		Days taken from transplanting to marketable maturity		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	124.8	125.9	125.3
N_2	150	128.4	128.6	128.5
N_3	200	132.8	133.0	132.9
SE(m)$\pm$		0.21	0.37	-
CD 5%		0.36	0.63	-
Boron levels (kg ha^{-1})				
B_1	15	132.9	134.8	133.8
B_2	20	128.5	128.8	127.6
B_3	25	126.6	126.8	126.7
SE(m)$\pm$		0.21	0.37	-
CD 5%		0.36	0.63	-
Transplanting dates				
D_1	12th October	125.9	119.8	122.8
D_2	26th October	125.4	125.4	125.4
D_3	10th November	134.8	136.3	135.5
SE(m)$\pm$		0.21	0.37	-
CD 5%		0.36	0.63	-

125.9 and 119.8 days where as the 10th November, planting took 134.8 and 136.3 days to marketable maturity during 1993-94 and 1994-95.

The data in Table 4.2 and 4.3 revealed that interactions between DxN and NxB were significant during both the years of study. The combination D_1 N_1 took minimum 120.17 and 121.00 days while combination D_3 N_3 took maximum (137.58 and 140.33) number of days to marketable maturity. During the year 1994-95, the D_1 N_3 combination was at par with D_2 N_3. The interaction between N and B was also found significant. The minimum 125.00 and 123.42 days and maximum 133.08 and 128.83 days were taken to marketable maturity by N_1 B_3 and N_3 B_3 treatment combinations in 1993-94 and 1994-95, respectively.

The data in Table 4.4 depicts that during both the years, the interactions between boron x dates were non-significant.

4.2 Number of leaves per plant

The data in Table 4.5 indicated that with the increase in nitrogen level from 100 kg ha^{-1} to 200 kg ha^{-1} and boron level from 15 kg ha^{-1} to 20 kg ha^{-1} there was increase in number of leaves per plant during both the years. The number of leaves per plant recorded minimum 13.94 and 13.03 with 100 kg N ha^{-1} and 15.17 and 14.32 with 15 kg boron ha^{-1} and maximum 16.58 and 16.61 with 200 kg N ha^{-1} and 15.60 and 15.14 number of leaves with 20 kg B ha^{-1}, respectively. The data regarding transplanting dates

Table 4.2 Interaction effect of transplanting dates and nitrogen levels (DxN) on days taken from transplanting to marketable maturity

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	120.17	124.75	129.50	121.00	124.58	130.24
D_2	122.33	125.83	131.42	123.58	125.67	130.50
D_3	132.08	134.67	137.58	133.17	135.42	140.33
SE$\pm$	0.372			0.385		
CD 5%	0.620			0.655		

Table 4.3 Interaction effect of nitrogen and boron levels (NxB) on days taken from transplanting to marketable maturity

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	125.08	124.50	125.00	125.58	124.67	123.42
N_2	128.25	128.17	128.83	128.08	126.42	125.75
N_3	132.17	133.25	133.08	132.99	128.75	128.83
SE$\pm$	0.372			0.385		
CD 5%	0.620			0.655		

Table 4.4 Interaction effect of boron levels and transplanting dates (BxD) on days taken from transplanting to marketable maturity

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	125.50	125.17	134.83	125.99	124.67	136.00
B_2	125.92	125.50	134.50	116.92	126.08	136.83
B_3	126.25	125.67	135.00	116.58	125.33	136.08
SE$\pm$	N.S			N.S		
CD 5%	-			-		

N.S - Non significant

Table 4.5 Effect of transplanting dates, nitrogen and boron levels on average number of leaves per plant

Treatments		Average number of leaves		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	13.94	13.03	13.48
N_2	150	15.45	14.91	15.18
N_3	200	16.58	16.61	16.59
SE(m)$\pm$		0.14	0.15	-
CD 5%		0.23	0.86	-
Boron levels (kg ha^{-1})				
B_1	15	15.17	14.32	14.74
B_2	20	15.60	15.14	15.37
B_3	25	15.17	15.08	15.12
SE(m)$\pm$		0.14	0.15	-
CD 5%		0.23	0.86	-
Transplanting dates				
D_1	12th October	15.79	15.76	15.77
D_2	26th October	15.78	15.37	15.57
D_3	10th November	14.39	13.41	13.90
SE(m)$\pm$		0.14	0.15	-
CD 5%		0.23	0.86	-

revealed that with delay in transplanting, there was linear decrease in the number of leaves per plant. Maximum number of leaves per plant 15.79 and 15.77 were produced during 1993-94 and 1994-95 when seedling were transplanted on 12th October. 12th October and 26th October planting dates were, however, at par with each other whereas planting on 10th November, produced minimum (14.39 and 13.41) number of leaves, respectively in 1993-94 and 1994-95.

The data presented in Table 4.6 and 4.7 depicted that interaction between planting dates x nitrogen level and nitrogen x boron level were statistically significant. The treatment combination D_1 N_3 produced more number of leaves per plant (17.68 and 17.61) where as treatment combination D_3 N_1 produced less (13.87 and 11.71) number of leaves per plant. In case of nitrogen x boron interaction, the treatment combination N_3 B_2 produced maximum (17.03 and 17.30) and minimum (13.69 and 13.52) number of leaves per plant were produced by N_1 B_1 combination in 1993-94 and 1994-95, respectively. The Table 4.8 showed that interaction between levels of boron x planting dates was non-significant during both the years of study.

4.3 Leaf size

The analysis of variance (Appendix III) for leaf size showed highly significant differences among the different levels of nitrogen, boron and planting dates. There was linear increase in size of leaves with the increase in the levels of nitrogen and boron. However, with

Table 4.6 Interaction effect of transplanting dates and nitrogen levels (DxN) on average number of leaves per plant

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	14.09	15.62	17.68	13.89	15.80	17.61
D_2	13.87	16.45	17.02	13.48	15.50	17.14
D_3	13.87	14.27	15.04	11.71	13.43	15.09
SE$\pm$	0.238			0.148		
CD 5%	0.398			0.248		

Table 4.7 Interaction effect of nitrogen and boron levels (NxB) on average number of leaves per plant

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	13.69	13.70	14.25	12.51	13.00	13.56
N_2	15.04	16.10	15.20	14.11	15.68	14.94
N_3	16.65	17.03	16.06	16.36	17.30	15.37
SE$\pm$	0.238			0.148		
CD 5%	0.398			0.248		

Table 4.8 Interaction effect of boron levels and transplanting dates (BxD) on average number of leaves per plant

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	15.60	15.43	14.55	15.25	14.84	12.89
B_2	16.16	16.09	14.57	16.04	15.59	13.61
B_3	15.63	15.82	14.07	16.01	15.68	13.73
SE$\pm$	N.S			N.S		
CD 5%	-			-		

N.S - Non significant

the delay in transplanting dates, there was decrease in leaf size. The data in Table 4.9 indicated that nitrogen at 200 kg ha^{-1} and boron at 20 kg ha^{-1} individually gave the better leaf size (700.32 and 736.73 cm^2) and (629.11 and 639.65 cm^2), respectively while 100 kg N and 15 kg B ha^{-1} gave least leaf size (496.26 and 471.08 cm^2) and 586.75 and 578.72 cm^2 during both the years. The 12th October planting produced maximum (755.86 and 779.42 cm^2) leaf size while as minimum leaf size (420.67 and 419.34 cm^2) was observed with 10th November transplanting date.

All the interactions were observed to be highly significant during both the crop years. A perusal of data in Table 4.10, 4.11 and 4.12 revealed that the treatment combination D_3 N_1 produced the smallest sized leaves (402.81 and 394.96 cm^2) whereas the D_1 N_3 (12th October transplanting and 200 kg N ha^{-1}) combination produced largest sized leaves (964.68 and 1024.32 cm^2). Similarly the treatment combination N_1 B_1 (100 kg N and 15 kg B ha^{-1}) gave the minimum sized leaves (468.05 and 438.76cm^2 an d treatment combination N_3 B_2(200 kg N and 20 kg B ha^{-1}) gave the maximum (730.84 and 785.51 cm^2) sized leaves. Among the interactions between levels of boron x planting dates, the combination B_1 D_3 (15 kg B ha^{-1} and 10th November transplanting) produced minimum (539.69 and 410.18 cm^2) and combination B_2 D_1 (20kg B ha^{-1} and 12th October transplanting) produced the maximum (796.09 and 847.06 cm^2) leaf size during 1993-94 and 1994-95.

Table 4.9 Effect of transplanting dates, nitrogen and boron levels on average size of leaves (cm^2)

Treatments		Average size of leaves		
		1993-94	1994-95	Mean
Nitrogen levels ($kg\ ha^{-1}$)				
N_1	100	496.26	471.08	483.67
N_2	150	611.91	610.24	611.07
N_3	200	700.32	736.73	718.52
SE(m)$\pm$		2.21	5.34	-
CD 5%		3.69	8.92	-
Boron levels ($kg\ ha^{-1}$)				
B_1	15	586.75	578.72	582.73
B_2	20	629.11	639.65	634.38
B_3	25	592.62	599.69	596.15
SE(m)$\pm$		2.21	5.34	-
CD 5%		3.69	8.92	-
Transplanting dates				
D_1	12th October	755.86	779.42	767.64
D_2	26th October	631.96	619.30	625.63
D_3	10th November	420.67	419.34	420.00
SE(m)$\pm$		2.21	5.34	-
CD 5%		3.69	8.92	-

Table 4.10 Interaction effect of transplanting dates and nitrogen levels (DxN) on average size of leaves (cm^2)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	564.27	781.20	964.68	526.93	787.00	1024.32
D_2	521.69	642.02	689.58	491.34	622.05	744.49
D_3	402.81	412.50	446.70	394.96	421.68	441.38
SE$\pm$	3.833			9.252		
CD 5%	6.402			15.452		

Table 4.11 Interaction effect of nitrogen and boron levels (NxB) on average size of leaves (cm^2)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	468.05	481.03	539.69	438.76	452.79	521.68
N_2	606.59	675.47	553.66	589.76	680.64	560.32
N_3	685.62	730.84	684.51	707.62	785.51	717.06
SE$\pm$	3.833			9.252		
CD 5%	6.402			15.452		

Table 4.12 Interaction effect of boron levels and transplanting dates (BxD) on average size of leaves (cm^2)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	721.85	628.86	539.69	732.60	593.37	410.18
B_2	796.09	684.50	553.67	847.06	647.98	423.91
B_3	749.65	655.32	611.69	758.59	616.54	423.93
SE$\pm$	3.833			9.252		
CD 5%	6.402			15.452		

4.4 Leaf area index

The data presented in Table 4.13 revealed that there was linear increase in leaf area index with the increase in levels of nitrogen and boron. However, there was decrease in the leaf area index with delayed transplanting dates. The nitrogen at 200 kg ha^{-1} and boron at 20 kg ha^{-1} individually gave the better leaf area index (430.04 and 453.22) and (358.68 and 363.48), respectively while as least leaf area index was given by 100 kg N and 15 kg B ha^{-1} (227.34 and 256.22) and (306.93 and 329.67) during both the years. The highest leaf area index (442.04 and 454.95) was recorded with 12th October transplanting date where as lowest (208.27 and 224.20) with 10th November transplanting date.

All the interactions were observed to be highly significant during both the years. The data presented in Table 4.14, 4.15 and 4.16 depicted that treatment combinations D_1 N_3 produced the highest leaf area index (631.69 and 668.08) where as D_3 N_1 (12th October transplanting and 100 Kg N ha^{-1}) produced the lowest leaf area index (171.29 and 206.92). Similarly, the treatment combination B_2 D_1 (20 kg B ha^{-1} and 12th October transplanting date) gave the maximum (460.97 and 503.312) and treatment combination B_3 D_3 (25 kg B ha^{-1} and 10th November transplanting date) gave the minimum leaf area index. Among the interactions between nitrogen x boron levels N_3 B_2 (200 kg N and 20 kg B ha^{-1}) produced highest

Table 4.13 Effect of transplanting dates, nitrogen and boron levels on leaf area index (cm^2)

Treatments		Leaf area index 1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	227.34	256.22	241.78
N_2	150	336.99	350.15	343.57
N_3	200	430.04	453.22	441.63
SE(m)$\pm$		3.83	9.25	-
CD 5%		6.40	15.45	-
Boron levels (kg ha^{-1})				
B_1	15	306.93	329.67	318.30
B_2	20	358.68	363.48	361.08
B_3	25	332.96	334.94	333.95
SE(m)$\pm$		3.83	9.25	-
CD 5%		6.40	15.45	-
Transplanting dates				
D_1	12th October	442.04	454.95	448.49
D_2	26th October	352.54	369.34	360.94
D_3	10th November	208.27	224.20	216.23
SE(m)$\pm$		3.83	9.25	-
CD 5%		6.40	15.45	-

Table 4.14 Interaction effect of transplanting dates and nitrogen levels (DxN) on leaf area index (cm^2)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	271.07	451.94	631.69	294.45	460.54	668.08
D_2	245.30	357.10	434.69	267.99	391.16	472.61
D_3	171.29	209.75	246.68	206.92	218.01	246.68
SE$\pm$	3.52			4.28		
CD 5%	6.09			7.43		

Table 4.15 Interaction effect of boron levels and transplanting dates (BxD) on leaf area index (cm^2)

Levels	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	195.82	413.78	326.13	290.83	417.07	359.38
B_2	213.69	433.96	374.15	298.78	476.47	407.91
B_3	215.58	449.81	358.05	318.76	503.21	383.97
SE$\pm$	3.52			4.28		
CD 5%	6.09			7.43		

Table 4.16 Interaction effect of nitrogen and boron levels (NxB) on leaf area index (cm^2)

Levels/Dates	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	284.84	261.99	218.01	311.69	244.08	284.84
N_2	460.97	402.78	310.04	503.31	408.19	337.89
N_3	395.27	308.20	203.29	428.76	407.16	237.32
SE$\pm$	3.52			4.28		
CD 5%	6.09			7.43		

(449.81 and 503.21) and N_1 B_1 (100 kg N and 15 kg B ha^{-1}) produced lowest (195.82 and 290.83) leaf area index during 1993-94 and 1994-95.

4.5 Stalk length

The analysis of variance (Appendix IV) depicted that differences among the different levels of nitrogen, boron and planting dates for stalk length of the plant were not significant during both the crop years. Data given in Table 4.17 for main effects and in Tables 4.18, 4.19 and 4.20 depicted that different interaction effects had no-significant differences for stalk length.

4.6 Curd gross weight

The average gross weight of the curd showed significant differences among the treatments. During both the years, there were significant differences among the treatments for average gross weight of the curd. Data presented in Table 4.21 revealed increase in gross weight of curd with the increase in nitrogen levels from 100 to 200 kg ha^{-1}. The highest (1.45 and 1.55 kg) with 200 kg N ha^{-1} and lowest (0.93 and 1.04 kg) with 100 kg N ha^{-1}. Similar trend was recorded in case of boron levels. There was significant and linear increase in gross weight of the curd with the increase in levels of boron from 15 to 20 kg ha^{-1}. A maximum gross weight of 1.23 and 1.33 kg and minimum 1.09 and 1.19 kg had been recorded with 20 kg and 15 kg B ha^{-1}, respectively during 1993-94 and 1994-95. With delayed planting dates, there was linear decrease in the gross

Table 4.17 Effect of transplanting dates, nitrogen and boron levels on stalk length (cm)

Treatments		Average stalk length		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	3.45	3.29	3.37
N_2	150	3.70	3.71	3.70
N_3	200	3.80	3.77	3.78
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-
Boron levels (kg ha^{-1})				
B_1	15	3.62	3.55	3.58
B_2	20	3.72	3.63	3.67
B_3	25	3.60	3.59	3.59
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-
Transplanting dates				
D_1	12th October	3.61	3.62	3.61
D_2	26th October	3.62	3.56	3.59
D_3	10th November	3.71	3.61	3.66
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-

N.S - Non significant

Table 4.17 Effect of transplanting dates, nitrogen and boron levels on stalk length (cm)

Treatments		Average stalk length		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	3.45	3.29	3.37
N_2	150	3.70	3.71	3.70
N_3	200	3.80	3.77	3.78
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-
Boron levels (kg ha^{-1})				
B_1	15	3.62	3.55	3.58
B_2	20	3.72	3.63	3.67
B_3	25	3.60	3.59	3.59
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-
Transplanting dates				
D_1	12th October	3.61	3.62	3.61
D_2	26th October	3.62	3.56	3.59
D_3	10th November	3.71	3.61	3.66
SE(m)$\pm$		N.S	N.S	-
CD 5%		-	-	-

N.S - Non significant

Table 4.18 Interaction effect of transplanting dates and nitrogen levels (DxN) on the stalk length (cm)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	3.38	3.74	3.72	3.36	3.81	3.67
D_2	3.38	3.72	3.76	3.25	3.64	3.78
D_3	3.59	3.63	3.92	3.27	3.67	3.87
SE±	N.S			N.S		
CD 5%	-			-		

Table 4.19 Interaction effect of boron and transplanting dates (BxD) on the stalk length (cm)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	3.60	3.52	3.73	3.68	3.47	3.51
B_2	3.60	3.73	3.84	3.64	3.62	3.63
B_3	3.63	3.60	3.57	3.51	3.59	3.69
SE±	N.S			N.S		
CD 5%	-			-		

Table 4.20 Interaction effect of nitrogen x Boron levels (NxB) on stalk length (cm)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	3.46	3.53	3.36	3.24	3.29	3.36
N_2	3.63	3.79	3.67	3.56	3.71	3.84
N_3	3.75	3.86	3.78	3.85	3.88	3.59
SE±	N.S			N.S		
CD 5%	-			-		

N.S - Non significant

Table 4.21 Effect of transplanting dates, nitrogen and boron levels on average gross curd weight (kg)

Treatments		Average gross weight (kgs)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	0.93	1.04	0.99
N_2	150	1.17	1.25	1.21
N_3	200	1.45	1.55	1.50
SE(m)$\pm$		0.17	0.13	-
CD 5%		0.29	0.21	-
Boron levels (kg ha^{-1})				
B_1	15	1.09	1.19	1.14
B_2	20	1.23	1.33	1.28
B_3	25	1.22	1.31	1.26
SE(m)$\pm$		0.17	0.13	-
CD 5%		0.29	0.21	-
Transplanting dates				
D_1	12th October	1.54	1.61	1.58
D_2	26th October	1.21	1.42	1.31
D_3	10th November	0.80	0.81	0.81
SE(m)$\pm$		0.17	0.13	-
CD 5%		0.29	0.21	-

weight of the curd. The highest 1.54 and 1.61 kg gross weight has been recorded with 12th October, the normal planting date and the lowest 0.80 and 0.81 kg gross weight with 10th November i.e. the last transplanting date during both the years.

