RESPONSE OF MAIZE VARIETIES GROWN IN RICE FALLOWS TO GRADED LEVELS OF NITROGEN

BY

K. JALEESA

THESIS
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D E C L A R A T I O N

I hereby declare that this thesis entitled "RESPONSE OF MAIZE VARIETIES GROWN IN RICE FALLOWS TO GRADED LEVELS OF NITROGEN" 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.

K. JALEESA

Vellayani,
25.04.1987.

C E R T I F I C A T E

Certified that this thesis entitled "RESPONSE OF MAIZE VARIETIES GROWN IN RICE FALLOWS TO GRADED LEVELS OF NITROGEN" is a record of research work done independently by Smt. K. JALEESA 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.

(Dr. V.K. SASIDHAR)
CHAIRMAN
Advisory Committee
&
PROFESSOR AND HEAD OF
THE DEPARTMENT OF AGRONOMY

Vellayani,
25.04.1987.

APPROVED BY

CHAIRMAN

Dr. V.K. SASIDHAR

MEMBERS

1. Dr. V. MURALEEDHARAN NAIR

2. Sri. U. MOHAMED KUNJU

3. Dr. (Mrs.) P. SARASWATHY

EXTERNAL EXAMINER

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1. INTRODUCTION

Maize (*Zea mays* L.) occupies a unique position among foodgrains because of its adaptability to wide range of soil and climatic conditions. It is one of the important crops which not only meets the dietary needs of man but provides raw materials for a wide variety of industrial products also. Because of the above qualities and also of its world wide distribution and lower price, maize has a wider range of uses than any other cereal. It is used in direct human consumption in industrially processed foods, as a livestock food. In addition, industrial non-food products like starches are also produced from maize. Recently there has been interest in using maize for ethanol production as a substitute for petroleum based fuels.

It has been proved beyond doubt that use of hybrid varieties is the key to higher yields in maize. Hybrid maize being a heavy feeder is found to be very responsive to fertilizer nutrients. The average grain yield of maize in India is reported to be very low (1 ton/ha). However, the yields upto 11.5 t/ha have been reported at certain places through improved agronomic practices (Jain, 1981). It is very correctly said, "the sun never sets on a growing maize crop". This is because of its physiological adaptability to widely varying agroclimatic condition.

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INTRODUCTION

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Fertilisation of maize with nitrogen plays an important role in increasing productivity. Identification of suitable variety and optimum dose of nitrogen is an important step towards securing higher yield in maize. Crop breeders have developed hybrid and composite maize varieties which have much greater yield potentials than the indegenous maize varieties. Several researchers like Meenakshi et al (1975), Sharma (1978), Ranjodh Singh et al (1980), Halemani et al (1980), Singh (1982), Singh et al (1984) and Patel et al (1985) have reported that suitable maize varieties and proper nitrogen fertilisation have profound influence on yielding ability of maize.

High yield potential of hybrid and composite maize had lead its cultivation in different parts of the country. For the exploitation of yield potentials from these composites and hybrids also, proper fertilization is a must. On account of the vast variation in the agroclimatic regions of the country it is very important to initiate studies to screen out the most suitable hybrids or composites and the most economic level of nitrogen.

In Kerala it is not grown extensively except in the border areas of Tamil Nadu and Karnataka. However, greater possibilities exist in the partially shaded areas under coconut trees for the cultivation of maize in the state as revealed in a previous experiment conducted at Vellayani.

Another potential area available for the purpose is the rice fallows spread over the entire state with sufficient source of irrigation. However, suitable variety of maize and nitrogen dose have not been identified under the rice fallow situation so far. Therefore an experiment has been conducted in the rice fallows during the summer season with the following objectives.

1. To find out the most suitable variety of maize to be grown under rice fallows condition.

2. To fix up the optimum dose of nitrogen for each variety under rice fallows condition.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The available literature on the influence of nitrogen on various growth characters, yield components and yield, quality parameters and uptake of major nutrients by maize crop are reviewed here under.

2.1. Growth Characters

Growth characters of maize are probably more limited by a deficiency in nitrogen than by any other nutrient (Gangwar and Kalra, 1981). Considerable improvements in the general growth and drymatter accumulation of maize plants by the application of fertilizer nitrogen have been reported by workers like Ahlawat et al (1975) and Singh and Guleria (1979).

2.1.1. Plant height

Nitrogen application has a positive effect on height of plants. Nair et al (1966) reported that there was a linear increase in plant height with increasing levels of nitrogen. Rajput et al (1970) suggested that the increase in nitrogen rates were accompanied by a linear increase in plant height upto a level of 160 kg N/ha. According to Hati and Panda (1970) increase in the rates of fertilizers resulted in an increase in plant height. Sumbali and Omprakash (1971) reported that nitrogen had shown a significant increase in plant height and maximum height of

290 cm was recorded at 120 kg N/ha. Mandloi et al (1972) concluded that the crop growth expressed by plant height was successively improved with an increase in the rate of nitrogen. Sharma (1973) in his studies on the response of maize to nitrogen fertilization revealed that the increasing rates of applied nitrogen increased the plant height. Rajagopal and Morachan (1974) observed that nitrogen significantly increased the plant height. Rajan et al (1974) reported that the plant height was maximum at the highest dose of nitrogen (120 kg N/ha). Sattar et al (1975) found that maximum plant height was given by flint maize with 180 kg N/ha. El-Sharkawy et al (1976) observed that the plant height was increased with increasing nitrogen application. According to Rathore et al (1976) there was a steady increase in plant height with increasing levels of nitrogen. They also reported that the plant height of variety Vijay was higher than Gamga-101, but the difference recorded was not significant. The result of experiment conducted by Gangro (1977) revealed that the increase in applied nitrogen upto 300 kg N/ha increased the plant height Again Gangro (1978) reported a linear increase in stem height with increasing rates of nitrogen upto 200 kg/ha. Mohammed et al (1978) reported that the height per plant increased significantly with increasing levels of nitrogen.

According to Salem and Aly (1979) there was no significant difference between cultivars in plant height. Muthukrishnan and Subramonian (1980) reported that the plant height increased linearly with increasing levels of nitrogen fertilization. Shafenale *et al*. (1981) suggested that the growth components of maize were increased by increasing nitrogen fertilizer levels. Singh *et al*. (1982) reported that nitrogen application to maize increased the plant height. Similar trend was observed by Chao *et al*. (1982) and Salem *et al*. (1983). Adeteliyo *et al*. (1984) suggested that in maize shoots, stem growth appeared to have been influenced mostly by nitrogen application.

However, reduction in plant height with increase in nitrogen levels was also reported by many workers. El-Hattab *et al*. (1980) obtained a decrease in plant height with increasing nitrogen rate. Yahya and Andrew (1981) also observed a negative response in plant height. Russel (1984) reported that the effects of nitrogen treatments were not significant for plant height. Farah *et al*. (1984) reported a positive but diminishing response to increasing levels of nitrogen in terms of plant height.

2.1.2. Number of leaves per plant.

According to Rajput *et al*. (1970) number of leaves increased linearly with increasing levels of nitrogenous fertilizers. Hati and Panda (1970) reported linear increase in the number of leaves per plant with increasing nitrogen rates. Sumbali and Omprakash (1971) reported that eventhough the number of leaves per plant was not affected significantly with increasing levels of nitrogen individually, the maximum number of leaves was recorded at 90kg N/ha. The results of experiment conducted by Gangro (1977) showed increase in the number of leaves per plant with increased rate of nitrogen. Yahya and Andrew (1981) showed significant linear increase in leaf number with increasing levels of nitrogen. Adetiloye et al.(1984) suggested that the leaf growth has been influenced mostly by nitrogen fertilization.

2.1.3. Leaf Area Index.

Saxena and Singh (1965) estimated the use of a factor 0.75 for converting the product of length and maximum width of maize leaves to a closed approximation of the actual leaf area.

Hati and Panda (1970) suggested that the leaf area per plant increased as a result of the increases in the rate of fertilizers. According to Rajagopal and Morachan (1974) differences in LAI was reported to be increased by the application of nitrogenous fertilizers. Krishnamoorthy et al. (1974) reported that increasing rates of nitrogen had a significant effect on leaf area index. Studies conducted by Kuznetsov (1979) revealed that the increasing fertilizer nitrogen rates from 60 to 180 kg/ha increased the leaf area index. The results of experiment conducted by Krishnamurthy (1975) indicated that summer planting exhibited faster growth of crop enabling early achievement of larger leaf area index. Later Gangro (1977) showed that the leaf area index was increased with increasing nitrogen levels. Ignatova (1978) reported that the applied fertilizers increased the leaf area per plant. Mikhail and Shalaby (1979) found that high rates of nitrogen had a significant influence on leaf area index. Athar (1979) studied the physiological characteristics of hybrids and found that the mean leaf area index increased with increased application of nitrogen fertilizers and the mean leaf area index at high grain yields occurred at 100 kg N/ha. Investigation carried out by Elias et al. (1979) revealed that increased rates of nitrogen had a positivey effect on leaf area index and maximum dry matter yield was obtained at a leaf area index of 5.5.

Later El-Hattab et al. (1980) showed that leaf area and leaf area index were increased with increasing nitrogen rates and the leaf area index was greatest at silking. Studies conducted by Gangwar and Kalra (1981) found that the leaf area index of rainfed maize increased with increase in nitrogen rates from 40 to 120 kg N/ha.

