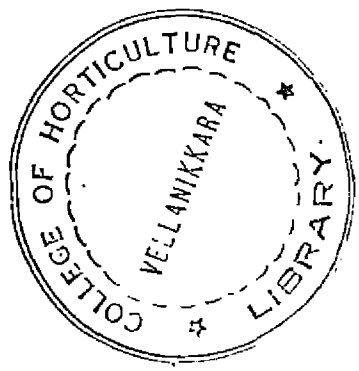
RESPONSE OF MAIZE VARIETIES TO GRADED LEVELS OF NITROGEN GROWN UNDER OPEN AND PARTIAL SHADE CONDITIONS

BY

LINCY XAVIER



THESIS

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VELLAYANI, TRIVANDRUM

1986

D E C L A R A T I O N

I hereby declare that this thesis entitled "RESPONSE OF MAIZE VARIETIES TO GRADED LEVELS OF NITROGEN GROWN UNDER OPEN AND PARTIAL SHADE CONDITIONS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title at any other University or Society.

LINCY XAVIER

Vellayani,
July 1986

C E R T I F I C A T E

Certified that this thesis entitled "RESPONSE OF MAIZE VARIETIES TO GRADED LEVELS OF NITROGEN GROWN UNDER OPEN AND PARTIAL SHADE CONDITIONS" is a record of research work done independently by Kumari LINCY XAVIER under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

INTRODUCTION

Maize is one of the most important cereal crops of the world. It stands first among cereals with its world average productivity of 27.8 q/ha. In India also maize occupies an important position and its area and production have steadily increased during the past two decades. It has been estimated that more than 85 per cent of production in maize is consumed directly as food in various forms in India.

In Kerala, maize is not cultivated much except in areas adjacent to Tamil Nadu and Karnataka. However, its use is increasing both as a human food and as an important ingredient of poultry and livestock feed. Kerala is now depending upon other States for the supply of maize grain. Although the soil and climatic conditions of Kerala are favourable for the growth of maize, the possible limitation is the unavailability of land for the purpose. The only area available is the partial shade condition in the coconut gardens and homesteads. However, no information is available about the performance of maize crop under partial shade situation as the maize crop is generally grown as a pure crop or as intercrop along with other field crops in other parts of the country. Therefore,

it was thought that a comparative evaluation of different maize varieties under open as well as partial shade will be useful to screen out suitable variety under both situations as well as to get an idea as to how much the yield is being reduced or increased in each variety due to partial shade condition as compared to open situation.

Although extensive fertilizer experiments have been conducted for maize crop in other States, not much works have been carried out in Kerala so far. Among the plant nutrients, nitrogen admittedly is the principal element influencing the yield of maize (Raheja et al.1957). Therefore, information about the optimum level of nitrogen for each variety selected under both open and partial shade situations is also necessary to proceed further to popularise the cultivation of maize in Kerala. Considering all the above points, an experiment has been organised to study the response of five maize varieties to graded levels of nitrogen grown under open and partial shade conditions with the following objectives.

1. To find out the most suitable variety of maize under open and partial shade conditions
2. To fix up the optimum dose of nitrogen under open and partial shade conditions for each variety.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Maize being a new introduction to the State of Kerala not much experiments have been conducted here on the nutritional as well as other requirements of the crop. Therefore works conducted in other parts of India are reviewed hereunder.

Role of Nitrogen on growth characters

1. Plant height

Nitrogen exerts significant effect on plant growth especially height of plants. Rajput et al. (1970) reported that N dose upto 160 kg/ha effected significant linear increase in plant height. Hati and Panda (1970) also reported increase in plant height with higher levels of N. Later Sharma (1973a) observed an increase in plant height with incremental doses of applied N in 3 maize varieties including Vijay composite. In a trial conducted at Libya, El-Sharkawy et al. (1976) also observed similar positive influence of N on plant height in maize.

In Yugoslavia, Gangro (1977a) observed a linear increase in plant height upto 300 kg N/ha. Later Al-Rudha and Al-Younis (1978) reported an increase in plant height with higher doses of N in Iraq. Again Gangro (1978)

reported a linear increase in stem height with increasing rates of N upto 200 kg/ha. According to Adetiloye et al. (1984) height of maize plant is greatly influenced by N fertilization and the effect is more prounced during vegetative growth.

Although majority of results are positive there are some reports showing negative response also. El-Hattab et al. (1980) reported a decrease in plant height with increasing N rate. Yahya and Andrew (1981) also observed a negative correlation between leaf N and vegetative characters. Russel (1984) reported that effects of N treatments were not significant for plant height. But Farah et al. (1984) reported a positive but diminishing response to increasing levels of N in terms of plant height.

2. Number of leaves per plant

It is well known that Nitrogen had significant effect on vegetative growth especially on leaf production. Rajput et al. (1970) reported that there was linear increase in the number of leaves per plant with increasing N rates upto 160 kg/ha. Hati and Panda (1970) also reported a linear increase in leaf area per plant with increasing doses of applied N. Later Gangro (1977) in Yugoslavia observed a significantly higher number of leaves per plant with the highest dose of applied N. Adetiloye et al. (1984) also reported the influence of N on leaf growth.

But Sambali and Omprakash (1971) reported that number of leaves per plant was not influenced by the increasing doses of N. El-Hattab et al. (1980) from Egypt reported a decrease in leaf area per plant with increasing N rate.

3. Drymatter production

Virmani et al. (1970) reported that increasing N rates upto 150 kg/ ha had a significant effect on drymatter production. Later Krishnamurthy et al. (1974) in a varietal trial reported the highest value of drymatter produced by Deccan with 200 kg N/ ha. Mikhail and Shalaby (1979) also reported an increasing trend in drymatter production with increased N rates.

According to Elias et al. (1979) this increasing trend was observed only upto 170 kg N/ ha. Similar results were obtained by Nayyar and Sawarkar (1980). Stoyanov (1983) reported that increasing NP rates favourably influenced the chlorophyl contents which in turn was correlated with drymatter accumulation.

Contrary to the above findings, Catanescu (1977) reported that application of N did not increase drymatter accumulation. Upto 100 kg N/ ha there was increase in drymatter accumulation, but from 100-200 kg N/ha, there occurred a decreasing trend.

Effect of N on yield components and yield

a. Yield components

Grain yield is highly correlated with yield components such as length, girth and weight of cobs, number of cobs per plant, number of grains/ cob and 1000 grain weight. Pande et al. (1971) reported a positive correlation between grain yield / ha and yield components such as number of grains / cob, grain yield/ plant and 1000 grain weight. Dornescu (1973) from a study of yield components reported a correlation between grain yield and yield components. Similar correlation was reported by Steynberg et al. (1983) also.

1. Number of cobs / plant

Sharma et al. (1969) reported that increasing rates of N had a significant effect on number of cobs/plant. Sharma (1973) also observed an increase in number of cobs/ plant with increased rates of applied N. Later Sattar et al. (1975) in his trials with 3 types of maize obtained a higher number of cobs/plant with 120 kg N/ha.

In field trials conducted for two years Brar and Khehra (1977) observed an increase in number of ears per unit area with increased rates of applied N upto 150 kg/ha. Later Short et al. (1982) also reported an increase in cob number/plant with increased N. Karim et al. (1983) also

reported same trend in number of cobs/plant. Russel (1984) observed significant linear increase in ears/plant with increased N levels upto 240 kg/ha. Adetiloye et al. (1984) also observed the same trend with number of cobs per plant.

2. Length, girth and weight of cobs

Hati and Panda (1970) reported a linear increase in cob length and weight with increase in fertilizer N upto 100 kg/ha. Rajput et al. (1970) also observed linear increase in number of grains/cob with increase in applied N upto 160 kg/ha.

In a study conducted with 3 varieties, Sharma (1973) reported significant effect of N on 1000 grain weight. Sattar et al. (1975) observed a higher number of grains/ear with 120 kg N/ha. El-Sharkawy et al. (1976) also reported increase in grain size, length and diameter upto 104 kg N/ha.

In field trials conducted for two years, Brar and Khehra (1977) reported an increase in cob weight upto 150 kg N/ha. Later Al-Rudha and Al-Younis (1978) also observed increased number of grains/cob and 1000 grain weight with increased N fertilization. Singh et al. (1978) also observed the influence of N rates on yield components.

Similar increasing trends in ear length, number of grains per cob, cob weight and 1000 grain weight with increased N upto 200 kg/ha was reported by Shalaby and Mikhail (1979) and Sciput et al.(1979). El-Hattab et al.(1980) also reported a similar trend with all yield components. According to Kharkar (1980) this increasing cob weight and 1000 grain weight were only upto 160 kg N/ha.

Karim et al.(1983) reported an increase in ear weight with increasing N rates, but ear length was uneffected. Farah et al.(1984) reported an increasing ear weight upto 300 kg N/ha. Russel (1984) from a varietal trial conducted to determine the response to N fertilizer rates reported that N had significant effect on ear length, ear diameter and 1000-grain weight. Adetiloye et al.(1984) also observed an increase in cob length with N rates.

3. 1000-grain weight

Rajput et al.(1970) reported that N levels upto 160 kg/ha increased the 1000-grain weight significantly. Sharma (1973) also reported a linear increase in 1000 grain weight with increased rates of applied N. Later Al-Rudha and Al-Younis (1978) observed an increase in 1000 grain weight upto 120 kg N/ha. According to Shalaby and Mikhail (1979) increasing trend in 1000 grain weight was seen upto

200 kg N/ha. Sciput et al. (1979) also, observed increased 1000 grain weight with 200 kg N/ha. But Kharkar (1980) observed a linear response upto 160 kg N/ha only. Later Russel (1984) reported a linear increase in 1000 grain weight upto 240 kg N/ha.

b. Grain yield

Nitrogen is considered as the most important nutrient required for good yield in maize. Sharma and Gupta (1968) reported a significant increase in grain yield of maize cv. Ganga safed-2 with increasing levels of N upto 100 kg/ ha and there was a further non-significant increase with 150-200 kg N/ha. Sharma et al. (1969) also reported highest grain yield response to applied N at 200 kg/ha in Ganga safed-2 Hati and Panda (1970) observed a linear increase in grain yield with fertilizer N from nil to 100 kg/ha. Rajput et al. (1970) also reported a linear increase in grain yield upto 180 kg N/ha.

From yield trials, Verma and Singh (1971) observed that increased rates of N from zero to 150 kg/ha increased average grain yields from 0.97 to 3.07 t/ha. But Sasidhar and Sadanandan (1972) obtained only a nominal increase in yield with increase in N rates from zero to 120 kg/ha. Increased grain yields with increasing N rates were reported

by Sharma (1973), Mahesh Pal and Panwar (1974), Reddy and Kaliappa (1974), Sandhu et al. (1975) and Borthakur et al. (1975). Joginder Singh (1974) found that maize varieties including Histarch, Deccan and Vijay respond to N rates upto 240 kg/ha.

In a field trial at Coimbatore, Kumaraswamy et al. (1975) observed that 193 kg N/ha was the optimum rate for maize cv Deccan. Many workers like Sreenivasan et al. (1976), El-Sharkawy et al. (1976), Verma and Singh (1976) and Nathu Singh et al. (1976) reported increased yields with increasing N rates upto 120 kg/ha. Dahotonde and Rahate (1977) reported increased grain yields upto 250 kg/ha. Brar and Khebra (1977) reported highest grain yield with 150 kg N/ha for Vijay. Ekka and Sahani (1977) also reported an yield of 3.9 t/ha with 160 kg N/ha for Vijay. Raut and Ali (1977) reported an increase in grain yield upto 180 kg N/ha. Vatsa et al. (1977) also observed the highest yield with 200 kg N/ha.

But according to workers like Reddy et al. (1977) Shinde and Khuspe (1978) and Prasad (1978), maize showed yield response only upto 150 kg/ha. Workers like Al-Rudha and Al-Younis (1978), Hera et al. (1978), Tripathi (1978) and Ranjodh Singh et al. (1979) obtained yield responses only upto 120 kg N/ha.

Sharma (1978) conducted trials with N rates upto 240 kg/ha and reported that the economic optimum N rate was 145-164 kg/ha. Shalaby and Mikhail (1979) reported an increasing trend in grain yield with increasing rates of N. Sciput et al.(1979) and Elias et al.(1979) also reported increased grain yields upto 200 and 170 kg N/ha respectively.

Trials conducted by Sood et al.(1979) and Sharma et al.(1979) revealed that maize respond to fertilizer N significantly upto 180 kg N/ha. And Koraiem et al.(1979) reported an yield response upto 225 kg N/ha and diminished thereafter. Rendig and Broadbent (1979) showed that 180 kg and 360 kg N/ha were not significantly different in yield response. El-Hatteb et al.(1980) also reported an increasing yield trend upto 213 kg/ha. Halemani et al.(1980) from a 3 year study concluded that a rainfed kharif crop showed yield response only upto 150 kg N/ha. But in another 3 year study Halemani et al.(1980) obtained an increasing yield response for irrigated kharif crop upto 240 kg N/ha.

In a trial conducted with 8 maize germplasms, all showed a linear increase in yield upto 180 kg N/ha and the economic optimum for a new germplasm was 250 kg/ha (Jain and Goel (1980). Zabelyi (1980) reported an yield response upto 150 kg/ha. Increased grain yields were

also reported by Gatmanets et al.(1981) and Singh et al. (1981) upto 180 and 120 kg N/ha. Pineda et al.(1981) and Short et al.(1982) reported yield increase upto 200 kg N/ha. But Gangwar and Kalra (1981) obtained response only upto 120 kg N/ha when grown as an intercrop. Later Okajima et al.(1983) observed that maize respond significantly upto 200 kg N/ha. Farah et al.(1984) also reported an yield increase upto 321 kg N/ha.

Contrary to the above findings some workers observed negative results also. Verma and Singh (1971) reported increased yields only upto 150 kg N/ha. Further increase in the N rates decreased yield. Again Verma and Singh (1976) observed an yield reduction with rates of applied N above 120 kg /ha. Sukla and Bardwaj (1976) also reported a decreasing trend in yield with higher doses of N above 60 kg/ha. Later Singh et al.(1978) also obtained same results with N rates above 60 kg/ha.

c. Stover yield

Sasidhar and Sadanandan (1972) reported that increase in N rates significantly increased the stover yield. Kumaraswamy et al.(1975) also reported that stover yield was significantly increased by N rates. Later El-Sharkawy et al.(1976) also observed the highest stover

yield with 104 kg N/ha. Dahotonde and Rahate (1977) reported an increase in straw yield from 2.21 to 5.02 t/ha with N rates from zero to 250 kg/ha.

Similar increase in stover yield was reported by several workers like Shalaby and Mikhail (1979), El-Baisary et al. (1980) and Pineda et al. (1981) with N levels upto 200 kg, 150 kg and 120 kg N/ha respectively.

Effect of N on grain quality

Reddy and Kaliappa (1974) reported that grain protein content in maize increased with increase in applied N from nil to 150 kg/ha. Verma and Singh (1976) observed increase in grain protein content from 10.2% to 12.7% with increasing N rates from zero to 120 kg/ha. There was increase in grain crude protein content upto 140 kg N/ha (Anon 1977). Later Sadiq et al. (1977) observed an increasing trend in protein upto 200 kg N/ha. But Albinet (1978) reported increase in grain crude protein content only upto 160 kg N/ha.

Rendig and Jimenez (1978) in their experiment on nitrogen nutrition observed that the level of N supplied to the crop affects the proportions and total concentrations of various kinds of proteins. Later Rendig and

Broadbent (1979) reported that grain CP content increased from zero to 10% when applied N increased from zero or 90 kg/ha to 180 and 360 kg/ha. Mikhail and Shalaby (1979) also reported a CP content in grain with 200 kg N/ha. Gawad et al.(1980) also observed a similar increasing trend in grain protein content with increasing N application.

According to El-Hattab et al.(1980) grain CP content increased along with total carbohydrate content with increasing N levels. Yahya and Andrew (1981) and Shafshak et al. (1981) observed a similar increasing trend in protein content with higher levels of applied N. But Getmanetz et al.(1981) reported that even though increased rates of N increased the grain protein content, grain quality was found to be decreased. The reason is attributed to the increased Ze in content and decreased lysine and tryptophan contents.

Effect of N on uptake of Nutrients

The nutrient uptake was found to vary widely depending upon the fertility levels of the soil and the environmental conditions. Mahapatra and Jha (1973) reported a nutrient uptake of 150 to 250 kg N, 35-90 kg P_2O_5 and 100-200 kg K_2O/ha for a maize crop of 6000 kg grain per hectare.

Meyer (1973), Sreenivasan et al. (1976), Tripathi (1978) and Al-Rudha and Al-Younish (1978) all observed that increasing the levels of N resulted in higher percentage of plant nitrogen resulting in increased N uptake. Gangro (1978) also reported an increase in leaf content of N with increasing levels of applied N upto 200 kg/ha. Later Dass and Ranjodh Singh (1979) observed that N uptake increased upto 120 kg N/ha. Mikhail and Shalaby (1979) also reported the same trend upto 200 kg N/ha. Later Okajima et al. (1983) and Farah et al. (1984) reported increasing N uptake with increased levels of N upto 200 and 300 kg N/ha respectively.

But El-Baisary et al. (1980) and Albegov (1981) reported that increased N levels had no significant effect on N uptake.

Thien and Mc Fee (1969 and 1972) reported that the N pretreatment in maize significantly increased P absorption and translocation rates. At lower concentration of N only uptake of P was stimulated, while at higher concentrations translocation was also stimulated. They also suggested the involvement of more than one P uptake mechanisms and separate physiological influence of N on uptake and translocation. Virmani et al. (1970) in pot trials observed that

P uptake increased with increasing N rates upto 150 kg N/ha. It was reported that maize took upto 30 per cent of its requirement during the first 50 days.

Later Idris et al. (1976) reported that N, NP and NPK application increased plant P uptake at all stages of growth. Dass and Ranjodh Singh (1979) observed an increase in P and K uptake with increased N upto 120 kg/ha. Smith and Jackson (1982) also suggested that treatment with N effects the mechanism of P uptake rather than subsequent translocation, via the activation of pre-existing proteins.

Effect of N on growth analysis functions

Krishnamurthy et al. (1974) reported that increasing rates of N had a significant effect on growth analysis functions like leaf area duration, leaf area index and net assimilation rate. Elias et al. (1979) observed a positive effect on growth analysis functions by increased rates of N. Mikhail and Shalaby (1979) reported that high rates of N had a significant effect on LAI.

Later El-Hattab et al. (1980) observed that NAR at 30-40 and 45-60 days after sowing was increased with applied N rates upto 213 kg/ha. But RGR at 45-60 days was decreased with increased rates of N. LAI also decreased with increased N rates.

Varietal response to N fertilization

Sharma et al. (1969) observed that maize var. Ganga Safed-2 showed grain yield response upto 200 kg N/ha. Such varietal differences are also reported by Hati and Panda (1970), Mahesh and Panwar (1974), Sandhu et al. (1975) and Santos and Olsen (1977).

Gangro (1977) reported that varietal differences are existing in LAI with different rates of N. Krishnamurthy et al. (1977) also observed significant difference between varieties in yield components with different levels of N. Gangro (1978) reported that varietal differences are existing in leaf N content and grain protein content with different rates of N. Rao et al. (1978) from trials with 10 maize cultivars highest primary production was reported by GS-2 and the concentration of chlorophyll contents also differ with varieties. Sharma (1978) reported that hybrid cultivars are significantly superior to composites in grain yield at all levels of applied N upto 240 kg/ha. Such varietal differences are also reported by Shinde and Khuspe (1978). Sharma et al. (1979) reported that variety x N level interactions were significant in a varietal trial. Halemani et al. (1980) also observed that varieties differ in their response to N. Later Russel (1984) reported that there were highly significant differences among lines for linear yield responses to N treatments.

MATERIALS AND METHODS

MATERIALS AND METHODS

An experiment was conducted to find out the response of five maize varieties to graded levels of nitrogen grown under open and partially shaded conditions simultaneously. The materials and methods adopted for the investigation are given below.

Experimental site

The trial was conducted at the Instructional farm, College of Agriculture, Vellayani. The location lies between 8° and 29° latitudes at 76° $57'$ longitudinally at an altitude of 64.3 m above MSL.

Experiment was conducted under two situations one as intercrop in coconut garden representing partial shade condition and the other under full sunlight.

Soil

The soil of the locations were red loam and moderately acidic (pH 5.3). Data on the mechanical and chemical analysis of the soil are given below.