The data in Table 4.22 indicated that interaction between planting dates x nitrogen was significant. The treatment combination D_1 N_3 gave maximum gross weight of 1.87 and 2.02 kg whereas combination D_3 N_1 gave the minimum 0.70 and 0.71 kg.

The interaction between BxD was also found to be significant during both the years. The combination B_2 D_1 gave the highest 1.59 and 1.69 kg gross curd weight during 1993-94 and 1994-95, respectively. However, this was not statistically superior over B_1 D_1, B_1 D_2, B_2 D_2 and B_3 D_1 treatment combinations during 1993-94. Similarly the combination B_1 D_3 gave the lowest 0.78 and 0.78 kg gross weight, respectively during both the years (Table 4.23).

The data in Table 4.24 revealed that all NxB interactions were significant. The treatment combination N_3 B_2 gave maximum 1.62 and 1.71 kg gross weight which was superior among all the treatment combinations except N_3 B_3, N_3 B_1 and N_2 B_2 during 1993-94. Also the same combination was found to be superior among all during 1994-95, closely followed by N_3 B_1 and N_3 B_3 combinations.

4.7 Curd size (cm)

The analysis of variance (Appendix VI) for curd size

Table 4.22 Interaction effect of transplanting dates and nitrogen levels (DxN) on gross curd weight (kg)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	1.23	1.53	1.87	1.28	1.55	2.02
D_2	0.85	1.18	1.59	1.14	1.37	1.73
D_3	0.70	0.81	0.89	0.71	0.83	0.89
SE±	0.302			0.227		
CD 5%	0.504			0.379		

Table 4.23 Interaction effect of boron levels and transplanting dates (BxD) on gross curd weight (kg)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	1.45	1.07	0.78	1.50	1.31	0.78
B_2	1.59	1.31	0.81	1.69	1.47	1.83
B_3	1.59	1.25	0.81	1.64	1.46	0.83
SE±	0.302			0.227		
CD 5%	0.504			0.379		

Table 4.24 Interaction effect of nitrogen and boron levels (NxB) on gross curd weight (kg)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	0.88	0.92	0.98	0.98	1.04	1.11
N_2	1.09	1.27	1.16	1.18	1.31	1.24
N_3	1.33	1.62	1.40	1.43	1.71	1.50
SE±	0.302			0.227		
CD 5%	0.504			0.379		

of Pusa Snowball K-1 showed highly significant differences among different levels of nitrogen, boron and transplanting dates during both the years.

It is evident from Table 4.25 that with the increase in dose of nitrogen from 100 to 200 kg ha^{-1}, there was significant increase in curd size. However, the higher dose of nitrogen i.e. 200 kg ha^{-1} increased to maximum curd size (178.34 and 198.15 cm^2) as compared to 100 kg N ha^{-1} which gave 102.41 and 148.51 cm^2 curd size. Similarly, soil application of boron at the rate of 20 kg ha^{-1} resulted in significant increase in curd size (145.45 and 180.65 cm^2) as compared to 15 kg B ha^{-1} (125.96 and 163.55 cm^2) which was closely followed by 25 kg B ha^{-1} during both the crop seasons. The curd size decreased with the delay in transplanting dates. The maximum curd size (164.77 and 168.45 cm^2) was recorded with 12th October transplanting date. The 26th October transplanting date was at par with it during both the years. 10th November transplanting date gave the minimum (90.56 and 94.95 cm^2) curd size in both the years.

The data presented in Tables 4.26, 4.27 and 4.28 reflected that interactions D_1 N_3, B_2 D_1 and N_3 B_2 produced the largest sized curds. Among the interaction of transplanting dates x nitrogen, D_1 N_3 combination gave largest sized curds (220.54 and 254.19 cm^2), while the combination D_3N_1 produced (79.12 and 83.14 cm^2) sized curds (Table 4.26).

Table 4.25 Effect of transplanting dates, nitrogen and boron levels on average curd size (cm^2)

Treatments		Average size of the curd		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	102.41	148.51	125.46
N_2	150	135.54	174.99	155.26
N_3	200	178.34	198.15	188.24
SE(m)±		3.08	7.38	-
CD 5%		5.14	12.23	-
Boron levels (kg ha^{-1})				
B_1	15	125.96	163.55	144.75
B_2	20	145.45	180.65	163.05
B_3	25	144.89	177.45	161.17
SE(m)±		3.08	7.38	-
CD 5%		5.14	12.23	-
Transplanting dates				
D_1	12th October	164.77	168.45	166.61
D_2	26th October	160.96	164.15	162.55
D_3	10th November	90.56	94.95	92.75
SE(m)±		3.08	7.38	-
CD 5%		5.14	12.23	-

Table 4.26 Interaction effect of transplanting dates and nitrogen levels (DxN) on average curd size (cm^2)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	114.15	159.61	220.54	183.18	217.52	254.19
D_2	113.96	154.84	214.08	179.21	210.81	235.17
D_3	79.12	92.16	100.39	83.14	96.63	105.09
SE$\pm$	5.333			1.233		
CD 5%	8.905			2.136		

Table 4.27 Interaction effect of boron and transplanting dates (BxD) on average curd size (cm^2)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	147.79	143.93	86.15	202.57	197.19	90.88
B_2	173.96	170.12	92.27	229.32	214.89	97.72
B_3	172.56	168.84	93.25	222.99	213.11	96.25
SE$\pm$	5.333			1.233		
CD 5%	8.905			2.136		

Table 4.28 Interaction effect of nitrogen and boron levels (NxB) on average curd size (cm^2)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	90.91	113.24	103.07	135.82	147.22	162.48
N_2	124.75	143.59	138.28	168.20	180.91	175.85
N_3	162.20	194.99	177.82	186.63	209.28	198.53
SE$\pm$	5.333			1.233		
CD 5%	8.905			2.136		

Data regarding interactions between boron x transplanting dates (Table 4.27) revealed that maximum sized curds (173.96 and 229.32 cm^2) were produced with B_2 D_1 combination. The combinations B_3 D_1, B_2 D_2 and B_3 D_2 were at par with B_2 D_1 during 1993-94. The minimum sized curds (86.15 and 90.88 cm^2) have been recorded with B_1 D_3 combination.

The interaction between nitrogen x boron reflected that maximum (194.99 and 209.88 cm^2) and minimum (90.91 and 135.82 cm^2) sized curds were obtained with 200 kg N and 20 kg B ha^{-1} (N_3 B_2) and 100 kg N and 15 kg B ha^{-1} (N_1 B_1) combination, respectively during 1993-94 and 1994-95 (Table 4.28).

4.8 Average weight of marketable curd (kg)

A perusal of analysis of variance values (Appendix VII) showed significant differences among different levels of nitrogen, boron and transplanting dates for average weight of marketable curd.

The values in Table 4.29 revealed that with the increase in levels of nitrogen from 100 to 200 kg ha^{-1}, there was significant increase in the weight of marketable curd from 0.510 to 0.759 and 0.529 kg to 0.873 kg, respectively during 1993-94 and 1994-95. Similar, trend was observed in case of boron application from 15 to 20 kg ha^{-1}. However, with the higher dose of 25 kg ha^{-1} a slight reduction in average curd weight was observed. However, the best results were obtained with 20 kg B ha^{-1} giving (0.659

Table 4.29 Effect of transplanting dates, nitrogen and boron levels on average weight of marketable curd (kg)

Treatments		Average weight of marketable curd		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	0.510	0.529	0.519
N_2	150	0.653	0.657	0.655
N_3	200	0.759	0.873	0.816
SE(m)$\pm$		0.016	0.011	-
CD 5%		0.032	0.023	-
Boron levels (kg ha^{-1})				
B_1	15	0.597	0.648	0.622
B_2	20	0.659	0.745	0.702
B_3	25	0.649	0.667	0.658
SE(m)$\pm$		0.016	0.011	-
CD 5%		0.032	0.023	-
Transplanting dates				
D_1	12th October	0.857	0.989	0.923
D_2	26th October	0.693	0.727	0.710
D_3	10th November	0.354	0.345	0.349
SE(m)$\pm$		0.016	0.011	-
CD 5%		0.032	0.023	-

and 0.745 kg) marketable weight of curd and the least (0.597 and 0.648 kg) marketable weight was recorded with 15 kg B ha^{-1} during both the years of crop study. With the increase in time of planting, the weight of marketable curd decreased. Almost similar trend was observed with regards to dates of transplanting. 12th October transplanting proved to be ideal transplanting date giving average marketable curd weight (0.857 and 0.989 kg) and with delay in transplanting dates, there was significant reduction in average marketable curd weight. Minimum curd weight was observed in 10th November transplanting (0.354 and 0.345) during 1993-94 and 1994-95.

A perusal of data in Table 4.30 depicted that 12th October transplanting with 200 kg N ha^{-1} (D_1 N_3) combination gave the maximum curd weight (1.002 and 1.319 kg) while 10th November transplanting and 100 kg N ha^{-1} (D_3 N_1) combination the minimum (0.313 and 0.312 kg) during both the years. However, during 1993-94, 12th October transplanting and 200 kg N ha^{-1} (D_1 N_3) was closely followed by 26th October transplanting and 200 kg N ha^{-1} (D_2 N_3).

Similar trend was recorded in boron x dates interactions (Table 4.31). The highest average weight of marketable curd (0.885 and 1.034 kg) was recorded with 20 kg B ha^{-1} and 12th October transplanting date (B_2 D_1). However, the combinations B_1 D_1, B_1 D_2, B_2 D_2, B_3 D_1 and B_3 D_2 were at par with B_2 D_1 in 1993-94. During 1994-95, the same treatment i.e. B_2 D_1 was closely followed by B_1 D_1, B_2

Table 4.30 Interaction effect of transplanting dates and nitrogen levels (DxN) on weight of marketable curd (kg)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	0.715	0.854	1.002	0.734	0.912	1.319
D_2	0.502	0.692	0.885	0.542	0.712	0.927
D_3	0.313	0.359	0.390	0.312	0.347	0.375
SE$\pm$	0.168			0.187		
CD 5%	0.278			0.313		

Table 4.31 Interaction effect of boron and transplanting dates (BxD) on weight of marketable curd (kg)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	0.814	0.638	0.346	0.917	0.685	0.334
B_2	0.885	0.734	0.358	1.034	0.842	0.342
B_3	0.872	0.714	0.359	1.014	0.654	0.358
SE$\pm$	0.166			0.187		
CD 5%	0.278			0.313		

Table 4.32 Interaction effect of nitrogen and boron levels (NxB) on weight of marketable curd (kg)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	0.486	0.507	0.537	0.507	0.556	0.526
N_2	0.597	0.685	0.623	0.623	0.682	0.667
N_3	0.708	0.847	0.723	0.815	0.997	0.810
SE$\pm$	0.166			0.187		
CD 5%	0.278			0.313		

D_2 and B_3 D_1 treatments in order of merit.

Among nitrogen x boron interactions, the treatment combination N_3 B_2 (200 kg N and 20 kg B ha^{-1}) was found to be superior giving 0.847 and 0.997 kg average marketable weight of curd. The treatments N_2 B_1, N_2 B_2, N_2 B_3, N_3 B_1 and N_3 B_3 were at par with N_3 B_2 during both the years of crop study. The lowest marketable weight of curd 0.537 and 0.526 kg was observed with N_1 B_3 (100 kg N and 25 kg B ha^{-1}) combination (Table 4.32).

4.9 Net curd weight (kg)

The data on net curd weight as influenced by different levels of nitrogen, boron and transplanting dates is presented in Table 4.33. All the main effects were significant during both the crop seasons. Average net curd weight increased in a linear fashion with increase in the levels of nitrogen from 100 to 200 kg ha^{-1}. Highest net curd weight to the tune of 0.429 and 0.499 kg was obtained during 1993-94 and 1994-95 with the application of 200 kg N ha^{-1} and was significantly superior over 100 kg and 150 kg N ha^{-1}.

Average net curd weight was also increased in a similar manner as that of nitrogen with boron application from 15 to 20 kg ha^{-1} but showed slight decrease with higher dose of boron i.e. 25 kg B ha^{-1}. Table 4.33 showed that a maximum 0.378 and 0.435 kg of net curd weight was observed with 20 kg B ha^{-1} during 1993-94 and 1994-95.

With the delay in transplanting dates, there was

Table 4.33 Effect of transplanting dates, nitrogen and boron levels on average net weight of the curd (kg)

Treatments		Average net weight of the curd		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	0.285	0.307	0.296
N_2	150	0.354	0.382	0.368
N_3	200	0.429	0.499	0.464
SE(m)±		0.005	0.005	-
CD 5%		0.008	0.009	-
Boron levels (kg ha^{-1})				
B_1	15	0.332	0.372	0.352
B_2	20	0.378	0.435	0.406
B_3	25	0.358	0.381	0.369
SE(m)±		0.005	0.005	-
CD 5%		0.008	0.009	-
Transplanting dates				
D_1	12th October	0.495	0.539	0.517
D_2	26th October	0.400	0.413	0.406
D_3	10th November	0.173	0.234	0.203
SE(m)±		0.005	0.005	-
CD 5%		0.008	0.009	-

linear decrease in the net curd weight. Highest net curd weight of 0.495 and 0.539 kg was recorded with 12th October transplanting date.

A perusal of data in Table 4.34, 4.35 and 4.36 revealed that application of 200 kg N ha^{-1} x 12th October transplanting (D_1 N_3) produced the maximum (0.589 and 0.702 kg) net curd weight. Similarly, 20 kg B ha^{-1} x 12th October transplanting (B_2 D_1) gave the highest (0.515 and 0.567 kg) net curd weight. As regards N x B interaction, application of 200 Kg N and 20 kg B ha^{-1} (N_3 B_2) recorded maximum (0.504 and 0.585 kg) net curd weight during 1993-94 and 1994-95, respectively.

4.10 Compactness of the curd

The data presented in Table 4.37, depicted that application of nitrogen from 100 to 200 kg ha^{-1} and boron from 15 to 25 kg ha^{-1} showed significant effects on the compactness of curd during both the years of study. The highest dose of nitrogen i.e. 200 kg ha^{-1} gave more compact curds (109.94^o and 110.65^o) but they were not significantly superior to 150 kg N ha^{-1}. Likewise in case of boron application also more compact (108.18^o and 110.64^o) curds were produced with 20 kg ha^{-1} where as 25 kg B ha^{-1} application was at par with it. The different planting dates exhibited significant effect with respect to compactness of curd. The 12th October and 26th October transplanting dates produced compact curds (108.73^o and 109.62^o) and (107.84^o and 109.33^o) almost at par with each

Table 4.34 Interaction effect of transplanting dates and nitrogen levels (DxN) on net weight of curd (kg)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	0.406	0.491	0.589	0.406	0.511	0.702
D_2	0.297	0.399	0.505	0.319	0.396	0.524
D_3	0.153	0.172	0.193	0.196	0.239	0.269
SE±	0.009			0.009		
CD 5%	0.015			0.016		

Table 4.35 Interaction effect of boron and transplanting dates (BxD) on net weight of curd (kg)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	0.472	0.358	0.167	0.504	0.371	0.222
B_2	0.515	0.442	0.176	0.567	0.487	0.231
B_3	0.499	0.398	0.176	0.548	0.382	0.251
SE±	0.009			0.009		
CD 5%	0.015			0.016		

Table 4.36 Interaction effect of nitrogen and boron levels (NxB) on net weight of curd (kg)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	0.269	0.284	0.302	0.292	0.322	0.307
N_2	0.334	0.382	0.347	0.364	0.397	0.384
N_3	0.393	0.504	0.390	0.461	0.585	0.450
SE±	0.009			0.009		
CD 5%	0.015			0.016		

Table 4.37 Effect of transplanting dates, nitrogen and boron levels on compactness of curd (Degree angle)

Treatments		Compactness of curd (Degree angle)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	102.70	103.65	103.17
N_2	150	108.94	109.80	109.37
N_3	200	109.94	110.65	110.29
SE(m)$\pm$		0.34	0.48	-
CD 5%		0.64	0.99	-
Boron levels (kg ha^{-1})				
B_1	15	107.30	108.50	108.15
B_2	20	108.18	110.64	109.41
B_3	25	107.80	109.25	108.19
SE(m)$\pm$		0.34	0.48	-
CD 5%		0.64	0.99	-
Transplanting dates				
D_1	12th October	108.73	109.62	109.17
D_2	26th October	107.84	109.33	108.58
D_3	10th November	102.15	102.20	102.47
SE(m)$\pm$		0.34	0.48	-
CD 5%		0.64	0.99	-

other. However, 10th November transplanting produced semi-compact curds (102.15^{o} and 102.20^{o}) during both the years.

Among the transplanting dates x nitrogen interaction, 12th October planting and 200 kg N ha^{-1} (D_1 N_3) combination produced very compact curds (109.58^{o} and 110.45^{o}) closely followed by 26th October planting and 200 kg N ha^{-1} (D_2 N_3) combination where as semi-compact curds (101.45^{o} and 100.15^{o}) were observed with 10th November planting and 100 kg N ha^{-1} (D_3 N_1) combination during both the years (Table 4.38).

The data given in Table 4.39 showed that in case of boron x transplanting dates interaction, maximum (109.45 and 110.45^{o}) compactness of curd was recorded with 20 kg B ha^{-1} and 12th October transplanting (B_2 D_1) combination which was closely followed by 25 kg B ha^{-1} and 12th October transplanting date (B_3 D_1) combination. During both the years, minimum ($101^{o}.00$ and 101.45^{o}) compactness of curd was recorded with 25 kg B ha^{-1} and 10th November (B_3 D_3) combination.

The data in Table 4.40 depicted no significant effect of nitrogen x boron level interaction on curd compactness.

4.11 Gross plant weight per plot

The analysis of variance (Appendix X) for gross plant weight per plot showed highly significant differences among different levels of nitrogen, boron and transplanting dates during 1993-94 and 1994-95.