Nagy (1982) suggested that the highest yields were associated with 6-6.12 leaf area index. According to Salem et al. (1983) nitrogen application indreased the leafarea index significantly.

2.1.4. Days to Silking

Studies conducted by Sharma (1970))revealed that the application of higher doses of nitrogen enhanced the days to maturity by a week. According to Mandloi et al. (1972) early silking was recorded with the application of nitrogen at different dose. They also found that the number of days to silking after planting was significantly less by 6-10 days with the application of 160 kg N/ha. Sharma (1973) suggested that increasing the rates of applied nitrogen decreased the days to silking.

Rathore et al.(1976) found that the silking was earlier with 160 kg N/ha by a margin of 10 days over control. This result was in accordance with the results of Sharma and Gupta (1968). Athar (1979) reported that the days to 50% silking increased with increasing plant population but decreased with increased nitrogen fertilization.

El-Hattab et al. (1980) found that increasing level of nitrogen led to early silking. Later Yadav et al. (1983) observed that the application of 70-120 kg N/ha encorraged the days to silking by 5 to 7 days.

However, according to Nair et al. (1966) earliness is cobbing was not significantly influenced by the various nitrogen treatments.

2.1.5. Drymatter Production

Virmani et al. (1970) reported that increasing nitrogen rates upto 150 kg/ha had a significant effect on drymatter production Later Chan and Mackonjic (1972) found that the nitrogen increased the drymatter yields during vegetative growth. Gill et al. (1972) found significant increased in drymatter yield with increasing nitrogdn levels upto 100 kg/ha while Krishnamoorthy et al.(1974) in a varietal trial reported that the highest value of drymatter was recorded by Deccan with 200 kg N/ha. Agarwal et al.(1974) reported that there was a significant increase in the yield of drymatter with increase in nitrogen application. According to Ahlawat et al.(1975) nitrogen fertilization increased the drymatter accumulation and the rate of drymatter accumulation was faster in nitrogen fertilized plants and the per plant dryweight increased continuously upto 90-95 days.

Later, Martin (1978) suggested that the highest drymatter yields were obtained with the combinations containing the highest proportion of nitrogen. Hamissa et al.(1979) and Mikhail and Shalaby (1979) reported an increasing trend in drymatter production with increased nitrogen rates.

Kuznetsov (1979) observed that there was a relationship between fertilizer rates, increases in biomass production and drymatter accumulation.

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) also. But Muthukrishnan and Subramonian (1980) reported that the plant drymatter increased linearly with increasing levels of nitrogen, maximum drymatter being recorded at 180 kg N/ha

Stoyahov (1983) reported that increasing NP rates favourably influenced the chlorophyll content which inturn was correlated with drymatter accumulation. Later Meisinger *et al*.(1985) found that the corn drymatter yields exhibited strong nitrogen response.

2.2. Yield Components

2.2.1. Number of Cobs per plant

Studies conducted by Singh (1964) showed that nitrogen increased the number of cobs per plant. Sharma *et al*. (1969) reported that increasing rates of nitrogen had a significant effect on the number of cobs per plant. Sharma (1973) also reported an increase in the number of cobs per plant with increased rates of applied nitrogen. Later, Sattar et al.(1975) observed higher number of cobs per plant with 120 kg N/ha. Rathore et al.(1976) found that the number of cobs per plant increased significantly with increase in nitrogen levels.

The results of field trials conducted by Brar and Khehra (1977) revealed that there was an increase in the number of cobs per unit area with increased rate of applied nitrogen upto 150 kg/ha. According to Kayode and Agboola (1981) nitrogen affected the number of cobs per plant. Later Short et al. (1982) also reported an increase in number of cobs per plant with increased nitrogen. Similar trend in number of cobs per plant was reported by Karim et al. (1983) and Adetiloye et al. (1984). Russel (1984) also observed significant linear increase in the number of ears per plant with increased nitrogen levels upto 240 Kg N/h

2.2.2. Number of grains per cob

Rajput et al.(1970) reported that increasing levels of nitrogen not only increased the number of cobs per plant, but increased the number of grains per cob also. Similar trend was seen by Arora et al.(1973). Sattar et al. (1975) observed a higher number of grains per ear with 120 kg N/ha. According to Rathore et al.(1976) the number of grains per cob showed a linear increase with increasing levels of nitrogen upto 160 kg/ha.

Krishnamoorthy et al. (1977) found that the variety Vijay had the highest number of grains (491) per ear. Later Al-Rudha and Al-Younis (1978) observed an increasing trend in number of grains per cob with increasing rates of nitrogen. Kharkar (1980) reported a linear increase in the grain weight per ear with increasing levels of nitrogen. Muthukrishnan and Subramonian (1980) found that the number of grains per ear showed a positive effect with each additional level of applied nitrogen.

2.2.3. Length of Cob

Hati and Panda (1970) reported a linear increase in cob length with increase in fertilizer nitrogen upto 100 kg/ha. However, according to Rathore et al. (1976) the length of cob increased linearly upto 160 kg N/ha. Further Gangro (1978) observed that the ear length was increased with increase in applied nitrogen upto 300 kg Nh/ha. Similar increasing trend in earlength with increased nitrogen upto 200 kg N/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. Studies conducted by Muthukrishnan and Subramonian (1980) revealed that the length of cob was increased with increasing levels of nitrogen in cv. Ganga-5.

The results of experiment conducted by Subramonian et al. (1982) revealed that the cob length exhibited progressive increase with each additional level of nitrogen starting from 60 kg N/ha. Later Russel (1984) observed a significant linear reponse in ear length higher doses of nitrogen. Adetiloye et al. (1984) also observed an increase in cob length with nitrogen fertilization.

However, Karim et al. (1983) suggested that the ear length was unaffected by nitrogen fertilization.

2.2.4. Girth of Cobs

Nair et al. (1966) found that there was an increase in the girth of cob with increase in nitrogen levels. El-Sharkawy et al. (1976) reported an increase in the diameter of cobs upto 104 kg N/ha. Rathore et al. (1976) observed that the thickness of cob increased linearly in girth upto 160 kg N/ha. Subramonian et al. (1982) also reported significant increase in the girth of cob with increasing levels of applied nitrogen. Recent investigation by Russel (1984) showed significant linear response in the ear diameter with different levels of nitrogen.

2.2.5. Weight of Cob

In field trails conducted, Nair et al. (1966) reported an increase in nitrogen level. Hati and Panda (1970) reported a linear increase in cob weight with increase in fertilizer nitrogen upto 100 kg N/ha. The results of investigation done by Rajan and Sankaran (1974) revealed that the cob weight was influenced mainly by different levels of nitrogen fertilization. Rathore et al. (1976) found significant increase in the weight of cobs with the addition of nitrogen upto 160 kg N/ha. The results of field trial conducted by Brar and Khehra (1977) revealed an increase in cob weight upto 150 kg N/ha. Similar increasing trend in cob weight with increased nitrogen upto 200 kg/ha was reported by Shalaby and Mikhail (1979), Sciput et al. (1979), El-Hattab et al. (1980) and Karim et al. (1983). But according to Kharkar (1980) the increase in cob weight was only upto 160 kg N/ha.

2.2.6. Thousand grain weight

According to Singh (1964) application of nitrogen fertilizers increased the weight of grains. But studies conducted by Nair et al. (1966) revealed that nitrogen levels had no significant effect on the test weight of grains. However, there was a progressive trend showing that as nitrogen level increased the test weight was also increased. The lack of significance may be because the difference between levels of nitrogen may not be sufficient to show a significant increase in the test weight of grains.

Rajput et al. (1970) reported that nitrogen levels upto 160 kg/ha increased the thousand grain weight significantly. Tripathi (1971) observed that the best weight of grains increased linearly with increasing nitrogen levels. Sharma (1973) also observed a linear increase in thousand grain weight with increased rate of applied nitrogen. Rajan and Sankaran (1974) found that the grain weight was influenced chiefly by levels of nitrogen.

According to Rathore et al. (1976) thousand grain weight increased progressively with increasing levels of nitrogen upto 160 kg/ha after which it showed a negative trend. Later Subramonian (1977) reported that applied nitrogen increased the thousand grain weight. Krishnamoorthy et al. (1977) found the lowest thousand grain weight (232 g) in Cv. Vijay.

Al-Rudha and Al-Younis (1978) observed an increase in thousand grain weight upto 120 kg N/ha. However, according to Sciput et al. (1979) the increasing trend in thousand grain weight was seen upto 200 kg N/ha. Shalaby and Mikhail (1979) also observed increased thousand grain weight with 200 kg N/ha. But Kharkar (1980) in his rainfed trials with hybrids recorded a linear response only upto 160 kg N/ha.

Studies conducted by Muthukrishnan and Subramonian (1980) revealed that increasing levels of nitrogen increased the thousand grain weight. The results of investigation done by Subramonian et al. (1982) showed that the test weight of grain increased with successive application of nitrogen.

Later Russel (1984) reported a linear increase in thousand grain weight upto 240 kg N/ha.

2.3. Yield

Nair *et al.* (1966) observed a linear increase in grain yield of maize with fertilizer nitrogen at different levels. According to Singh (1967), the grain yields increased with increasing levels of applied nitrogen only upto 89.67 kg/ha, but higher rates were not effective. Singh and Sharma (1968) found significant increase in grain yield with 80 kg N/ha. Nair and Bains (1968) reported that the highest yields were obtained with 120 kg N/ha. But Overton and Long (1969) in their studies with graded doses of nitrogen in maize observed maximum grain yield at 150 kg N/ha.