Table 1 a. Mechanical composition of the soil

	Open Area	Shaded Area
Gravel	2.9%	2%
Coarse sand	25.3%	14%
Fine sand	27.2%	31.2%
Silt	24.8%	28%
Clay	19.8%	24.8%

Table 1 b. Chemical composition of the soil

	Open Area	Shaded Area
Total Nitrogen	0.090%	0.067%
Available P_2O_5	44.4 kg/ha	43.1 kg/ha
Available K_2O	42.00 kg/ha	40.3 kg/ha

Climate

The weekly average minimum and maximum temperatures, relative humidity and weekly total rainfall during the cropping period were recorded from the Meteorological observatory of the farm and are presented in Fig.1. The weather data during the cropping period and for the past 25 years are also given in Appendices 1a and 1 b.

Season

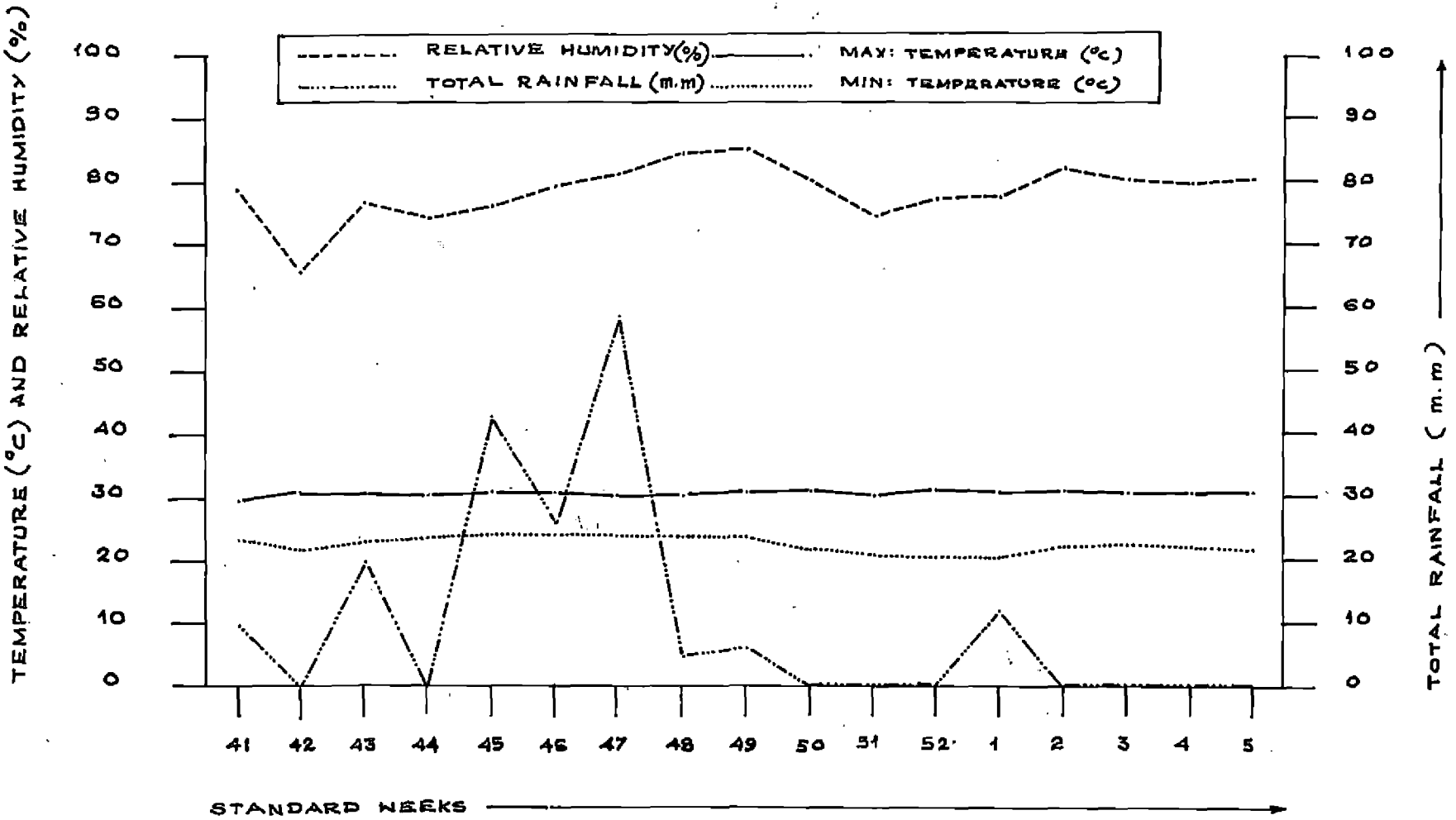
The experiment was conducted during the second crop season (September/October to December/January) of 1984-85.

The seeds were sown on 10th October 1984 simultaneously in both fields. Gap filling and thinning were done after one week. The harvest was done during the period from 10th January to 30th January 1985. The duration of varieties ranged from 90-110 days.

Cropping history

The experimental areas were kept fallow during the previous two crop seasons.

FIG. 1. WEATHER CONDITIONS DURING THE CROP PERIOD (1984-'85)
AS WEEKLY AVERAGES



M A T E R I A L S

Varieties

Five varieties including hybrids and composites have been used for the trial. The varieties used were Ageti-76, Deccan-101, Ganga safed-2, Hi-starch and Vijay.

Ageti-76 — This is a composite variety. Pedigree is JML 603/J 603 and duration is 88 days. Short plant with slightly broader dark green leaves. Grain is medium bold, sound and orange yellow coloured.

Deccan-101 — Hybrid variety. Pedigree- (CM 202 x CM 206) x (CM 115 x CM 114). Duration 105-115 days. Plant sturdy with dark green leaves. Grain bold and yellow coloured.

Ganga safed-2 — This is a widely adapted medium maturing hybrid very popular in maize growing areas. Pedigree is (CM 400 x CM 300) CM 600. Duration is 100-110 days. Grain is medium white in colour.

Hi-starch — Hybrid variety. Pedigree (CM 400 x CM 300) x CM 601. Duration is 95 days. Popular in all maize growing areas of India. Plant is tall

with broad dark green thick leaves. Grain white coloured.

Vijay — This is a composite variety. Pedigree is J_1. Duration is 100-105 days. Plant is sturdy vigorous with dark green leaves. Grain is medium yellow orange coloured.

Seeds

Quality seeds were obtained from the National Seeds Corporation, Bangalore. The seeds were tested for viability and were found to give 96% germination.

Fertilizers

Urea, superphosphate and muriate of potash analysing 46% N, 16% P_2O_5 and 60% K_2O respectively were used for the experiment.

M E T H O D S

Lay out of the experiment

The experiment was laid out in a 5 x 5 simple lattice design with two replications and 25 treatment combinations. The lay out plan of the experiment is given in Fig.2.

FIG. 2. LAY OUT PLAN. 5 x 5 SIMPLE LATTICE DESIGN

PARTIAL SHADE CONDITION

	REPLICATION -1					REPLICATION - 2				
B_1	V_3N_2	V_2N_3	V_1N_4	V_5N_0	V_4N_1	V_1N_1	V_5N_4	V_4N_3	V_1N_0	V_2N_1
B_2	V_3N_3	V_4N_2	V_5N_1	V_2N_4	V_1N_0	V_4N_0	V_1N_2	V_3N_4	V_5N_1	V_2N_3
B_3	V_2N_2	V_1N_3	V_5N_4	V_4N_0	V_3N_1	V_4N_1	V_2N_4	V_3N_0	V_1N_2	V_5N_2
B_4	V_5N_3	V_3N_0	V_2N_1	V_1N_2	V_4N_4	V_4N_4	V_1N_1	V_3N_3	V_5N_0	V_2N_2
B_5	V_2N_0	V_4N_3	V_3N_4	V_5N_2	V_3N_2	V_5N_3	V_4N_2	V_3N_1	V_2N_0	V_1N_4

OPEN CONDITION

	REPLICATION -1					REPLICATION - 2				
B_1	V_1N_0	V_2N_3	V_4N_4	V_3N_1	V_5N_2	V_4N_3	V_5N_3	V_3N_3	V_1N_3	V_2N_3
B_2	V_4N_3	V_3N_0	V_2N_2	V_5N_1	V_1N_4	V_1N_2	V_4N_2	V_5N_2	V_2N_2	V_3N_2
B_3	V_4N_2	V_1N_3	V_3N_4	V_5N_0	V_2N_1	V_1N_0	V_4N_0	V_3N_0	V_2N_0	V_5N_0
B_4	V_3N_2	V_1N_1	V_5N_3	V_2N_4	V_4N_0	V_3N_1	V_5N_1	V_4N_1	V_2N_1	V_1N_1
B_5	V_4N_1	V_3N_3	V_2N_0	V_1N_2	V_5N_4	V_2N_4	V_1N_4	V_3N_4	V_5N_4	V_4N_4

NITROGEN		VARIETIES
N_0 ---- 0 kg/ha		V_1 --- AGETI - 76
N_1 ---- 50 " "		V_2 --- DECCAN - 101
N_2 --- 100 " "		V_3 --- GANGA SAFED - 2
N_3 --- 150 " "		V_4 --- HI - STARCH
N_4 --- 200 " "		V_5 --- VIJAY

Treatments

Varieties	Levels of Nitrogen
V_1 - Ageti-76	n_0 - 0 kg/ha
V_2 - Deccan-101	n_1 - 50 kg/ha
V_3 - Ganga safed-2	n_2 -100 kg/ha
V_4 - Histarch	n_3 -150 kg/ha
V_5 - Vijay	n_4 -200 kg/ha

Design - 5 x 5 simple lattice

Replications - 2

Treatment combinations - 25

Total Number of plots

(a) Under partial shade condition) 50

(b) Under open condition) 50

Spacing - 60 cm x 30 cm

Plot size

Gross - 6 x 5.4 m^2

Net - 4.2 x 4.8 m^2

One row of plants were left out from all the four sides of each plot as border row and one row from each plot as destructive row.

Details of field cultivation

The package of practice recommendations of Kerala Agricultural University was closely observed while field culturing the experimental crop.

The fields were deeply dug and levelled before planting. The seeds were sown at 2 seeds per hill. Thinning was done 16 days after planting. One hand-weeding was given 30 days after planting. Life saving irrigation was given whenever necessary.

Application of fertilizers

Nitrogen as urea was applied according to the treatments. One third nitrogen was given as basal dose before planting, 1/3 at knee-high stage (30 days after planting) and the remaining 1/3 at the tasseling stage (60 days after planting). The entire doses of P_2O_5 and K_2O were applied as basal dose at the rate of 65 kg/ha and 15 kg/ha respectively , to all plots as per the package of practices.

Plant protection

Need based plant protection measures were undertaken as and when required.

Harvest

The crop was harvested plot-wise after a period of 90-110 days after planting. The border rows of all plots were harvested and threshed separately. The crop in each net plot was harvested and processed.

OBSERVATIONS

A. Observations on growth characters

For periodical observations 10 plants were randomly selected in each plot and the following observations were recorded.

1. Height of the plant

Height of the plant was recorded at 25 days interval and at harvest and the mean height was then worked out.

2. Number of leaves per plant

Total number of leaves of each ten plants was recorded at 25 days interval and the mean number of leaves per plant was worked out.

3. Leaf Area Index (LAI)

For calculating the LAI, the maximum length and

breadth of all leaves from each sample plant were measured. Then LAI was calculated using the following formula.

$$LAI = \frac{(L \times B) \times K}{\text{Land area occupied by the plant}}$$

Where

(L x B) = Sum of products of length and breadth of leaves in a plant.

K = The factor 0.75 (Hunt, 1978)

Then average LAI was worked out.

4 Dry matter production

The dry weight of oven dry plant samples were found out and from this dry weight/plant was computed and recorded.

B Observations on yield components and yield

1 Days to silking

Days to silking of 50 per cent of the plants from the date of seeding in each treatment was recorded and the mean was worked out.

2 Number of cobs per plant

Number of cobs of each of ten plants were recorded and mean was worked out for each treatment.

3 Length of cob

Cobs from sample plants were measured for its length from its base to the tip and mean was worked out.

4. Girth of cob

Cobs from sample plantswere measured for its girth at maximum point and the mean was worked out.

5. Weight of cob

All cobs from sample plants were weighed and weight per cob was calculated.

6. Number of grains per cob

The number of grains of cobs from the sample plants was counted and the mean was computed.

7. Thousand grain weight

Weight of 1000 grains drawn at random from each treatment was recorded and the mean was computed.

8. Grain yield

The grains harvested from each net plot were cleaned and sun dried. The weight was adjusted to 14% moisture content. The grains were then weighed and the grain yield was expressed in quintals per hectare.

9. Stover yield

Stover harvested from the net plot was uniformly sun dried, weighed and expressed in quintals per hectare.

10 Harvest index (HI)

Harvest Index was worked out from the data on grain yield and stover yield obtained for each plot using the following formula and expressed as number.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

CHEMICAL ANALYSIS

A. Plant Analysis

The chemical analysis of the plant samples drawn at 25 days interval was done. The observational plants, the grain and the stover were oven dried at $80^{\circ}C \pm 5^{\circ}C$ till a constant weight was obtained.

1. Total Nitrogen

The total nitrogen content of the plant samples was analysed employing the modified microKjeldahl digestion method (Jackson 1967).

2. Uptake of nitrogen by crop

Nitrogen content of plant samples was multiplied with their respective dry matter yield and the uptake of Nitrogen was computed in kg/ha.

3 Protein content of grain

The percentage of protein in the grain was calculated and recorded as the product of the content of nitrogen in the grain and a factor 6.25 (Simpson et al., 1965).

B. Soil Analysis

Soil samples were taken from the experimental area before and after the experiment and analysed for total nitrogen, available phosphorus and exchangeable potassium. Total nitrogen content was estimated by the modified micro-Kjeldahl method, available phosphorus by Bray's method and exchangeable potassium by ammonium acetate method (Jackson, 1967).

Statistical Analysis

Data on yield, yield attributes, growth characters, chemical analyses of plant and soil samples were statistically analysed by using the analysis of variance technique for simple lattice design (Cochran and Cox, 1967). The relationship between yield and levels of nitrogen was explained by the function

$$y = a + bN + cN^2, \quad c \quad 0$$

and the optimum dose of nitrogen was determined as

$$N \text{ opt} = \frac{-b}{2c} \text{ (Mathematical) and}$$

$$= \frac{PN/py-b}{2c} \text{ (Economical), where}$$

PN and Py are the prices of input and output per unit.

RESULTS

RESULTS

The data relating to the various biometric observations under both open and partial shade conditions were analysed statistically. The analysis of variance tables are given in the Appendices II to IX.

I. Open condition

A. Growth characters.

1. Height of plants

The data on the mean height of plants recorded during the four growth stages are presented in Table 2 and the analysis of variance in Appendix II.

It was observed that nitrogen and varieties exerted significant influence on the height of plants at all stages. Interaction between nitrogen and varieties was also significant at 75 DAS (days after sowing).

During the first stage viz. 25 DAS height of plants increased significantly upto n_4 level. Among the varieties, Histarch recorded the maximum height and Deccan-101 recorded the lowest height. Ganga safed-2 and Vijay were on par and were superior to Ageti-76.

During the second stage, viz. 50 DAS also height of plants increased significantly upto n_4 level. Among the

Table 2 Height of plants (cm)

	25 DAS						50 DAS					
	V_1	V_2	V_3	V_4	V_5	Mean	V_1	V_2	V_3	V_4	V_5	Mean
n_0	25.5	21.3	33.0	34.4	28.7	28.6	84.2	76.1	96.8	82.9	83.1	84.6
n_1	29.1	24.0	35.7	38.5	33.1	32.1	124.6	114.9	130.7	116.4	113.2	120.0
n_2	31.5	26.3	38.4	41.0	36.1	34.7	129.7	123.8	135.8	133.7	131.7	130.9
n_3	33.3	28.3	39.1	44.8	39.2	36.9	137.0	130.0	141.7	144.6	143.5	139.3
n_4	36.7	32.2	41.2	47.1	42.6	39.9	149.3	136.8	162.7	154.9	154.2	151.6
Mean	31.2	26.4	37.5	41.2	35.9		125.0	116.3	133.5	126.5	125.1	

CD (N/V) = 1.64 SE (N/V) 0.774
SE for two treatments in the same block = 1.7345
SE for two treatments not in the same block = 1.7345

CD (N/V) = 4.50 SE (N/V) = 2.62
SE for two treatments in the same block = 4.645
SE for two treatments not in the same block = 4.797

	75 DAS						Harvest					
n_0	118.0	101.9	116.5	117.2	114.5	113.6	116.2	201.4	119.8	116.2	113.9	113.5
n_1	145.2	127.1	153.4	149.6	147.9	144.6	145.3	127.4	156.6	150.2	149.4	145.8
n_2	154.7	136.9	160.8	164.0	166.7	156.6	151.3	136.2	164.9	166.5	169.3	157.6
n_3	162.1	144.0	186.6	177.4	185.5	171.1	165.8	145.6	185.9	178.9	185.4	172.3
n_4	178.9	172.9	202.2	192.8	199.0	189.1	182.1	175.0	203.3	190.9	200.1	190.3
Mean	151.8	136.5	163.9	160.2	162.7		152.1	137.1	166.1	160.5	163.1	

CD (N/V) = 3.83 CD (NV) = 8.56
SE (N/V) 1.806
SE for two treatments in the same block = 3.891
SE for two treatments not in the same block = 4.109

CD (N/V) 4.91 SE (N/V) = 2.316
SE for two treatments in the same block = 5.012
SE for two treatments not in the same block = 5.263

DAS - Days after sowing

varieties, Ganga safed-2 recorded the maximum height, Histarch, Vijay and Ageti-76 were on par and were superior to Deccan-101.

During the third stage also (75 DAS) height of plants increased significantly upto n_4 level. Among the varieties, Ganga safed-2 which recorded the maximum height was on par with Vijay which in turn was on par with Histarch. Deccan-101 recorded the minimum height. Among the combinations, n_4v_3 recorded the maximum height.

At harvest also height of plants increased significantly upto n_4 level. Among the varieties, Ganga safed-2 recorded the maximum height which was on par with Vijay which in turn on par with Histarch. Deccan-101 recorded the minimum height.

2. Number of leaves/plant

The data on the mean number of leaves/plant are given in Table-3 and the analysis of variance in Appendix-III.

It was observed that nitrogen and varieties had significant effect on the number of leaves/plant. However, interaction effect was not significant.

At 25 DAS, the highest number of leaves/plant was observed at n_4 level, n_3 and n_2 were on par which in turn

Table 3 Number of leaves/plant

25 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	4.0	3.5	4.0	4.5	4.5	4.1
n_1	4.5	4.0	5.0	5.0	5.0	4.7
n_2	5.0	4.0	5.5	5.5	5.5	5.1
n_3	5.5	4.5	6.0	5.5	5.5	5.4
n_4	6.0	5.0	7.5	7.5	6.0	6.4
Mean	5.0	4.2	5.6	5.6	5.3	

CD (N/v) = 0.63 SE (N/v) = 0.297

SE for two treatments in the same block = 0.665
SE for two treatments not in the same block = 0.665

50 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	6.5	6.0	8.0	7.0	7.0	6.9
n_1	8.0	8.0	9.0	9.5	7.5	8.4
n_2	8.0	9.0	10.0	9.5	9.5	9.2
n_3	9.5	9.5	10.5	10.5	10.5	10.1
n_4	10.0	10.0	11.0	10.5	10.0	10.3
Mean	8.4	8.5	9.7	9.4	8.9	

CD (N/v) = 0.85 SE (N/v) = 0.401

SE for two treatments in the same block = 0.899
SE for two treatments not in the same block = 0.899

75 DAS

n_0	7.0	6.5	8.5	7.5	6.5	7.2
n_1	8.5	8.0	9.5	10.0	7.5	8.7
n_2	9.0	10.0	10.0	10.0	10.0	9.8
n_3	9.0	10.0	10.5	11.0	10.5	10.2
n_4	9.5	10.5	11.5	11.5	11.5	10.9
Mean	8.6	9.0	10.0	10.0	9.2	

CD (N/v) = 0.79 SE (N/v) = 0.373

SE for two treatments in the same block = 0.837
SE for two treatments not in the same block = 0.837

on par with n_1. There was significant difference between control and n_2 and n_3 levels. Among the varieties, Ganga Safed-2 recorded the maximum number of leaves/plant which was on par with Histarch, Vijay and Ageti-76. Deccan-101 recorded the lowest number of leaves/plant.

At 50 DAS, n_4 and n_3 levels were on par and n_2 and n_1 levels were also on par. There was significant difference between treatments and control. Among the varieties, Ganga safed-2 recorded the maximum number of leaves/plant which was on par with Histarch and Vijay which in turn on par with Deccan-101 and Ageti-76.