Data presented in Table 4.41 depicted that all the main

Table 4.38 Interaction effect of transplanting dates and nitrogen levels (DxN) on the compactness of curd (Degree angle)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	107.58	108.45	109.58	108.00	108.68	110.45
D_2	106.42	108.00	108.45	106.55	108.33	110.30
D_3	101.45	102.18	102.58	100.15	101.68	102.35
SE$\pm$	0.454			0.714		
CD 5%	0.758			1.192		

Table 4.39 Interaction effect of boron and transplanting dates (BxD) on the compactness of curd (Degree angle)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	106.33	106.00	102.15	108.35	107.38	102.68
B_2	109.45	108.63	101.45	110.45	109.33	101.65
B_3	108.53	107.85	101.00	109.25	108.63	101.45
SE$\pm$	0.454			0.714		
CD 5%	0.758			1.192		

Table 4.40 Interaction effect of nitrogen and boron levels (NxB) on the compactness of curd (Degree angle)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	107.57	108.43	107.60	107.36	111.79	108.73
N_2	108.85	110.69	109.37	109.93	111.64	110.73
N_3	107.84	110.38	108.62	108.65	111.03	107.63
SE$\pm$	N.S			N.S		
CD 5%	-			-		

N.S - Non significant

Table 4.41 Effect of transplanting dates, nitrogen and boron levels on gross plant weight per plot (kg)

Treatments		Average gross plant weight per plot (kg)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	31.29	32.74	32.01
N_2	150	40.97	41.01	40.99
N_3	200	50.75	50.89	50.82
SE(m)$\pm$		0.57	0.41	-
CD 5%		0.95	0.69	-
Boron levels (kg ha^{-1})				
B_1	15	38.44	38.53	38.48
B_2	20	42.48	43.21	42.85
B_3	25	42.23	42.76	42.49
SE(m)$\pm$		0.57	0.41	-
CD 5%		0.95	0.69	-
Transplanting dates				
D_1	12th October	51.02	54.16	52.58
D_2	26th October	42.33	45.02	43.67
D_3	10th November	27.12	28.01	27.56
SE(m)$\pm$		0.57	0.41	-
CD 5%		0.95	0.69	-

effects were significant during both the years. With the increase in levels of nitrogen from 100 to 200 kg ha^{-1}, there was linear increase in the gross plant weight per plot and all the treatments differed significantly from each other. Maximum gross plant weight (50.77 and 50.89 kg) was obtained with 200 kg N ha^{-1}. Similarly, as the levels of boron increased from 15 to 20 kg ha^{-1}, the gross plant weight per plot increased (42.48 and 43.21 kg) but with further increase in boron level up to 25 kg ha^{-1}, there was marginal decrease (42.23 and 42.76 kg). However, statistically 20 kg and 25 kg ha^{-1} doses were at par with each other. Delay in transplanting dates gradually decreased the gross plant weight per plot. The maximum (51.02 and 54.16 kg) and minimum (27.13 and 28.01 kg) gross yield per plot was obtained with 12th October, and 10th November transplanting dates during 1993-94 and 1994-95, respectively.

Data in Table 4.42 revealed that among transplanting dates x nitrogen interaction, D_1 N_3 (12th October planting and 200 kg N ha^{-1}) produced the highest (62.78 and 65.41 kg) while D_3 N_1 (10th November planting and 100 kg N ha^{-1}) the lowest (24.63 and 23.40 kg) gross plant weight per plot.

As regards to boron levels x transplanting dates interactions, the data in Table 4.43 showed that 20 kg B ha^{-1} and 12th October planting (B_2 D_1) gave the maximum (52.12 and 56.17 kg) and treatment combination 15 kg B ha^{-1} and 10th November transplanting (B_1 D_3) the minimum (26.05 and

Table 4.42 Interaction effect of transplanting dates and nitrogen levels (DxN) on gross plant weight per plot (kg)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	38.68	51.58	62.78	43.54	53.52	65.41
D_2	31.78	41.15	55.79	30.04	43.70	59.56
D_3	24.63	28.35	30.33	23.40	27.65	31.06
SE$\pm$	0.98			0.71		
CD 5%	1.64			1.19		

Table 4.43 Interaction effect of boron levels and transplanting dates (BxD) on gross plant weight per plot (kg)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	48.26	37.68	26.05	50.66	41.00	27.24
B_2	52.66	45.70	28.29	56.17	47.14	27.65
B_3	52.12	43.60	28.51	55.63	46.90	27.67
SE$\pm$	0.98			0.71		
CD 5%	1.64			1.19		

Table 4.44 Interaction effect of nitrogen and boron levels (NxB) on gross plant weight per plot (kg)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	29.13	31.19	33.55	31.06	32.30	34.85
N_2	37.33	43.70	40.60	38.06	44.36	41.89
N_3	46.46	54.37	49.07	48.86	56.73	49.44
SE$\pm$	0.98			0.71		
CD 5%	1.64			1.19		

27.24 kg) gross plant weight per plot during both the crop years.

The interactions between nitrogen x boron have been found to be highly significant. The treatment combination 200 kg N and 20 kg B ha^{-1} (N_3 B_2) showed excellent performance (54.37 and 56.73 kg) and 100 kg N and 15 kg B ha^{-1} (N_1 B_1) combination the least (29.13 and 31.06 kg) gross plant weight per plot (Table 4.44).

4.12 Marketable yield per plot (kg)

An examination of analysis of variance (Appendix XI) indicated highly significant differences among different levels of nitrogen, boron and transplanting dates during both the years.

Observations on marketable yield per plot were affected by different levels of nitrogen, boron and transplanting dates and data presented in Table 4.45. The data depicted that an application of 200 kg N ha^{-1} produced highest marketable curd yield of 24.25 and 25.57 kg and was significantly better than other levels of nitrogen applied. Similar, trend was recorded with respect to boron application, The soil application of 20 kg B ha^{-1} produced the highest (21.78 and 23.13 kg) marketable curd yield over other treatments. The delay in transplanting dates reduced the marketable curd yield considerably. 12th October transplanting date produced maximum (26.94 and 28.54 kg) marketable curd yield per plot while late transplanting dates produced lower yields of 10.54 and 10.45 kg during

Table 4.45 Effect of transplanting dates, nitrogen and boron levels on marketable yield per plot (kg)

Treatments		Average marketable yield per plot (kg)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	16.42	17.14	16.78
N_2	150	20.57	21.21	20.89
N_3	200	24.25	25.57	24.91
SE(m)$\pm$		0.32	0.25	-
CD 5%		0.54	0.42	-
Boron levels (kg ha^{-1})				
B_1	15	19.60	20.66	20.13
B_2	20	21.78	23.13	22.45
B_3	25	19.85	20.13	19.99
SE(m)$\pm$		0.32	0.25	-
CD 5%		0.54	0.42	-
Transplanting dates				
D_1	12th October	26.94	28.54	27.74
D_2	26th October	23.76	24.92	24.34
D_3	10th November	10.54	10.45	10.50
SE(m)$\pm$		0.32	0.25	-
CD 5%		0.54	0.42	-

both the years of crop study.

The data in Table 4.46 indicated that 12th October transplanting date x 200 kg N ha^{-1} (D_1 N_3) produced maximum (31.93 and 34.10 kg) marketable curd yield per plot. This was significantly superior over all other interactions.

Similarly 20 kg B ha^{-1} x 12th October transplanting (B_2 D_1) gave the maximum (28.72 and 30.17 kg) marketable curd yield per plot as compared to all other treatment combinations (Table 4.47).

A perusal of data in Table 4.48 showed that application of 200 kg N x 20 kg B ha^{-1} (N_3 B_2) produced the highest (26.91 and 28.74 kg) marketable curd yield per plot during 1993-94 and 1994-95.

4.13 Marketable curd yield per hectare (q)

The data in Table 4.49 revealed that application of nitrogen at 200 kg ha^{-1}, boron at 20 kg ha^{-1} and 12th October transplanting date gave the highest marketable curd yields of (256.59, 230.35 and 284.94 q/ha) and (261.74, 239.57 and 289.97 q/ha) in 1993-94 and 1994-95, respectively.

It is evident from Table 4.50 that interaction D_1 N_3 (12th October transplanting and 200 kg N ha^{-1}) gave the maximum yield of 337.87 and 340.27 q/ha.

Similarly among boron x transplanting dates interaction, the combination 20 kg B ha^{-1} and 12th October transplanting (B_2 D_1) gave the highest marketable curd yield per hectare to the tune of 303.94 and 310.49 q/ha (Table

Table 4.46 Interaction effect of transplanting dates and nitrogen levels (DxN) on marketable yield per plot (kg)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	22.04	26.84	31.93	23.15	28.37	34.10
D_2	17.64	24.37	29.41	18.99	24.95	30.83
D_3	9.57	10.63	11.41	9.28	10.30	11.76
SE$\pm$	0.56			0.43		
CD 5%	0.93			0.72		

Table 4.47 Interaction effect of boron levels and transplanting dates (BxD) on marketable yield per plot (kg)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	25.79	22.74	10.28	27.60	23.99	10.38
B_2	28.72	25.98	10.63	30.17	28.11	11.09
B_3	26.29	22.55	10.69	27.85	22.67	9.88
SE$\pm$	0.56			0.43		
CD 5%	0.93			0.72		

Table 4.48 Interaction effect of nitrogen and boron levels (NxB) on marketable yield per plot (kg)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	15.54	16.29	17.41	16.25	18.06	17.11
N_2	20.05	22.13	19.52	21.04	22.58	20.00
N_3	23.22	26.91	22.62	24.68	28.74	23.29
SE$\pm$	0.56			0.43		
CD 5%	0.93			0.72		

Table 4.49 Effect of transplanting dates, nitrogen and boron levels on marketable curd yield (q/ha)

Treatments		Average marketable yield/hectare		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	173.58	181.14	177.36
N_2	150	217.37	219.50	218.43
N_3	200	256.59	261.74	259.16
SE(m)$\pm$		3.52	2.57	-
CD 5%		5.87	4.29	-
Boron levels (kg ha^{-1})				
B_1	15	205.95	213.35	209.65
B_2	20	230.35	239.57	234.96
B_3	25	211.24	209.45	210.34
SE(m)$\pm$		3.52	2.57	-
CD 5%		5.87	4.29	-
Transplanting dates				
D_1	12th October	284.94	289.97	287.45
D_2	26th October	251.29	262.62	256.95
D_3	10th November	111.31	109.79	110.55
SE(m)$\pm$		3.52	2.57	-
CD 5%		5.87	4.29	-

Table 4.50 Interaction effect of transplanting dates and nitrogen levels (DxN) on marketable curd yield (q/ha)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	233.22	283.73	337.87	243.38	286.25	340.27
D_2	186.24	256.46	311.18	200.92	263.21	323.71
D_3	101.27	111.93	120.73	99.11	109.04	121.22
SE±	6.096			4.447		
CD 5%	10.180			7.426		

Table 4.51 Interaction effect of boron levels and transplanting dates (BxD) on marketable curd yield (q/ha)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	272.62	236.51	108.74	277.08	253.86	106.10
B_2	303.94	274.56	112.54	310.49	294.05	109.10
B_3	278.26	242.81	112.65	282.32	239.94	114.16
SE±	6.096			4.447		
CD 5%	10.180			7.426		

Table 4.52 Interaction effect of nitrogen and boron levels (NxB) on marketable curd yield (q/ha)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	164.48	172.07	184.19	171.20	191.18	181.03
N_2	211.88	234.21	206.02	216.58	233.60	208.32
N_3	241.50	284.76	243.52	252.26	293.57	239.01
SE±	6.096			4.447		
CD 5%	10.180			7.426		

4.51).

The data given in Table 4.52 depicted that maximum marketable curd yield per hectare 284.76 and 293.57 q/ha with 200 kg N x 20 kg N ha^{-1} (N_3B_2) combination was recorded during 1993-94 and 1994-95 respectively.

4.14 Harvest index (%)

The analysis of variance (Appendix XIII) for harvest index showed highly significant differences among the different levels of nitrogen, boron and transplanting dates during both the years.

A perusal of data presented in Table 4.53 indicated that with the increase in levels of nitrogen from 100 to 200 kg ha^{-1}, there was significant increase in the harvest index. Nitrogen at 200 kg ha^{-1} showed higher (29.55 and 31.65) harvest index which was closely followed by 150 kg N ha^{-1}. Similar observations were recorded in case of boron levels. Boron at 20 kg ha^{-1} gave the highest (29.24 and 32.00) harvest index during both the years. However, during 1993-94, 25 kg B ha^{-1} was at par with 20 kg B ha^{-1}. The delay in transplanting dates decreased the harvest index significantly. 12th October transplanting gave the maximum (33.18 and 33.25) harvest index which was closely followed by 26th October transplanting during both the years.

It is evident from Table 4.54 that interaction 12th October transplanting x 200 kg N ha^{-1} (D_1 N_3) combination was superior over all other combinations giving harvest index of 34.35 and 34.94 per cent.

Table 4.53 Effect of transplanting dates, nitrogen and boron levels on the harvest index (%)

Treatments		Average harvest index (%) 1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	28.32	29.17	28.74
N_2	150	29.02	30.28	29.65
N_3	200	29.55	31.65	30.60
SE(m)$\pm$		0.31	0.52	-
CD 5%		0.51	0.86	-
Boron levels (kg ha^{-1})				
B_1	15	28.42	28.48	28.45
B_2	20	29.24	32.00	30.62
B_3	25	29.22	30.62	29.92
SE(m)$\pm$		0.31	0.52	-
CD 5%		0.51	0.86	-
Transplanting dates				
D_1	12th October	33.18	33.25	33.21
D_2	26th October	32.12	29.06	30.59
D_3	10th November	21.58	22.79	22.18
SE(m)$\pm$		0.31	0.52	-
CD 5%		0.51	0.86	-

Table 4.54 Interaction effect of transplanting dates and nitrogen levels (DxN) on the harvest index (%)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	31.87	33.89	34.35	31.81	38.99	34.94
D_2	31.31	31.88	32.61	28.19	28.92	30.09
D_3	21.69	21.29	21.77	27.52	28.94	29.92
SE$\pm$	0.53			N.S		
CD 5%	0.89			-		

Table 4.55 Interaction effect of boron levels and transplanting dates (BxD) on the harvest index (%)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	32.44	33.79	21.42	33.27	29.09	29.50
B_2	33.96	32.14	21.62	33.33	32.81	30.06
B_3	31.79	31.79	21.71	33.14	26.82	25.82
SE$\pm$	0.53			0.89		
CD 5%	0.89			1.49		

Table 4.56 Interaction effect of nitrogen and boron levels (NxB) on the harvest index (%)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	29.56	29.89	29.19	29.69	30.60	27.22
N_2	29.46	28.97	28.64	30.61	31.57	28.68
N_3	28.64	28.86	27.45	31.65	33.84	29.54
SE$\pm$	N.S			N.S		
CD 5%	-			-		

N.S - Non significant

Among interaction between boron levels x transplanting dates, the Table 4.55 indicated that during 1993-94, 20 kg B ha^{-1} and 12th October transplanting (B_2 D_1) gave maximum (33.96) harvest index which was closely followed by 15 kg B ha^{-1} and 12th October transplanting (B_1 D_1), 15 kg B ha^{-1} and 26th October transplanting (B_1 D_2) and 20 kg B ha^{-1} and 26th October transplanting (B_2 D_2) combinations gave the highest (33.33) harvest index. The combinations 15 kg B_1 ha^{-1} and 12th October transplanting (b1 D_1), 20 kg B ha^{-1} and 26th October transplanting (B_2 D_2) and 25 kg B ha^{-1} and 12th October transplanting (B_3 D_1) were also at par with this treatment combination.

The data presented in Table 4.56 depicted that interactions among nitrogen x boron levels were non-significant for this trait during 1993-94 and 1994-95.

Dry matter content

The data depicted in Table 4.57 revealed that all the main effects were significant during both the crop seasons. With the increase in levels of nitrogen, from 100 to 200 kg ha^{-1}, there was significant increase in dry matter content of the plant. The maximum dry matter content (9.00 and 9.23 per cent) was recorded with 200 kg N ha^{-1} which was not significantly superior over 150 kg N ha^{-1}. Both the doses of nitrogen were at par with each other for dry matter content during both the years. Similarly there was significant increase in the dry matter content with the increase in doses of boron. The highest dry matter content

Table 4.57 Effect of transplanting dates, nitrogen and boron levels on dry matter content (%)

Treatments		Dry matter content (%)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	8.45	8.36	8.40
N_2	150	8.92	9.13	9.02
N_3	200	9.00	9.30	9.15
SE(m)$\pm$		0.16	0.10	-
CD 5%		0.37	0.20	-
Boron levels (kg ha^{-1})				
B_1	15	8.73	9.29	9.01
B_2	20	9.00	9.37	9.18
B_3	25	9.33	9.65	9.49
SE(m)$\pm$		0.16	0.10	-
CD 5%		0.37	0.20	-
Transplanting dates				
D_1	12th October	9.23	9.30	9.26
D_2	26th October	8.90	8.97	8.93
D_3	10th November	8.12	8.20	8.16
SE(m)$\pm$		0.16	0.10	-
CD 5%		0.37	0.20	-

(9.33 and 9.65 per cent) was recorded with soil application of 25 kg B ha^{-1}. The soil application of 20 kg ha^{-1} was at par with 25 kg B ha^{-1} during both the years. As regards to transplanting dates, the dry matter content decreased with the delayed transplanting dates. The highest dry matter content was obtained with 12th October transplanting (9.23 and 9.30%). However, 26th October transplanting was at par with 12th October transplanting date. The lowest dry matter content (8.12 and 8.20%) was observed with 10th November transplanting.

Among transplanting dates x nitrogen levels interactions, the interaction D_1N_3 (12th October transplanting and 200 kg N ha^{-1} combination recorded the highest dry matter content to the tune of 9.29 and 9.35 per cent. The combination D_2 N_3 (26th October transplanting and 200 kg N ha^{-1}) was however, at par with D_1 N_3 combination during 1994-95 only (Table 4.58).

The data presented in Table 4.59 depicted that among different levels of boron x transplanting dates interactions, 25 kg B ha^{-1} and 12th October transplanting (B_3 D_1) combination was significantly superior to all other treatment combinations which recorded 9.73 and 9.78 per cent dry matter content during both the years. However, the treatment combinations, B_2 D_1 and B_3 D_2 were at par with B_3 D_1 combination during 1993-94 and B_2 D_1, B_3 D_2 and B_1 D_1 combinations in 1994-95 in order of merit.

It is evident from Table 4.60 that interaction 200 kg N x 20 kg

Table 4.58 Interaction effect of transplanting dates and nitrogen levels (DxN) on the dry matter content (%)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	8.20	8.25	9.29	8.23	8.38	9.35
D_2	8.18	8.77	8.42	8.23	8.82	8.85
D_3	8.04	8.09	8.10	8.05	8.08	8.10
SE$\pm$	0.26			0.34		
CD 5%	0.63			0.69		

Table 4.59 Interaction effect of boron and transplanting dates (BxD) on the dry matter content (%)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	9.21	8.49	8.14	9.30	8.53	8.12
B_2	9.40	8.77	8.17	9.45	8.82	8.16
B_3	9.73	9.34	8.14	9.78	9.37	8.12
SE$\pm$	0.26			0.34		
CD 5%	0.63			0.69		

Table 4.60 Interaction effect of nitrogen x Boron levels (NxB) on the dry matter content (%)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	8.24	8.64	8.24	8.60	8.68	8.10
N_2	8.65	9.19	8.28	8.69	9.24	8.14
N_3	8.75	9.47	8.28	8.75	9.50	8.16
SE$\pm$	0.26			0.34		
CD 5%	0.63			0.69		

ha^{-1} (N_3 B_2) combination gave the highest dry matter content (9.47 and 9.50%) which was not significantly superior to N_3 B_1 treatment combination, but both were at par with each other. The lowest dry matter content (8.24 and 8.10%) have been observed with 100 kg N and 15 kg B ha^{-1}.