Tewary *et al.* (1970) reported a linear increase in grain yield with 150 kg N/ha. Hati and Panda (1970) observed a linear increase in grain yield with fertilizer nitrogen upto 100 kg N/ha, where as Rajput *et al.* (1970) reported a linear increase in grain yield upto 180 kg N/ha. Verma and Singh (1971) reported that increasing nitrogen rates from zero to 150 kg/ha increased the average grain yields from 0.97 to 3.07 t/ha and further increase in nitrogen rates decreased the yields. The linear response of maize upto 180 kg N/ha was reported by Shah et al. (1971, Sumbali and Omprakash (1971) obtained maximum grain yield with 120 kg N/ha. But Srivastava et al. (1971) observed a significant yield increase with nitrogen level upto 160 kg N/ha. According to Rathi and Ali (1972) application of nitrogen exerted a linear increse in grain yield upto the highest dose of 120 kg N/ha. Similar linear increase in grain yield was reported by Sasidhar and Sadanandan (1972) during summer in red loam soils of Kerala. Mandloi et al. (1972) showed a significant increase in grain yield with increase in nitrogen level upto 160 kg N/ha.

Studies conducted by Sinha and Umar (1972) indicated that the yield of maize increased with nitrogen application upto 165 kg/ha, but decreased at 220 kg/ha. Applied nitrogen showed both positive linear and a negative quadratic effect on yields. With the higher nitrogen rates increases in yield resulted from nitrogen fertilization, but the yields decreased at nitrogen rates above 224 kg/ha (Powell and Webb, 1972). Krishnamoorthy and Weeks (1972) also observed an increase in grain yield upto 160 kg N/ha, but declined beyond this level. But Power et al. (1972) reported that the corn production was highest at 110 kg N/ha.

Malik (1973) found a significant increase in grain yield upto 120 kg N/ha, while Arora et al. (1973) obtained a significant yield increase upto 150 kg N/ha. Significant increase in yield with 80 kg N/ha was reported by Dungarwal et al. (1973).

Joginder Singh (1974) reported that the application of nitrogen from zero to 240 kg N/ha increased the grain yields. The results of experiment conducted by ShanmughasSundaram et al. (1974). showed that increasing nitrogen rates from nil to 72 kg/ha increased grain yields from 3.41 to 5.19 t/ha. Rajan and Sankaran (1974) recorded the maximum grain yield with 120 kg. N/ha. This was in agreement with the studies conducted by Agrawal et al.(1974), Rajan et al.(1974) and Reddy and Kaliappa (1974).

The results of trials conducted by Bharthakur et al. (1975) and Mehta and Kothari (1975) during summer revealed that the nitrogen rates of 160 kg/ha resulted increase in the average grain yield. But Kumaraswamy et al.(1974) observed a linear increase in grain yield with increasing nitrogen application upto 180 kg/ha. There was an increase in grain yield with increase in nitrogen rates though not significant as reported by Naidu and Reddy (1975). Sandhu et al.(1975) obtained the highest average yield of 6.19 t/ha at 150 kg. N/ha and lowest yield of 3.91 t/ha were obtained at 59 kg. N/ha.

Nathu Singh et al.(1976) observed that in sandy loam soil, increasing nitrogen rates from zero to 120 kg. N/ha increased the grain yields from 1.49 to 2.9 t/ha. El-Sharkawy et al.(1976) and Verma and Singh (1976) observed a linear increase in grain yield upto 120 kg. N/ha, after which led to reduction in yield. But significant response were obtained by Moolu *et al.* (1976) upto 80 kg N/ha.

Reddy *et al.* (1977), Brar and Khehra (1977) and Bhushan *et al.* (1977) found a significant yield increase with increase in applied nitrogen upto 150 kg/ha. The results of experiment conducted by Santos and Olson (1977) revealed that nitrogen fertilizers significantly increased the grain yields but there was no significant difference in yield between nitrogen applied at 75 or 150 kg/ha. Raut and Ali (1977) reported an increase in grain yield upto 180 kg N/ha. Vatsa *et al.* (1977) obtained the highest grain yield with 200 kg N/ha. Dahotonde and Rahata (1977) reported increased grain yields upto 250 kg N/ha. Gonzales *et al.* (1977) reported that the best yield of 4.89 t/ha was obtained from plot given 120 kg N/ha.

Shukla *et al.* (1978) in their studies on the response of rainfed maize to nitrogen application revealed that the highest grain yield was obtained with 60 kg N/ha. Tripathi (1978), Singh and Sheo Prasad (1978) Hussein and Hanna (1978), Al-Rudha and Al-Younis (1978) and Hera *et al.* (1978) obtained yield responses only upto 120 kg N/ha. Studies conducted by Mohammed *et al.* (1978) and Prasad (1978) revealed that the grain yields increased significantly with increasing nitrogen rates upto 150 kg N/ha. Ranjodh Singh *et al.* (1979) observed high response to nitrogen application upto 80 kg N/ha. However Sharma *et al.*

(1979) and Sood et al.(1979) observed significant response of fertilizer nitrogen upto 180 kg N/ha. But Rendig and Broadbent (1979) found that 180 kg and 360 kg N/ha were not significantly different in yield response. Koraiem et al.(1979) reported a linear increase in grain yield with nitrogen levels upto 225 kg/ha but was depressed by higher rates. Shalaby and Mikhail (1979) and Salem and Aly (1979) reported an increasing trend in grain yield with increasing rates of nitrogen. Sciput et al. (1979) and Elias et al.(1979) also reported increased grain yield upto 200 and 170 kg N/ha respectively. But Palacios (1979) found that 140 kg N/ha was the most efficient nitrogen rate. Zabelyi (1980), Dev et al.(1980) and Halemani et al. (1980) reported an yield increase upto 150 kg N/ha. The results of trials conducted by Kapur and Rana (1980) and Inshin (1980) showed significant yield response to nitrogen fertilizers upto 120 kg/ha. Workers like Magdoff and Amadon (1980), Grove et al. (1980), Guleria and Singh (1980) El-Hattab et al.(1980), Gawael (1980), Kharkar (1980) Effimov and Naumenko (1980) also recorded similar observations.

Stancjlovic and Pantovic (1981) in their studies observed that the optimum rate of nitrogen was 130 kg/ha. Mate and Ciobanu (1981) found that the economic optimum nitrogen rate was 98 - 127 kg/ha. According to Hera and Mihalia (1981) highest grain yields were obtained with 160 kg N/ha. But Gangwar and Kalra (1981) and Singh et al.(1981) found response only upto 120 kg N/ha. 100 kg N/ha was found to increase the grain yield according to Baltasar (1981), Sarkar and Sinha (1981) and Kayode and Agboola (1981).

Ciobanu (1981) reported that the maximum grain yield were achieved with 128 - 178 kg nitrogen and more economic yields were obtained with 87 - 127 kg/ha. According to Tianu et al. (1981) the economically optimum rate of nitrogen ranged from 178 to 184 kg/ha. But Knapp and Reid (1981) suggested that the optimum nitrogen was 120 to 180 kg N/ha. Gotmanota et al. (1981) found that increasing nitrogen rates from 0 - 180 kg/ha increased the grain yield. Barua et al. (1981) observed 80 kg N/ha is the optimum fertilizer dose for obtaining profitable yield of high yielding varieties of maize.

Mihajlovic (1982) suggested the optimum nitrogen rate for obtaining economic return as 140 kg N/ha. But Marinkovic (1982) and Barnard and Hornby (1982) observed yield response upto 150 kg N/ha. Subramoniam et al. (1982) and Short et al. (1982) and Rucka (1982) found that the application of graded doses of nitrogen exhibited pronounced effect on grain yield. But the highest yield being achieved with 120 kg N/ha as reported by Reddy and Patil (1982) and Tripathi and Singh (1982). Balasubramoniam and Singh (1982) observed higher yield response to nitrogen and they found that the calculated nitrogen rate for maximum yield was 177.5 kg N/ha.

Later Okajima *et al.* (1983) and Rouf and Islam (1983) observed that maize responds well upto 200 kg N/ha. According to Curic and Savic (1983) maize grain yield showed appreciable response to nitrogen rates upto 100 kg/ha. Several workers viz., Huq (1983) Salem *et al.* (1983), Suwanarit *et al.* (1983, Kumar *et al.* (1983) reported that increasing nitrogen rate increased the grain yield. Yadav *et al.* (1983) observed yield response only upto 120 kg N/ha.

Grain yield of maize increased significantly with increas in nitrogen upto 99 kg/ha (Singh *et al.*, 1984). Farah *et al.* (1984) observed the yield response upto 321 kg N/ha. According to El-Hattab and Gheith (1984) grain yield increased from 3.63 to 6.7 t/ha with increasing nitrogen rates. This results was in agreement with the studies of Below *et al.* (1984) and Bagal and Shinglo (1984).

Negrilla *et al.* (1984) in their studies conducted under non-irrigated condition revealed that the most economic nitrogen rate for grain production was 143 kg N/ha. Increased grain yield due to nitrogenous fertilisation was reported by Brar and Bhajan Singh (1984), Yahya (1984) Podolok (1984) Kitur *et al.* (1984).

Isfan (1985) found significant yield increase with increased nitrogen rates. According to Palmer (1985) yield responded to nitrogen application and generally the yields were higher in dry season than in wet season. But Patel et al. (1985) found increased grain yield due to nitrogen application only upto 120 kg N/ha.