At 75 DAS, maximum number of leaves/plant was recorded at n_4 level which was on par with n_3 which in turn on par with n_2. Among the varieties, Ganga safed-2 recorded the maximum number of leaves/plant which was on par with Histarch. Vijay, Deccan-101 and Ageti-76 were also on par.

3. Leaf area index (LAI)

The data on mean LAI are presented in Table-4 and the analysis of variance in Appendix IV.

The data revealed that nitrogen and varieties had significant influence on LAI. But interaction effect was not significant.

Table 4 Leaf Area Index

25 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	0.10	0.09	0.10	0.11	0.11	0.10
n_1	0.11	0.10	0.12	0.13	0.12	0.12
n_2	0.12	0.11	0.14	0.14	0.14	0.13
n_3	0.14	0.12	0.15	0.14	0.14	0.14
n_4	0.15	0.14	0.18	0.18	0.15	0.16
Mean	0.12	0.11	0.14	0.14	0.13	

CD (N/V) 0.011 SE (N/V) = 0.00519
SE for two treatments in the same block = 0.112
SE for two treatments not in the same block = 0.112

50 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	1.50	1.40	1.82	1.64	1.54	1.58
n_1	1.83	1.85	2.02	2.12	1.67	1.90
n_2	1.95	2.04	2.27	2.18	2.13	2.11
n_3	2.14	2.15	2.41	2.38	2.41	2.29
n_4	2.28	2.30	2.58	2.40	2.31	2.37
Mean	1.94	1.95	2.22	2.14	2.01	

CD (N/V) = 0.15 SE (N/V) = 0.071
SE for two treatments in the same block = 0.156
SE for two treatments not in the same block = 0.156

75 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	1.66	1.55	1.96	1.74	1.60	1.70
n_1	1.98	1.89	2.19	2.30	1.84	2.04
n_2	2.09	2.30	2.35	2.37	2.28	2.28
n_3	2.30	2.34	2.51	2.49	2.55	2.44
n_4	2.33	2.44	2.66	2.65	2.63	2.54
Mean	2.07	2.10	2.33	2.31	2.18	

CD (N/V) = 0.123 SE (N/V) = 0.058
SE for two treatments in the same block = 0.130
SE for two treatments not in the same block = 0.130

During the first stage, LAI increased with increasing level of nitrogen, although n_3 and n_2 were on par which in turn on par with n_1. Among the varieties, Histarch recorded the maximum leaf area index which was on par with Ganga safed-2 and Vijay which in turn on par with Ageti-76. Deccan-101 recorded the lowest LAI.

At 50 DAS also, LAI increased with increase in level of nitrogen although n_3 and n_4 were on par. Among the varieties, Ganga safed-2 recorded the maximum LAI which was on par with Histarch which in turn on par with Vijay. Deccan-101 and Ageti-76 were also on par with Vijay.

At 75 DAS also, LAI increased with increase in levels of nitrogen although n_3 and n_4 were on par. Among the varieties, Ganga safed-2 recorded the maximum LAI which was on par with Histarch which in turn on par with Vijay.

4. Dry weight / plant

The data regarding the mean dry weight/plant are given in Table 5 and the analysis of variance in Appendix V.

The effect of nitrogen and varieties on dry weight/ plant was significant at all the four growth stages. Interaction was significant only during second and fourth stages.

Table 5 Dry weight/plant (g)

	25 DAS						50 DAS					
	V_1	V_2	V_3	V_4	V_5	Mean	V_1	V_2	V_3	V_4	V_5	Mean
n_0	1.8	2.4	1.9	2.3	3.0	2.2	23.8	24.3	28.1	28.6	27.6	26.5
n_1	2.4	2.9	3.1	3.8	4.2	3.3	30.3	24.3	31.1	29.5	35.0	30.0
n_2	3.1	3.8	4.8	4.2	5.5	4.3	26.5	28.0	40.5	36.7	37.2	33.8
n_3	3.8	4.2	5.5	5.6	6.0	5.0	33.8	29.8	52.6	48.0	38.5	40.5
n_4	4.2	4.5	6.1	6.0	6.4	5.4	42.9	35.4	56.7	59.6	45.1	47.9
Mean	3.0	3.5	4.3	4.3	5.0		31.5	28.3	41.8	40.5	36.7	

CD (N/V) = 0.44 SE (N/V) = 0.208
SE for two treatments in the same block = 0.465
SE for two treatments not in the same block = 0.465

CD (N/V) = 2.57 CD (NV) = 5.74
SE (N/V) = 1.212
SE for two treatments in the same block = 2.6114
SE for two treatments not in the same block = 2.759

	75 DAS						Harvest					
n_0	44.3	40.2	45.9	41.9	41.5	42.7	108.3	97.0	108.9	114.0	123.5	110.3
n_1	55.9	49.8	55.6	54.0	52.3	53.5	135.6	121.3	134.5	141.0	147.6	135.9
n_2	65.2	64.0	60.4	59.4	59.4	61.6	188.4	167.1	167.8	177.0	187.2	177.5
n_3	76.8	75.0	68.3	68.6	70.0	71.7	215.5	186.5	192.0	194.4	200.8	197.8
n_4	85.0	76.5	77.6	76.4	84.8	80.0	225.2	205.8	221.3	223.1	240.5	223.2
Mean	65.4	61.1	61.5	60.0	61.6		174.6	155.5	164.9	169.9	179.9	

CD (N/V) = 2.97 SE(N/V) = 1.401
SE for two treatments in the same block = 3.128
SE for two treatments not in the same block = 3.128

CD (N/V) = 3.15 CD (NV) = 7.06
SE(N/V) = 1.486
SE for two treatments in the same block = 3.33
SE for two treatments not in the same block = 3.33

During the first stage, the maximum dry weight/plant was recorded at n_4 level which was on par with n_3 level. Among the varieties, Vijay recorded the maximum dry weight/plant. Ageti-76 recorded the lowest dry weight.

At 50 DAS also, dry weight/plant increased significantly with increase in nitrogen levels. Variety Ganga safed-2 recorded the highest dry weight/plant which was on par with Histarch. Deccan-101 recorded the lowest dry weight/plant. Among the combinations, n_4v_4 recorded the maximum dry weight which was on par with n_4v_3.

During third stage also dry weight/plant increased significantly with increase in nitrogen levels. Among the varieties, Ageti-76 recorded the maximum dry weight/plant. All other varieties were on par in this respect.

At harvest also nitrogen levels increased significantly the dry weight/plant upto n_4 level. Among the varieties, Vijay recorded the maximum dry weight/plant and Deccan-101 recorded the lowest dry weight. Among the combinations, n_4v_5 recorded the maximum dry weight/plant.

B. Yield Attributes and Yield.

1.Number of cobs/plant

The data regarding mean number of cobs/plant are given in Table 6 and the analysis of variance in Appendix VI.

It was seen that the effects of nitrogen and varieties on the number of cobs/plant were significant. Interaction was also found to be significant.

The data revealed that number of cobs increased with increase in nitrogen levels upto n_4 level although n_2 and n_3 were on par. Among the varieties, Ganga safed-2 recorded the maximum number of cobs/plant which was on par with Vijay. Deccan-101 recorded the lowest number of cobs/plant which was on par with Ageti-76 and Histarch. Among the combinations, n_4v_3 recorded the maximum number of cobs/plant.

2.Length, girth and weight of cobs

The data on the mean length, girth and weight of cobs are presented in Table 7a, b and c. and the analysis of variance in Appendix VI.

It was observed that the effects of nitrogen and varieties were significant on length, girth and weight of cobs. However, the interactions were not significant for any of these characters.

Table 6 Number of cobs/plant

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	1.00	1.80	1.00	0.99	1.00	1.00
n_1	1.00	1.10	1.10	1.05	1.11	1.07
n_2	1.10	1.15	1.18	1.12	1.13	1.13
n_3	1.16	1.05	1.21	1.15	1.21	1.16
n_4	1.20	1.10	1.25	1.19	1.20	1.19
Mean	1.09	1.08	1.15	1.10	1.13	

CD (N/V) = 0.022 CD (NV) = 0.050

SE (N/V) = 0.010

SE for two treatments in the same block = 0.0228

SE for two treatments not in the same block = 0.0236

Table 7a Length of cobs (cm)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	10.51	8.48	12.14	10.42	10.07	10.32
n_1	12.11	11.38	12.50	10.92	11.57	11.70
n_2	12.77	12.69	13.51	12.68	13.46	13.02
n_3	14.01	13.23	15.75	15.42	14.57	14.60
n_4	14.52	13.49	16.51	15.93	15.83	15.26
Mean	12.79	11.85	14.08	13.08	13.10	

CD (N/V) = 0.632 SE (N/V) = 0.298

SE for two treatments in the same block = 0.659

SE for two treatments not in the same block = 0.670

Table 7b Girth of cobs (cm)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	9.00	8.50	10.25	10.25	9.00	9.40
n_1	10.50	9.50	11.25	11.25	10.50	10.60
n_2	10.25	10.00	12.00	12.25	11.25	11.15
n_3	12.00	10.50	13.25	13.00	12.25	12.20
n_4	12.50	11.50	13.50	13.30	13.10	12.78
Mean	10.85	10.00	12.05	12.01	11.22	

CD (N/V) = 0.582 SE (N/V) = 0.274

SE for two treatments in the same block = 0.61

SE for two treatments not in the same block = 0.61

Table 7c Weight of cobs (g)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	75.5	68.5	75.2	73.0	69.5	72.3
n_1	85.7	74.5	90.0	87.4	89.5	85.4
n_2	114.0	103.4	113.9	102.9	110.5	108.9
n_3	157.0	141.5	172.0	169.5	166.7	161.3
n_4	161.1	143.9	177.2	173.8	168.8	164.9
Mean	118.7	106.4	125.7	121.3	121.0	

CD (N/V) = 5.52 SE (N/V) = 2.60

SE for two treatments in the same block = 5.83

SE for two treatments not in the same block = 5.83

It was seen that the nitrogen levels increased significantly the cob length upto n_4 level. Among the varieties, Ganga safed-2 recorded the maximum cob length. Vijay, Histarch and Ageti-76 were on par and were superior to Deccan-101.

Girth of cobs also increased with increase in nitrogen levels although n_1 and n_2, and n_3 and n_4 levels were on par. Among the varieties, Ganga safed-2 recorded the maximum girth of cobs which was on par with Histarch. Deccan-101 recorded the lowest girth of cobs.

Weight of cobs also increased significantly with nitrogen levels upto n_4 which was on par with n_3. Among the varieties, Ganga safed-2 recorded the maximum cob weight which was on par with Histarch and Vijay. Deccan-101 recorded the lowest cob weight.

3. Number of grains/cob

The data on the mean number of grains per cob are presented in Table 8 and the analysis of variance in Appendix VI.

It was seen that nitrogen and varieties had significant effect on the number of grains/cob. Interaction effect was also significant.

Table 8 Number of grains/cob

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	202.5	179.6	187.8	156.0	196.8	184.6
n_1	209.6	201.7	204.7	216.6	245.4	215.6
n_2	295.7	266.0	274.4	299.5	302.4	287.6
n_3	334.8	330.5	342.9	324.3	329.2	332.3
n_4	343.2	336.9	354.2	353.0	345.0	346.5
Mean	277.2	262.9	272.8	269.9	283.8	

CD (N/V) = 12.13 CD (NV) = 27.13

SE (N/V) = 5.72

SE for two treatments in the same block = 12.38

SE for two treatments not in the same block= 13.00

Number of grains/cob was significantly increased with increase in nitrogen levels upto n_4 level. Among the varieties, Vijay recorded the maximum number of grains/cob which was on par with Ageti-76 and Histarch. Deccan 101 had the lowest number of grains/cob. Among the combinations, n_4v_3 recorded the maximum number of grains/cob.

4. Thousand grain weight

The data on mean thousand grain weight are presented in Table 9 and the analysis of variance in Appendix VII.

There was significant effect of nitrogen and varieties on thousand grain weight. However, interaction between nitrogen and varieties was not significant.

The highest level of nitrogen (n_4) recorded the maximum thousand grain weight which was on par with n_3. Among the varieties, Ganga safed-2 recorded the highest thousand grain weight which was on par with Histarch. Deccan-101 recorded the lowest value which was on par with Vijay and Ageti-76.

5. Days to silking

The data on mean number of days to silking are presented in Table 10 and the analysis of variance in Appendix VII.

Table 9 Thousand grain weight (g)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	67.5	63.5	72.0	67.0	66.5	67.3
n_1	101.0	95.0	96.8	96.5	99.0	97.7
n_2	115.0	122.0	130.5	132.0	121.5	124.2
n_3	172.0	165.5	181.5	179.0	168.5	173.3
n_4	174.8	170.7	185.0	182.0	176.5	177.8
Mean	126.1	123.3	133.2	131.3	126.4	

CD (N/V) = 4.91 SE (N/V) = 2.32

SE for two treatments in the same block = 5.176

SE for two treatments not in the same block = 5.179

Table 10 Days to silking

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	73.1	68.6	74.3	72.9	70.0	71.8
n_1	69.7	64.2	71.4	68.5	67.6	68.3
n_2	65.0	60.5	68.2	64.3	65.4	64.7
n_3	62.4	57.8	64.0	61.6	61.7	61.5
n_4	61.0	56.0	61.7	60.8	60.9	60.1
Mean	66.2	61.4	67.9	65.6	65.1	

CD (N/V) = 1.274 SE (N/V) = 0.60

SE for two treatments in the same block = 1.28
SE for two treatments not in the same block = 1.37

The data revealed that there was significant effect of nitrogen and varieties on the number of days to silking. However, interaction was not significant.

Increasing levels of nitrogen significantly decreased the number of days to silking. Among the varieties Ganga safed-2 has taken the maximum number of days to silking and Deccon - 101, the minimum.

6. Grain yield

The data on mean grain yield are presented in Table 11 and the analysis of variance in Appendix VII.

The data revealed that there was significant effect of nitrogen and varieties on the grain yield. However, the interaction was not significant.

Grain yield increased with increase in nitrogen levels although n_3 and n_4 were on par and n_1 and n_2 were also on par. But there was significant difference between control and treatments. Among the varieties, Ganga safed-2 recorded the highest yield which was on par with other varieties.

7. Stover yield

The data on mean stover yield are presented in Table 12 and the analysis of variance in Appendix VII.

Table 11 Grain yield (Q/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	2.82	1.87	4.07	3.89	3.67	3.26
n_1	10.42	8.85	11.55	11.06	10.81	10.54
n_2	13.62	11.71	15.34	14.66	14.10	13.89
n_3	19.71	18.19	22.38	21.67	21.61	20.71
n_4	21.09	19.87	24.62	24.12	23.96	22.73
Mean	13.53	12.10	15.59	15.08	14.83	

CD (N/V) = 3.496 SE (N/V) = 1.65

SE for two treatments in the same block = 3.58
SE for two treatments not in the same block= 3.74

Table 12 Stover yield (Q/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	10.11	9.41	9.82	9.74	12.91	10.40
n_1	25.91	23.31	24.57	24.01	28.61	25.29
n_2	32.47	28.88	31.14	31.17	35.02	31.74
n_3	44.58	42.18	44.25	45.13	51.28	45.49
n_4	48.22	45.82	46.08	47.07	52.87	48.01
Mean	32.26	29.92	31.17	31.42	36.14	

CD (N/V) = 1.394 SE (N/V) = 0.658

SE for two treatments in the same block = 1.414

SE for two treatments not in the same block = 1.497

In the case of stover yield also there was significant effect of nitrogen and varieties. However, interaction was not significant.

The data revealed that stover yield increased with increase in nitrogen level upto n_4. Among the varieties, Vijay recorded the maximum stover yield. Ageti-76, Histarch and Ganga safed-2 were not only on par among themselves but were on par with Deccan-101 also.

8. Harvest index (HI)

The data on mean harvest indices are presented in Table 13 and the analysis of variance in Appendix VII.

Nitrogen and varieties had significant effect on harvest index also. Interaction was also significant.

It was observed that HI increased with increase in levels of nitrogen although n_3 and n_4 were on par. Nitrogen levels n_2 and n_1 were also on par. Among the varieties, Ganga safed-2 recorded the maximum HI. Vijay had the lowest HI. Among the combinations, n_3v_3 recorded the maximum harvest index.

Table 13 Harvest index

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	0.245	0.214	0.267	0.256	0.196	0.236
n_1	0.307	0.305	0.316	0.314	0.274	0.303
n_2	0.314	0.310	0.331	0.325	0.285	0.310
n_3	0.325	0.325	0.347	0.335	0.305	0.328
n_4	0.318	0.319	0.341	0.334	0.304	0.323

CD (N/V) = 0.0075 CD (NV) = 0.017

SE (N/V) = 0.0035

SE for two treatments in the same block = 0.008

SE for two treatments not in the same block = 0.0081

C. Quality Aspects.

Protein content of grains

The data on mean protein content of grains are presented in Table 14 and the analysis of variance in Appendix VII.

It was seen that nitrogen and varieties exerted significant influence on the grain protein content. But the interaction effect was not significant.

The highest level of nitrogen resulted in maximum protein content. Among the varieties, Ageti-76 recorded the maximum protein content of grains and Deccan recorded the lowest protein content.

D. Uptake of Nutrients.

Uptake of nitrogen

The data on mean nitrogen uptake by plants are presented in Table 15 and the analysis of variance in Appendix VIII.

The data revealed that nitrogen and varieties exerted significant influence on the uptake of nitrogen at all stages of growth. Interaction was significant at first two stages only.

Table 14 Protein content of grains (%)

	n_1	n_2	n_3	n_4	n_5	Mean
n_0	9.82	8.83	9.72	9.45	9.14	9.39
n_1	11.05	9.52	10.83	10.33	9.68	10.28
n_2	11.92	11.04	11.80	11.27	11.02	11.41
n_3	12.97	11.67	12.46	12.58	12.41	12.42
n_4	13.61	12.32	12.92	13.04	12.51	12.90
Mean	11.87	10.68	11.54	11.33	10.95	

CD (N/V) = 0.216

SE (N/V) = 0.102

SE for two treatments in the same block = 0.218

SE for two treatments not in the same block=0.232

Table 15 Uptake of Nitrogen (kg/ha)

25 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	2.2	2.9	2.3	2.8	3.5	2.7
n_1	3.8	4.5	4.8	6.0	6.7	5.1
n_2	5.7	6.3	8.1	7.3	10.1	7.5
n_3	7.4	7.9	10.3	10.7	11.9	9.6
n_4	8.7	8.8	12.4	12.3	13.3	11.1
Mean	5.6	6.1	7.6	7.8	9.1	

CD (N/V) = 0.72 CD (NV) = 1.60
SE (N/V) = 0.339

SE for two treatments in the same block = 0.757
SE for two treatments not in the same block = 0.757

50 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	27.2	28.7	30.9	34.3	30.8	30.4
n_1	37.6	33.3	38.6	39.6	44.9	38.8
n_2	37.9	39.3	53.1	55.7	53.2	47.9
n_3	49.6	42.5	73.7	76.7	59.9	60.5
n_4	67.7	53.9	85.9	97.5	72.7	
Mean	44.0	39.6	56.5	60.7	52.3	

CD (N/V) = 3.47 CD (NV) 7.77
SE (N/V) = 1.64

SE for two treatments in the same block = 3.526
SE for two treatments not in the same block = 3.730

75 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	45.4	42.2	44.6	42.7	41.7	47.3
n_1	71.3	57.5	60.0	60.0	72.3	64.2
n_2	79.7	78.1	68.6	74.5	69.6	74.1
n_3	107.1	99.8	90.2	95.3	94.6	97.4
n_4	127.0	114.6	111.8	115.2	122.9	118.3
Mean	86.1	78.4	75.0	77.5	80.2	

CD (N/V) = 6.39 SE (N/V) = 3.014
SE for two treatments in the same block = 6.739
SE for two treatments not in the same block = 6.739

Harvest

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	42.6	33.4	46.0	49.7	52.8	44.9
n_1	58.0	46.8	67.9	73.6	71.4	63.6
n_2	95.3	78.4	94.1	107.2	102.9	95.6
n_3	130.9	113.4	120.0	127.5	125.5	121.3
n_4	142.0	125.8	140.2	148.1	156.9	142.6
Mean	91.7	79.3	93.6	101.2	101.9	

CD (N/V) = 4.64 SE (N/V) = 2.189
SE for two treatments in the same block =4.897
SE for two treatments not in the same block=4.897

At 25 DAS nitrogen uptake increased with increase in levels of nitrogen. Among the varieties, Vijay had the highest nitrogen uptake and Ageti-76 recorded the minimum uptake. Among the combinations n_4v_5 recorded the maximum uptake.