4.16 Nitrogen content of the leaves (%)

The data presented in Table 4.61 for main effects depicted that with the increase in levels of nitrogen there was gradual increase in the nitrogen content of the leaves. The application of nitrogen at 200 kg ha^{-1} and boron at 20 kg ha^{-1} individually gave the highest (2.57 and 2.65%) and (2.39 and 2.44%) nitrogen content of leaves, respectively, during 1993-94 and 1994-95. Delay in transplanting date gradually decreased the nitrogen content of leaves. 2.52 and 2.56 per cent nitrogen content of leaves was obtained in the treatment 12th October transplanting date whereas 2.10 and 2.15 per cent nitrogen content of leaves was observed with 10th November transplanting date in 1993-94 and 1994-95, respectively.

Data presented in Table 4.62 indicated that interaction among transplanting dates and nitrogen levels were significant better nitrogen content of leaves (2.43 and 2.44%) was obtained with 12th October transplanting and 200 kg N ha^{-1} (D_1 N_3) combination as compared to D_3 N_1 combination in which (2.09 and 2.07%) nitrogen content of leaves was recorded.

Among the boron x transplanting dates interaction

Table 4.61 Effect of transplanting dates, nitrogen and boron levels on nitrogen content of leaves (%)

Treatments		Nitrogen content of leaves (%)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	2.20	2.30	2.25
N_2	150	2.48	2.50	2.49
N_3	200	2.57	2.65	2.61
SE(m)±		0.04	0.008	-
CD 5%		0.01	0.003	-
Boron levels (kg ha^{-1})				
B_1	15	2.37	2.41	2.39
B_2	20	2.37	2.44	2.41
B_3	25	2.33	2.37	2.35
SE(m)±		0.04	0.008	-
CD 5%		0.01	0.003	-
Transplanting dates				
D_1	12th October	2.52	2.56	2.54
D_2	26th October	2.45	2.47	2.46
D_3	10th November	2.10	2.15	2.12
SE(m)±		0.04	0.008	-
CD 5%		0.01	0.003	-

Table 4.62 Interaction effect of transplanting dates and nitrogen levels (DxN) on nitrogen content of leaves (%)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	2.37	2.40	2.43	2.38	2.41	2.44
D_2	2.35	2.38	2.38	2.35	2.37	2.40
D_3	2.09	2.10	2.12	2.07	2.09	2.10
SE$\pm$	0.014			0.004		
CD 5%	0.029			0.008		

Table 4.63 Interaction effect of boron and transplanting dates (BxD) on nitrogen content of leaves (%)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	2.43	2.39	2.09	2.46	2.43	2.12
B_2	2.42	2.37	2.12	2.44	2.42	2.15
B_3	2.34	2.37	2.16	2.37	2.40	2.17
SE$\pm$	0.014			0.004		
CD 5%	0.029			0.008		

Table 4.64 Interaction effect of nitrogen x Boron levels (NxB) on nitrogen content of leaves (%)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	2.19	2.38	2.24	2.28	2.35	2.32
N_2	2.36	2.45	2.42	2.37	2.40	2.38
N_3	2.49	2.50	2.45	2.44	2.54	2.48
SE$\pm$	0.014			0.004		
CD 5%	0.029			0.008		

(Table 4.63) reflected that nitrogen content of the leaves was significantly superior in B_2 D_1 combination (2.43 and 2.46%) as compared with B_1 D_3 combination in which (2.09 and 2.12%) nitrogen content of leaves was recorded.

The data given in Table 4.64 revealed that interaction among nitrogen x boron levels was significant during both the years of study. The combination 200 kg N and 20 kg B ha^{-1} (N_3 B_2) gave the maximum (2.50 and 2.54%) nitrogen content of leaves where as 100 kg N and 15 kg B ha^{-1} (N_1 B_1) produced the minimum (2.19 and 2.28%) nitrogen content of leaves.

4.17 Nitrogen content of the curd

A perusal of data in Table 4.65 depicted that with the increase in level of nitrogen from 100 to 200 kg ha^{-1}, there was increase in the nitrogen content of the curd. The nitrogen application @200 kg ha^{-1} gave the maximum 4.55 and 4.68 per cent nitrogen content. Similar trend was observed in case of boron application. A soil application of 20 kg B ha^{-1} produced the maximum (4.09 and 4.10%) nitrogen content. The nitrogen content of the curd decreased with the delay in transplanting dates. Highest nitrogen content of the curd (4.58 and 4.70%) was observed with 12th October transplanting and lowest (3.96 and 4.12%) with 10th November transplanting during 1993-94 and 1994-95, respectively.

The interactions among nitrogen x transplanting dates, boron x transplanting dates and nitrogen x boron levels were significant during both the years of crop study. The data

Table 4.65 Effect of transplanting dates, nitrogen and boron levels on nitrogen content of curd (%)

Treatments		Nitrogen content of curds (%)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	3.95	3.67	3.81
N_2	150	4.24	4.29	4.26
N_3	200	4.55	4.68	4.61
SE(m)$\pm$		0.005	0.008	-
CD 5%		0.010	0.016	-
Boron levels (kg ha^{-1})				
B_1	15	4.02	4.03	4.02
B_2	20	4.09	4.12	4.10
B_3	25	4.06	4.07	4.06
SE(m)$\pm$		0.005	0.008	-
CD 5%		0.010	0.016	-
Transplanting dates				
D_1	12th October	4.58	4.70	4.64
D_2	26th October	4.39	4.56	4.47
D_3	10th November	3.96	4.12	4.04
SE(m)$\pm$		0.005	0.008	-
CD 5%		0.010	0.016	-

presented in Table 4.66 indicated that the treatment combination D_1 N_3 (12th October transplanting and 200 kg N ha^{-1}) gave the highest (3.87 and 3.90%) nitrogen content of curd. The treatment combination D_2 N_3 was at par with it.

It was evident from Table 4.67 that interaction among boron levels x transplanting dates was significant. The highest nitrogen content of curd 3.94 and 3.96 per cent was recorded with 20 kg B ha^{-1} and 12th October transplanting (B_2 D_1) combination during 1993-94 and 1994-95, respectively.

The nitrogen x boron interactions were also found to be significant during both the years. The treatment combination N_3 B_2 recorded maximum 4.26 and 4.28 per cent nitrogen content in the curd whereas minimum 3.91 and 3.92 per cent was with N_1 B_1 combination during 1993-94 and 1994-95, respectively. (Table 4.68)

4.18 Boron content of leaves (ppm)

The boron content of leaves indicated significant differences among the treatments except all levels of nitrogen during both the years. The data presented in Table 4.69 indicated that boron at 20 kg ha^{-1} and 12th October transplanting date individually gave better (16.30 and 16.68 ppm) and (14.86 and 15.37 ppm) boron content of leaves during 1993-94 and 1994-95, respectively.

Significant differences among transplanting dates x nitrogen level interactions were observed. Table 4.70 revealed that boron content of leaves was highest (17.37 and

Table 4.66 Interaction effect of transplanting dates and nitrogen levels (DxN) on nitrogen content of curd (%)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	3.82	3.84	3.87	3.84	3.86	3.90
D_2	3.79	3.82	3.87	3.81	3.82	3.89
D_3	3.20	3.22	3.22	3.19	3.20	3.22
SE$\pm$	0.04			0.02		
CD 5%	0.07			0.05		

Table 4.67 Interaction effect of boron and transplanting dates (BxD) on nitrogen content of curd (%)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	3.85	3.83	3.20	3.87	3.83	3.19
B_2	3.94	3.92	3.25	3.96	3.93	3.23
B_3	3.87	3.85	3.22	3.90	3.86	3.21
SE$\pm$	0.04			0.02		
CD 5%	0.07			0.05		

Table 4.68 Interaction effect of nitrogen x Boron levels (NxB) on nitrogen content of curd (%)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	3.91	3.99	3.93	3.92	4.01	3.93
N_2	3.93	4.04	4.02	3.94	4.05	4.05
N_3	4.21	4.26	4.00	4.23	4.28	4.04
SE$\pm$	0.04			0.02		
CD 5%	0.07			0.05		

Table 4.69 Effect of transplanting dates, nitrogen and boron levels on boron content of leaves (ppm)

Treatments		Boron content of leaves (ppm)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	14.67	15.14	14.90
N_2	150	15.55	16.00	15.77
N_3	200	15.80	16.68	16.24
SE(m)±		N.S	N.S	-
CD 5%		N.S	N.S	-
Boron levels (kg ha^{-1})				
B_1	15	14.39	14.89	14.64
B_2	20	16.30	16.28	16.29
B_3	25	15.37	16.10	15.73
SE(m)±		0.24	0.35	-
CD 5%		0.47	0.72	-
Transplanting dates				
D_1	12th October	14.86	15.37	15.11
D_2	26th October	14.84	15.22	15.03
D_3	10th November	13.89	13.97	13.93
SE(m)±		0.24	0.35	-
CD 5%		0.47	0.72	-

17.43 ppm) with 12th October transplanting date and 200 kg N ha^{-1} (D_1 N_3) combination in both the years.

Boron content of the leaves was also affected by boron x dates interaction. The treatment B_3 D_1 (25 kg B ha^{-1} and 12th October transplanting) recorded the maximum (16.45 and 16.59 ppm) boron content of leaves which was closely followed by B_3 D_2 combination during 1993-94 and B_2 D_1 and B_3 D_2 combinations during 1994-95 (Table 4.71).

A perusal of data in Table 4.72 depicted that interaction among nitrogen x boron levels were significant during both the years for this trait. The maximum (16.94 and 17.59 ppm) boron content of leaves recorded with the combination. 200 kg N and 25 kg B ha^{-1} (N_3B_3). The combinations N_2 B_3 and N_3 B_2 were at par with N_3 B_3 combination during 1993-94 and 1994-95, respectively.

4.19 Boron content of the curd

The data presented in Table 4.73 reflected that all the main effects were significant with respect to boron content of the curd during both the years. The boron content of the curd increased with the increase in levels of nitrogen from 100 to 200 kg ha^{-1}. Nitrogen at 200 kg ha^{-1} gave the maximum 20.18 and 20.37 ppm boron content of the curd. Similar trend was recorded with boron application. The boron at 20 kg ha^{-1} gave the maximum 18.38 and 18.62 ppm boron content of the curd. As regards to transplanting dates, the highest 18.36 and 18.64 ppm boron content of curd was obtained with 12th October transplanting. The 26th

Table 4.73 Effect of transplanting dates, nitrogen and boron levels on boron content of curd (ppm)

Treatments		Boron content of curd (ppm)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	16.62	16.90	16.76
N_2	150	18.30	18.42	18.36
N_3	200	20.18	20.37	20.27
SE(m)$\pm$		0.41	0.40	-
CD 5%		0.84	0.94	-
Boron levels (kg ha^{-1})				
B_1	15	16.60	16.74	16.67
B_2	20	18.38	18.62	18.50
B_3	25	17.70	17.84	17.77
SE(m)$\pm$		0.41	0.40	-
CD 5%		0.84	0.94	-
Transplanting dates				
D_1	12th October	18.36	18.64	18.50
D_2	26th October	17.96	18.20	18.08
D_3	10th November	17.12	17.36	17.24
SE(m)$\pm$		0.41	0.40	-
CD 5%		0.84	0.94	-

October transplanting date was at par with 12th October transplanting during both the years.

A perusal of data in Tables 4.74, 4.75 and 4.76 revealed that all the interactions among transplanting dates x nitrogen, boron levels x transplanting dates and nitrogen x boron levels were non-significant during both the years.

4.20 Uptake of nitrogen (kg ha^{-1})

Nitrogen application increased the uptake of nitrogen significantly during both the years. The data presented in Table 4.77 indicated that N uptake increased significantly with every increase in nitrogen level from 100 to 200 kg ha^{-1}. The higher level of nitrogen i.e. 200 kg ha^{-1} gave the maximum (146.1 and 140.2 kg ha^{-1}) nitrogen uptake while minimum (124.5 and 108.1 kg) nitrogen uptake was recorded with 100 kg N ha^{-1}. Similarly with regards to boron application in the soil, all the levels of boron showed almost similar response with regard to N uptake. However, the highest (155.6 and 152.3 kg ha^{-1}) N uptake was recorded with 20 kg B ha^{-1} during both the years. The delay in transplanting decreased the uptake of nitrogen . The maximum (165.8 and 162.1 kg ha^{-1}) N uptake was recorded with 12th October transplanting date which was closely followed by 26th October transplanting date during both the years.

The data presented in Tables 4.78, 4.79 and 4.80 revealed that interaction between transplanting dates x nitrogen level, boron levels x transplanting dates and nitrogen x boron levels were significant during both the

Table 4.74 Interaction effect of transplanting dates and nitrogen levels (DxN) on boron content of curd (ppm)

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	18.00	18.26	19.11	18.33	17.81	18.89
D_2	17.52	17.33	18.81	17.81	17.30	18.37
D_3	15.96	17.07	17.67	15.85	16.30	17.70
SE$\pm$	N.S			N.S		
CD 5%	-			-		

Table 4.75 Interaction effect of boron and transplanting dates (BxD) on boron content of curd (ppm)

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	16.37	16.89	15.36	16.37	16.37	15.20
B_2	17.44	17.41	15.40	17.56	17.16	15.22
B_3	19.15	18.11	15.43	19.25	18.74	15.26
SE$\pm$	N.S			N.S		
CD 5%	-			-		

Table 4.76 Interaction effect of nitrogen x boron levels (NxB) on boron content of curd (ppm)

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	16.11	16.74	17.26	16.22	16.78	16.65
N_2	16.63	17.70	18.85	17.26	17.70	18.22
N_3	17.33	18.67	19.04	17.74	18.33	18.96
SE$\pm$	N.S			N.S		
CD 5%	-			-		

Table 4.77 Effect of transplanting dates, nitrogen and boron levels on N uptake (kg ha^{-1})

Treatments		N uptake (kg ha^{-1}) 1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	124.5	108.1	116.3
N_2	150	131.8	123.5	127.6
N_3	200	146.1	140.2	143.1
SE(m)±		6.43	7.18	-
CD 5%		12.5	14.2	-
Boron levels (kg ha^{-1})				
B_1	15	149.2	146.4	147.8
B_2	20	155.6	152.3	153.9
B_3	25	152.3	150.2	151.2
SE(m)±		6.43	7.18	-
CD 5%		12.5	14.2	-
Transplanting dates				
D_1	12th October	165.8	162.1	163.9
D_2	26th October	160.2	158.4	159.3
D_3	10th November	116.7	115.8	116.2
SE(m)±		6.43	7.18	-
CD 5%		12.5	14.2	-

Table 4.78 Interaction effect of transplanting dates and nitrogen levels (DxN) on N uptake (kg ha^{-1})

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	123.2	132.2	145.7	108.2	122.4	140.3
D_2	126.0	129.5	142.0	105.1	119.5	137.0
D_3	109.7	116.2	124.3	99.7	101.2	102.4
SE±	5.7			3.6		
CD 5%	10.4			7.4		

Table 4.79 Interaction effect of boron and transplanting dates (BxD) on N uptake (kg ha^{-1})

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	152.0	148.5	106.8	142.5	135.5	94.0
B_2	160.4	157.3	118.2	155.3	144.4	102.3
B_3	158.2	155.4	118.9	148.3	141.8	108.5
SE±	5.7			3.6		
CD 5%	10.4			7.4		

Table 4.80 Interaction effect of nitrogen and boron levels (NxB) on N uptake (kg ha^{-1})

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	139.4	145.4	148.2	134.3	140.3	145.2
N_2	142.3	152.4	157.5	137.6	146.6	151.5
N_3	148.5	158.5	163.4	141.2	153.5	158.4
SE±	5.7			3.6		
CD 5%	10.4			7.4		

years. The treatment combination D_1 N_3 (12th October transplanting and 200 kg N ha^{-1}) gave the highest (145.7 and 140.3 kg ha^{-1}) N uptake while least uptake (109.7 and 99.7 kg ha^{-1}) was recorded with 10th November and 100 kg ha^{-1} (D_2N_1) which was closely followed by 26th October transplanting date and 200 kg N ha^{-1} (D_2N_3) treatment combination. Likewise in case of boron levels x transplanting dates interaction, the treatment combination 20 kg B ha^{-1} and 12th October transplanting date (B_2D_1) recorded the maximum (160.4 and 155.3 kg) N uptake. The treatment combinations B_1 D_1, B_2 D_2, B_3 D_1 and B_3 D_2 were at par with B_2 D_1 treatment combination during 1993-94 while during 1994-95, the treatment combinations B_2 D_1 and B_3 D_1 were at par with each other. Regarding nitrogen x boron level interaction, the treatment combination N_3 B_2 (200 kg N and 20 kg B ha^{-1}) recorded the highest (158.3 and 153.5 kg) N uptake during both the years. The treatment combinations N_1 B_3, N_2 B_2, N_2 B_3, N_3 B_1 and N_3 B_3 were at par with N_3 B_2 treatment combination during 1993-94 whereas during 1994-95, N_3 B_2 was closely followed by N_2 B_2, N_2 B_3 and N_3 B_3 treatment combinations.

4.21 Uptake of boron (kg ha^{-1})

The data depicted in Table 4.81 revealed that all the main effects were significant during both the years. With the increase in levels of nitrogen from 100 to 200 kg ha^{-1}, there was significant increase in the B-uptake. The maximum B-uptake (15.65 and 16.69 kg ha^{-1}) was recorded with 200 kg

Table 4.81 Effect of transplanting dates, nitrogen and boron levels on B-uptake (kg ha^{-1})

Treatments		Boron uptake (kg ha^{-1})		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	7.87	8.35	8.11
N_2	150	11.78	12.27	12.02
N_3	200	15.65	16.69	16.17
SE(m)$\pm$		1.65	1.89	-
CD 5%		3.21	3.75	-
Boron levels (kg ha^{-1})				
B_1	15	9.90	10.78	10.34
B_2	20	12.62	13.45	13.03
B_3	25	12.40	13.33	12.86
SE(m)$\pm$		1.65	1.89	-
CD 5%		3.21	3.75	-
Transplanting dates				
D_1	12th October	14.89	16.31	15.60
D_2	26th October	11.76	12.85	12.30
D_3	10th November	6.50	6.85	6.67
SE(m)$\pm$		1.65	1.89	-
CD 5%		3.21	3.75	-

N ha^{-1} which was not significantly superior to 150 kg ha^{-1}. Both the doses of nitrogen were at par with each other for B-uptake during both the years.