From the results of trial conducted by Gjanamoorthy and Iruthayaraj (1986), it is seen that the maize crop was the best remunerative crop in respect of yield, net profit, per day income and per rupee invested at a spacing of 50 x 20 cm with 120 kg N/ha.

2.3.1.2. Grain yield of different varieties

Sharma and Gupta (1968) reported a significant increase in grain yield of maize variety Ganga safed-2 with increasing levels of nitrogen upto 100 kg/ha and there was further non-significant increase with 160-250 kg N/ha. Sharma et al. (1969) also observed a highest grain yield response to applied nitrogen at 200 kg/ha in Ganga safed-2. Sharma (1970) in his experiment observed that the hybrid Ganga-5 out yielded Vijay and the economic optimum dose of nitrogen was in between 145 and 164 kg/ha. Pande et al.(1970) found that the grain yield of hybrid maize out yielded the local varieties. Bapna and Trivedi (1971) also reported a linear increase in grain yield in Ganga safed -2 with 150 kg N/ha. But Pathak et al.(1971) found that the hybrids recorded a large increment in yield with 100 kg N/ha.

According to Sinha and Umar (1972) Ganga safed-2 proved superior to the hybrids. The results of trial conducted by Jain et al. (1972) indicated that the hybrid Ganga-3 and composite Vijay gave significantly higher grain yields.

Sharma (1973) showed that the Cv. Hi-Starch gave an average yield of 8.08 t/ha. Experiment was conducted by Chaudhary et al. (1973) with recently evolved maize hybrids and composites and found that they differ in their yield potential and Ganga safed -2 yielded significantly higher than all other germplasm. According to them, among the composites Vijay gave significantly higher yield.

Maheshpal and Panwar (1974) reported that Ganga-101, Ganga-3 and Type 41 gave linear responses to nitrogen upto 144 kg N/ha, and the grain yields at this level of nitrogen were 3.32, 4.82 and 3.18 t/ha respectively. Meenakshi et al. (1975) reported that the hybrids Deccan and Hi-starch gave higher grain yields with an NPK schedule of 132-66-44 kg/ha in summer season and they found that Hi-starch is suited for summer alone.

Shukla and Bhardwag (1976) found that the average grain yield of maize hybrid Ganga-5 increased from 2.2 to 3.34 t/ha with increasing nitrogen rates from 30 to 60 kg N/ha. Khan and Singh (1979) reported that the hybrids and composites yielded 3.1 to 4.04 t/ha. According to Ekka et al. (1977), grain yields of maize cv. Vijay increased from 3.26 to 3.9 t/ha with increasing nitrogen rates from 80 to 160 kg N/ha. But Krishnamurthy (1977) obtained a grain yield of8.68 t/ha in Vijay at 120 kg N/ha. Shinde and Khuspe (1978) formed that the grain yield of Ganga-5 and Ganga Safed-2 given 0-159 kg N/ha increased linearly from 2.35 to 4.64 t/ha with increase in nitrogen rates. Sharma (1978) reported that the economic optimum rate was 145-164 kg/ha and the highest grain yield was obtained with hybrid cv. Ganga-5.

According to Ranjodh Singh et al. (1980) the grain yield of cv. Vijay, Ganga-5 and Ganga Safed-2 were 2,893,21 and 3.57 t/ha respectively. With regard to the varietal responses, Rai et al. (1981) observed that average yield of Hi-starch during Rabi season was 6.4 t/ha where as during Khariff it was 3.5 t/ha. Sarkar and Sinha (1981) found that the grain yields of Agethi-76 and Vijay were 3.08 t/ha and 2.99 t/ha respectively.

According to Singh et al. (1982) Ganga Safed-2 was proved as most adaptable among the Indian hybrids followed by Vijay and Ganga-4.

Contrary to the above findings, some workers observed non-significant response and even negative response. Naidu and Reddy (1975) indicated that the varieties in grain yield due to nitrogen levels was not significant. Again Verma and Singh (1976) observed an yield reduction with rates of applied nitrogen above 120 kg N/ha. Shukla and Bhardwaj (1976) also reported a decreasing trend in yield with higher doses of nitrogen above 60 kg N/ha. Later Singh et al. (1978) also obtained same results with nitrogen rates above 60 kg/ha. Khan et al. (1980) reported that nitrogen had no effect on grain yield. According to Santos et al. (1983) the increasing nitrogen rates accelerated the competition between ear differenciation and final harvest and thus inhibited grain formation which resulted in reduction in grain yield per plant.

2.3.2. Stover yield.

Nair et al. (1966) found that increase in nitrogen levels increased the yield of stover. This was in agreement with the results obtained by Singh (1967) and Singh and Sharma (1968), Bapna and Trivedi (1971) and Tripathi (1972). According to Sasidhar and Sadanandan (1972) also higher levels of nitrogen viz, 120 kg/ha gave significantly higher yield of stover. This result is in conformity with the findings of Sumbali and Omprakash (1972) who reported progressive increase in stover yields with increasing levels of nitrogen.

There was considerable increase in straw yield with every increment of nitrogen as suggested by Shanmughasundaram et al. (1974). Kumaraswamy (1975) observed that nitrogen fertilization progressively increased the straw yield. Mehta and Kothari (1975) obtained a stover yield of 93 quintals per hectare at 200 kg N/ha. But later El-Sharkarwy et al.(1976) obtained the highest stover yield with 104 kg N/ha. According to Verma and Singh (1976) nitrogen application upto 120 kg N/ha increased the straw yields. Santos and Olson (1977) found significant differences in silage yields with increasing levels of nitrogen. But Dahotonde and Rahate (1977) reported an increase in straw yield from 2.21 to 5.02 t/ha with nitrogen rates from zero to 250 kg/ha.

According to Singh and Sheoprasad (1978) application of 120 kg N/ha progressively produced the highest stover yield. 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 nitrogen levels upto 200 kg, 150 kg and 120 kg N/ha respectively.

Gawad et al.(1980) reported that straw weight increased with increasing nitrogen application. Ranjodh Singh et al. (1980) reported that the stover yields of Vijay, Ganga-5 and Ganga safed-2 were 6.31, 6.9 and 8.0 t/ha respectively. Singh et al.(1982) suggested that the stover yield improved with different levels of nitrogen application. Burnard and Hornby (1982) observed significant increase in the forage yield upto 150 kg N/ha.

2.3.3. Harvest Index.

Mikhail and Shalaby (1979) reported that the harvest index increased with increased nitrogen rates. Similar result was obtained by Elias et al.(1979) also.

Investigations conducted by Grove t et al.(1980) revealed that there was no significant change in harvest index with increasing fertilizer nitrogen rates. According to Hemcoff (1983) harvest index was the same for high as well as low nitrogen levels.

2.4.1. Effect of nitrogen on grain quality.

Increased protein content due to application of nitrogen was reported by many workers, viz, Luber et al.(1954), Hunter and Yunger (1955) and Puntamkar et al.(1965).

Labshina and Moslov (1967) found that the protein content of maize grain was progressively and significant increased by increasing the nitrogen levels.

Investigation carried out by Shukla and Wassay (1970) found that the high protein content is not only a varietal character but it can be increased to 10.42% by the application of nitrogenou fertilizers at the rate of 112 kg N/ha. Tripathi (1971) also foun increased protein content with increasing levels of nitrogen.

Singh Verma *et al.* (1972) found that increased doses of nitrogen application increased the protein content in grains. Gill *et al.* (1972) reported that application of nitrogen @ 100 kg/ha showed a marked increase in crude protein content of hybrid maize.

Studies conducted by Gupta *et al.* (1972) revealed that the nitrogen concentration and hence the crude protein in grain were significantly increased by the application of nitrogen. Sinha and Umar (1972) observed that the protein content increased with increasing levels of nitrogen. This was in agreement with the findings of Chowdhary *et al.* (1973).

According to Shanmugasundaram *et al.* (1974) the effect of increased fertilizer was seen in the crude protein content of grain which was increased upto 72 kg N/ha and there after it declined. Rajagopal *et al.* (1974) reported that the different levels of nitrogen increased the protein content of the whole plant. Reddy and Kaliappa (1974) conducted studies on the effect of graded doses of nitrogen on the protein content of grain in maize and found that the grain protein content in maize increased with increase in applied nitrogn upto 150 kg/ha. Perry and Olson (1975) also found that nitrogen levels influenced the protein content of grain. Verma and Singh (1976) found that the protein content of grain was improved by increased nitrogen application. Subramonian (1977) found an increase in grain protein content with increased doses of nitrogen fertilizers.

Investigations carried out by Sadiq et al. (1977) found that the nitrogen fertilization upto 200 kg N/ha increased the protein content of grain. According to Rendig and Jimenoz (1978) as the level of nitrogen fertilizers increased, nitrogen concentration in the grain rises as a result of which the protein content was increased. Gangro (1978) in his study found that the grain protein content was increased by increase in applied nitrogen. The results of experiment conducted by Lixandru et al. (1979) showed that grain protein content ranged from 10.1 to 11.8% at 100 kg N/ha. Rendig and Broadbent I1979) reported that grain crude protein content increased from zero to 10% when applied nitrogen increased from zero to 90 kg/ha to 180 and 360 kg N/ha. Effimov and Naumenko (1980) found that the application of nitrogen fertilizers increased the protein content. This was in confirmation with the findings of Gawad (1980) and El-Hattab et al. (1980).