At 50 DAS also, n_4 recorded the maximum nitrogen uptake. Among the varieties, Histarch recorded the highest nitrogen uptake and Deccan 101 the lowest. Among the combinations, n_4v_4 recorded the maximum uptake.

During the third stage, nitrogen uptake increased with increase in levels of nitrogen. Among the varieties, Ageti-76 recorded the maximum uptake which was on par with Vijay.

At harvest also, the maximum nitrogen uptake was recorded at n_4 level. Among the varieties, Vijay recorded the highest nitrogen uptake which was on par with Histarch.

E. Nutrient Status of the soil.

1. Total nitrogen content of the soil

The data on mean total nitrogen content of the soil are presented in Table 16 and the analysis of variance in Appendix IX.

The data revealed that nitrogen and varieties had significant effect on soil nitrogen content. Interaction was also significant.

Table 16 Total nitrogen content of the soil (%)

	v_1	v_2	v_3	v_4	v_5	Mean
n_0	0.061	0.031	0.030	0.030	0.030	0.036
n_1	0.060	0.061	0.031	0.031	0.033	0.043
n_2	0.075	0.062	0.105	0.060	0.035	0.067
n_3	0.091	0.091	0.061	0.076	0.047	0.073
n_4	0.091	0.030	0.061	0.061	0.120	0.072
Mean	0.075	0.055	0.057	0.051	0.053	

CD (N/V) = 0.0126 CD (NV) = 0.0281

SE (N/V) = 0.0102

SE for two treatments in the same block = 0.013

SE for two treatments not in the same block= 0.013

Soil nitrogen content increased upto n_3 level and thereafter it decreased. Among the varieties, Histarch extracted maximum nitrogen from soil.

2. Available phosphorus content of the soil

The data on mean available soil phosphorus content are presented in Table 17 and the analysis of variance in Appendix IX.

It was observed that nitrogen and varieties did not influence the soil phosphorus content. Interaction effect was also not significant.

3. Exchangeable potassium content of the soil

The data on mean exchangeable potassium content of soil are presented in Table 18 and the analysis of variance in Appendix IX.

It was observed that nitrogen had no significant effect on soil potassium content. But varieties had significant effect. Interaction also was not significant.

Among the varieties, Histarch extracted maximum potassium from the soil.

Table 17 Available phosphorus content of the soil (kg/ha)

	v_1	v_2	v_3	v_4	v_5	Mean
n_0	42.5	43.1	43.0	42.0	42.9	42.7
n_1	41.4	41.5	41.9	41.9	43.2	41.9
n_2	43.0	43.0	42.5	42.5	43.2	42.8
n_3	42.4	42.1	42.5	42.5	41.8	42.3
n_4	42.7	43.4	42.6	41.5	41.3	42.3
Mean	42.4	42.6	42.5	42.1	42.5	

SE for two treatments in the same block = 1.21
SE for two treatments not in the same block = 1.21

Table 18 Exchangeable potassium content of the soil (kg/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	39.7	39.6	38.2	40.1	40.4	39.6
n_1	40.1	38.5	39.2	38.3	41.6	39.5
n_2	41.1	40.6	40.8	39.3	40.3	40.4
n_3	40.5	40.1	40.3	38.4	40.2	39.9
n_4	40.4	40.6	40.3	38.1	41.2	40.1
Mean	40.3	39.9	39.8	38.9	40.8	

CD (V) = 1.19 SE (V) = 0.56

SE for two treatments in the same block = 1.21

SE for two treatments not in the same block = 1.28

II Partial Shade Condition

A. Growth Characters.

1. Height of plants

The data on the mean height of plants taken at four growth stages are presented in Table 19 and the analysis of variance in Appendix II.

It was observed that nitrogen and varieties exerted significant influence on the height of plants at all stages. Interaction was also significant at 75 DAS.

During the first stage, ie 25 DAS, height of plants increased significantly upto n_3 level and then declined. But n_3 was statistically on par with n_2 which in turn on par with n_1. Among the varieties, Ganga safed-2 was found to be superior to other varieties but was on par with Ageti-76 which in turn on par with Histarch and Vijay.

During the second stage, ie 50 DAS, the height of plants increased significantly with increase in levels of nitrogen upto n_4 level. Among the varieties, Vijay had the maximum height which was on par with Histarch and Ganga safed-2. Deccan 101 recorded the lowest height.

During the third stage also height increased with increasing levels of nitrogen and attained a maximum value

Table 19 Height of plants (cm)

	25 DAS						50 DAS					
	V_1	V_2	V_3	V_4	V_5	Mean	V_1	V_2	V_3	V_4	V_5	Mean
n_0	56.2	42.9	53.5	46.0	42.3	48.2	116.2	108.9	113.7	114.3	121.5	114.9
n_1	64.1	50.6	68.3	56.9	53.4	58.7	138.6	135.5	153.4	161.0	159.7	149.6
n_2	70.0	53.1	73.3	60.9	60.2	63.5	166.4	162.9	182.9	187.0	180.7	176.0
n_3	72.5	53.9	75.4	65.6	68.8	67.2	188.7	185.2	201.0	203.8	201.3	196.0
n_4	35.6	53.0	45.4	43.9	44.0	44.4	210.7	198.6	227.3	214.1	226.0	215.3
Mean	59.7	50.7	63.2	54.7	53.7		164.1	158.2	175.7	176.0	177.8	

CD (N/V) = 7.86 SE (N/V) = 3.71

SE for two treatments in the same block = 7.95
SE for two treatments not in the same block = 8.46

CD (N/V) = 5.57 SE (N/V) 2.63

SE for two treatments in the same block =5.874
SE for two treatments not in the same block =5.874

	75 DAS						Harvest					
n_0	130.6	138.5	143.3	139.2	133.0	137.0	131.7	138.0	141.9	138.9	134.4	137.0
n_1	187.4	175.8	191.3	192.4	188.0	187.0	185.9	175.0	190.2	192.3	187.8	186.3
n_2	201.7	192.4	205.2	217.8	204.2	204.3	203.1	189.7	202.3	217.9	251.5	212.9
n_3	216.0	200.6	236.4	234.3	233.8	224.2	215.9	202.2	226.3	235.1	233.8	222.7
n_4	233.4	214.9	248.4	245.3	248.7	238.1	232.9	216.5	249.1	242.7	246.6	237.5
Mean	193.8	184.4	204.9	205.8	201.5		193.9	184.3	202.0	205.4	210.8	

CD (N/V) = 3.63 CD (NV) = 8.11 CD (N/V) = 11.834 SE (N/V) = 5.58
SE (N/V) = 1.71

SE for two treatments in the same block = 3.732
SE for two treatments not in the same block= 3.873

SE for two treatments in the same block = 12.345
SE for two treatments not in the same block = 12.551

with the highest level of nitrogen. Among the varieties, Histarch attained the maximum height which was on par with Ganga safed-2. At this stage also Deccan 101 recorded the lowest height and all others were superior to it. Interactions were also significant. n_4v_5 and n_4v_3 combinations were superior to other combinations although they were on par.

At the fourth stage, ie. at harvest, height of plants increased with increasing nitrogen levels although n_2 and n_3 were on par. Among the varieties, Vijay had the maximum height which was on par with Histarch and Ganga safed-2 . Ageti-76 and Deccan-101 were also on par.

2. Number of leaves/plant

The data on the mean number of leaves/plant are given in Table 20 and the analysis of variance in Appendix III

It was observed that nitrogen and varieties had significant effect on number of leaves, but interaction was not significant.

At 25 DAS increase in number of leaves was noticed only between n_o and n_3 levels and thereafter n_3 was on par with n_4. Among the varieties, Ganga safed-2 was superior to other varieties but was on par with Histarch and Ageti-76.

Table 20 Number of leaves/plant

	25DAS						50 DAS					
	V_1	V_2	V_3	V_4	V_5	Mean	V_1	V_2	V_3	V_4	V_5	Mean
n_0	5.5	4.5	5.5	5.5	5.0	5.2	8.5	8.0	8.5	9.0	7.5	8.3
n_1	5.5	4.0	6.0	6.0	5.5	5.4	10.0	9.0	10.0	10.0	9.5	9.6
n_2	6.0	5.0	6.0	6.0	5.5	5.7	11.0	10.0	11.5	10.5	10.0	10.6
n_3	6.5	5.5	6.5	6.5	6.0	6.2	12.0	10.5	12.0	11.5	10.0	11.2
n_4	7.0	6.0	7.5	6.5	6.5	6.7	12.5	11.0	12.5	12.0	11.5	11.9
Mean	6.1	5.0	6.3	6.1	5.7		10.8	9.7	10.9	10.6	9.7	

CD (N/V) = 0.54 SE (N/V) = 0.255
SE for two treatments in the same block =0.57
SE for two treatments not in the same block =0.57

CD (N/V) = 0.95 SE (N/V) = 0.448
SE for two treatments in the same block = 1.004
SE for two treatments not in the same block = 1.004

	75 DAS					
n_0	9.5	8.2	8.6	9.3	8.6	8.8
n_1	10.5	9.6	10.5	10.7	10.1	10.3
n_2	10.4	10.5	11.5	11.1	10.5	10.8
n_3	12.3	11.0	11.9	11.5	10.9	11.5
n_4	12.7	11.4	12.8	12.5	11.8	12.2
Mean	11.1	10.1	11.0	11.0	10.4	

CD (N/V) = 0.58 SE (N/V) = 0.274
SE for two treatments in the same block =0.591
SE for two treatments not in the same block = 0.616

At 50 DAS also, number of leaves increased with increase in levels of nitrogen although n_2 and n_3 levels and n_3 and n_4 levels were on par. Among the varieties, Ganga safed-2 was superior to other varieties but was on par with Ageti-76 and Histarch. Deccan had the lowest number of leaves.

During the third stage also number of leaves increased with increase in levels of nitrogen although n_1 and n_2 were on par. Among the varieties, Ageti-76 had the maximum number of leaves which was on par with Ganga safed-2 and Histarch.

3. Leaf Area Index (LAI)

The data on mean LAI are presented in Table 21 and the analysis of variance in AppendixIV

Statistical analysis of the data revealed that nitrogen and varieties had significant effect on LAI. However, interaction was not significant.

During the first stage, LAI increased with increase in levels of nitrogen. Although n_1 and n_2 were on par, n_4 produced the highest LAI. Among the varieties, Histarch had the highest LAI which was on par with Vijay, Ganga safed-2 and Ageti-76. Deccan had the lowest LAI.

Table 21 Leaf Area Index

	25 DAS						50 DAS					
	V_1	V_2	V_3	V_4	V_5	Mean	V_1	V_2	V_3	V_4	V_5	Mean
n_0	0.23	0.19	0.21	0.24	0.23	0.22	2.46	2.31	2.53	2.75	2.32	2.47
n_1	0.23	0.20	0.24	0.26	0.25	0.24	2.90	2.64	3.01	2.93	2.73	2.84
n_2	0.22	0.21	0.24	0.26	0.25	0.24	3.22	2.94	3.41	3.07	2.91	3.11
n_3	0.28	0.23	0.27	0.27	0.27	0.26	3.27	3.00	3.62	3.18	2.96	3.26
n_4	0.30	0.25	0.31	0.29	0.29	0.29	3.71	3.23	3.90	3.88	3.39	3.62
Mean	0.25	0.22	0.26	0.26	0.26		3.17	2.82	3.29	3.16	2.86	

CD (N/V) = 0.016 SE (N/V) = 0.00755

SE for two treatments in the same block = 0.0165

SE for two treatments not in the same block = 0.0165

CD (N/V) = 0.263 SE (N/V) = 0.124

SE for two treatments in the same block = 0.277

SE for two treatments not in the same block = 0.277

	75 DAS					
n_0	2.73	2.50	2.75	2.97	2.44	2.68
n_1	3.06	2.74	3.13	3.08	2.85	2.97
n_2	3.26	3.13	3.54	3.24	3.17	3.27
n_3	3.62	3.20	3.83	3.34	3.12	3.46
n_4	3.81	3.56	3.96	3.94	3.54	3.76
Mean	3.30	3.02	3.44	3.31	3.06	

CD (N/V) = 0.232 SE (N/V) = 0.109

SE for two treatments in the same block = 0.244

SE for two treatments not in the same block = 0.244

During the second stage also, LAI increased with increase in levels of nitrogen. But n_3 was on par with n_2 which in turn on par with n_1. n_4 recorded the maximum LAI. Varieties also differed significantly in the case of LAI. Ganga safed-2 had the highest LAI which was on par with Ageti-76 and Histarch. Deccan-101 had the lowest LAI which was on par with Vijay.

During the third stage also, n_4 produced the highest LAI which was superior to all other levels. n_3 and n_2 were on par which were superior to n_1 and n_0. Among the varieties, Ganga safed-2 had the highest LAI which was on par with Histarch and Ageti-76. Deccan-101 had the lowest LAI which was on par with Vijay.

4. Dry weight/plant

Observations recorded at four stages of growth have been analysed and the data are presented in Table 22 and the analysis of variance in Appendix V.

It was seen that nitrogen and varieties had significant effect on plant dry weight. Interaction was also effective during second, third and fourth stages.

During the first stage, dry weight increased with increase in nitrogen levels. Among the varieties, Vijay produced the maximum dry weight while Deccan was the lowest in this respect.

Table 22 Dry weight/plant (g)

25 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	3.7	2.4	3.9	3.9	4.6	3.7
n_1	4.6	2.8	4.4	4.5	5.1	4.3
n_2	5.0	3.2	5.6	5.3	6.0	5.0
n_3	5.7	4.8	6.7	6.0	6.6	5.9
n_4	7.1	5.9	7.1	7.0	7.1	6.9
Mean	5.2	3.8	5.6	5.3	5.9	

CD (N/V) = 0.30 SE(N/V) = 0.142

SE for two treatments in the same block = 0.304

SE for two treatments not in the same block = 0.323

50 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	31.9	33.3	35.6	40.6	45.3	38.3
n_1	46.9	41.4	43.6	43.2	49.9	45.0
n_2	51.7	45.7	50.9	53.5	50.9	50.6
n_3	56.7	47.6	59.9	59.5	58.6	56.5
n_4	62.0	49.9	65.2	66.7	67.4	62.2
Mean	50.8	43.6	51.0	52.7	54.4	

CD (N/V) = 1.81 CD (NV) = 4.04

SE (N/V) = 0.854

SE for two treatments in the same block = 1.826

SE for two treatments not in the same block = 1.945

75 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	50.4	44.1	50.4	54.2	60.6	51.9
n_1	64.7	53.4	57.9	65.9	64.6	61.3
n_2	65.0	57.5	68.6	69.2	71.1	66.3
n_3	71.9	64.4	84.1	73.9	78.1	74.5
n_4	91.6	86.4	98.7	98.4	101.3	95.3
Mean	68.7	61.2	71.9	72.3	75.2	

CD (N/V) = 2.16 CD (NV) = 4.83

SE (N/V) = 1.019

SE for two treatments in the same block = 2.236

SE for two treatments not in the same block = 2.298

Harvest

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	134.5	127.3	134.9	141.8	146.9	137.1
n_1	151.2	137.5	164.6	161.9	179.6	158.9
n_2	189.1	156.8	187.4	183.3	205.2	184.4
n_3	223.0	195.9	211.0	213.8	241.9	217.1
n_4	250.8	221.7	233.3	236.3	258.7	240.2
Mean	189.7	167.8	186.3	187.4	206.5	

CD (N/V) = 2.43 CD (NV) = 5.43

SE (N/V) = 1.146

SE for two treatments in the same block = 2.497

SE for two treatments not in the same block = 2.596

During the second stage also, dry weight increased with increase in nitrogen levels. Among the varieties, Vijay recorded the maximum dry weight but was on par with Histarch. Deccan recorded the lowest dry weight. Among the different combinations, n_4v_5 was superior to all other combinations.

During the third stage also, dry weight increased with increase in levels of nitrogen. Among the varieties, Vijay continued to record the maximum dry weight and Deccan had the lowest. Interactions were also significant. n_4v_5 combination was found to be superior to all the other combinations.

Mean table revealed that at fourth stage also dry weight increased with increase in levels of nitrogen. Among the varieties, Vijay recorded the maximum dry weight and Deccan 101 the least. Among the combinations, n_4v_5 recorded the highest dry weight.

B Yield Attributes and Yield.

1 Number of cobs/plant

The data on the mean number of cobs/plant are presented in Table 23 and the analysis of variance in Appendix VI.

Results of statistical analysis revealed that nitrogen and varieties had significant effect on number of

Table 23. Number of cobs/plant

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	1.03	1.00	1.01	0.96	1.01	1.00
n_1	1.07	0.99	1.16	1.11	1.18	1.10
n_2	1.16	1.13	1.22	1.16	1.22	1.18
n_3	1.20	1.20	1.29	1.18	1.24	1.22
n_4	1.26	1.18	1.35	1.20	1.28	1.25
Mean	1.14	1.10	1.21	1.12	1.19	

CD (N/V) = 0.030 CD (NV) = 0.067

SE (N/V) = 0.014

SE for two treatments in the same block = 0.030

SE for two treatments not in the same block = 0.032

cobs/plant. Interaction was also found to be significant.

The data revealed that number of cobs increased with increase in nitrogen levels. Among the varieties, Ganga safed-2 had the maximum number of cobs/plant which was on par with Vijay. Deccan-101 had the lowest number of cobs/plant. But it was on par with Histarch. Among the combinations n_4v_3 produced the maximum number of cobs/plant.

2. Length, girth and weight of cobs

The data on the mean length, girth and weight of cobs are presented in Table 24a,b & c and the analysis of variance in Appendix VI.

The significant effect of nitrogen and varieties could be observed from the mean tables. However, the interaction effect was significant only for the weight of cobs.

In the case of cob length, n_4 recorded the maximum cob length but was on par with n_3 which in turn on par with n_2. Among the varieties, Histarch produced cobs with maximum length which was on par with Vijay. Also Ageti-76 recorded the minimum cob length which was on par with Ganga safed-2.

Table 24a Length of cobs (cm)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	11.93	9.90	11.83	11.15	11.77	11.32
n_1	11.14	11.21	13.54	11.97	13.08	12.19
n_2	14.85	12.12	14.60	15.62	14.79	14.39
n_3	14.49	13.36	16.34	16.17	15.66	15.21
n_4	14.30	14.07	17.05	16.88	15.99	15.66
Mean	10.37	12.13	11.26	14.36	14.26	

CD (N/V) = 1.043 SE (N/V) = 0.492

SE for two treatments in the same block = 1.050

SE for two treatments not in the same block = 1.124

Table 24b Girth of cobs (cm)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	10.70	10.50	10.75	11.25	10.00	10.64
n_1	11.00	11.00	12.00	12.50	11.25	11.55
n_2	11.50	11.75	13.00	13.00	12.25	12.30
n_3	12.50	12.00	14.25	13.90	13.50	13.23
n_4	12.95	12.75	14.50	14.00	14.05	13.65
Mean	11.73	11.60	12.90	12.93	12.21	

CD (N/V) = 0.616 SE (N/V) = 0.291

SE for two treatments in the same block = 0.6499

SE for two treatments not in the same block = 0.6499

Table 24c Weight of cobs (g)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	72.5	60.0	84.5	70.5	67.5	71.0
n_1	87.5	86.7	101.5	111.5	106.3	98.7
n_2	121.6	115.7	144.5	127.0	128.5	127.5
n_3	169.5	137.0	196.0	186.0	184.5	174.6
n_4	176.5	140.0	204.0	192.0	188.5	180.3
Mean	125.5	108.0	146.1	137.4	135.1	

CD (N/V) = 8.23 CD (NV) = 18.40

SE (N/V) 3.882

SE for two treatments in the same block = 8.682

SE for two treatments not in the same block = 8.682

Regarding the girth of cobs, nitrogen had a significant effect on this character. n_4 produced the maximum girth which was on par with n_3. Among the varieties, Histarch produced the maximum girth of cobs which was on par with Ganga safed-2. Vijay, Ageti-76 and Deccan-101 were also on par in this character.

Regarding weight of cobs also, nitrogen had a significant effect. Maximum cob weight was produced by n_4 treatment which was on par with n_3. Among the varieties, Ganga safed-2 produced the maximum cob weight which was significantly superior to other varieties. Histarch and Vijay were on par and were superior to Ageti-76. Deccan had the lowest cob weight. The n_4v_3 combination was superior to all the other combinations in this respect.

3. Number of grains/cob

The data on the mean number of grains/cob are presented in Table 25 and the analysis of variance in Appendix VI.

It was seen that nitrogen and varieties had significant effect on the number of grains/cob. However, interaction was not significant.