The application of boron significantly increased the B-uptake. All the levels of boron applied to the soil showed similar response i.e. all the levels of boron were at par with each other with regard to B-uptake.

As regards to transplanting dates, the B-uptake decreased with the delay in transplanting dates. The highest B-uptake was obtained with 12th October transplanting date (14.89 and 16.31 kg ha^{-1}). However, the 26th October transplanting date was at par with 12th October transplanting date. The lowest B-uptake was recorded with 10th November transplanting date (6.50 and 6.85 kg ha^{-1}) during both the years.

Among transplanting dates x nitrogen levels interactions, the interaction D_1 N_3 (12th October transplanting date and 200 kg N ha^{-1}) combination recorded the highest B-uptake to the tune of 20.26 and 21.15 kg ha^{-1}. The lowest B-uptake was observed with D_3 N_1 combination (10th November transplanting dates and 100 kg N ha^{-1}) viz. 5.61 and 5.32 kg ha^{-1} during both the years (Table 4.82).

The data presented in Table 4.83 depicted that among different levels of boron x transplanting dates interaction B_3 D_1 (25 kg B ha^{-1} and 12th October transplanting) combination was significantly superior to all other treatment combinations which recorded 17.19 and 18.57 kg

Table 4.82 Interaction effect of transplanting dates and nitrogen levels (DxN) on B-uptake (kg ha^{-1})

Dates/Levels	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	10.37	14.15	20.26	11.85	14.75	21.15
D_2	8.21	11.41	15.69	7.77	12.20	17.42
D_3	5.61	6.75	7.39	5.32	6.42	7.58
SE$\pm$	1.73			1.82		
CD 5%	3.45			3.62		

Table 4.83 Interaction effect of boron and transplanting dates (BxD) on B-uptake (kg ha^{-1})

Levels/Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	12.85	9.41	5.35	13.77	10.17	5.96
B_2	15.42	11.79	6.88	16.90	12.88	6.11
B_3	17.19	13.33	6.25	18.57	14.67	6.09
SE$\pm$	1.73			1.82		
CD 5%	3.45			3.62		

Table 4.84 Interaction effect of nitrogen x boron levels (NxB) B-uptake (kg ha^{-1})

Levels	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	6.83	8.04	8.66	7.75	8.53	8.68
N_2	9.61	12.73	11.42	10.16	13.32	11.29
N_3	12.40	16.96	13.92	13.46	17.19	14.04
SE$\pm$	1.73			1.82		
CD 5%	3.45			3.62		

ha^{-1} boron uptake during 1993-94 and 1994-95, except combinations B_2D_1.

It is evident from Table 4.84 that N_3 B_2 (200 kg N and 20 kg B ha^{-1}) combination recorded the highest B-uptake (16.96 and 17.19 kg ha^{-1}) but was not significantly superior to N_3 B_3 treatment combination. The lowest B-uptake (6.83 and 7.75 kg ha^{-1}) had been observed with 100 kg N and 15 kg B ha^{-1} (N_1 B_1) combination.

4.22 Curd protein content (%)

The data presented in Table 4.85 revealed that there was linear increase in the protein content with the increase in level of nitrogen from 100 to 200 kg ha^{-1}. The maximum curd protein content (28.43 and 29.25%) was recorded with 200 kg N ha^{-1} and minimum (22.93 and 24.68%) curd protein recorded with 100 kg N ha^{-1}. Likewise in case of boron application all the levels of boron showed almost similar response with regard to curd protein content. However, maximum (25.56 and 25.75%) curd protein was recorded with 20 kg B ha^{-1} during both the years. The delay in transplanting dates decreased the curd protein content. The highest (28.62 and 29.37%) curd protein content was recorded with 12th October transplanting date which was followed by 26th October transplanting date. The lowest (24.75 and 25.75%) curd protein was recorded with 10th November transplanting date.

All the interactions were observed to be highly significant during both the years. The data presented in Tables 4.86, 4.87 and 4.88 depicted that treatment combination D_1 N_3 (12th October transplanting date x 200 kg

Table 4.85 Effect of transplanting dates, nitrogen and boron levels on protien content in curds (%)

Treatments		Protien content in curds (%)		
		1993-94	1994-95	Mean
Nitrogen levels (kg ha^{-1})				
N_1	100	22.93	24.68	23.80
N_2	150	26.50	26.81	26.65
N_3	200	28.43	29.25	28.84
SE(m)$\pm$		0.65	0.74	-
CD 5%		1.35	1.42	-
Boron levels (kg ha^{-1})				
B_1	15	25.12	25.18	25.15
B_2	20	25.56	25.75	25.65
B_3	25	25.37	25.43	25.40
SE(m)$\pm$		0.65	0.74	-
CD 5%		1.35	1.42	-
Transplanting dates				
D_1	12th October	28.62	29.37	28.99
D_2	26th October	27.43	28.50	27.96
D_3	10th November	24.75	25.75	25.25
SE(m)$\pm$		0.65	0.74	-
CD 5%		1.35	1.42	-

Table 4.86 Interaction effect of transplanting dates and nitrogen levels (DxN) on protein content in curds (%)

Dates	1993-94			1994-95		
	N_1	N_2	N_3	N_1	N_2	N_3
D_1	23.87	24.00	24.19	24.00	24.12	24.37
D_2	23.31	23.87	24.19	23.81	23.87	24.31
D_3	20.00	20.12	20.12	19.93	20.00	20.12
SE$\pm$	0.54			0.57		
CD 5%	1.06			1.12		

Table 4.87 Interaction effect of boron and transplanting dates (BxD) on protein content in curds (%)

Dates	1993-94			1994-95		
	D_1	D_2	D_3	D_1	D_2	D_3
B_1	24.06	23.94	20.00	24.19	23.94	19.94
B_2	24.65	24.50	20.31	24.75	24.56	20.19
B_3	24.18	24.06	20.12	24.37	24.12	20.06
SE$\pm$	0.54			0.57		
CD 5%	1.06			1.12		

Table 4.88 Interaction effect of nitrogen x boron levels (NxB) on protein content in curds (%)

Dates	1993-94			1994-95		
	B_1	B_2	B_3	B_1	B_2	B_3
N_1	24.43	24.94	24.56	24.50	25.06	24.56
N_2	24.56	25.25	25.12	24.62	25.31	25.31
N_3	26.31	26.62	25.00	26.44	26.75	25.25
SE$\pm$	0.54			0.57		
CD 5%	1.06			1.12		

N ha^{-1}) produced highest (24.19 and 24.37%) curd protein content closely followed by D_2 N_3 (26th October transplanting date x 200 kg N ha^{-1}) D_1 N_1, D_1 N_2, D_2 N_1 and D_2 N_2 combinations during both the years. Similarly in case of boron x transplanting dates interactions, B_2 D_1 (20 kg B ha^{-1} and 12th October transplanting date) produced maximum (24.65 and 24.75%) curd protein content followed by B_1 D_1, B_1 D_2, B_2 D_1, B_2 D_2, B_3 D_1 and B_3 D_2 treatment combinations. In case of nitrogen x boron level interactions all the treatments were at par with each other as regards to protein content in the curds.

4.23 Economic studies

The data on gross returns, net returns and benefit : cost ratio for different treatments have been presented in Table 4.89.

An appraisal of data in Table 4.89 indicated that maximum gross return of Rs 74603 and 75584 was obtained by the 12th October transplanting + 200 kg N + 20 kg B ha^{-1} (D_1 N_3 B_2) combination which was followed by 26th October transplanting + 200 kg N + 20 kg B ha^{-1} (D_2 N_3 B_2) combination giving the gross return to the tune of Rs. 71296 and Rs. 74892. The same treatment (D_1 N_3 B_2) exhibited maximum net income of Rs. 48426 and 49407 and net profit per rupee invested (benefit : cost ratio) to the tune of 1.85 and 1.89 during both the years. While all the treatment combinations with late transplanting i.e. 10th November transplanting date showed negative response with respect to

Table 4.89 Response of transplanting dates, nitrogen and boron levels on economics of cauliflower curd crop

Treatment combination	Cost of cultivation (Rs)	Yield (q/ha)		Gross income (Rs)		Net income (Rs/ha)		Average net income	Net profit/Rupee invested		Average net profit/Rupee invested
		1993-94	1994-95	1993-94	1994-95	1993-94	1994-95		1993-94	1994-95	
$D_1 N_1 B_1$	24356	216.401	225.65	43280	45130	18924	20774	19849	0.78	0.85	0.81
$D_1 N_1 B_2$	25456	232.605	245.30	46521	49060	21065	23604	22334	0.83	0.93	0.86
$D_1 N_1 B_3$	26556	250.661	259.19	50132	51838	23576	25282	24429	0.89	0.95	0.92
$D_1 N_2 B_1$	24716	278.174	280.62	55634	56124	30918	31408	31163	1.25	1.27	1.26
$D_1 N_2 B_2$	25816	306.217	308.26	61243	61652	35427	35836	35631	1.37	1.39	1.38
$D_1 N_2 B_3$	26916	266.798	269.87	53359	53974	26443	27058	26750	0.98	1.00	0.99
$D_1 N_3 B_1$	25077	317.328	317.90	63465	63580	38388	38503	38445	1.53	1.53	1.53
$D_1 N_3 B_2$	26177	373.015	377.92	74603	75584	48426	49407	48916	1.85	1.89	1.87
$D_1 N_3 B_3$	27277	323.280	324.98	64656	64996	37379	37719	37549	1.37	1.38	1.37
$D_2 N_1 B_1$	24356	178.240	183.79	35648	36758	11292	12402	11847	0.47	0.51	0.49
$D_2 N_1 B_2$	25456	183.267	227.77	36652	45554	11196	20098	15647	0.44	0.78	0.61
$D_2 N_1 B_3$	26556	198.479	191.20	39695	38240	13139	11684	12411	0.49	0.44	0.46
$D_2 N_2 B_1$	24716	249.074	261.11	49815	52222	25099	27506	26302	1.01	1.11	1.06
$D_2 N_2 B_2$	25816	285.185	279.90	57037	55980	31221	30164	30692	1.21	1.17	1.19
$D_2 N_2 B_3$	26916	235.185	248.61	47037	49722	20121	22806	21463	0.75	0.85	0.80
$D_2 N_3 B_1$	25077	282.275	287.43	56455	57486	21378	32409	31893	1.25	1.29	1.27
$D_2 N_3 B_2$	26177	356.481	374.46	71296	74892	45119	48715	46917	1.72	1.86	1.79
$D_2 N_3 B_3$	27277	294.775	309.26	58955	61852	31678	34575	33126	1.16	1.27	1.21
$D_3 N_1 B_1$	24356	98.809	96.75	19762	19350	-4594	-5006	-4800	-0.14	-0.21	-0.17
$D_3 N_1 B_2$	25456	101.586	100.46	20317	20092	-5319	-5364	-5341	-0.21	-0.21	-0.21
$D_3 N_1 B_3$	26556	103.439	100.12	20688	20024	-5868	-6532	-6200	-0.22	-0.24	-0.23
$D_3 N_2 B_1$	24716	108.465	108.00	21693	21600	-3023	-3116	-3069	-0.12	-0.13	-0.12
$D_3 N_2 B_2$	25816	111.243	112.63	22249	22526	-3567	-3290	-3428	-0.14	-0.13	-0.13
$D_3 N_2 B_3$	26916	117.567	106.48	23513	21296	-3403	-5620	-4511	-0.12	-0.21	-0.16
$D_3 N_3 B_1$	25077	118.956	122.55	23791	24510	-1286	-567	-926	-0.05	-0.02	-0.03
$D_3 N_3 B_2$	26177	124.801	129.41	24960	25882	-1217	-295	-756	-0.04	-0.01	-0.02
$D_3 N_3 B_3$	27277	118.452	111.70	23690	22340	-3587	-4937	-4262	-0.13	-0.18	-0.15

Sale rate of cauliflower was Rs 200/q.

net income and net profit per rupee invested during 1993-94 and 1994-95.

4.24 Correlation studies

At the phenotypic level days taken to marketable maturity showed significant negative correlation with marketable yield (r=-0.39), harvest index (-0.84), boron content of leaves (-0.54) and nitrogen content of leaves (-0.64). Although a negative correlation existed between days taken to marketable maturity, leaf size (-0.27), gross weight of plant (-0.15), curd size (-0.11), marketable curd weight (-0.33) and net curd weight (-0.37) but it was statistically non-significant.

Average number of leaves per plant showed highly significant positive correlation with leaf size (0.74), gross weight of plant (0.77), curd size (0.87), marketable curd weight (0.74), net weight of curd (0.72), curd compactness (0.90), and marketable yield (0.75) where as significant positive correlation was obtained with dry matter content (0.49) and nitrogen content of leaves (0.48). The non-significant positive correlation was obtained with harvest index (0.35) and boron content of leaves (0.31).

The association of leaf size with curd size (0.86), marketable curd weight (0.86), net weight of curd (0.87), curd compactness (0.82), marketable yield per plot (0.90), harvest index (0.62) and nitrogen content of leaves (0.60) was highly significant and positive.

Correlation coefficient of gross weight of plant with curd size (0.93), marketable curd weight (0.98), net weight of curd (0.97), curd compactness (0.88) and marketable yield per plot (0.93) were highly significant and positive. The association of gross weight of plant with harvest index (0.56), dry matter content (0.48) and nitrogen content of leaves (0.45) was significant and positive but the relationship of gross weight of plant with boron content of leaves (-0.24) was non-significant and negatively correlated.

The relationship of curd size index was fairly high and positive with marketable curd weight (0.93), net weight of curd (0.91), curd compactness (0.95), marketable yield per plot (0.92),harvest index (0.57) and significant with dry matter content (0.42). Although a negative correlation existed between curd size and boron content of leaves (-0.52) and nitrogen content of leaves (-0.58) but it was statistically significant.

The associationship of marketable curd weight with net weight of curd (0.99), curd compactness (0.85), marketable yield per plot (0.98), harvest index (0.71) and nitrogen content of leaves (0.66) was positive and highly significant. Correlation coefficient of marketable curd weight with dry matter content (0.40) was positive and significant whereas association with boron content of leaves (-0.62) was negative and highly significant.

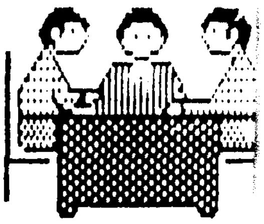
Correlation coefficient of net weight of curd with curd compactness (0.84), marketable yield per plot (0.97), harvest index (0.74) and nitrogen content of leaves (0.52) was fairly high and positive. Correlation coefficient of net weight of curd with dry matter content (0.42) was positive and significant but association with boron content of leaves (-0.62) was negative and highly significant.

The relationship of curd compactness was fairly high and positive with marketable yield per plot (0.88) and harvest index (-.51). The correlation coefficient of curd compactness with dry matter content (0.32) and nitrogen content of leaves (0.20) was positive but non-significant. The association of curd compactness with boron content of leaves (-0.42) was negative and significant.

The association of harvest index with dry matter content (0.56) was positive and highly significant but relationship with boron content of leaves (0.24) and nitrogen content of leaves (0.32) was positive and non-significant.

The correlation coefficient of dry matter content with nitrogen content of leaves (0.50) was positive and highly significant but the association with boron content of leaves (0.28) was positive and non-significant.

The relationship of boron content of leaves with nitrogen content of leaves (0.16) was positive but non-significant.



DISCUSSION

Chapter 5

DISCUSSION

The plant is the product of its genetic constitution and surrounding environment. The genetic pattern is fixed for a given plant and determines its potential for maximum growth under favourable environment. The analysis based upon responses to various factors provide means to improve yield of a genotype by modifying controllable factors of the environment. The crop yield is the result of a number of individual and interacting physical and physiological processes that occur during the growing period. These processes are influenced by weather, soil and input management practices. Of these weather plays an important role particularly in the Indian sub-continent. Rainfall determines the water availability for crop production which in turn govern higher use of other vital inputs like improved seeds and fertilizers. Rainfall and temperature also play a key role in nutrient dynamics in soil which can influence the nutrient management practices and the types of crops to be grown.

As agriculture becomes more intensive and the extent and severity of nutrient deficiencies increases, so does the practical significance of nutrient interactions. Indian agriculture has already entered into the stage of multiple nutrient deficiencies. Nutrient interactions have a key role to play in determining the course and out come of two major issues of interest in fertilizer management. These are balanced fertilizer use, efficient fertilizer use under proper transplanting of the crop. Balance is the pre-requisite for high efficiency the back bone of efficient fertilizer use (Tandon, 1992).

Once a reasonable good stand is established in cauliflower crop, the growth, development and yields are perhaps directly related to cultural practices and soil environment. Consequently improvement in plant performance has occurred with manipulations of soil environment to provide a more suitable meilieu for growth (Maynard, 1978).

Further, the response of cauliflower to different nutrients varies under soil and agro-climatic conditions. The transplanting dates also vary with agro-climatic regions, varieties and the purpose of raising the crop, either for seed production or curd production for market. By virtue of change in thermal regimes and microclimate, the dates of transplanting have significant role to play in influencing the plant growth, development and yield contributing characters which are ultimately reflected in the overall crop yield. The results obtained during the course of present studies have been discussed in the light of current information available.

Days taken from transplanting to marketable maturity were influenced with the increase in nitrogen application from 100 to 200 kg ha^{-1}. The higher doses significantly extended curd maturity. These observations are in conformity with the findings of Gill et al (1975), Roy (1981) and Thakur _et al._ (1991) who had also reported that curd maturity was delayed with the increase in dose of nitrogen in cauliflower.

Application of boron hastened curd maturity. The nitrogen content of leaves also decreased in boron applied plants. Perhaps boron application neutralizes, to some extent delaying, maturity process of nitrogen. These results are in line with those of Mehrotra and Mishra (1974) and Thakur _et al._ (1991) who had observed delayed curd formation in boron deficient plants.

The delayed transplanting than the normal planting period helped in delaying maturity of curds to some extent. This might have been due to slow growth of the plant. Further delay in transplanting reduced the vegetative growth markedly resulting in less metabolic activities and ultimately low yields. These results are in close conformity with the results of Singh _et al_. (1978).

The interactions among nitrogen levels x transplanting dates, transplanting dates x boron levels and nitrogen x boron levels exhibited superior response regarding days taken from transplanting to marketable curd maturity. The crop took less number of days to mature in early transplanting along with low dose of nitrogen. The number of days to marketable curd maturity increased with delay in transplanting and with higher dose of nitrogen. This may be attributed to better development of roots and more absorption of mineral nutrients from the soil whereas in case of much delayed planting, the root development was less and thus might have affected adversely the absorption of mineral nutrients from the soil. The best results were obtained with 200 kg N ha^{-1} along with 12th October transplanting date. These results are in line with those of Singh et al. (1978) who observed 15th October transplanting and 195 kg N ha^{-1} beneficial for cauliflower cv. SnowBall-16. This also confirms the earlier observations that crop should attain proper vegetative growth before temperature goes down for better curd size.