Saad et al. (1981) reported that grain protein content showed an increase from 11.75 to 15.5% which increasing nitrogen rates. Increasing nitrogen rates from 0-180 kg/ha increased the grain protein contents (Getmanets et al., 1981)

Yahya and Andrew (1981) and Shafshak et al. (1981) observed a similar increasing trend in protein content with higher levels of applied nitrogen.

Mercy George and Mohammedakunju (1983) found that the crude protein yield of maize could be increased significantly by the application of fertilizers @ 160:80:80 kg NPK/ha.

2.5.1. Effect of nitrogen on the uptake of major nutrients.

An understanding of soil plant relationships, plant nutrition and fertilization requires a knowledge of variability of the chemical composition and uptake of elements by the plants.

Studies conducted by Pathak *et al.* (1971) found that the increasing levels of nitrogen fertilization increased the nutrient uptake of maize. Saxena and Gautam (1971) reported that there was a trend for increase in the nitrogen content as the nitrogen level was raised upto 134 kg N/ha. The results of experiment conducted by Paliwal and Maliwal (1971) revealed that the uptake of nitrogen was increased at all stages of plant growth with the application fertilizers. Later Pathak and Tewari (1972) reported an increase in the nitrogen and phosphorus content of maize plant and decrease in potassium content with increasing levels of nitrogen. They also reported that the total uptake of nutrients was higher in hybrids than local varieties.

According to Khera and Tyagi (1972) maize crop varieties differ in their nutrient removal and therefore in their fertilizer requirements. They found that Ganga-5 removes 2.78 kg nitrogen per one quintal production of grain where as Vijay removes only 2.65 kg nitrogen per quintal of grain. There was an appreciable increase in soil nitrogen uptake byamaize crop which increased with increase in applied nitrogen levels. Mahapatra and Jha (1973) reported a nutrient uptake of 150 kg to 250 kg nitrogen, 35-90 kg P_2O_5 and 100-200 kg K_2O/ha for maize crop of 6000 kg grain per hectare. Rajan and Sankaran (1974) reported that the nutrient uptake by the crop was indreased for each increment of nitrogen from 0-120 kg/ha.

Singh Verma et al.(1972) Meyer (1973) El-Shafery et al. (1975), Sharma et al.(1975) Ildris et al.(1976) Sreenivasan et al. (1976). Al-Rudha and Al-Younis (1978) all observed that increasing the levels of nitrogen resulted in higher per cent of plant nitrogen resulting in increased nitrogen uptake.

In irrigated trials conducted by Tripathi (1978) when maize was given combinations of 0-120 kg N and 0-90 kg P_2O_5/ha, the uptake of nitrogen and phosphate was almost in 2:1 rates. Gangro (1978) also reported an increase in leaf content of nitrogen with increasing levels of applied nitrogen upto 200 kg/ha. But Dass and Ranjodh Singh (1979) found that the nitrogen uptake increased only upto 120 kg N/ha.

Hamissa et al.(1979), gGhaly et al.(1979) Cancino and Mabbayad (1979) and Khan et al.(1980) also found that higher level of nitrogen increased the nitrogen uptake. Grove et al.(1980) observed that the average uptake of soil nitrogen was 70 kg/ha per crop and the average nitrogen content of above ground drymatter at maximum yield was 1.18% where as the average nitrogen content in the grain ranged from 1.45 to 2.27% nitrogen (Russel and Pierre 1980). They also indicated that the nitrogen per cent of maize given at maiximum yield might serve as a usuful supplementary guide in nitrogen sufficiency diagnosis. El-Hattab et al. (1980) reported that increasing nitrogen rates led to the increasing total nitrogen content and phosphorus contents of grain. According to Nayyar and Sawarkar (1980) the uptake of fertilizers increased with nitrogen and phosphorus rates. According to the resuts of trials conducted by Hera and Mihalia (1981) the grain containied 1.15 to 1.41% N, 0.46 to 0.57% P_2O_5 and 0.35 to 0.42% K_2O when maize was given 160 kg N and 120 kg P/ha. The uptake of N, P & K increased significantly as the nitrogen application was enhanced (Subramonian et al, 1982).

Later Chao et al. (1982) reported an increase in grain nitrogen content and nitrogen uptake in maize with increasing nitrogen fertilization. Similar increased uptake of nitrogen was observed by several workers like Singh et al. (1982), Balasubramoniam and Singh (1982) and Salem et al. (1983).

Rouf and Islam (1983) observed that grain nitrogen and phosphorus content which were 1.36 to 1.75% and 0.15 to 0.22% respectively increased with increased nitrogen application but relatively unaffected by phosphorus. The results of experiment conducted by Curic and Savic (1983) revealed that the nitrogen concentration in plants increased in response to nitrogen rates upto 150 kg/ha. According to them, the amounts of phosphorus and potassium taken up also increased with rate of nitrogen applied. Later Okajima *et al.* (1983) and Farah *et al.* (1984) reported increasing nitrogen uptake with increased levels of nitrogen upto 200 and 300 kg N/ha respectively. Martin *et al.* (1984), Nemoth (1984) and Below *et al.* (1984) observed increase in the nitrogen concentration in plants response to different rates.

Lack of influence of nitrogen on the uptake of nutrients was also reported by many workers. El-Baissary *et al.* (1980), Albegov (1981) and Rhoads and Stanly (1981) reported that increased nitrogen levels had no significant influence on nitrogen uptake. According to Huq (1983) increasing nitrogen application from zero to 100 kg/ha reduced the grain with nitrogen content from 1.75% to 1.6%, but increasing application from 150 to 450 kg N/ha increased the nitrogen content oto 1.97%.

Virmani *et al.* (1970) observed that phosphorus uptake was increased with increasing nitrogen rates upto 150 kg/ha. Thein and Mefees (1972) reported that the nitrogen treatment in maize significantly increased the phosphorus absorption. Barber (1978) reported that phosphorus uptake by plants growing in soil is affected by the rate of phosphorus supply from the o soil and phosphorus absorption characterstics of the roots. Dass and Ranjodh Singh (1979) found that the plant content of phosphorus and potash increased with increased nitrogen dose upto 120 kg N/ha. According to Khan et al. (1980) phosphorus content decreased with nitrogen application. Smith and Jackson (1982) also observed that nitrogen treatment affects the mechanism of phosphorus uptake.

Shah et al. (1971) found that the response of maize variety Ganga.101 to potassium application was statistically significant only when 180 kg nitrogen was applied per hectare.

Roy and Chatterjee (1972) observed that the uptake of potassium in maize safflower sequence was higher than that in the groundnut sequence when the crop was supplied with 120 kg nitrogen, 25.8 kg phosphorus and 33.2 kg potash/ha. Bajwa and Paul (1978) reported that the total removal of potash by the maize crop increased appreciably with the application of nitrogen alone and also of nitrogen in combination with phosphorus.

2.5. Correlation Studies

Puntamaker et al. (1965) reported that the crop yield was correlated with the uptake of nitrogen by the plant. Studies conducted by Singh (1970) revealed that grain yields showed the highest positive correlation with ear girth followed by earlength. But Pande et al. (1970) found that the plant height, no. of grains/ cobs, grainyield per plant and 1000 grain weight were positively correlated with grain yield/ha. Saxena and Gautam (1971) reported that the percentage of nitrogen and phosphorus in the green leaves showed a highly significant positive correlation with the grain yield. But Venoni (1974/75) observed that eventhough grain yield/ha was not correlated with ear-characters, earlength was positively correlated with number and weight of grains per ear. According to Srinivasan et al.(1976) the grainyields in maize given 0-90 kg N/ha were positively correlated with nitrogen contents of the whole plant at all stages, Trials conducted by Singh and Verma (1977) revealed that the grainyield/plant was positively and significantly correlated with no.of cobs per plant, girth of cobs, no.of rows/cobs and 2.. grain weight. Later Goerts et al.(1978) reported that there was a highly positive a correlated between grainyield and no.of ears per plant and both of them were positively associated with protein yields. According to Muthukrishnan and Subramonian (198.) in Cv. Ganga-5 the LAI showed the highest positive and direct effect on yield followed by grains/per ear and ear length, while thousand grain weight showed a negative direct effect. Tianu et al.(1981) found that the grainyield and nitrogen rates were significantly correlated. But Yahya and Andrew (1981) suggested that the yield and LAI were positively correlated with vegetative characters and yield components.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was undertaken with the objective of selecting the most suitable maize variety that can be grown in rice fallows and also to find out the optimum level of nitrogen for maize cultivation under such situation. The materials used and methods adopted are detailed below:

3.1. MATERIALS

3.1.1. Location.

The field experiment was conducted in the rice fallows of Palappoor area of the Instructional Farm attached to the College of Agriculture, Vellayani in an area of 1500 sq. m. The College is located at 8° N latitude, 76°57' longitude and at an altitude of 29 m above MSL.

3.1.2. Cropping History.

The experiment site was cultivated with a bulk crop of paddy during the previous season.

3.1.3. Season.

Experiment was conducted during summer season (January to April) of the year 1986.

The seeds were sown on 11th January 1986 and gapfilling and thinning were done after one week. The harvest was conducted from 8.4.1986 to 15.4.1986. The duration of varieties ranged from 88-95 days.

3.1.4. Soil.

The soil comes under the textual class of sandy clay loam. Data on the mechanical and chemical analysis of the soil are given below:

Table 1. Soil characteristics of the experimental area.