It was observed that number of grains/cob increased with increase in nitrogen levels and the highest number was produced by n_4 although it was on par with n_3.

Table 25 Number of grains/cob

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	191.5	165.8	196.4	161.6	201.2	183.3
n_1	254.7	205.0	281.1	232.0	257.6	246.1
n_2	329.4	257.6	307.4	304.4	312.0	302.2
n_3	386.8	358.1	392.8	385.9	370.7	378.9
n_4	396.6	363.8	411.3	401.7	402.5	395.2
Mean	311.8	270.1	317.8	297.1	308.8	

CD (N/V) = 19.86 SE (N/V) = 9.368

SE for two treatments in the same block = 20.673

SE for two treatments not in the same block = 21.087

Among the varieties, Ganga safed-2 produced the highest number of grains/cob which was on par with Ageti-76 and Vijay. Deccan 101 produced the lowest number of grains/cob.

4. Thousand grain weight

The data on mean thousand grain weight are presented in Table 26 and the analysis of variance in Appendix VII.

There was significant effect of nitrogen and varieties on thousand grain weight. However, interaction was not significant.

The highest level of nitrogen recorded the maximum thousand grain weight which was on par with n_3. Among the varieties, Ganga safed-2 recorded the highest thousand grain weight but was not statistically different from Histarch which was on par with Ageti-76. Deccan recorded the lowest thousand grain weight.

5. Days to silking

The data on mean number of days to silking are presented in Table 27 and the analysis of variance in Appendix VII.

The data revealed that there was significant effect of nitrogen and varieties on the number of days to silking.

Table 26 Thousand grain weight (g)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	74.3	71.3	80.5	77.1	71.6	75.0
n_1	114.2	100.6	113.3	103.9	99.9	106.4
n_2	149.5	120.4	157.7	152.2	129.8	141.9
n_3	181.9	168.9	198.6	195.7	186.2	186.3
n_4	187.9	173.4	205.6	202.7	192.0	192.3
Mean	141.6	126.9	151.1	146.3	135.9	

CD (N/V) = 7.73 SE (N/V) = 3.646

SE for two treatments in the same block = 8.049

SE for two treatments not in the same block = 8.199

Table 27 Days to silking

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	67.2	63.6	65.6	68.7	67.4	66.5
n_1	62.6	62.1	63.1	65.1	63.4	63.3
n_2	61.8	60.8	60.8	63.3	62.6	61.9
n_3	59.7	59.1	59.1	60.1	61.4	59.9
n_4	58.1	58.1	58.1	58.1	56.8	57.8
Mean	61.9	60.7	61.3	63.1	62.3	

CD (N/V) = 0.634 CD (NV) = 1.419

SE (N/V) = 0.299

SE for two treatments in the same block = 0.637

SE for two treatments not in the same block = 0.685

Interaction between nitrogen and varieties was also significant.

The linear decrease in number of days to silking with increase in levels of nitrogen was observed from the mean table. There was significant difference between nitrogen levels. Varieties also differed in the number of days to silking. Histarch has taken the highest number of days to silking and Deccan 101 the least. Among the combinations, n_4v_5 were superior to all other combinations.

6. Grain yield

The data on the mean grain yield are presented in Table 28 and the analysis of variance in Appendix VII.

It was seen that there was significant effect of nitrogen and varieties on the grain yield. The interaction was also significant.

Grain yield recorded linear increase with increase in levels of nitrogen. The yield recorded at n_4 treatment was on par with that of n_3. Among the varieties, Ganga safed-2 produced significantly higher grain yield than other varieties. Histarch was on par with Vijay which in turn was on par with Ageti-76. Deccan 101 recorded the lowest yield.

Table 28 Grain yield (Q/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	3.80	3.26	3.95	3.76	3.93	3.74
n_1	12.45	11.99	13.06	12.50	12.80	12.56
n_2	16.72	16.85	17.85	16.75	16.75	16.99
n_3	24.75	23.27	26.78	25.64	24.99	25.08
n_4	24.90	23.37	26.91	25.83	25.18	25.24
Mean	16.52	15.75	17.71	16.90	16.73	

CD (N/V) = 0.353 CD (NV) = 0.788

SE (N/V) = 0.166

SE for two treatments in the same block = 0.370

SE for two treatments not in the same block = 0.373

The interactions were also significant. The n_4v_3 and n_3v_3 combinations were on par and were superior to all the other combinations.

7. Stover yield

The data on mean stover yield are presented in Table 29 and the analysis of variance in Appendix VII.

In the case of stover yield also there was significant effect for nitrogen and varieties. However, interaction was not seen significant.

The data revealed that stover yield increased with increase in nitrogen levels and n_4 produced the maximum stover yield. Among the varieties, Vijay recorded the maximum stover yield which was significantly superior to all other varieties. Ganga safed-2 was on par with Ageti-76 which in turn on par with Histarch. Deccan 101 yielded the minimum quantity of straw.

8. Harvest index (HI)

The data on mean HI are presented in Table 30 and the analysis of variance in Appendix VII.

Statistical analysis of the data revealed that nitrogen and varieties had significant effect on HI. However, interaction was not significant.

Table 29 Stover yield (Q/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	11.42	8.72	10.20	8.90	14.21	10.69
n_1	30.13	25.38	28.02	26.96	31.73	28.73
n_2	37.44	36.19	37.83	35.37	39.79	37.32
n_3	51.25	49.00	55.49	53.13	56.90	53.15
n_4	52.75	50.81	56.59	53.68	58.65	54.49
Mean	36.60	34.02	37.62	35.61	40.25	

CD (N/V) 1.337 SE (N/V) = 0.631

SE for two treatments in the same block = 1.354

SE for two treatments not in the same block = 1.437

Table 30 Harvest index

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	0.246	0.250	0.278	0.277	0.198	0.249
n_1	0.296	0.315	0.319	0.311	0.278	0.304
n_2	0.312	0.311	0.326	0.324	0.289	0.313
n_3	0.330	0.330	0.330	0.330	0.300	0.326
n_4	0.330	0.330	0.330	0.330	0.310	0.323
Mean	0.303	0.305	0.318	0.310	0.276	

CD (N/V) = 0.0094 SE (N/V) = 0.0044

SE for two treatments in the same block = 0.0095

SE for two treatments not in the same block = 0.0101

It was observed that HI increased with increase in levels of nitrogen upto n_3. The HI recorded by n_4 and n_3 treatments were on par and were significantly superior to all. n_1 and n_2 were also on par and were superior to n_0.

Among the varieties, Ganga Safed-2 was superior to all the other varieties even though on par with Histarch which in turn on par with Deccan-101. Vijay had the lowest HI.

C. Quality Aspects.

Protein content of grains

The data on mean protein content of grains are presented in Table 31 and the analysis of variance in Appendix VII.

It was seen that nitrogen and varieties exerted significant influence on the grain protein content. Interaction was also significant.

The highest level of nitrogen resulted in the maximum protein content. Each higher level of nitrogen recorded significant increase from the immediate lower level. Among the varieties, Ganga safed-2 produced the maximum protein content which was on par with Vijay which in turn on par with Ageti-76 also. Deccan 101 recorded the lowest protein content which was on par

Table 31 Protein content of grains (%)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	8.18	7.51	7.94	7.84	8.09	7.91
n_1	8.95	8.83	8.94	8.75	8.92	8.88
n_2	9.88	10.08	10.12	10.35	10.16	10.12
n_3	10.91	10.72	11.35	10.65	11.33	10.99
n_4	11.69	11.78	12.26	11.62	11.68	11.81
Mean	9.92	9.78	10.12	9.84	10.04	

CD (N/V) = 0.166 CD (NV) = 0.372

SE (N/V) = 0.078

SE for two treatments in the same block = 0.169

SE for two treatments not in the same block = 0.179

with Histarch and Ageti-76. Among the combinations, n_4v_3 was superior to other combinations in respect of the protein content of grains.

D. Uptake of Nutrients.

Uptake of nitrogen

The data on mean uptake of nitrogen by plants are presented in Table 32 and the analysis of variance in Appendix VIII.

The data revealed that nitrogen and varieties exerted significant effect on nitrogen uptake. Interaction was also significant at all stages except during the first stage.

At 25 DAS, nitrogen uptake increased with increase in levels of nitrogen. Among the varieties, Vijay had the highest nitrogen uptake but was on par with Ageti-76 and Histarch. Deccan 101 recorded the lowest uptake.

At 50 DAS, nitrogen uptake increased with increase in levels of nitrogen. Among the varieties, Vijay had the highest nitrogen uptake. Histarch was on par with Ganga safed-2 which in turn on par with Ageti-76. Deccan 101 recorded the lowest uptake. Among the combinations, n_4v_5

Table 32 Uptake of Nitrogen (kg/ha)

25 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	4.3	2.6	4.1	4.1	5.3	4.1
n_1	6.6	3.7	5.6	6.2	6.8	5.8
n_2	8.6	4.8	8.8	8.6	9.3	8.0
n_3	11.1	8.5	10.5	11.5	12.3	10.8
n_4	14.2	11.0	13.9	14.0	14.0	13.4
Mean	9.0	6.1	8.6	8.9	9.5	

CD (N/V) = 0.76 SE (N/V) = 0.358

SE for two treatments in the same block = 0.774
SE for two treatments not in the same block = 0.810

50 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	33.4	31.8	35.8	35.6	37.7	34.9
n_1	49.0	43.8	46.3	45.5	51.6	47.2
n_2	60.6	52.9	59.3	64.1	63.9	60.2
n_3	73.1	56.1	77.5	80.0	82.3	73.8
n_4	87.1	68.9	93.7	96.7	100.5	89.4
Mean	60.6	50.7	62.5	64.4	67.2	

CD (N/V) = 2.37 CD (NV) = 5.30

SE (N/V) = 1.12
SE for two treatments in the same block = 2.416
SE for two treatments not in the same block = 2.538

75 DAS

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	37.1	32.1	38.8	42.4	45.7	39.2
n_1	57.6	48.4	54.1	60.0	55.5	55.1
n_2	63.9	57.4	71.2	76.0	74.7	68.6
n_3	80.4	70.5	94.6	91.5	89.6	85.3
n_4	116.1	104.9	126.4	131.7	130.4	121.9
Mean	71.0	62.6	77.1	80.3	79.2	

CD (N/V) = 3.12 CD (NV) = 6.96
SE (N/V) 1.47

SE for two treatments in the same block = 3.30
SE for two treatments not in the same block = 3.30

Harvest

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	53.1	42.9	62.3	61.6	66.1	57.2
n_1	73.1	56.4	87.5	82.4	90.0	77.9
n_2	109.1	83.7	118.8	109.2	122.6	108.7
n_3	143.8	115.4	146.1	139.4	159.1	140.8
n_4	159.1	145.5	168.0	161.5	175.5	161.9
Mean	107.6	88.8	116.5	110.8	122.7	

CD (N/V) 3.49 CD (NV) = 7.81
SE (N/V) 1.646

SE for two treatments in the same block =3.491
SE for two treatments not in the same block =7.805

had the highest nitrogen uptake which was on par with n_4v_4 which in turn on par with n_4v_3 also.

During the third stage also, nitrogen uptake increased with nitrogen levels. Among the varieties, Histarch had the highest nitrogen uptake which was on par with Vijay. Ganga safed-2 was also on par with Vijay. Deccan 101 had the lowest nitrogen uptake. Among the combinations, n_4v_4, n_4v_5 and n_4v_3 were on par and recorded the highest uptake of nitrogen.

At the harvesting stage also, nitrogen uptake increased with increase in levels of nitrogen. Among the varieties, Vijay had the highest nitrogen uptake. Ganga safed-2 was significantly superior to Histarch which was on par with Ageti-76.Deccan 101 had the lowest N uptake. Among the combinations, n_4v_5 had the highest nitrogen uptake which was on par with n_4v_3.

E. Nutrient Status of the Soil.

1. Total nitrogen content of the soil

The data on mean total nitrogen content of the soil are presented in Table 33 and the analysis of variance in Appendix IX.

The data revealed that nitrogen and varieties had significant effect on soil residual nitrogen interaction was also significant.

Table 33 Total nitrogen content of the soil (%)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	0.060	0.060	0.035	0.025	0.086	0.053
n_1	0.065	0.086	0.035	0.035	0.061	0.057
n_2	0.095	0.087	0.035	0.035	0.061	0.063
n_3	0.118	0.060	0.054	0.058	0.150	0.088
n_4	0.148	0.060	0.054	0.030	0.030	0.064

CD (N/V) = 0.0048 CD (NV) = 0.0107

SE (N/V) = 0.0023

SE for two treatments in the same block = 0.0049

SE for two treatments not in the same block = 0.0051

Soil nitrogen content increased upto n_3 treatment and thereafter it decreased. Varieties also differed significantly in the residual nutrients left in the soil. It was seen that Ageti-76 had left the highest amount of nitrogen in the soil. Histarch recorded the least amount of nitrogen in the soil.

Interaction was also found to be significant. Among the combinations, n_3v_5 left the highest amount of nitrogen in soil and n_0v_4 the lowest.

2. Available phosphorus content of the soil

The data on mean available soil phosphorus content are presented in Table 34 and the analysis of variance in Appendix IX.

The data revealed that nitrogen and varieties had significant effect on soil phosphorus. Interaction was not significant.

The higher amount of available phosphorus was recorded by n_1 treatment. The highest nitrogen level resulted in the lowest soil phosphorus content. Among the varieties, Deccan -101 had left the highest phosphorus content in the soil but was on par with Vijay, Ganga safed-2 and Ageti-76. Histarch recorded the lowest soil phosphorus content.

Table 34 Available phosphorus content of the soil (kg/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	39.0	41.6	41.6	39.0	41.3	40.5
n_1	42.6	42.8	43.2	39.4	42.1	42.0
n_2	42.5	42.3	41.9	38.6	41.6	41.4
n_3	41.2	42.7	41.0	40.0	41.5	41.3
n_4	40.2	40.2	39.1	39.0	41.1	39.9
Mean	41.1	41.9	41.4	39.2	41.5	

CD (N/V) 1.08 SE (N/V) = 0.509

SE for two treatments in the same block = 1.093

SE for two treatments not in the same block= 1.159

3. Exchangeable potassium content of the soil

The data on mean exchangeable potassium content of the soil are given in Table 35 and the analysis of variance in Appendix IX.

It was seen that there was significant effect of nitrogen and varieties on soil potassium content. However, interaction was not significant.

As nitrogen level increased from n_1 to n_4, exchangeable potassium content of soil found to be decreased. Among the varieties Ageti-76 recorded the lowest amount of exchangeable potassium in soil.

Table 35 Exchengeable potassium content of the soil (kg/ha)

	V_1	V_2	V_3	V_4	V_5	Mean
n_0	37.2	38.8	35.8	37.7	36.4	37.2
n_1	37.5	38.9	38.6	40.4	39.2	38.9
n_2	37.4	39.3	38.3	39.1	36.6	38.1
n_3	38.0	38.0	38.5	37.9	37.6	38.0
n_4	36.1	36.7	36.4	38.8	38.0	37.2
Mean	37.3	38.4	37.5	38.8	37.6	

CD (N/V) = 0.95 SE (N/V) = 0.448

SE for two treatments in the same block = 0.962

SE for two treatments not in the same block = 1.021

III Results of pooled analysis

A. Vegetative Characters

The data on height of plants, number of leaves/plant, leaf area index and dry weight/plant under open and partial shade conditions have been pooled and subjected to statistical analyses and the mean values are presented in Table 36. The analysis of variance are presented in Appendix X.

It was observed that interaction between treatments and location was significant only for height of plants and dry weight/plant. Both these characters showed differential response at each location and partial shade condition was found to be significantly superior to open condition.

However, interaction between treatments and location was not significant with regard to number of leaves/plant and leaf area index. Thus it is revealed that both these characters responded consistently under open and partial shade conditions.

B. Yield attributes and yield

The data on yield attributes and yield viz. days to silking, number of cobs/plant, length, girth and weight

Table 36 Vegetative characters

Treatments	1. Height of plants (cm)		2. Number of leaves	
	Partial shade	Open	Partial shade	Open
n_0v_1	130.6	118.0	9.6	7.0
n_0v_2	138.5	101.9	8.2	16.5
n_0v_3	143.3	116.5	8.6	8.5
n_0v_4	139.2	117.2	9.3	7.5
n_0v_5	133.0	114.5	8.6	6.5
n_1v_1	187.4	145.2	10.5	8.5
n_1v_2	175.8	127.1	9.6	8.0
n_1v_3	191.3	153.4	10.5	9.5
n_1v_4	192.4	149.6	10.7	10.0
n_1v_5	188.0	147.8	10.1	7.5
n_2v_1	201.7	154.7	10.4	9.0
n_2v_2	192.4	136.9	10.6	10.0
n_2v_3	205.2	160.8	11.5	10.0
n_2v_4	217.8	163.9	11.1	10.0
n_2v_5	204.2	166.7	10.5	10.0
n_3v_1	215.9	162.1	12.3	9.0
n_3v_2	200.6	143.9	11.0	10.0
n_3v_3	236.4	186.6	11.9	10.5
n_3v_4	234.3	177.4	11.6	11.0
n_3v_5	233.8	185.5	10.9	10.5
n_4v_1	233.8	178.9	12.7	9.5
n_4v_2	214.9	172.9	11.4	10.5
n_4v_3	248.4	202.2	12.8	11.5
n_4v_4	245.3	192.8	12.5	11.5
n_4v_5	248.7	198.9	11.8	11.5
Mean	198.1	155.0	10.7	9.4
F test	Significant		Not significant	
CD (5%)	5.408			
SE	2.651			

Table 36 (contd.)