The beneficial effect of N x B interactions is well understood and in the present investigations too, it exhibited superiority regarding days taken to marketable curd maturity.

5.1 Morphological characters

The studies revealed that nitrogen, boron and transplanting dates significantly affected various characters such as number of leaves per plant, leaf size and leaf area index.

The stalk length could not be influenced by any treatment combination. There was linear increase in vegetative parameters with increase in nitrogen rates from 100 to 200 kg ha^{-1}. The plants receiving N at 200 kg ha^{-1} produced more number of leaves per plant, leaf size and leaf area index which was significantly superior over other N applications. Similar are the findings of Roy (1981) and

Sharma and Arora (1984).

Boron application exhibited significant differences in vegetative parameters except stalk length. Out of three levels of boron tried only 20 kg ha^{-1} yielded beneficial effect on vegetative parameters studied. This might be the optimum boron requirement of cauliflower under mid hill conditions. The findings of Devlin, 1973, Nelson, 1975, Gupta and Cutclife, 1976, Kuramoto et al. (1970) Thakur et al. (1991) and Bhagat (1994) also confirm the beneficial role of boron application. The findings of Mehrotra and Mishra (1974) and Reynold et al (1987) also indirectly confirm the same.

There was decrease in number of leaves per plant, leaf size and leaf area index with delayed transplanting dates. It might have been due to the reasons that low temperature and short days were not congenial environmental conditions for vegetative growth. The crops transplanted on 12th October and 26th October got comparatively sufficient longer period to complete its vegetative growth as compared to 10th November transplanting. Similar are the findings of Wurr and Fellows (1990), Singh et al. (1978) and Singh et al. (1994).

The interactions among transplanting dates as well as nitrogen and boron levels showed beneficial effects on number of leaves per plant, leaf size and leaf area index. This can be attributed to better utilization of mineral nutrients from the soil. The present findings are in accordance with the observations of Singh _et al._ (1978) and Singh _et al._ (1994).

The interactions between boron levels x transplanting dates were also found significant. The application of 200 kg N and 20 kg B ha^{-1} showed significant increase in respect of vegetative parameters. These findings are in line with those of Sharma _et al._ (1994), Thakur _et al._ (1991) and Bhagat (1994).

5.2 Curd yield and its allied characters

The useful role of nitrogen, boron and transplanting dates in curd production of cauliflower has been reflected in the form of significant increase of characters such as weight (Gross, marketable and net), compactness, curd size and curd yield studied.

Nitrogen appeared to be more effective in increasing the weight. The gross curd weight increased by increasing levels of nitrogen from 100 to 200 kg ha^{-1}. This can be attributed to more number of leaves, bigger leaf size and more photosynthesis at higher nitrogen levels i.e. 200 kg ha^{-1}. Similar is the case with regard to marketable curd weight, net curd weight and curd yield per plot and per hectare. These results are in agreement with the findings of Arora _et al._ (1970), Genkov _et al._ (1972), Roy 1981, Balyan _et al._ 1988, Thakur _et al._ 1991 and Bhagat 1994. The variations observed by different workers might have been due to differences in cultivars used and varied agroclimatic conditions under which the crops were grown.

With increase in boron dose from 15 to 20 kg ha^{-1}, there had been significant increase in the curd weight (i.e. gross, marketable and net weight) curd size and marketable curd yield. The increase in average curd weight, size and curd yield with increase in levels of boron might be due to its role in enhancing the translocation of carbohydrates and better uptake of other elements as reported by Devlin 1973 and Tisdale and Nelson, 1975., Increase in curd diameter, curd weight and curd yield with the soil application of boron have also been reported by Parsad and Singh (1988). The present findings also revealed that 20 kg boron application per hectare had its influence in increasing the curd yield in deficient soils. These findings have the support from the work of Kotur and Kumar (1989) and Thakur et al. (1991). Increase in boron application from 20 to 25 kg ha^{-1} slightly decreased the above mentioned characters. The decrease might be due to the toxic effect of excessive boron application in comparison to other nutrients, there by upsetting the Ca/B ratio in the plants. Similar views have been expressed by Nieuwhof (1969) and Randhawa and Bhail (1976).

The transplanting dates caused significant variations in morpho-physiological characters which resulted in significant effect on curd and its allied characters. The data depicted that the two transplanting dates i.e. 12th October and 26th October increased the curd yield and its allied characters in comparison to 10th November transplanting date during both the years. The plants of these dates must have completed their vegetative growth before on set of low temperature and hence gave good yields. The various growth contributing components i.e. number of leaves leaf size and leaf area index which help in building an initial base for subsequent growth, development and final yield of crop were lowest and consequently reflected in poor curd yield per hectare in case of 10th November transplanting date. Similar findings have also been opined by Singh et al. (1978) and Singh et al. (1994).

The interactions, transplanting dates x nitrogen, boron x transplanting dates and nitrogen x boron were significant for curd yield and its allied characters. The curd yield increased with 200 kg N ha^{-1} and 12th October transplanting date. Perhaps higher N levels and timely transplanting accelerated the synthesis of chlorophyll and aminoacids resulting in better vegetative growth of different plant parts which ultimately affected the yield. These results are in accordance with those of Singh et al. (1994). Similar trend has been recorded in case of boron x transplanting dates interactions. 20 kg B ha^{-1} and 12th October transplanting date gave better curd yield and its allied characters. The present findings are in accordance with the findings of Singh et al. (1978) using SnowBall-16 cultivar. The decrease in curd yield with delayed transplanting might be due to poor plant growth before the receipt of cold stimulus which ultimately resulted in very small curds. Early planted crops had more time and better temperature conditions to complete vegetative growth and had greater leaf number which seem to have accelerated the anabolic activities and helped in greater accumulation of total solids.

The curd yield and its allied characters depicted significant response regarding the nitrogen x boron interactions. 200 kg N and 20 kg B ha^{-1} proved the most beneficial in this regard. These results are in line with the findings of Pandey et al. (1978), Mehdi (1987) and Thakur et al. (1991) who also reported 200 kg N and 20 kg B ha^{-1} as optimum rates for getting higher curd yield and its contributing characters.

The compactness of the curd, an important quality, character from market point of view was found to be influenced by the rate of nitrogen application. 200 kg N ha^{-1} gave the more compact curds than other rates of nitrogen applied. Such effect of nitrogen was due to the fact that nitrogen is mainly responsible for improving the quality and quantity of produce by way of increasing metabolic activities in the plant system. Similar effects of nitrogen have been reported by Pandey et al. (1984) and Balyan et al. (1988).

The increase in the boron dose from 15 to 20 kg ha^{-1} increased compactness of curd significantly and at par with 25 kg B ha^{-1}. The increase in compactness with the increase in levels of boron may be due to its role in enhancing the translocation of carbohydrates to the storage tissues in the curds as also has been reported by Mehdi (1987).

The transplanting dates played a significant role in increasing the compactness of the curd. Both the transplanting dates i.e. 12th October and 26th October produced more compact curds perhaps because the plants transplanted on these dates got sufficient longer period to grow and absorb more nutrients from the soil under better temperature conditions which helped in more accumulation of total solids.

The interactions, transplanting dates x nitrogen, boron x transplanting dates and nitrogen x boron levels were significant for curd compactness. N3 x D1 (200 kg N ha^{-1} along with 12th October transplanting date) combination gave more compact curds which ultimately reflected in the improvement of marketable yield. Similar observations have been recorded with Boron x transplanting dates interactions. B2 D1 combination (20 kg B ha^{-1} and 12th October transplanting) gave the more compact curds which was closely followed by B3 D1 combination i.e. 25 kg B ha^{-1} and 26th October transplanting date. It was also observed that nitrogen and boron interaction gave better compactness of curd. 200 kg N along with 20 kg B ha^{-1} gave more compact curds which indicated that nitrogen and boron have synergistic effect on this trait. The present findings are in close conformity with the findings of Mehdi (1987) and Balyan _et al_. (1988).

The dry matter content of the curd and plants increased with the increase of nitrogen application from 100 to 200 kg ha^{-1}. High nitrogen dose increased leaf size, leaf area index and number of leaves which increased the assimilating surface and ultimately higher dry matter production and accumulation. Similar, findings have been reported by Sharma and Parashar (1982) and Thakur et al. (1991). Similar trend has been observed with the increase of boron levels from 15-20 kg ha^{-1}. The dry matter accumulation also depends upon nutrient status, levels of metabolites and growth substances synthesised within the plant. These findings are in conformity with those of Sisler et al. (1956), Devlin (1973), Tisdale and Nelson (1975) and Malewar and Indulkar (1993).

The dry matter content decreased with the delay in transplanting of crop. The early transplanted crop got opportunity to utilize the growth factors for a relatively longer duration under more congenial conditions in the form of moisture, temperature, sunshine hours and relative humidity which favourably helped in increased accumulation of photosynthates in plants. On the other hand, delayed transplanted crop was relatively subjected to very low temperature, less sunshine hours etc. at later stages of growth resulting in reduced metabolic activity.

The interactions, nitrogen x transplanting dates, transplanting dates x boron and nitrogen x boron levels showed positive response with respect to dry matter production. The reasons for increase in dry matter content in the plants have already been described in this chapter. The results are in agreement with the findings of Thakur et al. (1991) and Singh et al. (1994).

5.3 Nitrogen and boron contents in leaves and curds and their uptake

The nutrient status of the experimental field showed medium levels of available nitrogen (386 and 390 kg ha^{-1} and low in available boron (0.43 and 0.44 ppm). Transplanting dates and nitrogen and boron levels showed significant effect on nitrogen and boron contents of leaves and curds. There was linear increase in nitrogen content of leaves and curd with the increase in levels of nitrogen. Increased nitrogen content of 2.57 and 2.65 per cent in leaves and 4.55 and 4.68 per cent in curd was recorded with 200 kg N ha^{-1}. Boron levels of old leaves and young tissues particularly the head are the most reliable indicators of boron toxicity. The application of nitrogen had a small but very important influence on the total amount of boron in leaves. These findings are in accordance with the findings of Randhawa and Bhail (1976) Sharma and Parashar (1982), Kathan (1986), Gunadi and Asandhi (1988), Markovic et al. (1990) and Gupta et al. (1991) who had also reported increase in nitrogen uptake in plants and leaf nitrate content by the application of nitrogen.

Similar trend has also been observed in case of boron application. The higher boron rates 20 and 25 kg ha^{-1}

increased nitrogen content of leaves and curds both. Boron application is instrumental in influencing inhibition of indole-acetic-acid oxidation and possibly promoting pyridine nucleotide quinone reductase activity which is specially high in roots when applied upto 20 kg ha^{-1}. The results are in agreement with the findings of Randhawa and Bhail (1976), who had also reported that Ca/B ratio in the plants is upset with increase in Boron dose from 15 to 20 kg ha^{-1}. The deterimental response of higher levels of boron in the present investigations can also be explained that toxic effects are developed with higher rates of boron there by reducing its availability. Likewise, the nitrogen content in leaves and curd and their uptake was influenced by the transplanting dates. The nitrogen content in leaves and curds was more in 12th October transplanting and 26th October transplanting as compared to 10th November transplanting date. This can be explained on the basis of better absorption and better utilization of mineral nutrients by the plants transplanted in the first two dates than the third date. The late transplanting resulted in poor growth and perhaps also poor uptake of nutrients. Similar results had been obtained by Gupta and Cutcliffe (1976), Kotur and Kumar (1989) and Thakur et al. (1991).

5.4 Protein content of curd

The protein content of the curd increased with the higher dose of nitrogen i.e. 200 kg ha^{-1}. The probable reason for increase in protein content in the curd might be that nitrogen is related to carbohydrate utilization. When nitrogen supplies are adequate and conditions are favourable for growth, proteins are formed from the manufactured carbohydrates. These can further be explained as per findings of Tisdale and Nelson, 1975. The ammonium ions form glutamic acid which in turn is elaborated to different aminoacids. These aminoacids are then joined together through peptide linkages to form proteins. The findings of Randhawa and Bhail (1976) also confirm the same. Similar trend has also been observed with the increase in levels of boron from 15 to 25 kg ha^{-1}. All the levels of boron were at par with each other as regard to protein content of the curd. The beneficial role of boron has been reported in carbohydrate metabolism particularly in the translocation of photosynthates - the sugars which ultimately help in the formation of proteins.

There was linear decrease in the protein content of the curd with delay in transplanting dates. The 12th October and 26th October transplanting dates exhibited better protein content of the curd as compared to 10th November transplanting date. It might be due to the fact that early transplanted crops had more time and better temperature conditions to absorb and accumulate mineral nutrients from the soil whereas decrease in curd protein with delayed transplanting might be due to poor plant growth and less absorption and accumulation of mineral nutrients from the soil.

5.5 Economics

The economics of mineral nutrition of nitrogen, boron and transplanting dates and all treatment combinations was worked out. The results indicated that 12th October transplanting date + 200 kg N + 20 kg B ha^{-1} gave the maximum gross returns, net income and benefit : cost ratio to the tune of Rs. 74603 and Rs. 75584; Rs. 48426 and Rs. 49407; 1.85 and 1.89, respectively followed by 26th October transplanting date + 200 kg N + 20 kg B ha^{-1} during both the years. The results are in accordance with those of Singh and Srivastava (1987), Bhagat (1994) and Singh and Singh (1994). Thus, it can be concluded that for obtaining higher net returns 12th October and 26th October transplanting dates along with 200 kg N and 20 kg B ha^{-1} is ideal recommendation for mid hill humid areas of Himachal Pradesh.

5.6 Correlation studies

An attempt has been made to study inter-relationship among marketable yield per plant, days taken to curd maturity, number of leaves per plant, leaf size, curd size, gross yield per plant, curd compactness, harvest index and contents of nitrogen and boron in leaves at curd maturity stage of plant growth, to find suitable explanation for the nature of effect that a character produces on other attributes. The association of characters like net curd weight, number of leaves, dry matter content, marketable curd yield, curd compactness positively influenced marketable yield per plot in cauliflower. The number of leaves per plant, leaf size and net weight of curd increased with increase in N and B content of leaves. The increased number of leaves, dry matter content and net weight of curd in turn increased gross yield of the plant. The plants taking more number of days to marketable maturity in general produced higher curd yield per plant and per plot, higher gross weight per plant, more curd size and more harvest index. Similar reports in this crop have been given by workers like Jamwal (1984), Pandey and Naik (1991) and Kher (1995).

SUMMARY

Chapter 6

SUMMARY

The present investigations were undertaken at Vegetable Research Farm of HPKV, Palampur during 1993-94 and 1994-95 Rabi seasons to assess the influence of different planting dates (12th October, 26th October and 10th November), different levels of nitrogen (100, 150 and 200 kg ha^{-1}) and boron (15, 20 and 25 kg ha^{-1}) on morphological characters, curd yield, nutrient status of leaf and curds and uptake of nutrients by the plants in cauliflower.

The experiment was laid out in 3^3 factorial partial confounded design replicated four times. The phosphorus and potassium were applied as single basal dose while nitrogen in three split doses. The boron was also applied in the soil in the form of borax before transplanting. The initial status of the soil was medium in available nitrogen, phosphorus and potassium and low in available boron. The characters studied were time taken from transplanting to marketable maturity, number of leaves per plant, leaf size, leaf area index, curd size index, gross curd weight per plant, net curd weight per plant, compactness of curd, stalk length, gross plant weight per plot, marketable yield (q ha^{-1}), harvest index, dry matter content, protein content in the curd, nitrogen and boron contents in leaves and curds, uptake of nitrogen and boron and economics of the crop.

The increase in levels of N from 100 to 200 kg ha^{-1}

delayed curd maturity (132.8 and 133.0) days and increased leaf numbers (16.58 and 16.61), leaf size (700.32 and 736.73 cm^2), leaf area index (430.4 and 453.22 cm^2), gross weight of curd (1.45 and 1.55 kg), curd size (178.34 and 198.15 cm^2), weight of marketable curd (0.759 and 0.873 kg), net curd weight (0.429 and 0.499 kg), curd compactness (109.94^o and 110.65^o), gross plant weight per plot (50.75 and 50.89 kg), marketable yield per plot (24.25 and 25.57 kg), harvest index (29.55 and 31.65%), dry matter content (9.00 and 9.30%), nitrogen content of leaves (2.57 and 2.65%), nitrogen content of curd (4.55 and 4.68%), boron content of leaves (15.80 and 16.68 ppm), boron content of curd (20.18 and 20.37 ppm), uptake of N (146.1 and 140.2 kg ha^{-1}), uptake of B (15.65 and 16.69 kg ha^{-1}) and curd protein content (28.43 and 29.25%).

The boron application @20 kg ha^{-1} increased significant number of leaves (15.60 and 15.14), leaf size (629.11 and 639.65 cm^2), leaf area index (358.68 and 363.48 cm^2), gross weight of curd (1.23 and 1.33 kg), curd size (145.45 and 180.65 cm^2), weight of marketable curd (0.659 and 0.745 kg), net curd weight (0.378 and 0.435 kg), curd compactness (108.18^o and 110.64^o), gross plant weight per plot (21.78 and 23.13 kg), harvest index (29.24 and 32.00%), nitrogen content of leaves (2.37 and 2.44%), nitrogen content of curd (4.09 and 4.12%), boron content of leaves (16.30 and 16.28%), boron content of curd (18.38 and 18.62 ppm), uptake of N (155.6 and 152.3 kg ha^{-1}), uptake of B (12.62 and 13.45

kg ha^{-1}) and curd protein content (25.56 and 25.75%). The application of 25 kg B ha^{-1} was at par with 20 kg B ha^{-1} with respect to number of leaves per plant, gross curd weight, curd size, marketable curd weight, curd compactness, gross plant weight per plot, harvest index, nitrogen content of leaves, uptake of N and B and curd protein content during 1993-94 and 1994-95.

The different planting dates also indicated a significant increase in all the characters studied. The 12th Oct. transplanting date was considered as the best transplanting date which was closely followed by 26th Oct. transplanting date whereas 10th November transplanting date had adverse effect on the characters studied.