A. Mechanical composition

Coarse sand	(%)	-	46%
Fine sand	(%)	-	10.4%
Silt	(%)	-	6.6%
Clay	(%)	-	33%

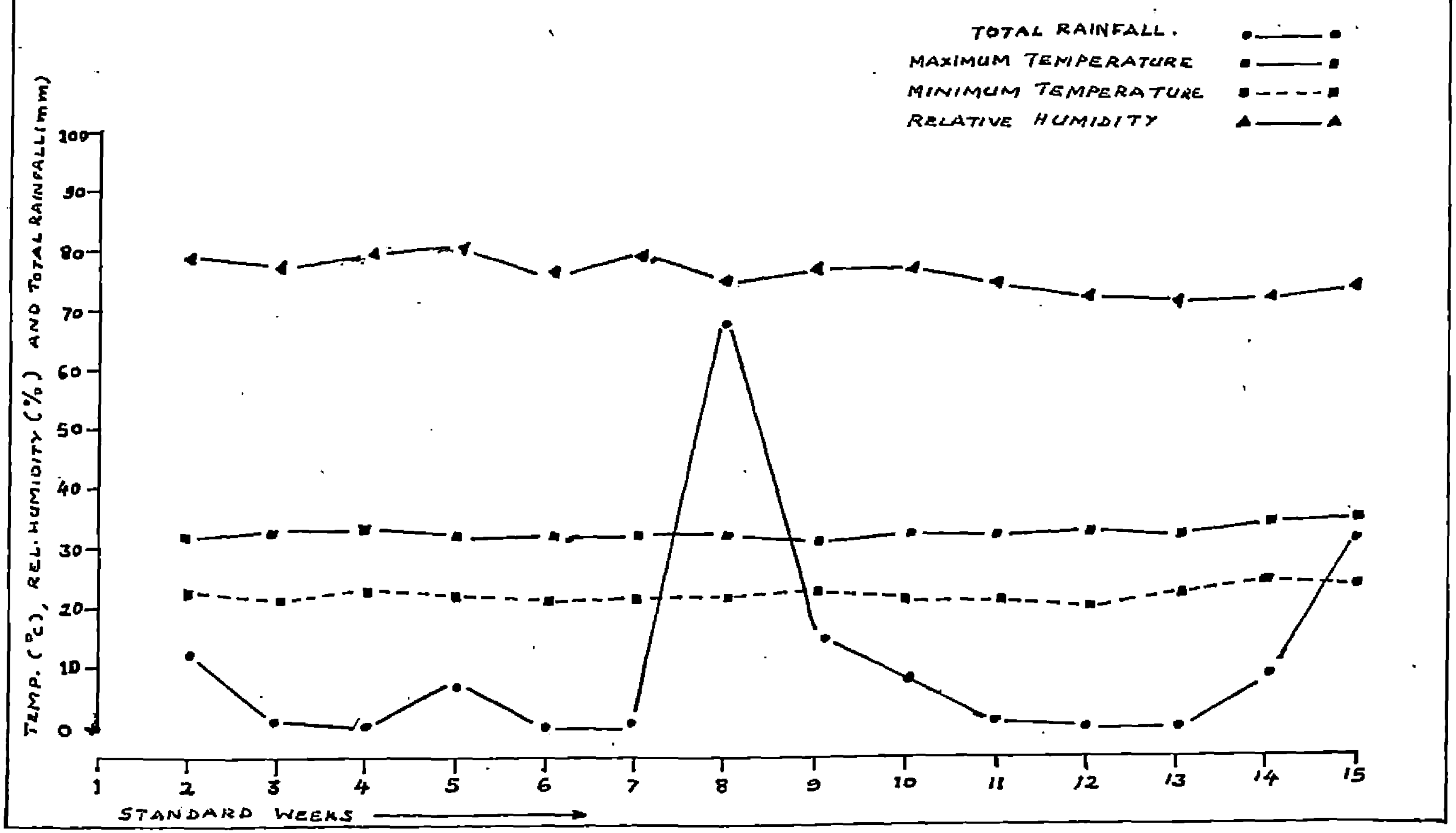
B. Chemical composition

Total Nitrogen	(%)	-	0.074
Available P_2O_5	(kg/ha)	-	12.5
Available K_2O	(kg/ha)	-	208
pH		-	5.3

3.1.5. Climate.

The experimental area enjoys a warm, humid tropical climate and receives a good amount of rainfall by way of South-West and North-East monsoons. The meteorological parameters like rainfall, minimum and maximum temperatures

FIG. 1. WEATHER CONDITIONS DURING THE CROPPING PERIOD



and relative humidity pertaining to the period of field experimentation were recorded from the meteorological observatory of the farm and are presented as weekly averages in Appendix I(a) and monthly averages for the past 25 years are presented in Appendix I(b). It is seen from the data that there was only very little rainfall during sowing time and that at the time of harvest there was no rain.

3.1.6. Variety.

Five varieties of maize (*Zea mays* L.) including hybrids and composites were used for the trial. The varieties for the trial were Ganga Safed-2, Agethi-76, Hi-starch, Vijay and Ganga-5.

Ganga Safed-2 (v_1)	-	White, Semiflint, medium maturing, widely adapted hybrids very popular in maize growing areas. Grain medium, white in colour and resistant to lodging - Pedigree is (cm 400 x cm 300) x (cm 600).
Agethi-76 (v_2)	-	A composite variety Pedigree is JML 603/J 603 and duration is 88 days. Short plant with slightly broader dark gray leaves, grain is medium bold, sound and orange - yellow coloured.
Hi-starch (v_3)	-	Hybrid variety. Pedigree is (cm 400 x cm 300) x cm 601. White, bold dent to semident, medium maturity, good high starch content, tolerant to top shoot borers. Duration is 90 days. Popular in all maize growing areas of India. Plant is tall with broad green thick leaves.

Vijay (V_4) - A composite variety. Pedigree is J1. Duration 95 days. Semiflint yellow seeded fairly resistant to most of the foliar diseases, ears well developed, plants vigorous and study with dark green thick leaves. Grain is medium yellow orgnge coloured.

Ganga - 5 (V_5) - Hybrid variety. Pedigree is (cm 202 x 111) x (cm 500), Very popular in full the maize growing countries of India. Yellow, bold seeded, flint to semiflint, medium maturity considerable resistance to leaf blights, brown stripe, dowry mildew and stem borer.

3.1.7. Seeds.

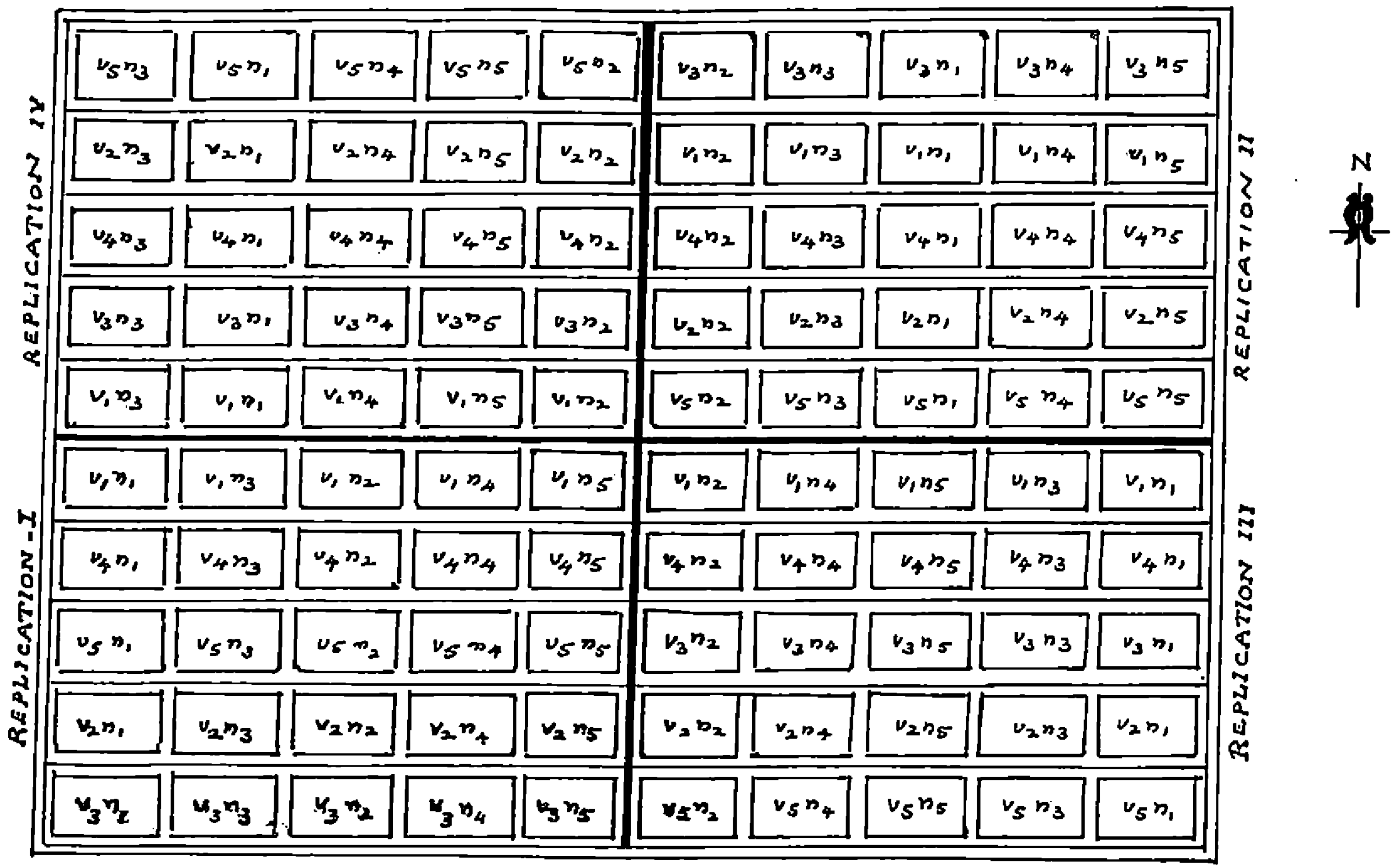
Certified seeds were obtained from the National seeds Corporation, Bangalore. The seeds were tested for viability and were found to give 99 - 100% germination.