Treatments	3. Leaf Area Index		4 Dry weight/plant(g)	
	Partial shade	Open	Partial shade	Open
n_0v_1	2.73	1.66	134.5	108.3
n_0v_2	2.50	1.55	127.3	97.0
n_0v_3	2.75	1.96	135.0	109.0
n_0v_4	2.97	1.74	141.8	114.0
n_0v_5	2.44	1.60	146.9	123.5
n_1v_1	3.06	1.98	151.2	135.6
n_1v_2	2.74	1.89	137.5	121.3
n_1v_3	3.12	2.19	164.6	134.5
n_1v_4	3.08	2.30	161.9	141.0
n_1v_5	2.85	1.84	179.6	147.6
n_2v_1	3.26	2.09	189.1	138.4
n_2v_2	3.13	2.30	156.8	167.1
n_2v_3	3.54	2.35	187.4	167.8
n_2v_4	3.24	2.37	183.3	177.0
n_2v_5	3.17	2.28	205.2	187.2
n_3v_1	3.62	2.30	223.0	215.5
n_3v_2	3.20	2.34	195.9	186.5
n_3v_3	3.83	2.51	211.0	192.0
n_3v_4	3.34	2.49	213.8	194.4
n_3v_5	3.32	2.55	242.0	200.8
n_4v_1	3.81	2.33	250.8	225.2
n_4v_2	3.56	2.44	221.7	205.8
n_4v_3	3.96	2.66	233.3	221.3
n_4v_4	3.93	2.65	236.2	223.1
n_4v_5	3.54	2.63	258.7	240.5
Mean	2.23	2.20	187.5	168.9
F test	Not significant		Significant	
CD (5%)			4.49	
SE			2.20	

Table 37 Yield attributes and yield

Treatments	1. Number of cobs/ plant		2.Length of cob (cm)		3. Girth of cob (cm)	
	Partial shade	Open	Partial shade	Open	Partial shade	Open
n_0v_1	1.03	1.00	11.93	10.51	10.70	9.00
n_0v_2	1.00	1.00	9.90	8.48	10.50	8.50
n_0v_3	1.01	1.00	11.83	12.14	10.75	10.25
n_0v_4	0.96	0.99	11.15	10.42	11.25	10.25
n_0v_5	1.01	1.00	11.77	10.07	10.00	9.00
n_1v_1	1.07	1.00	11.14	12.11	11.00	10.50
n_1v_2	0.99	1.10	11.21	11.38	11.00	9.50
n_1v_3	1.16	1.10	13.54	12.50	12.00	11.25
n_1v_4	1.11	1.05	11.97	10.92	12.50	11.25
n_1v_5	1.18	1.11	13.08	11.57	11.25	10.50
n_2v_1	1.16	1.10	14.85	12.77	11.50	10.25
n_2v_2	1.13	1.15	12.12	12.69	11.75	10.00
n_2v_3	1.22	1.18	14.60	13.51	13.00	12.00
n_2v_4	1.16	1.12	15.62	12.68	13.00	12.25
n_2v_5	1.22	1.13	14.79	13.46	12.25	11.25
n_3v_1	1.20	1.16	14.49	14.01	12.50	12.00
n_3v_2	1.20	1.05	13.36	13.23	12.00	10.50
n_3v_3	1.29	1.20	16.33	15.75	14.25	13.25
n_3v_4	1.18	1.15	16.17	15.42	13.90	13.00
n_3v_5	1.24	1.20	15.66	14.57	13.50	12.25
n_4v_1	1.26	1.20	14.30	14.52	12.95	12.50
n_4v_2	1.18	1.10	14.07	13.49	12.75	11.50
n_4v_3	1.35	1.25	17.05	16.51	14.50	13.50
n_4v_4	1.20	1.19	16.88	15.93	14.00	13.30
n_4v_5	1.28	1.20	15.99	15.83	14.05	13.10
Mean	1.15	1.11	13.23	12.98	12.27	11.2
F test	Significant		Not significant		Not significant	
CD (5%)	0.021					
SE	0.010					

Table 37 Yield attributes and yield

Treatments	1. Number of cobs/ plant		2. Length of cob (cm)		3. Girth of cob (cm)	
	Partial shade	Open	Partial shade	Open	Partial shade	Open
n_0v_1	1.03	1.00	11.93	10.51	10.70	9.00
n_0v_2	1.00	1.00	9.90	8.48	10.50	8.50
n_0v_3	1.01	1.00	11.83	12.14	10.75	10.25
n_0v_4	0.96	0.99	11.15	10.42	11.25	10.25
n_0v_5	1.01	1.00	11.77	10.07	10.00	9.00
n_1v_1	1.07	1.00	11.14	12.11	11.00	10.50
n_1v_2	0.99	1.10	11.21	11.38	11.00	9.50
n_1v_3	1.16	1.10	13.54	12.50	12.00	11.25
n_1v_4	1.11	1.05	11.97	10.92	12.50	11.25
n_1v_5	1.18	1.11	13.08	11.57	11.25	10.50
n_2v_1	1.16	1.10	14.85	12.77	11.50	10.25
n_2v_2	1.13	1.15	12.12	12.69	11.75	10.00
n_2v_3	1.22	1.18	14.60	13.51	13.00	12.00
n_2v_4	1.16	1.12	15.62	12.68	13.00	12.25
n_2v_5	1.22	1.13	14.79	13.46	12.25	11.25
n_3v_1	1.20	1.16	14.49	14.01	12.50	12.00
n_3v_2	1.20	1.05	13.36	13.23	12.00	10.50
n_3v_3	1.29	1.20	16.33	15.75	14.25	13.25
n_3v_4	1.18	1.15	16.17	15.42	13.90	13.00
n_3v_5	1.24	1.20	15.66	14.57	13.50	12.25
n_4v_1	1.26	1.20	14.30	14.52	12.95	12.50
n_4v_2	1.18	1.10	14.07	13.49	12.75	11.50
n_4v_3	1.35	1.25	17.05	16.51	14.50	13.50
n_4v_4	1.20	1.19	16.88	15.93	14.00	13.30
n_4v_5	1.28	1.20	15.99	15.83	14.05	13.10
Mean	1.15	1.11	13.23	12.98	12.27	11.23
F test	Significant		Not significant		Not significant	
CD (5%)	0.021					
SE	0.010					

Table 37 (contd.)

Treatments	4. Weight of cob (g)		5. Thousand grain weight (g)		6. Days to silking	
	Partial shade	Open	Partial shade	Open	Partial shade	Open
n_0v_1	72.5	75.5	74.3	67.5	67.2	73.1
n_0v_2	60.0	68.5	71.2	63.5	63.6	68.6
n_0v_3	84.5	75.2	80.5	72.0	65.6	74.3
n_0v_4	70.5	73.0	77.1	67.0	68.7	72.8
n_0v_5	67.5	69.5	71.6	66.5	67.4	70.0
n_1v_1	87.5	85.7	114.2	101.0	62.6	70.0
n_1v_2	86.7	74.5	100.6	95.0	62.1	64.2
n_1v_3	101.5	90.0	113.3	96.8	63.1	71.4
n_1v_4	111.5	87.4	103.9	96.5	65.1	68.5
n_1v_5	106.3	89.5	99.9	99.0	65.4	67.6
n_2v_1	121.6	113.9	149.5	115.0	61.8	65.0
n_2v_2	115.7	103.4	120.4	122.0	60.8	60.5
n_2v_3	144.5	113.9	157.7	130.5	60.8	68.2
n_2v_4	127.0	102.9	152.2	132.0	63.3	64.3
n_2v_5	128.5	110.5	129.8	121.5	62.6	65.4
n_3v_1	169.5	157.0	182.0	172.0	59.6	62.3
n_3v_2	137.0	141.5	168.9	165.5	59.1	57.8
n_3v_3	196.0	172.0	198.6	181.5	59.1	64.0
n_3v_4	186.0	169.5	195.7	179.0	60.1	61.6
n_3v_5	184.5	166.7	186.2	168.5	61.4	61.7
n_4v_1	176.5	161.1	188.0	174.8	58.1	61.0
n_4v_2	140.5	143.9	173.4	170.7	58.1	56.0
n_4v_3	204.0	177.2	205.6	185.0	58.1	61.7
n_4v_4	192.0	173.8	202.7	182.0	59.1	60.8
n_4v_5	188.5	168.8	192.0	176.5	56.8	60.9
Mean	130.4	118.9	140.4	128.1	61.9	65.3
F test	Significant		Not significant		Significant	
CD (5%)	4.54				1.134	
SE	2.23				0.56	

Table 37 (contd.)

Treatments	7. Grain yield (q/ha)		8. Stover yield (q/ha)		9. Harvest index	
	Partial shade	Open	Partial shade	Open	Partial shade	Open
n_0v_1	3.80	2.82	11.42	10.11	0.246	0.245
n_0v_2	3.26	1.87	8.72	9.41	0.250	0.214
n_0v_3	3.95	4.07	10.20	9.82	0.278	0.268
n_0v_4	3.76	3.89	8.90	9.74	0.277	0.256
n_0v_5	3.93	3.67	14.21	12.91	0.198	0.196
n_1v_1	12.45	10.42	30.13	25.91	0.296	0.307
n_1v_2	11.99	8.85	25.38	23.31	0.315	0.305
n_1v_3	13.06	11.55	28.02	24.57	0.320	0.316
n_1v_4	12.50	11.06	26.96	24.01	0.311	0.314
n_1v_5	12.80	10.81	31.73	28.61	0.278	0.274
n_2v_1	16.72	13.62	37.44	32.47	0.312	0.314
n_2v_2	16.85	11.71	36.19	28.87	0.311	0.310
n_2v_3	17.85	15.34	37.83	31.14	0.326	0.332
n_2v_4	16.75	14.66	35.37	31.17	0.324	0.325
n_2v_5	16.75	14.10	39.79	35.02	0.289	0.285
n_3v_1	24.75	19.71	51.25	44.58	0.330	0.325
n_3v_2	23.27	18.19	49.00	42.18	0.325	0.325
n_3v_3	26.78	22.38	55.49	44.25	0.332	0.347
n_3v4	25.64	21.67	53.13	45.13	0.328	0.335
n_3v_5	24.99	21.61	56.90	51.28	0.303	0.305
n_4v_1	24.90	21.09	52.75	42.22	0.330	0.318
n_4v_2	23.37	19.87	50.80	45.82	0.325	0.319
n_4v_3	26.91	24.61	56.59	46.08	0.332	0.341
n_4v_4	25.83	24.12	53.68	47.07	0.328	0.334
n_4v_5	25.18	23.96	58.65	52.87	0.313	0.304
Mean	16.72	14.23	36.82	32.18	0.303	0.300
F test	Not significant		Significant		Not significant	
CD (5%)			1.273			
SE			0.624			

of cob, thousand grain weight, grain yield, straw yield and harvest index under both open and partial shade conditions have been pooled and analysed and the mean values are presented in Table 37. The analysis of variance are given in Appendix XI.

It was observed that interaction between treatment and location was significant for days to silking, number of cobs/plant, weight of cob and stover yield. The maximum value for number of cobs/plant, weight of cob and stover yield was observed under partial shade conditions. Minimum number of days to silking was also recorded under partial shade condition.

But regarding other characters, viz. length of cob, girth of cob, thousand grain weight, grain yield and harvest index, interaction between treatments and location was not significant. This revealed that all these characters showed similar response under both open and partial shade conditions.

C. Protein content of grains

The data on protein content of grains under open and partial shade conditions have been pooled and analysed and the mean values are presented in Table 38. The analysis of variance are presented in Appendix XII.

Table 38 Protein content of grains (%)

Treatments	Partial shade	Open
n_0v_1	8.18	9.82
n_0v_2	7.51	8.82
n_0v_3	7.94	9.72
n_0v_4	7.84	9.45
n_0v_5	8.09	9.14
n_1v_1	8.95	11.05
n_1v_2	8.83	9.52
n_1v_3	8.94	10.83
n_1v_4	8.75	10.33
n_1v_5	8.92	9.68
n_2v_1	9.88	11.92
n_2v_2	10.08	11.04
n_2v_3	10.12	11.80
n_2v_4	10.35	11.27
n_2v_5	10.16	11.02
n_3v_1	10.90	12.97
n_3v_2	10.72	11.67
n_3v_3	11.35	12.46
n_3v_4	10.65	12.58
n_3v_5	11.33	12.41
n_4v_1	11.69	13.61
n_4v_2	11.78	12.32
n_4v_3	12.26	12.92
n_4v_4	11.62	13.04
n_4v_5	11.68	12.51
Mean	9.94	11.28
F test	Significant	
CD (5%)	0.209	
SE	0.102	

It was observed that interaction between treatments and location was significant for protein content of grains. This revealed that grain protein content differed significantly between locations. Open condition was found to be superior to partial shade condition in this respect.

D. Uptake of nitrogen

The data on uptake of nitrogen under open and partial shade conditions have been pooled and analysed and the mean data are presented in Table 39. The analysis of variance are given in Appendix XII.

It was observed that interaction between treatments and location was significant for the uptake of nitrogen. The maximum uptake of nitrogen was recorded under partial shade condition.

Table 39 Uptake of nitrogen (kg/ha)

Treatments	Partial shade	Open
n_0v_1	53.1	42.6
n_0v_2	42.9	33.4
n_0v_3	62.2	46.0
n_0v_4	61.6	49.7
n_0v_5	66.1	52.8
n_1v_1	73.1	58.0
n_1v_2	56.4	46.8
n_1v_3	87.5	68.0
n_1v_4	82.4	73.6
n_1v_5	90.0	71.4
n_2v_1	109.1	95.3
n_2v_2	83.7	78.4
n_2v_3	118.7	94.1
n_2v_4	109.2	107.2
n_2v_5	122.6	102.9
n_3v_1	143.8	130.9
n_3v_2	115.4	113.4
n_3v_3	146.1	120.0
n_3v_4	139.4	127.5
n_3v_5	159.1	125.5
n_4v_1	159.1	142.0
n_4v_2	145.5	125.7
n_4v_3	168.1	140.2
n_4v_4	161.5	148.1
n_4v_5	175.5	156.9
Mean	109.3	94.0

F test	Significant
CD (5%)	3.255
SE	1.596

IV Response of Maize to Nitrogen

Response function of grain yield and nitrogen levels under open condition was explained by the quadratic function

$$y = 15.2309 + 4.9105\ x - 0.5025\ x^2$$

Under partial shade condition the response was explained by the quadratic function

$$y = 18.5922 + 5.5523\ x - 0.9356\ x^2$$

The mathematical and economic optimum N rate under both conditions are given in Table 40.

Table 40. Optimum N rates under open and partial shade conditions

	Mathematical optimum N rate	Economic optimum N rate
Open condition	344.33 kg/ha	178.64 kg/ha
Partial shade condition	248.36 kg/ha	159.38 kg/ha

DISCUSSION

DISCUSSION

An investigation was carried out at the Instructional farm, College of Agriculture, Vellayani to find out the optimum dose of nitrogen for maize crop and to screen out the best suited variety of maize for both open and partial shade conditions. The results obtained on various aspects viz. vegetative characters yield attributes, yield, quality of produce and uptake of nutrients are discussed hereunder.

A. Growth characters

1. Height of plants

There was significant increase in plant height at all stages of growth due to the application of nitrogen under both open and partial shade conditions. The highest level of nitrogen, ie. 200 kg/ha produced the maximum height of 190.3 cm under open condition and 238.1 cm under partial shade condition. Several workers viz. Rajput *at al* (1970) and Sharma (1973) reported similar linear increase in plant height with increasing levels of applied nitrogen. Gangro (1978) specifically reported a linear increase in plant height with increasing rates of nitrogen upto 200 kg/ha. The fact that control plots recorded only lesser height at all stages compared to treated plots clearly indicated that fertilizer application will tend to increase the vegetative growth of plant.

Varieties also recorded significant difference in plant height at all stages of plant growth under both situations. Under partial shade condition, Vijay and under open condition, Ganga safed-2 recorded maximum plant height. More or less the same trend was shown by Histarch under partial shade and Vijay under open conditions. However, Deccan-101 recorded the minimum height under both situations. Mandloi et al. (1972) found that Vijay recorded the maximum plant height when compared to other composites and hybrids in a varietal trial.

2. Number of leaves/plant

It was observed that nitrogen had significant effect on the number of leaves/plant at all stages of growth under both open and partial shade conditions. The highest level of nitrogen produced a maximum of 12.2 leaves/plant under partial shade condition. But under open condition, only 150 kg N/ha was sufficient to produce higher number of leaves/plant. Nitrogen being a major nutrient could significantly increase the vegetative growth especially leaf production (Adetiloye et al. (1984) . Similar increase in the number of leaves/plant with increasing rates of nitrogen was reported by Rajput et al. (1970) and Gangro (1977). The fact that control plots recorded only less number of leaves/plant indicates that application of nitrogen will promote

the vegetative growth of plant.

Varietal effect was also significant during all stages of growth under both open and partial shade conditions. Ganga safed-2 and Histarch produced the higher number of leaves/plant under open condition. But under partial shade, Ageti-76, Ganga safed-2 and Histarch were not statistically different in the case of number of leaves/plant.

3. Leaf Area Index (LAI)

It was found that nitrogen had significant effect on LAI under both open and partial shade situations. The highest LAI values of 3.76 under partial shade and 2.54 under open condition were observed at 200 kg N/ha. It is evident that as the dose of nitrogen increases leaf area also increases on account of the role of nitrogen on vegetative characters. This result corroborates the findings of Appa Rao (1969) and Rajagopal (1971) that nitrogen application increased leaf area in maize. Russel (1973) also stated that for many crops the amount of leaf area available for photosynthesis is roughly proportional to the amount of nitrogen supplied.

Varietal effect was also significant under both conditions. Ganga safed-2 recorded the maximum LAI which was on par with Histarch under both open and partial shade conditions.

4. Dry weight/plant

Application of nitrogen exerted prounced influence on the dry weight of plant at all stages of growth under open and partial shade conditions. The highest level of nitrogen (200 kg/ha) produced the maximum dry weight of 223.1 g/plant under open condition and 240.2 g/plant under partial shade condition. It was also seen that maximum dry weight was recorded at the harvest stage in the case of all varieties.

A positive linear response was observed with increasing levels of nitrogen. During all the stages, the treated plants recorded marked increase in dry weight as compared to control plants. It is observed that nitrogen had a positive role in increasing vegetative characters like number of leaves/plant, leaf area index, height of plants etc. All these would have directly and indirectly helped in increasing total dry matter yield.

The results obtained is in conformity with the findings of Virmani et al. (1970) and Mikhail and Shalaby (1979) that increased application of nitrogen resulted in an increased dry matter production is maize. Krishnamurthy et al. (1974) also reported the highest value of dry matter production with 200 kg N/ha. Stoyanov (1983) explained the result that increasing nitrogen rates increased the

chlorophyll content which is correlated with dry matter production.

Varietal effect was also significant during all the stages under both situations. Vijay recorded the maximum dry weight both under open and partial shade conditions. Vijay at 200 kg N/ha produced the maximum dry weight of 240.45 g/plant under open condition and 258.71 g/plant under partial shade condition.

The data on dry weight of plant at different stages of growth indicated that maximum growth of plant occurred during the post flowering period and the highest dry weight was observed at the harvest stage. This may be due to additional accumulation of dry weight on account of reproductive development.

B. Yield attributes and Yield

1. Number of cobs/plant

The data clearly indicated that application of nitrogen at different levels had a significant effect on the number of cobs/plant under both open and partial shade conditions. The highest number of cobs was produced by the highest level of nitrogen (200 kg/ha) under both situations. A linear increase was also observed with the application of nitrogen.

Varieties also recorded significant difference in the number of cobs/plant. Under both open and partial shade conditions, Ganga safed-2 produced the maximum number of cobs/plant. Next was Vijay composite in this respect.

A comparison between the treated plots and control plots revealed that the application of nitrogen is essential for producing relatively higher number of cobs/plant. This finding is in conformity with the results of Sharma (1973), Short et al. (1982) and Karim et al.(1983). Russel (1984) also observed a significant linear increase in cobs/plant with increased levels of nitrogen upto 240 kg/ha.

It was also observed that the number of cobs/plant is a character influenced by both nutrient status and varietal characters. Ganga safed-2 at 200 kg N/ha produced the maximum number of cobs/plant under both open and partial shade situations.

2. Length of cobs

From the results it was observed that nitrogen had significant effect on length of cobs both under open and partial shade conditions. A direct linear increase was observed with increasing levels of nitrogen. But the two

top levels did not differ significantly under partial shade condition. Varieties also differed significantly. Under open condition Ganga safed-2 and under partial shade condition Histarch produced the longest cobs.

These findings were in conformity with the results of Hati and Panda (1970). Similar increasing trend in cob length with increased levels of nitrogen upto 200 kg/ha was reported by Shalaby and Mikhail (1979) and Sciput et al. (1979).

3. Girth of cobs

Girth of cobs was also found to increase with increasing levels of nitrogen under both open and partial shade conditions. Highest girth was obtained with the highest level of nitrogen (200 kg/ha). But the topmost two levels did not differ significantly in this respect under both conditions. Thus it is seen that there was significant linear response only upto 150 kg N/ha and thereafter the increase was only marginal. This finding is in conformity with the results of Kharkar (1980) who also found a linear increase only upto 160 kg N/ha.

Among the varieties, Ganga safed-2 and Histarch recorded higher girth of cobs under open condition. However under partial shade condition only Histarch recorded the maximum girth of cobs.

4. Weight of cobs

Nitrogen produced a linear increase in the weight of cobs with increasing levels. However, this linear increase was significant only upto 150 kg/ha and thereafter the increase was only marginal. The trend was similar under both open and partial shade conditions. Similar results were obtained by workers like Karim et al. (1983). However, Kharkar (1980) observed a similar increasing trend only upto 160 kg N/ha. Russel (1984) also got the similar result. It is seen that the treated plants produced a marked increase in cob weight compared to control plants.

Among the varieties, Ganga safed-2 had the highest weight of cobs under both open and partial shade conditions.

5. Number of grains/cob

Under both open and partial shade conditions there was significant linear increase in the number of grains/cob with increasing levels of nitrogen. However, this significant increase was seen only upto 150 kg N/ha under partial shade condition. With 200 kg N/ha, there was only a marginal increases (5%) in the number of grains/cob. But under open condition, 200 kg N/ha produced the maximum number of grain/cob. Al-Rudha and Al-Younis (1978) observed such an increasing trend in number of grains/cob with increasing rates of

nitrogen. Rajput et al (1970) also obtained linear significant increase upto 160 kg N/ha.

Varieties also exhibited a significant difference in the number of grains/cob. Under open condition Vijay had the highest number of grains/cob. But under partial shade condition, variety Ganga safed-2 had the highest number of grains/cob. Ageti-76 stood next in this respect. Under both conditions, Deccan 101 produced the lowest number of grains/cob.

All the treated plots produced a marked increase in the number of grains/cob compared to control plots. Thus it is revealed that application of nitrogen is definitely beneficial in this respect.

6. Thousand grain weight

It is seen that nitrogen had a pronounced effect on the thousand grain weight under both open and partial shade conditions. When the nitrogen levels were increased there was significant positive increase in the thousand grain weight upto 150 kg/ha under both situations. With 200 kg N/ha there was only a marginal increase in thousand grain weight. Similar results were observed by Shalaby and Mikhail (1979) and Sciput et al. (1979) who recorded increased thousand grain weight upto 200 kg N/ha. However, Rajput et al.

(1970) observed this increasing trend only upto 160 kg N/ha which is in conformity with the present finding.