The interactions viz. DxN, BxD and NxB were also significant for most of the characters studied. In transplanting dates x nitrogen (DxN) interaction, the treatment combination D_1N_3 (12th October transplanting and 200 kg N ha^{-1}) recorded the highest number of leaves per plant (17.68 and 17.61), leaf size (964.68 and 1024.32 cm^2), leaf area index (631.69 and 668.08 cm^2), gross curd weight (1.87 and 2.02 kg), curd size (220.54 and 254.19 cm^2), weight of marketable curd (1.002 and 1.319 kg), net curd weight (0.539 and 0.702 kg), compactness of curd (109.58^o and 110.45^o), gross plant weight per plot (62.78 and 65.41 kg), marketable yield per plot (31.93 and 34.10 kg), dry matter content of plant (9.29 and 9.35%), nitrogen content of leaves (2.43 and 2.44%), nitrogen content of curd (3.87

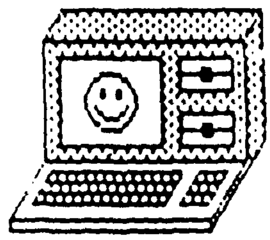
and 3.90%), boron content of leaves (17.37 and 17.43 ppm), boron content of curd (19.11 and 18.89 ppm), uptake of nitrogen (145.7 and 140.3 kg ha^{-1}), uptake of boron (20.26 and 21.15 kg ha^{-1}) and curd protein content (24.19 and 24.37%) during both the crop seasons of 1993-94 and 1994-95, respectively.

Similarly in case of boron levels x transplanting dates (BxD) interactions, the treatment combination B_2D_1 (20 kg B ha^{-1} and 12th October transplanting date) proved superior with respect to leaf size (796.09 and 847.06 cm^2), leaf area index (460.97 and 503.31 cm^2), gross curd weight (1.59 and 1.69 kg), curd size (173.96 and 229.32 cm^2), weight of marketable curd (0.885 and 1.034 kg), net curd weight (0.515 and 0.567 kg), compactness of curd (109.45^o and 110.45^o), gross plant weight per plot (52.66 and 56.17 kg), marketable yield per plot (28.72 and 30.17 kg), harvest index (33.96 and 33.33%), nitrogen content of leaves (2.42 and 2.44%), nitrogen content of curd (3.94 and 3.96%), uptake of N (160.4 and 155.3 kg ha^{-1}) and protein content of curd (24.65 and 24.75%) but the higher dry matter content (9.73 and 9.78%), boron content of leaves (16.45 and 16.59 ppm) and boron uptake (17.19 and 18.57 kg ha^{-1}) was recorded with B_3D_1 (25 kg B ha^{-1} and 12th October transplanting date) treatment combination during both the years. BxD interaction showed non-significant response with respect to number of leaves per plant, stalk length and boron content of curd.

The nitrogen x boron (NxB) interactions showed synergistic effects on various characters studied. However, N_3B_2 (200 kg N and 20 kg B ha^{-1}) treatment combination showed remarkable response with respect to number of leaves per plant (17.03 and 17.30), leaf size (730.84 and 785.51 cm^2), leaf area index (449.81 and 503.21 cm^2), gross curd weight (1.62 and 1.71 kg), curd size (194.99 and 209.28 cm^2), weight of marketable curd (0.847 and 0.997 kg), net curd weight (0.504 and 0.585 kg), gross plant weight per plot (54.37 and 56.73 kg), marketable yield per plot (26.91 and 28.74 kg), dry matter content (9.47 and 9.50%), nitrogen content of leaves (2.50 and 2.54%), nitrogen content of curd (4.26 and 4.28%), uptake of boron (16.96 and 17.19 ppm) and protein content of the curd (26.62 and 26.75%) where as highest boron content of leaves (16.94 and 17.59 ppm) and uptake of nitrogen (163.4 and 158.4 kg ha^{-1}) was recorded with N_3B_3 treatment combination.

While working out the economics of different treatments, 12th October transplanting date + 200 kg N + 20 kg B ha^{-1} gave the maximum gross return, net income and benefit cost ratio to the tune of Rs. 74603 and Rs. 75584; Rs. 48426 and Rs. 49407 and 1.85 and 1.89, respectively which was followed by 26th October transplanting date + 200 kg N + 20 kg B ha^{-1} during both the crop seasons.

Thus it can be concluded that for obtaining higher net returns, 12th October to 26th October transplanting along with 200 kg N and 20 kg B ha^{-1} is ideal for cauliflower crop in mid hill humid areas of Himachal Pradesh.



REFERENCES

REFERENCES

Al-Jibouri,H.A.; Miller,P.A. and Robinson,H.P. 1958. Genotypic and environmental variance and covariance in an upland cotton cross of interspecific origin. Agron. J. 50:633-636.

Anonymous.1993. F.A.O. Production Year Book. Rome, United Nations.

Arora,P.N.; Joshi,B. and Pandey,S.L. 1970. Tips for raising the yield of cauliflower. Indian Hort. 15(3) : 19-20.

Balyan,D.S; Dhankar,B.S.; Rujal,D.S. and Singh,K.P. 1988. Growth and yield of caulrflower variety snowball-16 as influenced by nitrogen, phosphorous and Zinc. Haryana J. Hort. Sci. 17(3-4) :247-254.

*Bergmann,W. 1976. Ernahrungsstorungen bei Kultur Pflangen in Farbilldern. Fischer, Jeva : 81-113.

Bhagat,D.C. 1994. Effect of nitrogen, phosphorous and boron on growth and yield of cauliflower. M.Sc. Thesis, Sher-E-Kashmir, University of Agricultural Science and Technology (J&K):78.

Chakarabarty,B.K. 1976. Effect of boron and molybdenum on cauliflower. (Brassica oleracea var. botrytis). South Indian Horticulture 24(4) : 145-147.

Chakrabarty,P.K. 1987. Studies on curd rot of cauliflower. Ph.D. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, H.P. India, 169 pp.

Chapman,H.D. and Prat.,P.F. 1961. Methods of analysis of soils, plants and water.Univ. calif. Div. Agric. Serv. 281 pp.

Chaudhary,B. 1977. Vegetables. National Book Trust, New Delhi, 214 pp.

Cochran,W.G. and Cox,C.M. Experimental design. John Wilay and Sons. Inc. New York.

Devlin,R.M. 1973. Plant Physiology. Ind. Ed. Affiliated East West Press, Pvt. Ltd. New Delhi, 446 PP.

Dutta,S.K. and Korla,B.N. 1991. Variability studies in cauliflower (late group) II. Correlation and regression studies. The Hort. J. 4(2) : 33-38.

Epstein,E. 1972. Mineral nutrition of plants. Principles and Perspectives. Willey. New York, 303-305.

Fisher,R.A. and Yates,Y. 1963. Statistical Tables for Biological, Agricultural and Medical Research. Oliver and Boyd Ltd., Edinburgh, London.

*Geissler,T.; Brudel,F.; Grahl, W. and Muller,W. 1974. Organic and mineral fertilizer in the industrial production of cauliflower Gartenban. 21 : 134-136.

*Genkov,G.;Bobobsherska,D. and Georgieva,M. 1972. The influence of level of nitrogen application on the yield and nutrient uptake of cauliflower. Nanohni Trudovevissh Selskostopanski instut Georgi Dimitrov obsocho Zem edelie. 24 : 9-23.

Gill,H.S.; Thakur,P.C. and Bhullar,B.S. 1975. Effect of nitrogen and phosphorous fertilization on the seed yield of late cauliflower. Indian J. Hort. 32 (1-2) : 94-97.

Gulshan,Lal 1973. Genetical studies in cauliflower. Ph.D. Thesis P.G. School, I.A.R.I., New Delhi.

Gunadi,N and Asandhi,A.A. 1988. Effect of urea and chilean nitrate fertilizer application on nutrient uptake, produce quality and the incidence of clubrot in cauliflowers. Bulletin - Penelition - Hortikultura. 16(3): 81-86.

Gupta,U.C. 1971. Boron requirement of alfalfa, redclover, brussel sprout and cauliflower grown under green house conditions. Soil Science 112 (4) : 280-289.

Gupta,U.C. 1991. Boron, Molybdenum and selenium status in different plant parts in forage legume and vegetable crops. Journal of Plant Nutrition (USA). 14(6): 613-621.

Gupta,U.C. and Cutcliffe,J.A. 1976. Defeciency and optimum boron levels in cauliflower and Rutabaga. Haryana J. Hort. Sci. 6(1/2): 45-49.

Hatcher,J.J. and Wilcox,L.V. 1950. Colorometric determination of boron using carmine. Analytical chemistry 82 : 567-69.

Hewitt, E.J. 1983. The effect of mineral defeciencies and excesses on growth and composition of plants. Her Majesty's stationary office London : 54-100.

*Jackson,M.L. 1973. Soil and chemical analysis, Prentice Hall Inc. Englewood cliffs N.J. Chap. VII: 134-82. VIII: 183-204.

Jamwal,R.S. 1984. Inheritance studies in cauliflower (Brassica oleracea var. botrytis L.). Ph.D. Thesis, HPKV, Palampur.

Johri,B.M. and Vasil,I.K. 1961. Physiology of Pollen. Bot. Rev. 27 : 325-381.

*Kathan,J.G. 1986. Effect of manuring on nitrate uptake. Deutscher Garten bau, 40(1): 18-20.

Kher,A. 1995. Variation and association for some economic traits in late cauliflower (Brassica oleracea var. botrytis L.). M.Sc. Thesis submitted to HPKV, Palampur.

Khurana,S.C.; Singh,G.R. and Pandita,M.L. 1987. A note of nitrogen, phosphorous fertilization and spacing on cauliflower cv. Pusa synthetic. Haryana J. Hort. Sci. 16 (3-4) : 298-300.

Kotur,S.C. and Kumar,S. 1989. Response of cauliflower (Brassica oleracea var. botrytis. to boron in Chotanagpur region. Indian J. of Agricultural Research. 59(10): 640-644.

Kumar,S. and Kotur,S.C. 1991. Effect of boron on susceptibility of cauliflower to black rot. Indian Phytopathology. 44(2): 153-157.

*Kuramoto,M.; Oliveira,G.D. and Haag,H.P. 1970. Mineral nutrition of vegetable crops XII. Micronutrient defeciencies in cauliflower Anais da Escola Superior de Agricultura Luiz de Queirog. 27 : 335-345.

Lal,Murari. 1976. Genetical studies on compactness of curd in cauliflower. (Brassica oleracea L. var. botrytis). Ph.D. Thesis submitted to IARI, New Delhi.

Malewar and Indulkar,B.S. 1993. Effect of phosphorous and boron on cauliflower. Veg. Sci. 20 (1) : 26-30.

*Markovic, V. and Djurovka, M. 1990. Influence of different quantity of nitrogen on the yield quality and basic nutritive elements accumulation, in cauliflower. Proceedings of Yugoslav Symposium Intensive Vegetable Breeding and Green House Production Ohrid (Yugoslavia), 13-16 February. p81-89.

Mathur,M.M. and Vashishtha,K.S. 1976. Effect of different spacing cum nitrogen dose on the yield of cauliflower Udyanika 2 : 45-47.

Maynard,D.N. 1978. Introduction to the symposium "Increasing the biological efficiency of vegetable crops. Hort. Sci. 13(6):672.

Medhi,R.P. 1987. Effect of macro and micronutrients on curd yield, quality, seed yield and disease incidence in cauliflower Ph.D. Thesis, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, H.P. India. 213 pp.

Mehrotra,O.N. and MIshra,P.H. 1974. Micronutrient defeciences in cauliflower. Progressive Horticulture 5 (4) : 33-39.

Mehrotra,O.N.; R.D.I. Srivastava and Verma,H.R. 1975. Response of cauliflower to boron and molybdenum. Progressive Horticultrure 7 (2) : 59-64.

*Mishra,D.P. 1972. Cauliflower needs boron. Intensive Agriculture. 10 (10) : 11-12.

Mishra,H.P. 1989. Effect of sowing dates on cauliflower (Brassica oleracea var. botrytis L.). Early Patna Seed Production. Indian J. Hort. 46(2):230-233.

Morwin,H.D. and Peech,M. 1951. Exchange ability of soil potassium in the snad, silt and clay fractions as influenced by the nature of the complementary exchangable cations. Proceedings of American Society of Soil Science. 15 :125-128.

Nagda,C.L. and Chauhan,K.S. 1987. Response of cauliflower to nitrogen and sulphur application. Indian J. of Hort. 44 (1/2) : 62-68.

Nason,A.O. and Mc Elory,W.D. 1963. Modes of action of essential mineral elements. Plant Physiology 3 : 451.

Nieuwhoff,W. 1969. Cole Crops. Leonard Hill, London.

Oleson,S.R.; Cole,C.V.; Watanabble,F.S. and Dean,L.A. 1954. Estimation of available P in Soils by extraction with sodium bicarbonate. USDA, CIRC. 939 : 19-23.

Pandey,S.C. and Naik,G. 1985. Factor analysis of yield components in cauliflower (Brassica oleracea var. botrytis L.) cruciferae Newsletter 10:68-70.

Pandey,S.C. and Naik,G. 1991. Genetics and character association studies in biparental progenies of cauliflower. Indian J. Hort. 48 (4) : 351-355.

Pandey,U.C. and Singh,G.P. 1984. Studies on nitrogen fertilization and its methods of application of cauliflower variety SB-16. Haryana J. of Hort. Sci.. 11(1/2): 132-138.

Pandey,U.C.;Lal,S.;Mangal,J.L. and Singh Gujraj 1981. Effect of date of transplanting on yield of cauliflower var. Hissar 1. Haryana Agric. Uni. J. Res. 11(3):379-383.

Pandey,U.C.;Mangal,J.L. and Lal,S. 1978. Notes on the effect of Zinc and boron on yield and quality of cauliflower. Indian J. of Agric. Res. 12(1) : 55-56.

Pandey,U.C.;Mangal,J.L. and Singh,G.P. 1979. Effect of nitrogen, phosphorous and age of seedlings on the seed yield cauliflower var. Hissar-1. Punjab Hort. J. 19 (3) : 189-193.

Panse,V.G. and Sukhatme, V.G. 1989. Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Parsad,M.B.N.N. and Singh,D.P. 1988. Varietal screening in cauliflower agrinst boron defeciency. Indian J. of Hort.. 45(3-4): 307-311.

Parsad,M.B.N.N.; Kotur,S.C.; Singh,D.P. 1988. Screening of SnowBall cultivar genotypes for tolerance to boron defeciency in Chotanagpur region. Veg. Sci., 15(2): 137-140.

*Pimpini,F.;Venter,F. and Wunsch, A. 1971. The influence of various forms of nitrogen and increasing nitrogen levels on the growth of cauliflower in pots. Garten bauwissenschaft. 36 : 1-17.

Piper,C.S. 1966. Soil and Plant analysis. Hans Publications, Bombay, India. 47-49.

*Pirovski,M. and Dyankova, D. 1975. The effect of mineral fertilization on vegetative development, yield and quality of cauliflower. Gradinarska Lozarska Nauka. 12 (1) : 80-85.

Rajput,C.B.S. and Singh,K.B. 1975. Response of cauliflower cv. SB-16 to various levels and methods of nitrogen application. Bangladesh Horticulture, 3 (1) : 23-30.

Randhawa,K.S. and Bhail,A.S. 1976. Growth, yield and quality of cauliflower as influenced by N, P and B. Indian J. Hort. 33 (1) : 83-91.

Reynolds,S.B.;Scaife, A. and Turner,M.K. 1987. Effect of nitrogen form on boron uptake by cauliflower. Soil Science and plant analysis. 18 (10) : 1143-1153.

Roy,H.K. 1981. Effect of nitrogen on curd size and yield of cauliflower. Veg. Sci. 8(2) : 75-78.

Sharma, D.K.; Sharma,P.P. and Bhardwaj,S.S. 1994. Effect of dates of planting on growth and seed yield of cauliflower (Brassica oleracea var. botrytis) cv. Pusa snowball-1. Veg. Sci. 21(1) : 16-19.

Sharma,R.P. and Arora,P.N. 1984. Response of mid-season cauliflower to rates and. time of nitrogen application and plant density. Indian J. of Agron. 29(4) : 468-470.

Sharma,R.P. and Parashar,K.S. 1982. Response of cauliflower to soil moisture regimes, nitrogen and phosphorous levels. veg.sci. 9(2) : 75-81.

Sharma,R.P.; Parashar,K.S.; Patil,R.R. and Parshad,M. 1982. Note on multiple correlation and regression studies in cauliflower. Indian J. Agric. Sci. 52 :789-791.

*Shelp,B.J. and Shattuck, V.I. 1987. Boron nutrition and mobility, and its relation to hollow stem and the elemental composition of green house grown cauliflower. Journal of Plant Nutrition. 10(2): 143-162.

Singh, Balraj and Singh Karan 1994. Effect of nitrogen and spacing on economics of seed production in mid season cauliflower. Veg. Sci. 21 (1) : 32-35.

Singh, Gajraj, Singh,K.P. and Pandey, U.C. 1983. Effect of spacing, nitrogen and phosphorous levels on yield of cauliflower var. Hissar-1. HAU J. Res. 13(4) :577-578.

Singh,A. and Srivastava,V.K. 1987. A note on income from inter cropping in late grown cauliflower at Hissar. Haryana J. of Hort. Sci. 16 (3-4) : 301-303.

Singh,J.P.; Singh,M.K. and Singh,R.D. 1994. Effect of planting date and nitrogen level on growth and yield of tropical cauliflower (Brassica oleracea var. botrytis L.). Indian J. Agric. Sci. 64(8):540-542.

Singh,R.D.; Tiwari,S.N.; Singh,B.B. and Sethi,J.N. 1976. Effect of nitrogen and potash on growth and yield of cauliflower var. SB-16. Progressive Horticulture. 7(4):29-34.

Singh,R.V. and Naik,L.B. 1990. Response of cauliflower (Early Kunwari) to plant density, nitrogen and phosphorous levels. Progressive Horticulture 22 (1-4) : 160-163.

Singh,U.P.; Syamal,N.B. and Ram Kumar 1978. Effect of different dates of planting on growth and yield of cauliflower(Brassica oleracea var. botrytis L.). Indian J. Hort. Sci. 34(2): 138.

Sisler,E.C.; Dagger, W.M. and Gauch,H.G. 1956. The role of B in translocation of organic components in plants. Plant Physiology. 131 : 11-17.

Subbiah,B.V. and Asija,G.L. 1956. A rapid procedure for the estimation of available N in soils. Current Science. 25 : 259-60.

Takkar,P.N. and Randhawa,N.S. 1978. Micronutrients in Indian Agriculture. Fertilizer News. 23 : 13-26.

Tandon,H.L.S. 1992. Management of nutrient interactions in Agriculture. Fertilizer Development and Consultation Organisation. New Delhi.

Thakur,O.P.; Sharma,P.P. and Singh,K.K. 1991. Effect of nitrogen and phosphorous with and without boron on curd yield and stalk rot incidence in cauliflower. Veg. Sci. 18 (2) : 115-121.

Thamburaj,S.; Ayyaswamy, M.K.; Shanmuga subramanian,A. and Suresh M. 1982. Association of plant characters in cauliflower grown in the plains. Madras Agri. J. 69 : 256-257.

Tisdale Samuel and Nelson Werner, 1975. Soil fertility and Fertilizer. 3rd Ed. Macmillan Publishing Co. Inc. New York.