3.1.8. Fertilizers.

The following fertilizers were used for the experiments.

Urea	-	46% N
Super Phosphate	-	16% P_2O_5
Muriate of potash	-	60% K_2O

FIG.2. LAY OUT PLAN OF THE EXPERIMENT IN SPLIT PLOT DESIGN



NITROGEN

n_1 --- 50 $kg.ha^{-1}$
n_2 --- 80 "
n_3 --- 110 "
n_4 --- 140 "
n_5 --- 170 "

VARIETIES

v_1 --- GANGA-SAFED-2
v_2 --- AGETHI -76
v_3 --- HI-STARCH
v_4 --- VIJAY
v_5 --- GANGA-5

3.2. METHODS

3.2.1. Design and Layout.

The experiment was laidout in Split plot design with four replications and the plan of layout is presented in fig.2. The details of layout are furnished below:

Design - Split - Plot design.

Varieties		Levels of Nitrogen	
v_1	- Ganga safed - 2	n_1	- 50 kg/ha
v_2	- Agethi - 76	n_2	- 80 kg/ha
v_3	- Hi-starch	n_3	- 110 kg/ha
v_4	- Vijay	n_4	- 140 kg/ha
v_5	- Ganga - 5	n_5	- 170 kg/ha

9 (i) Main plot treatments (v) - 5

v_1	-	Ganga safed -2
v_2	-	Agethi - 76
v_3	-	Hi-starch
v_4	-	Vijay
v_5	-	Ganga - 5

(ii) Sub Plot treatment (n) - 5

n_1	-	50 kg/ha
n_2	-	80 kg/ha
n_3	-	110 kg/ha
n_4	-	140 kg/ha
n_5	-	170 kg/ha

No. of replications - 4 (four)

Treatment Combinations - 25

1. $v_1 n_1$	10. $v_2 n_5$	18. $v_4 n_3$
2. $v_1 n_2$	11. $v_3 n_1$	19. $v_4 n_4$
3. $v_1 n_3$	12. $v_3 n_2$	20. $v_4 n_5$
4. $v_1 n_4$	13. $v_3 n_3$	21. $v_5 n_1$
5. $v_1 n_5$	14. $v_3 n_4$	22. $v_5 n_2$
6. $v_2 n_1$	15. $v_3 n_5$	23. $v_5 n_3$
7. $v_2 n_2$	16. $v_4 n_1$	24. $v_5 n_4$
8. $v_2 n_3$	17. $v_4 n_2$	25. $v_5 n_5$
9. $v_2 n_4$		

Total No. of Plots - 100

Plot size : Gross : $5 \times 3\ m^2$

Net : $4.75 \times 2.4\ m^2$

Spacing : 60 X 25 cm.

No. of plants in the gross plot : 100

No. of plants in the net plot : 54

One row of plants was left out from all the four sides of each plot as border row.

3.2.2. Field Culture.

3.2.2.1. Preparation of field

Experimental field was ploughed twice, stubbles removed and clods broken. The layout of the experiment was made after measuring out the area for each block. The whole field was laid out into four blocks of 25 plots each. One soil sample was collected from each of the four blocks. The plots were seperated with bunds of 30 cm. width and individual blocks were given an outer bund of 50 cm. width. Irrigation channels were provided between the blocks. The area within the plot was thoroughly dug and levelled.

3.2.2.2. Fertilizer application

The different doses of nitrogen were applied according to the treatment schedule. The doses of phosphorus and potash were fixed at the rate of 65 kg. P_2O_5 and 15 kg. K_2O/ha respectively according to the recommendations in the package of practices of Kerala Agricultural University. (1984).

One third the amount of nitrogen and entire quantity phosphorus and potash were applied just before sowing as basal, dressing, one third at knee high stage (30 days after sowing) and the remaining one third at 60 days after sowing (tasseling stage).

3.2.2.3. Seeds and sowing

All the seeds were dibbled at the rate of 2 seeds/hole at a depth of 3 - 5 cm. Gapfilling and thinning were done on the seventh day after sowing to secure a uniform stand for the crop.

3.2.2.4. After cultivation

The soil was stirred lightly and weeds were removed at the time of dressing with nitrogen.

3.2.2.5. Irrigation

One light irrigation was given immediately after sowing followed by two more irrigations in alternate days.

3.2.2.6. Plant protection

Necessary plant protection measures were undertaken as and when required.

3.2.2.7. Crop Growth

In general, the stand of the crop was good. No lodging was observed in any of the treatment.

3.2.2.8. Harvest

The crop came to harvest within a duration of 88 - 95 days and the harvest was completed within a period of seven days, viz, from 8.4.86 to 15.4.86. The border rows of all the plots were harvested and threshed seperately. The crop in each net plot was harvested, threshed and cleaned. The grain and stover of each plot were sundried seperately for two days, and the plot war yields of grain and stover were recorded.

3.2.3. Observations.

All observation on growth characters, yield components and yield were recorded.

3.2.3.1. Observations on growth characters

Six sample plants of maize were selected at random at the rate of two plants from each row and tagged. The observations on growth characters were taken at 20 days interval.

3.2.3.1.1. Height of the plant

The height of the plant from the base to the tip of the top most leaf was measured in centimeters at four stages of growth viz, 20th, 40th, 60th days after sowing and at harvest. The mean height of the plant was then worked out and recorded.

3.2.3.1.2. Number of leaves per plant

Total number of leaves on each six plants were recorded at 20 days interval and the mean number of leaves per plant was worked out.

3.2.3.1.3. Leaf Area Index

Leaf Area Index (LAI) was calculated by dividing the sum of the products of length x breadth x 0.75 (Hunt, 1978) of all leaves of the plant with the land area occupied by the plants.

3.2.3.1.4. Days to silking

The period taken for silking of 50% of the plants from seeding were observed and recorded.

3.2.3.1.5. Leaf-stem Ratio

The sample plants selected at random were seperated into leaf and stem and the ratio was recorded.

3.2.3.2. Observations on Yield components

The observations on yield components were taken at harvest.

3.2.3.2.1. Number of cobs per plant

Number of cobs of each of six sample plants were counted and the mean was worked out for each treatment.

3.2.3.2.2. Length of cob

Cobs from sample plants were measured for length and mean length was then worked out.

3.2.3.2.3. Girth of cob

Girth of the cobs collected from the sample plants selected at random were measured and mean was worked out for each treatment.

3.2.3.2.4. Weight of cob

All the cobs from six sample plants selected at random were weighed and weight per cob was calculated.

3.2.3.2.5. Number of grains per cob

Number of grains per cob from the sample plants selected at random were counted and the mean was computed.

3.2.3.2.6. Thousand grain weight

Weight of thousand grains from each treatment was recorded and the mean was then computed.

3.2.3.3. Observations on Yield

3.2.3.3.1. Grain yield

The grains were seperated from the cobs harvested from each net plot. They were then cleaned and sundried to limit the moisture at 14%. The grains were then weighed and the grain yield was then expressed in kg. per hectare.

3.2.3.3.2. Stover yield

The weight of sundried stover was recorded plotwise and expressed in kg. per hectare.

3.2.3.3.3. Harvest Index

Harvest Index (HI) was worked out from the data on grain yield and stover yield obtained for each plot using the following formula.

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

3.2.4. Chemical Analysis.

3.2.4.1. Plant analysis

The chemical analyses of plant samples collected at harvest stage were done. Samples collected for chemical analysis were ovendried at 80 - 5 C and ground in a Wiley mill.

3.2.4.1.1. Nitrogen content

The total nitrogen content of the plant at the harvest stage was analysed employing the modified micro kjeldahl method (Jackson, 1967).

3.2.4.1.2. Phosphorus content

The Phosphorus content was determined colorimetrically using Vanado-molybdo phosphoric yellow colour method (Jackson, 1967). The colour intensities were read in a Klett Summerson Photo electric colorimeter.

3.2.4.1.3. Potassium content

The potassium contents of the samples were determined by using the EEL flame photometer (Jackson, 1967).

3.2.4.2. Uptake studies

The total quantities of nitrogen, phosphorus and potash absorbed by the crop at harvest were calculated. The value of total uptake was obtained as the product of the per cent content of these nutrients in the plant and the weight of drymatter. The values were expressed in kg. per hectare.

3.2.4.3. Grain protein content

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

3.2.4.4. Soil Analysis

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

3.2.5. Statistical Analysis.

Data on growth characters, yield, yield attributes and chemical analysis of plant and soil samples were statistically analysed by using the analysis of variance technique for split plot design (Cochran and Cox, 1965) and significance was tested by working out the critical difference. Important correlations were also worked out.