The significant effect of nitrogen on the thousand grain weight indicates that the nitrogen after absorption by plant has been utilized not only for vegetative growth and development but also for increasing the size of seeds by proper filling up of the grain and better packing of the aleuron layers of the seed thereby contributing to a higher seed weight.

Among the varieties, Ganga safed-2 had the highest thousand grain weight under both open and partial shade conditions.

7. Days to silking

It was observed that nitrogen had significant effect in reducing the number of days to silking under both open and partial shade conditions. The number of days required was comparatively less in the case of plants treated with the highest dose of nitrogen under both situations. Days to silking was reduced by 11 days under open condition and 9 days under partial shade condition compared to control. Sharma et al (1969) also found that days to silking was decreased with increasing rates of nitrogen upto 200 kg/ha. Mandloi et al (1972) also reported early silking with applica-

tion of nitrogen at higher doses.

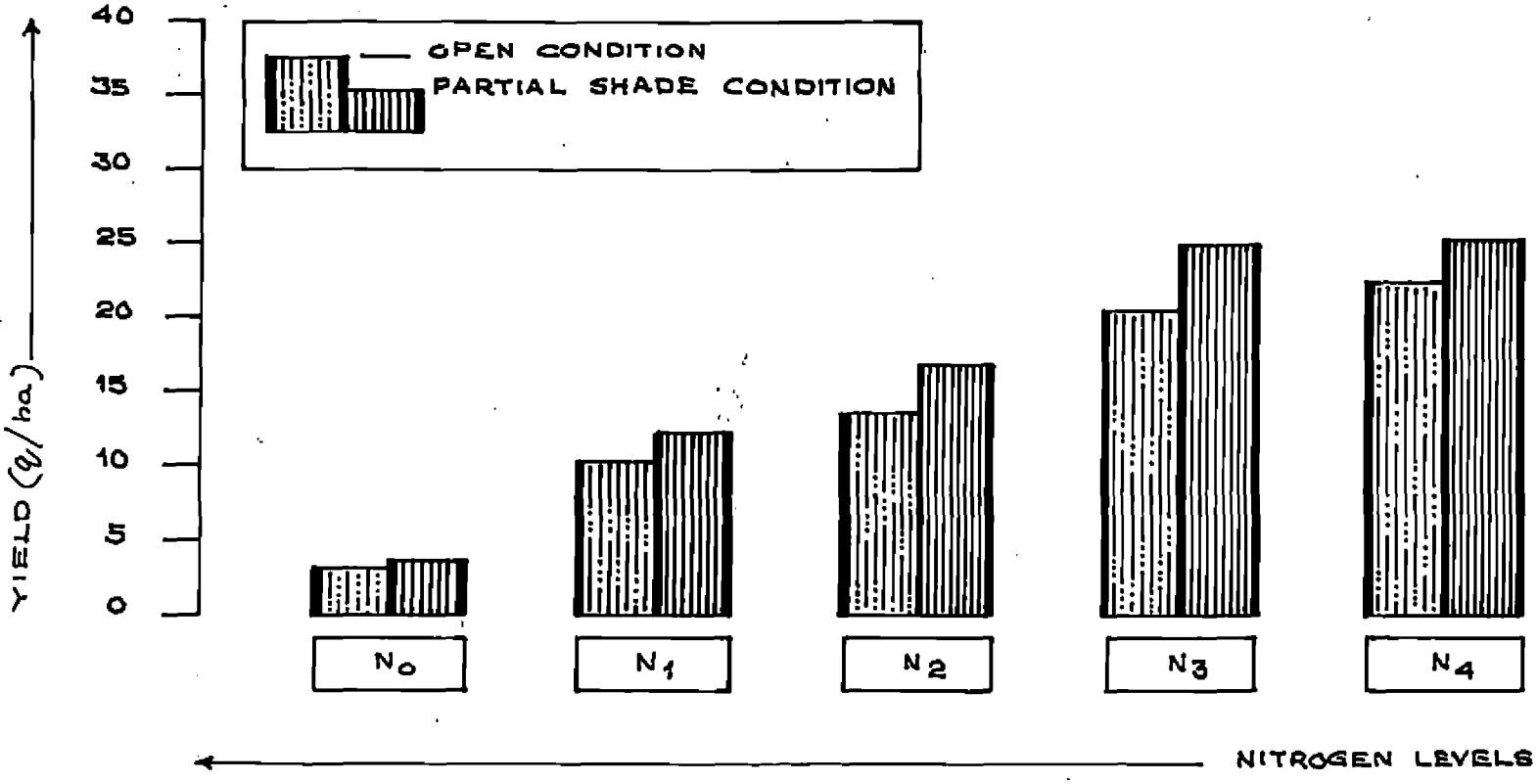
Varieties also showed difference in the number of days taken for silking. Among the varieties Deccan-101 required the lowest number of days for silking under both situations.

8. Grain yield

The data presented in Tables 11 and 28 revealed that application of nitrogen increased the total grain yield significantly under both open and partial shade conditions. A positive linear increase in grain yield was observed upto 150 kg N/ha under both situations. When the level of nitrogen increased to 200 kg/ha grain yield increased from 20.71 q to 22.73 q/ha under open condition and from 25.08 q to 25.24 q/ha under partial shade condition. Thus an increase of 50 kg N/ha produced only a marginal increase in grain yield. It may be mentioned in this connection that the same trend was observed in the case of cob characters and thousand grain weight also. Therefore it is quite natural that the yield was also increased only marginally at the highest level of nitrogen.

This phenomenon was explained by Hageman and Flesher (1960) in the following way. The nitrates reaching the tops represent the excess of absorption over reduction in the root system. The reduction of nitrates requires energy

FIG. 3. YIELD OF GRAIN UNDER OPEN AND PARTIAL SHADE CONDITIONS



and carbohydrates to provide the organic and skeleton for amino acids and acid amides. Thus the excess of nitrate absorption in plant tissues induces limitation over accumulation of carbohydrates in general and starch in particular in the seeds because of oxidation of carbohydrates to supply energy for nitrate reduction. Such a biochemical process in maize might have been responsible for a stagnation in grain yield after 150 kg N/ha. However, Parr (1967) stated that when larger amount of NO_3 is absorbed by plants, it is not properly reduced to NH_4 due to inefficient NO_3 reductase enzyme system. Thus excessive NO_3 accumulation results in plant metabolites and often limits the grain yield.

Varietal differences were also significant both under open and partial shade conditions. Variety Ganga safed-2 produced the highest grain yield under both situations. Under open condition, four varieties viz. Ganga safed-2, Histarch, Vijay composite and Ageti-76 did not differ significantly and Deccan-101 recorded the lowest grain yield. But under shade condition, Ganga safed-2 differed significantly from all the other varieties. However, Histarch, Vijay composite and Ageti-76 did not differ significantly between one another under partial shade condition also. Deccan recorded the lowest grain yield.

It is a well known fact that among the major plant nutrients, nitrogen admittedly is the principal element influencing the yield of maize (Raheja et al. 1957). The favourable effect of nitrogen in increasing the total grain yield has been reported by many workers like Pushpangaden (1965), Sharma (1973), Mahesh Pal and Panwar (1974), Reddy and Kaliappa (1974) Sandhu et al. (1975) and Barthakur et al. (1975). Workers like Rajput et al. (1970) and Verma and Singh (1971) specifically observed significant response upto 180 kg and 150 kg N/ha respectively. According to workers like Reddy et al. (1977), Shinde and Khuspe (1978) and Prasad (1978) maize shows yield response only upto 150 kg N/ha. Nair et al. (1966) reported an yield increase in maize upto 158 kg N/ha. Sharma (1978) conducted trials with nitrogen rates upto 240 kg/ha and reported that the economic optimum nitrogen rate was 145-164 kg/ha although there was marginal yield increase upto the highest level.

In varietal trials Sharma et al. (1969) reported the highest grain yield response to applied nitrogen at 200 kg/ha by Ganga safed-2. Brar and Khehra (1977) reported the highest grain yield for Vijay with 150 kg N/ha. Rao et al. (1978) from trials with 10 maize cvs, highest primary production was reported by Ganga safed-2 and the concentration of chlorophyll contents also differed with varieties.

Varietal differences were also reported by several workers like Sharma et al. (1970), Hati and Panda (1970), Mahesh and Panwar (1974) and Sandhu et al. (1975).

9. Stover yield

Nitrogen had significant influence on stover yield under both open and partial shade conditions. It is seen that the data on vegetative characters like height of plants, number of leaves/plant and dry weight/plant also increased with increasing levels of nitrogen under both situations. (Tables 2,3,5,19,20 and 22). Therefore it is quite natural that the yield of stover which is the final expression of all the vegetative characters also varied very much on account of different levels of nitrogen. There was a linear significant increase in stover yield upto 200 kg N/ha under both situations.

Varieties also differed significantly in this character. Vijay recorded the highest stover yield both under open and partial shade conditions.

The present result is in conformity with the findings of several workers like Sasidhar and Sadanandan (1972) Kumaraswamy et al. (1975) and Dahotonde and Rahate (1977).

10. Harvest Index (HI)

In the present study it is seen that nitrogen had significant influence on harvest index under both open and partial shade conditions. The maximum HI was obtained at 150 kg N/ha under both conditions. When the level was increased to 200 kg N/ha there was slight reduction in the HI. It is seen that the vegetative characters were significantly influenced by nitrogen and at the same time yield and yield components were promoted only upto 150 kg N/ha. This may probably be the reason for the slight decline in the HI at the highest level of nitrogen.

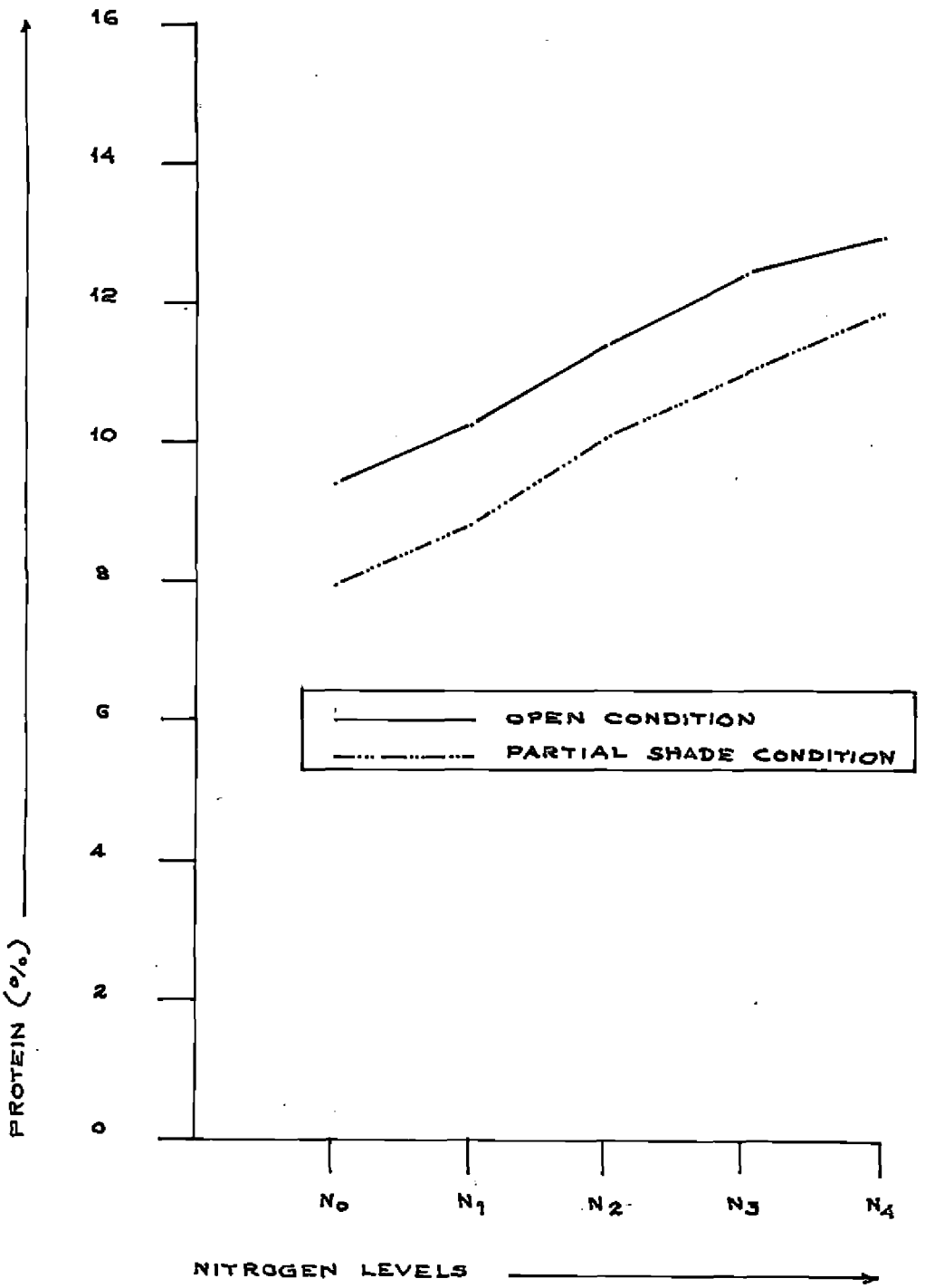
Varieties also had significant influence on HI. It is seen that the variety Ganga safed-2 recorded the highest HI under both open and partial shade situations. From the early discussions it is clear that Ganga safed-2 had recorded the highest grain yield and therefore the HI was also high for this variety. It is also seen that Vijay recorded the lowest HI which produced the highest stover yield.

C. Quality Attributes

Grain protein content

It is seen that the protein content of grain was significantly influenced by different levels of nitrogen under both open and partial shade conditions. There was significant linear increase in grain protein content with increasing levels of nitrogen. 200 kg N/ha produced the

FIG. 4. PROTEIN CONTENT OF GRAIN (%)



maximum grain protein content of 11.81% under partial shade and 12.90% under open conditions.

Increased application of nitrogen will definitely lead to adequate nitrogen supply to the plant which in turn will help for the conversion of higher amounts of carbohydrate into protein. The role of nitrogen in increasing the grain protein content was reported by several workers such as Reddy and Kaliappa (1974), Verma and Singh (1976) and Sadiq et al. (1977). Luber et al. (1954) reported that the crude protein percentage of maize increased with additional doses of nitrogen. Genter et al. (1956) and Hunter et al. (1955) also reported increased protein content with higher levels of nitrogen.

Varieties also differed significantly in their grain protein content. Under open condition, Ageti-76 recorded the highest grain protein content. However, under partial shade condition, Ganga safed- had the highest grain protein content.

D. Uptake of nutrients

Uptake of nitrogen

It is seen that the effect of nitrogen was significant on the uptake of nitrogen by plants at all stages of growth under both open and partial shade conditions. There was

progressive increase in nitrogen uptake with increasing levels of nitrogen. Application of 200 kg N/ha resulted in the maximum uptake of 142.6 kg N/ha under open condition and 161.9 kg N/ha under partial shade condition. Meyer (1973), Tripathi (1978) and Al-Rudha and Al-Younis (1978) also reported that increasing levels of nitrogen resulted in higher percentage of plant nitrogen resulting in increased nitrogen uptake.

Varieties also differed significantly in the nitrogen uptake at different nitrogen levels. Vijay recorded the highest nitrogen uptake under both open and partial shade conditions. This may be due to the higher rate of dry matter production of Vijay variety which has been discussed earlier.

E. Soil nutrient status

1. Total nitrogen content of the soil

The effect of different rates of nitrogen was significant on the total nitrogen content of soil after the experiment under both open and partial shade conditions. Soil nitrogen content decreased after the experiment under both conditions.

Varieties also differed in their effect on residual soil nitrogen. Under both conditions, Histarch extracted maximum amount of nitrogen from soil.

2. Available phosphorus content of the soil

No significant effect was observed on available soil phosphorus content by different levels of nitrogen and varieties under open condition. But under partial shade condition available phosphorus content of soil decreased with increase in nitrogen levels. The highest nitrogen level resulted in the lowest available phosphorus content of the soil. This increase in phosphorus uptake with increased nitrogen levels is supported by several workers like Virmani et al. (1970) and Idris et al. (1976). Among the varieties Histarch extracted the maximum amount of phosphorus from the soil.

3. Exchangeable potassium content of the soil

In this case also no significant difference was observed with increase in nitrogen levels under open condition. But under partial shade condition, the lowest potassium content was observed with the highest nitrogen level. This revealed that the potassium absorption increased with higher levels of nitrogen. This was in conformity with the findings of Dass and Ranjodh Singh (1979) who observed an increase in potassium uptake with increase in nitrogen levels.

Among the varieties, Ganga safed-2 extracted maximum potassium from the soil under open condition and Ageti-76 under partial shade condition.

F. Response of maize to nitrogen

The relationship between grain yield and levels of nitrogen was explained by the quadratic function given in Table 40. Under open condition, the mathematical and economic optimum nitrogen rates were found to be 344.33 kg/ha and 178.64 kg/ha respectively, whereas under partial shade condition, the mathetmatical and economic optimum were found to be 248.36 kg/ha and 159.38 kg/ha respectively. The economic optimum obtained under partial shade condition lies within the range obtained by Sharma (1978).

Pooled analysis of the data

A. Vegetative characters

The pooled analyses of the data on vegetative characters under open and partial shade conditions (Table 36) revealed that height of plants and dry weight/plant were maximum under partial shade condition. But the data on leaf area index and number of leaves/plant were not significantly different under open and partial shade conditions.

Thus it is seen that there was a profused vegetative growth under partial shade condition as compared to open condition. Under shade condition, plants have a tendency to grow high. A comparison of the data on height of plants

in the open (Table-2) and partial shade (Table 19) conditions clearly indicate this tendency of plants. This in turn will result in greater dry weight/plant. However, the exposed leaf area available was not significantly different under open and partial shade conditions.

It may be mentioned in this connection that partial shade condition was provided by locating the experiment in a coconut garden with 50 years old coconut trees. Under such situation about 50 per cent of sunlight will be infiltrated to the ground (Nair, 1979) providing appropriate environment in the interspaces for the proper vegetative growth of plants. On the other hand, the poor growth of plants under open field may be due to the direct exposure to sunshine and consequent high temperature which might have resulted in less availability of soil moisture. This situation has become further aggravated by the fact that the scarcity of soil moisture could not supplemented with irrigation as the crop was raised as rainfed.

This is in conformity with the findings of Harry et al. (1960) who observed that corn hybrids grown under shade performed better in vegetative characters.

B. Yield attributes and yield

The pooled analyses of the data on yield attributes and yield under open and partial shade conditions revealed that the interaction between treatment and location was significant for days to silking, number of cobs/plant, weight of cob and stover yield. But grain yield, length and girth of cobs, thousand grain weight and harvest index were responded uniformly under both open and partial shade conditions.

The stover yield recorded was higher under partial shade condition (Table 37). This was the result of the better vegetative growth under partial shade condition (Table 36). The number of cobs/plant and weight of cob recorded were also higher under partial shade condition (Table 37).

Contrary to the above finding, the grain yield, length and girth of cobs, thousand grain weight and harvest index recorded were on par under both open and partial shade conditions. One might expect a high yield under open condition especially for maize. However, the relatively low yield under open condition may be due to high light intensities in the open field as compared to partial shade which make the chlorophyll work faster, thereby reducing the CO_2 concentration within the leaves resulting in

reduced photosynthetic rate (Papadakis, 1966). The poor uptake of nitrogen under open condition may also influenced the grain yield adversely (Table 39). The reduced soil moisture content due to high rate of evaporation in the field (Wing and Machenzie 1972) would have lead to poor absorption of nutrients under open condition. All the above factors would have created limitations in realising a higher yield from the open condition.

C. Protein content of grains

The pooled analysis of the mean data on protein content of grains under open and partial shade conditions revealed that grain protein content was high under open condition. This result is in conformity with the findings of Barley et al. (1966). They reported that in general there was a significant decrease in grain protein content as light intensities decreased. Jain (1975) also reported that in dry weather, high rates of nitrogen have increased the protein content of the grain.

D. Uptake of nitrogen

The pooled analysis of the mean data on uptake of nitrogen under open and partial shade conditions revealed that nitrogen uptake by plants was higher under partial shade condition. This higher uptake was due to the increased dry matter production under partial shade condition (Table 39)

Wing and Machenzie (1972) reported that shading increased the average soil moisture contents significantly. This increased soil moisture under partial shade would have promoted better vegetative growth resulting in higher uptake of nitrogen.