Vaidya,S.J. and Patil,A.V. 1965. Influence of date of transplanting and age of seedlings on growth, yield and quality of cabbage. Indian J. Agron. 10 (4) : 420-422.

Verma,S.D. 1979. Characterstics and genesis of soil of H.P. Ph.D. Thesis submitted to HPKV, Palampur.

Wear,J.I. 1965. Boron. In methods of soil analysis Part II. Agronomy Monograph 9 : 1059-1063.

*Weier,U. and Scharpf,H.C. 1988. Nitrogen fertilization of cauliflower. Gemuse. 24(2): 54-56.

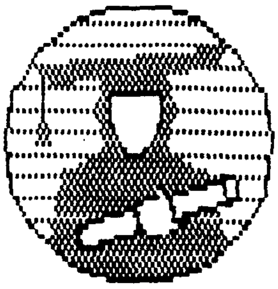
*Welch,N.C.; Tyler,K.B.; Ririe,D. and Broadbent,F.E. 1985. Nitrogen uptake by cauliflower. California Agriculture, 39 :516, 12-13.

Wurr,D.C.E. and Fellows, Jane, R. 1990. The influence of field environmental conditions on the growth and development of four cauliflower cultivars. J. Hort. Sci. 68 (3) : 565-572.

Yadav,B.R. and Paliwal,K.V. 1990. Response of cauliflower to nitrogen and phosphorous fertilization on irrigation with saline water. Veg. Sci. 17 (1) : 1-6.

---

* Original not seen



APPENDICES

APPENDIX I

Analysis of variance for days taken to marketable maturity

Source	Degree of freedom	S.S.	M.S.	F Calulated	F. Tabulated
		1993-94			
Replications	3	0.3750	0.1250	0.1509	2.74
Blocks	8	3.5000	0.4375	0.5280	2.07
A	2	1995.8750	997.9375	1204.4070	3.13
B	2	1148.3750	574.1875	692.9849	3.13
C	2	4.1250	2.0625	2.4892	3.13
AxB	4	109.6250	27.4063	33.0765	2.50
AxC	4	2.3750	0.5938	0.7166	2.50
BxC	4	9.6250	2.4063	2.9041	2.50
AxB^2xC^2	2	2.3750	1.1875	1.4332	2.74
AxB^2xC	2	0.6250	0.3125	0.3772	2.74
$AxBxC^2$	2	1.1250	0.5625	0.6789	2.74
AxBxC	2	0.5000	0.2500	0.3017	2.74
Error	70	58.0000	0.8286	-	-
		1994-95			
Replications	3	9.9082	0.3027	2.2832	
Blocks	8	2.0449	0.2556	1.9279	
A	2	115.0078	57.5039	433.6995	
B	2	232.0449	116.0225	875.0516	
C	2	14.8242	7.4121	55.9028	
AxB	4	0.5117	0.1279	0.9649	
AxC	4	0.684	0.171	0.1289	
BxC	4	15.4023	3.8506	29.0415	
AxB^2xC^2	2	0.8125	0.4063	3.0640	
AxB^2xC	2	0.4277	0.2139	1.6130	
$AxBxC^2$	2	0.7441	0.3721	2.8062	
AxBxC	2	0.2285	0.1143	0.8617	
Error	70	9.2813	0.1326	-	

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX II

Analysis of variance for numbers of leaves per plant

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	1.86	0.62	1.81
Blocks	8	8.25	1.03	3.01
A	2	46.51	23.25	67.97
B	2	125.92	62.96	184.02
C	2	4.35	2.17	6.36
AxB	4	28.14	7.03	20.56
AxC	4	2.62	0.65	1.91
BxC	4	11.27	2.82	8.24
AxB^2xC^2	2	1.30	0.65	1.91
AxB^2xC	2	2.71	1.36	3.97
$AxBxC^2$	2	3.51	1.76	5.13
AxBxC	2	4.57	2.29	6.68
Error	70	23.95	0.34	-
		1994-95		
Replications	3	0.91	0.30	2.28
Blocks	8	2.04	0.25	1.93
A	2	115.00	57.50	433.70
B	2	232.04	116.022	875.05
C	2	14.82	7.41	55.90
AxB	4	0.51	0.13	0.97
AxC	4	0.67	0.02	0.13
BxC	4	15.40	3.85	29.04
AxB^2xC^2	2	0.81	0.41	3.06
AxB^2xC	2	0.43	0.21	1.61
$AxBxC^2$	2	0.74	0.37	2.80
AxBxC	2	0.23	0.11	0.86
Error	70	9.28	0.13	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX III

Analysis of variance for size of leaves

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	308.00	102.67	1.16
Blocks	8	33940.00	4242.50	48.12
A	2	2068148.00	1034074.00	11728.00
B	2	754012.00	377006.00	4275.00
C	2	37924.00	18962.00	215.06
AxB	4	543792.00	135948.00	1541.86
AxC	4	11928.00	2982.00	33.82
BxC	4	103344.00	25836.00	293.02
AxB^{2}xC^2	2	14718.00	7359.00	83.46
AxB^{2}xC	2	8570.00	4285.00	48.60
AxBxC^2	2	8740.00	4370.00	49.56
AxBxC	2	67320.00	33660.00	381.76
Error	70	6172.00	88.17	-
		1994-95		
Replications	3	1380.00	460.00	0.89
Blocks	8	32528.00	4066.50	7.91
A	2	2343320.00	1171660.00	2281.02
B	2	1271268.00	635634.00	1237.47
C	2	69000.00	34500.00	67.16
AxB	4	611832.00	152958.00	297.78
AxC	4	36960.00	9240.00	17.99
BxC	4	116064.00	29016.00	56.49
AxB^{2}xC^2	2	20440.00	10220.00	19.89
AxB^{2}xC	2	21620.00	10810.00	21.04
AxBxC^2	2	4048.00	2024.00	3.94
AxBxC	2	21128.00	10564.00	20.37
Error	70	35956.00	513.66	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX IV

Analysis of variance for stalk length

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	0.52	0.17	5.06
Blocks	8	0.31	0.04	1.14
A	2	0.06	0.03	1.00
B	2	0.08	0.04	1.33
C	2	0.06	0.03	1.00
AxB	4	0.28	0.07	2.33
AxC	4	0.30	0.07	2.50
BxC	4	0.09	0.02	0.67
AxB^2xC^2	2	0.02	0.01	0.41
AxB^2xC	2	0.18	0.08	2.60
$AxBxC^2$	2	0.10	0.05	1.56
AxBxC	2	0.14	0.07	2.09
Error	70	2.38	0.03	-
		1994-95		
Replications	3	0.04	0.01	1.09
Blocks	8	0.12	0.01	1.077
A	2	0.06	0.03	2.41
B	2	0.02	0.01	1.78
C	2	0.01	0.005	0.35
AxB	4	0.12	0.03	2.14
AxC	4	0.14	0.03	2.50
BxC	4	0.10	0.02	1.78
AxB^2xC^2	2	0.01	0.005	0.41
AxB^2xC	2	0.09	0.04	3.45
$AxBxC^2$	2	0.001	0.007	0.05
AxBxC	2	0.02	0.01	0.91
Error	70	0.98	0.014	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX V

Analysis of variance for gross weight of curd

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	0.04	0.01	2.83
Blocks	8	0.08	0.01	2.05
A	2	9.93	4.96	908.72
B	2	4.92	2.46	450.01
C	2	0.40	0.20	36.67
AxB	4	1.08	0.27	49.57
AxC	4	0.14	0.03	6.50
BxC	4	0.42	0.10	19.18
AxB^2xC^2	2	0.09	0.04	8.97
AxB^2xC	2	0.04	0.02	3.53
$AxBxC^2$	2	0.04	0.02	3.38
AxBxC	2	0.07	0.04	6.91
Error	70	0.38	0.005	-
		1994-95		
Replications	3	0.004	0.001	0.52
Blocks	8	0.04	0.005	1.877
A	2	12.51	6.25	2021.40
B	2	4.60	2.30	753.99
C	2	0.36	0.18	59.64
AxB	4	1.04	0.26	84.34
AxC	4	0.08	0.02	6.49
BxC	4	0.33	0.08	26.92
AxB^2xC^2	2	0.01	0.006	1.93
AxB^2xC	2	0.03	0.019	6.12
$AxBxC^2$	2	0.01	0.006	2.01
AxBxC	2	0.05	0.025	8.14
Error	70	0.21	0.003	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX VI

Analysis of variance for average size of curd (cm^2)

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	6332.62	2110.87	12.37
Blocks	8	343.12	42.89	0.25
A	2	125745.90	62872.94	368.49
B	2	104326.90	52163.44	305.72
C	2	8863.25	4431.62	25.97
AxB	4	27634.88	6908.71	40.49
AxC	4	1926.50	481.625	2.82
BxC	4	2858.00	714.50	4.18
AxB^2xC^2	2	164.87	82.43	0.48
AxB^2xC	2	178.25	89.12	0.52
$AxBxC^2$	2	173.87	86.93	0.50
AxBxC	2	293.37	146.68	0.85
Error	70	11943.38	170.61	-
		1994-95		
Replications	3	50.50	16.83	1.71
Blocks	8	322.75	40.34	4.10
A	2	338179.80	169089.90	17216.42
B	2	44419.75	22209.83	2261.36
C	2	5948.00	2974.00	302.80
AxB	4	7675.75	1918.93	195.38
AxC	4	1333.00	333.25	33.93
BxC	4	2410.50	602.62	61.35
AxB^2xC^2	2	101.50	50.75	5.16
AxB^2xC	2	172.52	86.25	8.78
$AxBxC^2$	2	336.00	168.00	17.10
AxBxC	2	449.00	224.50	22.85
Error	70	687.50	9.82	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX VII

Analysis of variance for average weight of marketable curd

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	0.124	0.0041	2.48
Blocks	8	0.023	0.0029	1.73
A	2	4.73	2.36	1427.32
B	2	1.11	0.55	336.94
C	2	0.79	0.039	23.83
AxB	4	0.29	0.073	44.15
AxC	4	0.027	0.006	4.13
BxC	4	0.123	0.031	18.67
AxB^2xC^2	2	0.030	0.015	9.26
AxB^2xC	2	0.0015	0.0007	0.43
$AxBxC^2$	2	0.009	0.0045	2.89
AxBxC	2	0.008	0.004	2.58
Error	70	0.11	0.0017	-
		1994-95		
Replications	3	0.019	0.006	3.02
Blocks	8	0.03	0.003	1.86
A	2	7.54	3.77	1789.51
B	2	2.18	1.09	517.69
C	2	0.18	0.09	44.74
AxB	4	0.89	0.22	106.26
AxC	4	0.15	0.03	18.18
BxC	4	0.12	0.03	14.24
AxB^2xC^2	2	0.018	0.009	4.39
AxB^2xC	2	0.0057	0.002	1.34
$AxBxC^2$	2	0.016	0.008	3.81
AxBxC	2	0.007	0.003	1.71
Error	70	0.147	0.0021	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX VIII

Analysis of variance for net weight of curd

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	0.0018	0.0006	1.18
Blocks	8	0.016	0.002	4.06
A	2	1.97	0.98	1930.44
B	2	0.37	0.18	364.70
C	2	0.03	0.019	37.61
AxB	4	0.09	0.02	48.49
AxC	4	0.01	0.004	8.84
BxC	4	0.08	0.02	41.12
AxB^2xC^2	2	0.016	0.008	16.30
AxB^2xC	2	0.0021	0.001	2.03
$AxBxC^2$	2	0.008	0.004	8.13
AxBxC	2	0.009	0.004	9.14
Error	70	0.03	0.005	-
		1994-95		
Replications	3	0.004	0.001	2.62
Blocks	8	0.007	0.009	1.68
A	2	1.69	0.84	1528.12
B	2	0.67	0.33	607.16
C	2	0.08	0.04	74.95
AxB	4	0.16	0.04	73.01
AxC	4	0.04	0.01	20.42
BxC	4	0.06	0.01	29.05
AxB^2xC^2	2	0.007	0.003	7.12
AxB^2xC	2	0.001	0.009	1.56
$AxBxC^2$	2	0.008	0.004	7.20
AxBxC	2	0.002	0.001	2.58
Error	70	0.03	0.006	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX IX

Analysis of variance for compactness of curd

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	2.18	0.72	0.58
Blocks	8	3.75	0.45	0.37
A	2	1552.00	776.00	627.07
B	2	2404.25	1202.12	971.41
C	2	112.93	56.48	45.63
AxB	4	144.25	36.06	29.14
AxC	4	54.27	13.56	10.93
BxC	4	4.25	1.06	0.85
AxB^2xC^2	2	0.25	0.12	0.10
AxB^2xC	2	3.68	1.84	1.48
$AxBxC^2$	2	4.18	2.09	1.69
AxBxC	2	4.50	2.25	1.81
Error	70	86.62	1.24	-
		1994-95		
Replications	3	2.81	0.93	1.24
Blocks	8	15.00	1.87	2.48
A	2	2271.37	1135.68	1505.29
B	2	2294.12	1147.06	1520.36
C	2	140.87	70.43	93.36
AxB	4	90.93	22.73	30.13
AxC	4	26.87	6.71	8.90
BxC	4	4.31	1.07	1.43
AxB^2xC^2	2	8.31	4.15	5.50
AxB^2xC	2	10.62	5.31	7.04
$AxBxC^2$	2	15.50	7.75	10.27
AxBxC	2	7.56	3.78	5.01
Error	70	52.81	0.75	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX X

Analysis of variance for average gross yield per plot (kgs)

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	56.85	18.95	3.25
Blocks	8	123.18	15.39	2.64
A	2	12339.17	6169.58	1058.14
B	2	5855.17	2927.58	502.10
C	2	480.43	240.21	41.19
AxB	4	1274.31	318.57	54.63
AxC	4	167.39	41.84	7.17
BxC	4	533.75	133.43	22.88
AxB^2xC^2	2	135.68	67.84	11.63
AxB^2xC	2	38.28	19.14	3.28
$AxBxC^2$	2	41.10	20.55	3.52
AxBxC	2			
Error	70	408.14	5.83	-
		1994-95		
Replications	3	61.14	20.38	6.65
Blocks	8	19.75	2.46	0.80
A	2	11121.59	5560.79	1816.56
B	2	6914.81	3457.40	1129.44
C	2	369.50	184.75	60.35
AxB	4	1526.85	381.71	124.69
AxC	4	79.26	19.81	6.47
BxC	4	226.42	56.60	18.49
AxB^2xC^2	2	11.54	5.77	1.88
AxB^2xC	2	1.07	0.53	0.17
$AxBxC^2$	2	20.12	10.06	3.28
AxBxC	2	15.10	7.55	2.46
Error	70	214.28	3.06	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX XI

Analysis of variance for marketable yield per plot

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	7.76	2.58	1.38
Blocks	8	16.03	2.00	1.07
A	2	5446.63	2723.31	1462.62
B	2	1105.91	552.95	296.97
C	2	102.26	51.13	27.46
AxB	4	336.58	84.14	45.19
AxC	4	47.16	11.79	6.33
BxC	4	94.08	23.52	12.63
AxB^2xC^2	2	17.17	8.58	4.61
AxB^2xC	2	16.83	8.41	4.52
$AxBxC^2$	2	15.10	7.55	4.05
AxBxC	2	0.40	0.20	0.10
Error	70	130.33	1.86	-
		1994-95		
Replications	3	1.16	0.38	0.34
Blocks	8	27.56	3.44	3.06
A	2	6598.46	3299.23	2938.33
B	2	1278.43	639.21	569.29
C	2	183.79	91.89	81.84
AxB	4	321.03	80.25	71.47
AxC	4	66.31	16.57	14.76
BxC	4	68.53	17.13	15.26
AxB^2xC^2	2	9.86	4.93	4.39
AxB^2xC	2	5.35	2.67	2.38
$AxBxC^2$	2	1.48	0.74	0.66
AxBxC	2	7.26	3.63	2.23
Error	70	78.59	1.12	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX XII

Analysis of variance for marketable yield per hectare

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	889.50	296.50	1.32
Blocks	8	2506.00	313.25	1.40
A	2	610490.00	305245.00	1368.87
B	2	124175.00	62087.50	278.43
C	2	11858.00	5929.00	26.58
AxB	4	37973.00	9493.37	42.57
AxC	4	4937.00	1234.25	5.35
BxC	4	10134.00	2533.50	11.36
AxB^2xC^2	2	955.85	477.87	2.14
AxB^2xC	2	1424.75	712.37	3.19
$AxBxC^2$	2	1875.75	937.87	4.20
AxBxC	2	21.00	10.50	0.47
Error	70	15609.25	222.98	-
		1994-95		
Replications	3	336.50	112.16	0.94
Blocks	8	1531.50	191.43	1.61
A	2	678810.50	339405.30	2860.12
B	2	117018.50	58509.25	493.05
C	2	19313.50	9656.75	81.37
AxB	4	32974.50	8243.62	69.46
AxC	4	7776.00	1944.00	16.38
BxC	4	6779.00	1694.75	14.28
AxB^2xC^2	2	939.75	469.87	3.95
AxB^2xC	2	1170.25	585.12	4.93
$AxBxC^2$	2	242.75	121.37	1.02
AxBxC	2	662.00	331.00	2.78
Error	70	8306.75	118.66	-

A, B, C stands for dates, nitrogen and boron, respectively

APPENDIX XIII

Analysis of variance for harvest index (%)

Source	Degree of freedom	S.S.	M.S.	F Calulated
		1993-94		
Replications	3	6.28	2.09	1.22
Blocks	8	1.15	0.14	0.08
A	2	2961.82	1480.91	864.20
B	2	27.55	13.77	8.03
C	2	15.41	7.70	4.49
AxB	4	43.02	10.75	6.27
AxC	4	22.71	5.67	3.31
BxC	4	5.38	1.34	0.78
AxB^2xC^2	2	2.15	1.07	0.62
AxB^2xC	2	3.07	1.53	0.89
$AxBxC^2$	2	0.05	0.02	0.01
AxBxC	2	0.13	0.06	0.03
Error	70	119.95	1.71	-
		1994-95		
Replications	3	13.43	4.47	0.93
Blocks	8	37.92	4.74	0.98
A	2	448.19	224.09	46.71
B	2	111.03	55.51	11.57
C	2	226.82	113.41	23.64
AxB	4	6.03	1.50	0.31
AxC	4	184.32	46.08	9.60
BxC	4	9.58	2.39	0.49
AxB^2xC^2	2	18.05	9.02	1.88
AxB^2xC	2	2.46	1.23	0.25
$AxBxC^2$	2	22.38	11.19	2.33
AxBxC	2	9.12	4.56	0.95
Error	70	335.76	4.79	-

A, B, C stands for dates, nitrogen and boron, respectively