SUMMARY

SUMMARY

An experiment was conducted at the Instructional farm, College of Agriculture, Vellayani, during 1984-85, to find out the response of five maize varieties viz. Ageti-76, Deccan-101, Ganga safed-2, Histarch and Vijay, to graded levels of nitrogen, grown under open and partial shade conditions simultaneously. The different levels of nitrogen tried were 0,50,100,150 and 200 kg/ha. The experiment was laid out in a 5 x 5 simple lattice design with two replications and 25 treatment combinations. The results of the study are summarised below:

1. The effect of nitrogen on plant height was significant at all stages of growth under open as well as partial shade conditions. Nitrogen at 200 kg/ha produced the maximum height under both open and partial shade conditions. The variety Ganga safed-2 under open condition and variety Vijay under partial shade condition produced the maximum height.

2. Nitrogen at 200 kg/ha recorded the maximum number of leaves at all stages under both open as well as partial shade conditions. Varieties also had significant influence on the number of leaves at all stages under both situations. Variety Ganga safed-2 under open

condition and variety Ageti-76 under partial shade condition recorded the maximum number of leaves.

3. Levels of nitrogen significantly increased the leaf area index at all stages under open and partial shade conditions. However, nitrogen levels of 150 kg/ha and 200 kg/ha were on par in respect of leaf area index under open condition. But under partial shade condition 200 kg N/ha produced the maximum LAI. Among the varieties, Ganga safed-2 recorded the maximum LAI under both open and partial shade conditions.

4. The dry matter production increased with increase in levels of nitrogen at all stages of growth under both open and partial shade conditions. Variety Vijay recorded the maximum dry weight/plant under both situations.

5. Nitrogen at 200 kg/ha recorded the highest number of cobs/plant under both open and partial shade conditions. Varieties Ganga safed-2 and Vijay were on par in the number of cobs/plant under both situations.

6. While the maximum cob length was recorded by nitrogen at 200 kg/ha under open condition, 150 kg N/ha and 200 kg N/ha were on par under partial shade condition. Variety Ganga safed-2 under open condition and varieties Histarch and Vijay under partial shade conditions produced the maximum cob length.

7. Nitrogen rates of 150 kg/ha and 200 kg/ha were on par in respect of girth and weight of cobs under both open and partial shade conditions. In general, varieties Ganga safed-2 and Histarch performed well and almost similar under both conditions.

8. The maximum number of grains/cob was produced by nitrogen at 200 kg/ha under open condition. But under partial shade condition, nitrogen at 150 kg/ha was as good as 200 kg/ha in this respect. The varieties Vijay and Ganga safed-2 produced the maximum number of grains/cob under open and partial shade conditions respectively.

9 The nitrogen levels of 150 kg/ha and 200 kg/ha were on par in respect of thousand grain weight under both open and partial shade conditions. The varieties Ganga safed-2 and Histarch performed almost similar with higher thousand grain weight under both situations.

10. An increase in the levels of nitrogen from 50 to 200 kg/ha significantly reduced the number of days to silking under both open and partial shade conditions. The variety Deccan-101 took the minimum days to silking under both situations.

11. The nitrogen levels of 150 kg/ha and 200 kg/ha were on par under both open and partial shade conditions in respect of grain yield. The variety, Ganga safed-2 produced the maximum grain yield under both open and partial shade conditions.

12. Maximum stover yield was produced by the application of nitrogen at 200 kg/ha under both open and partial shade conditions. The variety Vijay at 200 kg/ha recorded the maximum stover yield under both situations.

13. Highest protein content of grain was recorded by nitrogen at 200 kg/ha under both open and partial shade situations. The variety, Ageti-76 under open and variety, Ganga safed-2 under partial shade produced the maximum protein content of grains at 200 kg N/ha.

14 The nitrogen levels of 150 kg/ha and 200 kg/ha were on par in respect of harvest index both under open and partial shade conditions. The variety, Ganga safed-2 recorded the highest harvest index under both situations.

15 Highest upteke of nitrogen was observed at 200 kg N/ha at all stages under both open and partial shade conditions. The variety, Vijay recorded the maximum

uptake of nitrogen under both open and partial shade situations.

16. The total nitrogen content of soil was significantly influenced by the levels of nitrogen under both open and partial shade conditions. The variety, Histarch extracted the maximum nitrogen from the soil under both situations.

17. The available phosphorus content of soil did not vary much with the levels of nitrogen and between varieties under open condition. But under partial shade situation the available soil phosphorus content decreased with nitrogen levels from 50 to 200 kg/ha. The variety Histarch extracted the maximum phosphorus from the soil.

18. Exchangeable potassium content of soil also did not vary much with the levels of nitrogen under open condition. However, under partial shade situation, exchangeable potassium content of soil decreased with increase in nitrogen levels while Ageti-76 extracted maximum potassium from soil under partial shade conditions, Ganga safed-2 extracted maximum potassium under open condition.

19. Economic optimum levels of nitrogen were worked out to be 178.64 kg/ha and 159.38 kg/ha under open and partial shade situations respectively.

20. Pooled analysis of the data revealed that the vegetative characters height of plants, dry weight/plant etc. performed better under partial shade condition. However, the yield and yield attributes were as good under partial shade situation as that of open condition.

Future line of work

Maize being a new crop being introduced to Kerala, detailed investigations on the management aspects are required. The different levels of phosphorus and potash also may be tried to find out the role of these nutrients on the growth and yield of maize under Kerala conditions.

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* Original not seen

APPENDICES

Appendix Ia

Weather data during the cropping period (1984-85)

Standard week Number	Date	Rainfall (mm)	Temperature (°C)		Humidity (%)
			Maximum	Minimum	
41	October 8-14	9.6	29.25	23.11	78.93
42	" 15-21	0	30.11	21.71	65.36
43	" 22-28	19.9	30.25	22.46	76.57
44	October 29-4th Nov.	0	30.32	23.71	74.21
45	Nov. 5-11	42.5	30.75	23.93	75.93
46	" 12-18	25.2	30.64	24.04	79.79
47	" 19-25	58.3	30.21	23.50	81.71
48	Nov. 26-2nd Dec.	4.6	30.36	23.86	85.00
49	Dec. 3-9	5.4	30.54	23.50	85.07
50	" 10-16	0	30.79	21.57	80.14
51	" 17-23	0	30.17	20.21	75.00
52	" 24-31	0	30.84	20.78	77.56
1	January 1-7	11.7	30.54	21.61	77.93
2	" 8-14	0	30.86	22.39	82.14
3	" 15-21	0	30.71	22.30	80.13
4	" 22-28	0	30.81	22.10	79.86
5	" 20-4th Feb.	0	30.40	21.70	80.50

Appendix Ib

Weather data- Average values for the past 25 years (1959-1983)

Month	Rain fall (mm)	Temperature (°C)		Humidity (%)
		Maximum	Minimum	
January	34.62	30.96	22.39	79.69
February	36.00	31.37	22.85	82.03
March	35.06	32.20	23.94	81.00
April	87.97	32.33	25.02	82.93
May	194.33	31.81	24.89	84.69
June	286.67	30.47	23.91	84.92
July	216.90	29.77	23.43	87.05
August	143.89	29.80	23.20	85.92
September	149.61	30.10	23.34	85.64
October	255.60	29.76	23.74	87.29
November	205.82	29.95	23.71	86.76
December	73.30	30.69	23.23	84.56

Appendix-II

Analysis of variance - height of plant

Open condition

Source	df	Mean square			Harvest
		25 DAS	50 DAS	75 DAS	
Treat (adj)	24	88.08	1171.24	1612.88	1661.69
N	4	191.66**	6506.27**	8118.19**	8381.31**
V	4	329.39**	376.11**	1290.91**	1379.38**
N x V	16	1.85	36.27	67.05**	52.37
Blocks within rep	8	0.93	31.28	38.38	52.73
Intra block error	16	3.01	20.15	13.40	22.54

Partial shade condition

Source	df	Mean square			Harvest
		25 DAS	50 DAS	75 DAS	
Treat (adj)	24	250.02	2752.18	2777.96	2934.54
N	4	963.44**	15537.03**	15464.91**	15621.94**
V	4	248.40*	758.44**	806.44**	1079.78*
N x V	16	72.73	54.41	99.11**	226.38
Blocks within rep	8	233.33	11.85	22.09	178.33
Intra block error	16	54.82	34.51	12.85	147.26

* Significant at 5% level
** Significant at 1% level

Appendix III

Analysis of variance - Number of leaves/plant

Open condition

Source	df	Mean square		
		25 DAS	50 DAS	75 DAS
Treat (adj)	24	1.98	3.98	4.61
N	4	7.33**	19.27**	20.93**
V	4	3.38*	3.17*	3.88*
N x V	16	0.29	0.36	0.71
Blocks within Rep	8	0.31	0.32	0.48
Intra block error	16	0.44	0.81	0.70

Partial shade condition

Source	df	Mean square		
		25 DAS	50 DAS	75 DAS
Treat (adj)	24	1.16*	3.99**	3.23**
N	4	3.73*	19.53*	16.46*
V	4	2.68	3.53	1.98
N x V	16	0.13	0.22	0.23
Blocks within Rep	8	0.23	0.47	0.60
Intra block error	16	0.33	1.0075	0.32

** Significant at 1% level

* Significant at 5% level

APPENDIX V

Analysis of variance - Dry weight/plant

Open condition

Source	df	Mean square			
		25 DAS	50 DAS	75 DAS	Harvest
Treat (adj)	24	3.98	205.85	377.79	3675.34
N	4	16.80**	733.96**	2158.40**	20916.97**
V	4	5.83**	332.69**	42.11*	873.78**
N x V	16	0.32	42.11**	16.55	65.32**
Blocks within Rep	8	0.12	17.63	9.01	7.56
Intra block error	16	0.22	6.03	9.78	11.10

Partial shade condition

Source	df	Mean square			
		25 DAS	50 DAS	75 DAS	Harvest
Treat (adj)	24	3.86	186.47	509.89	3294.01
N	4	16.15**	878.33**	2687.79**	17536.31**
V	4	6.36**	171.98**	287.80**	1884.13**
N x V	16	0.16	17.12**	20.93**	85.91**
Blocks within Rep	8	0.35	12.96	6.71	10.23
Intra block error	16	0.08	2.89	4.72	5.73

** Significant at 1% level

* Significant at 5% level

Appendix IV

Analysis of variance - Leaf Area Index

Open condition

Source	df	Mean square		
		25 DAS	50 DAS	75 DAS
Treat (adj)	24	0.0012**	0.209**	0.23**
N	4	0.0051	1.040	1.13
V	4	0.0015*	0.154*	0.14*
N x V	16	0.0001	0.015	0.02
Blocks within Rep	8	0.0001	0.023	0.03
Intra block error	16	0.0001	0.024	0.02

Partial shade condition

Source	df	Mean square		
		25 DAS	50 DAS	75 DAS
Treat (adj)	24	0.0020	0.408	0.43
N	4	0.0073**	1.879**	1.92
V	4	0.0037*	0.427*	0.66
N x V	16	0.0003	0.035	0.07
Blocks within Rep	8	0.0003	0.051	0.08
Intra block error	16	0.0003	0.077	1.01

** Significant at 1% level

* Significant at 5% level

APPENDIX VI

Analysis of variance - Number of cobs/plant, length of cob, girth of cob, weight of cob and Number of grains/cob

Open condition

Source	df	Mean square				
		Number of cobs/plant	Length of cob	Girth of cob	Weight of cob	Number of grains/cob
Treat (adj)	24	0.0128**	8.49**	4.29**	3181.52**	8772.08**
N	4	0.057**	41.26**	17.74**	18266.63**	50619.56**
V	4	0.0076**	6.35**	7.35**	532.16**	608.94*
N x V	16	0.0031**	0.82	0.16	72.59	350.99
Blocks within Rep.	8	0.0008	0.51	0.22	28.21	321.00
Intra block error	16	0.0005	0.42	0.37	33.94	137.58

Partial shade condition

Treat (adj)	24	0.0219**	8.46**	3.37**	4225.03**	14060.13**
N	4	0.1027**	36.33**	15.01**	22464.00**	79534.25*
V	4	0.0199*	10.63*	3.94	2110.31*	3580.50
NxV	16	0.0023	0.95	0.32	193.97	311.50
Blocks within Rep	8	0.0051	6.42	0.32	22.49	519.70
Intra block error	16	0.0008	0.94	0.42	75.37	410.05

** Significant at 1% level
* Significant at 5% level

APPENDIX VII

Analysis of variance - Thousand grain weight, Days to silking, Grain yield, Stover yield, harvest index and protein content of grains

Open condition

Source	df	Mean square					
		Thousand grain weight	Days to silking	Grain yield	Stover yield	Harvest index	Protein content of grains
Treat (adj)	24	3862.00**	48.85**	100.33**	406.29**	0.0030**	3.95**
N	4	22885.42*	230.70**	503.60*	2374.83**	0.0141**	21.10**
V	4	163.84	57.60**	50.37	55.90	0.0034*	2.26
N x V	16	30.68	1.21	12.00	1.75	0.0001	0.08
Blocks within Rep	8	26.92	10.83	22.51	5.61	0.0011	0.22
Intra block error	16	26.76	1.40	11.72	1.76	0.00005	0.04
				Partial shade condition			
Treat (adj)	24	4476.20	20.74	138.11	566.54	0.0022	4.21
N	4	25608.56**	109.52**	821.02**	3331.07**	0.0096**	24.69**
V	4	885.75**	7.97**	4.99**	54.48**	0.0026**	0.19*
N x V	16	90.72	1.74**	0.66**	3.42	0.00023	0.10**
Blocks within Rep	8	77.49	4.31	0.15	5.75	0.0003	0.09
Intra block error	16	62.35	0.34	0.14	1.60	0.0001	0.03

** Significant at 1% level

* Significant at 5% level

APPENDIX VIII

Analysis of variance - Uptake of nitrogen

Open condition

Source	df	Mean square			
		25 DAS	50 DAS	75 DAS	Harvest
Treat (adj)	24	23.24	731.16	1467.87	2839.52
N	4	113.40**	3189.05**	8491.20**	16102.59**
V	4	20.23**	765.08**	172.66*	834.27**
N x V	16	1.46*	108.21**	35.84	25.06
Blocks within Rep	8	0.27	33.70	22.64	7.06
Intra block error	16	0.57	10.95	45.41	23.98

Partial shade condition

Source	df	Mean square			
		25 DAS	50 DAS	75 DAS	Harvest
Treat(adj)	24	26.78	867.54	1786.57	3404.21
N	4	141.01**	4603.97**	10051.45**	13659.22**
V	4	17.82**	396.82**	534.84**	1644.03**
N x V	16	0.47	51.11**	33.28*	30.51*
Blocks within Rep.	8	1.13	12.39	7.48	43.79
Intra block error	16	0.54	5.23	10.86	10.84

** Significant at 1% level

* Significant at 5% level

APPENDIX IX

Analysis of variance - Total nitrogen content of soil, available phosphorus content of soil and exchangeable potassium content of soil

Open condition

Source	df	Mean square		
		Total nitrogen content of soil	Available phosphorus content of soil	Exchangeable potassium content of soil
Treat (adj)	24	0.0014	0.78	1.95
N	4	0.003**	1.33	1.42
V	4	0.001*	0.41	5.23*
N x V	16	0.0011*	0.73	1.27
Blocks within rep.	8	0.0001	1.06	4.08
Intra block error	16	0.0002	1.46	1.29

Partial shade condition

Total (adj)	24	0.0024	3.19	3.14
N	4	0.0019**	6.69*	7.48*
V	4	0.0062**	11.12*	4.60*
N x V	16	0.0015**	1.43	1.68
Blocks within rep.	8	0.00006	3.70	2.99
Intra block error	16	0.000025	1.04	0.81

** Significant at 1% level

* Significant at 5% level

APPENDIX X

Analysis of variance - Pooled analysis of vegetative characters

Source	df	Mean square			
		Height of plant	Number of leaves/plant	Leaf Area Index	Dry weight/ plant
Location (L)	1	22468.5	23.82	13,24	4317.38
Treat (adj)	24	2199.12	3.53	0.27	3425.46
N	4	11892.06	18.53	1.42	19085.34
V	4	1053.09	1.94	0.16	1301.47
N x V	16	62.39	0.18	0.01	41.48
Treat x Location	24	85.80**	0.38	0.022	59.24**
Error	32	13.075	0.255	0.006	4.21

** Significant at 1% level

APPENDIX XI

Analysis of variance - Pooled analysis of yield attributes and yield

Source	df	Mean square				
		Number of cobs per plant	Length of cob	Girth of cob	Weight of cob	Thousand grain weight
Location	1	0.022	7.62	13.73	1740.56	1896.81
Treat (adj)	24	0.016	8.07	3.75	3643.58	4133.19
N	4	0.078	38.24	16.32	20226.58	24203.88
V	4	0.013	7.80	5.40	1178.72	440.34
N x V	16	0.0015	0.54	0.19	114.04	38.60
Treat x Location	24	0.0013**	0.41	0.085	60.49*	35.92
Error	32	0.0003	0.34	0.20	27.33	22.28

** Significant at 1% level

* Significant at 5% level

(contd.)

APPENDIX XI (Contd.)

Source	df	Mean square			
		Days to silking	Grain yield	Stover yield	Harvest index
Location	1	144.16	77.80	269.02	0.000083
Treat (adj)	24	30.98	121.45	481.66	0.0025
N	4	163.36	715.71	2831.35	0.0117
V	4	20.47	10.87	52.59	0.00295
N x V	16	0.51	0.525	1.50	0.000136
Treat x Location	24	3.77**	1.20	4.76**	0.000057
Error	32	0.44	2.96	0.84	0.0000375

** Significant at 1% level

* Significant at 5% level

APPENDIX XII

Analysis of variance - Pooled analysis of protein content of grain and Uptake of nitrogen

Source	df	Mean square	
		Protein content of grain	Uptake of nitrogen
Location	1	22.33	2790.19
Treat (adj)	24	3.95	3121.86
N	4	22.83	17515.45
V	4	0.73	1132.74
N x V	16	0.033	20.74
Treat x Location	24	0.128*	31.09**
Error	32	0.016	8.70

** Significant at 1% level

* Significant at 5% level

RESPONSE OF MAIZE VARIETIES TO GRADED LEVELS OF NITROGEN GROWN UNDER OPEN AND PARTIAL SHADE CONDITIONS

BY

LINCY XAVIER

ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted at the Instructional farm, College of Agriculture, Vellayani, to find out the response of maize varieties to graded levels of nitrogen grown under open and partial shade conditions simultaneously with different levels of nitrogen viz. 0, 50, 100,150 and 200 kg/ha and five varieties viz. Ageti-76, Deccan-101, Ganga safed-2, Histarch and Vijay. The experimental was laid out in a 5 x 5 simple lattice design with two replications and 25 treatment combinations.

Nitrogen had significant effect on plant height, number of leaves, leaf area index and dry matter production and the highest values were recorded at 200 kg N/ha under both open and partial shade conditions. Under open condition, variety Ganga safed-2 produced the maximum height, number of leaves and leaf area index where as Vijay produced the maximum dry weight/plant. But under partial shade conditions Vijay recorded the maximum height of plants and dry weight/ plant whereas Ageti-76 recorded the maximum number of leaves and Ganga safed-2 the maximum leaf area index. Under open condition, application of 200 kg N/ha recorded the highest number of cobs/plant, length of cob and number of grains/cob, where as 150 kg N/ha was sufficient to produce the maximum girth and weight of cob and thousand grain weight. But

under partial shade condition 150 kg N/ha was sufficient to produce the maximum length, girth and weight of cobs, number of grains/cob and thousand grain weight where as 200 kg N/ha produced the maximum number of cobs/plant. The variety Ganga safed-2 performed good in these characters under both open and partial shade conditions. Minimum number of days to silking was recorded by Deccan-101 at 200 kg N/ha under both conditions.

Grain and straw yields were the highest with 150 and 200 kg N/ha respectively under both open and partial shade conditions. Variety Ganga safed-2 produced the maximum grain yield and Vijay recorded the maximum stover yield under both open and partial shade conditions.

Protein content of grains and nitrogen uptake were maximum at 200 kg N/ha under both open and partial shade conditions. Varieties Ageti-76 under open and Ganga safed-2 under partial shade condition recorded the highest protein content of grain. Variety Vijay recorded the maximum nitrogen uptake under both conditions.

Application of 150 kg N/ha was sufficient to produce the maximum harvest index under both situations. Variety Ganga safed-2 recorded the maximum harvest index under both situations.

Total nitrogen content of soil was significantly influenced by levels of nitrogen under both open and partial shade conditions. Histarch extracted maximum nitrogen under both situations. Available phosphorus and potassium content of soil were lowest at 200 kg N/ha under partial shade conditions. Under open condition, these values were not influenced by N levels. Varieties, Histarch and Ageti-76 extracted maximum phosphorus and potassium respectively under partial shade condition.