RESULTS

4. RESULTS

An experiment was conducted in the College of Agriculture, Vellayani during summer 1986 with the objective of selecting suitable maize varieties for rice fallows and also to standardise optimum level of nitrogen for these varieties. Observations were made on growth, yield and quality characters. The data recorded were statistically analysed and the results are given below. The mean values are given in Tables 2 to 8 and the analysis of variance in Appendices II to XII.

4.1. Growth Characters

4.1.1. Height of plants.

The data on mean height of the plants recorded at various growth stages are presented in Table 2(a) and (b) and their respective analysis of variance in Appendix II.

4.1.1.1. Twenty days after sowing

There was significant difference in height due to different levels of nitrogen. A maximum height of 59.62 cm was observed at n_5 level of nitrogen which was statistically on par with n_4 level. The effects due to n_4 and n_3 were also on par. n_1 was found to be inferior to all others.

The interaction effect of varieties and nitrogen levels was also significant. The treatment combination v_5n_4 recorded the maximum height which was significantly superior to all other combinations except v_5n_5 and v_1n_5 with which it was on par.

The different varieties did not differ significantly in plant height at this stage.

4.1.1.2. Forty days after sowing

At this stage also significant increase in height was observed with increase in levels of nitrogen. The maximum height of 105.52 cm. was recorded by the highest level of nitrogen (n_5) and was followed by 100.58 cm. with n_4 level. But their difference was not statistically significant. Neither the varieties nor the combined effect of varieties and nitrogen levels could exert any significant influence on plant height at this stage.

4.1.1.3. Sixty days after sowing

As in the case of two early stages height of the plant differed significantly with levels of nitrogen at this stage also. The different varieties and the interaction between varieties and nitrogen levels did not show any significant influence on plant height. The maximum height of 158.5 cm. was recorded by the n_4 level of nitrogen which was on par wit n_5 and n_3 levels.

4.1.1.4. Harvest stage

At this stage, the different levels of nitrogen and interaction between varieties and nitrogen levels could significantly influence plant height. The different variety also differed significantly in their plant height. However, a linear increase in height was observed only upto n_4 level after which a declaine in height was observed. The maximum height of 174.14 cm. was recorded by n_4 level.

Significant varietal influence was observed plant height at the harvest stage. Among the five varieties the maximum height of 180.35 cm. was observed in the variety v_5 closely followed by v_2 which recorded a height of 162.92 cm. The difference between these two varieties were not statistically significant.

Among the various interaction effects maximum height was obtained by v_2n_4 (191.32 cm.) which was on par with v_5n_4, v_5n_5, v_5n_3 and v_5n_2. The combination v_4n_1 recorded the lowest plant height (113.01 cm.).

4.1.2. <u>Number of leaves per plant.</u>

The data on the number of leaves per plant recorded at four stages were statistically analysed. The analysis of variance is given in Appendix III and the mean values are presented in Table 2(a) and (b).

Table 2(a) Plant height, Number of leaves and Leaf Area Index at various growth stages

Treatments	Plant height (cm)				Number of leaves per plant				Leaf Area Index			
	20DAS	40DAS	60DAS	Harvest	20DAS	40DAS	60DAS	Harvest	20DAS	40DAS	60DAS	Harvest
v_1	54.46	89.43	139.21	145.45	6.79	9.34	10.22	10.25	0.54	1.56	1.75	1.57
v_2	53.92	93.16	153.57	162.92	7.47	8.89	9.89	9.95	0.58	1.62	2.22	2.03
v_3	49.75	87.02	134.62	155.52	6.80	8.71	9.89	9.94	0.38	1.67	2.27	1.96
v_4	53.07	89.88	133.60	139.43	7.01	8.31	9.53	9.61	0.48	1.54	2.01	1.76
v_5	59.12	114.97	164.67	180.35	7.23	9.77	10.18	10.20	0.72	2.52	3.20	2.74
SE	2.45	6.42	10.89	8.02	0.30	0.38	0.38	0.39	0.07	0.10	0.16	0.17
CD	NS	NS	NS	24.72	NS	NS	NS	NS	NS	0.32	0.49	0.51
n_1	44.53	80.01	125.03	134.58	6.36	7.85	8.82	8.94	0.29	1.20	1.74	1.55
n_2	52.39	91.27	136.84	147.21	6.74	8.67	9.64	9.70	0.43	1.63	2.13	1.89
n_3	55.65	97.08	152.81	164.15	7.07	9.27	10.17	10.21	0.54	1.78	2.34	2.11
n_4	58.15	100.58	158.50	174.14	7.57	9.66	10.63	10.67	0.70	2.08	2.62	2.19
n_5	59.62	105.52	152.48	163.61	7.56	9.57	10.45	10.42	0.73	2.23	2.61	2.32
SE	1.19	1.96	2.83	2.48	0.08	0.09	0.10	0.10	0.03	0.06	0.06	0.07
CD	3.38	5.53	7.99	7.09	0.24	0.26	0.28	0.28	0.09	0.17	0.17	0.20

DAS - Days after sowing

Table 2(b) Plant height, Number of leaves and Leaf Area Index at various growth stages

Treat-ments	Plant height (cm)				Number of leaves per plant				Leaf Area Index			
	20DAS	40DAS	60DAS	Harvest	20DAS	40DAS	60DAS	Harvest	20DAS	40DAS	60DAS	Harvest
v_1n_1	44.42	76.84	128.33	135.29	6.21	7.79	9.0	9.17	0.31	1.37	1.34	1.21
v_1n_2	52.33	81.71	127.33	135.85	6.63	8.71	9.84	9.84	0.42	1.35	1.59	1.40
v_1n_3	55.50	92.92	147.62	153.77	6.75	9.75	10.54	10.50	0.50	1.56	1.72	1.56
v_1n_4	57.25	94.78	149.38	158.84	7.25	10.25	11.08	11.08	0.66	1.72	1.90	1.71
v_1n_5	62.80	100.92	143.38	143.46	7.13	10.21	10.69	10.69	0.79	2.09	2.20	1.96
v_2n_1	45.58	76.13	129.04	136.42	6.58	7.67	8.25	8.30	0.33	0.94	1.66	1.55
v_2n_2	51.92	89.21	158.04	153.78	7.08	8.75	9.83	9.97	0.54	1.45	2.15	2.06
v_2n_3	54.67	94.83	154.25	170.54	7.50	9.25	10.33	10.41	0.64	1.59	2.36	2.17
v_2n_4	58.59	102.14	174.54	191.32	8.04	9.59	10.67	10.69	0.71	1.98	2.57	2.33
v_2n_5	58.59	103.46	151.96	162.51	8.13	9.21	10.38	10.38	0.69	2.16	2.37	2.03
v_3n_1	46.38	67.67	108.75	128.84	6.17	7.79	9.05	9.10	0.24	1.01	1.50	1.29
v_3n_2	45.85	81.88	123.08	137.75	6.54	8.67	9.67	9.71	0.30	1.70	2.12	1.91
v_3n_3	53.52	89.29	151.79	172.06	6.92	8.96	10.01	10.09	0.35	1.71	2.44	2.06
v_3n_4	50.24	92.54	147.91	171.22	7.25	9.29	10.71	10.75	0.47	2.01	2.70	2.23
v_3n_5	52.75	103.71	141.58	167.75	7.13	8.83	10.0	10.05	0.53	1.93	2.57	2.29

Table 2(b) Contd.

Treatments	20DAS (1)	40DAS (1)	60DAS (1)	Harvest (1)	20DAS (2)	40DAS (2)	60DAS (2)	Harvest (2)	20DAS (3)	40DAS (3)	60DAS (3)	Harvest (3)
v_4n_1	45.29	78.96	115.0	113.01	6.33	7.25	8.63	8.84	0.24	1.05	1.51	1.38
v_4n_2	50.29	85.83	119.58	129.30	6.75	7.71	9.0	9.08	0.35	1.38	1.78	1.44
v_4n_3	57.84	95.17	144.98	140.66	7.08	8.58	9.79	9.79	0.52	1.50	2.02	1.83
v_4n_4	55.42	92.25	149.67	158.79	7.63	8.90	10.0	10.04	0.64	1.77	2.32	1.92
v_4n_5	56.54	97.21	144.75	155.40	7.25	9.08	10.25	10.29	0.63	2.01	2.43	2.24
v_5n_1	40.96	100.46	144.0	159.33	6.5	8.75	9.16	9.29	0.34	1.95	2.69	2.32
v_5n_2	61.54	117.71	156.16	179.37	6.71	9.50	9.83	9.93	0.57	2.25	3.07	2.63
v_5n_3	56.75	113.16	165.42	183.71	7.09	9.79	10.2[illegible]	10.26	0.68	2.54	3.16	2.92
v_5n_4	69.25	121.21	177.0	190.46	7.71	10.29	10.71	10.79	1.03	2.91	3.60	2.76
v_5n_5	67.13	122.33	180.75	183.92	8.17	10.54	10.96	10.71	1.0	2.97	3.49	3.09
SE	2.67	4.37	6.32	5.56	0.19	0.20	0.22	0.22	0.06	0.13	0.14	0.16
CD	7.55	NS	NS	15.72	NS	NS	NS	NS	NS	NS	NS	NS

4.1.2.1. Twenty days after sowing

Significant difference was observed in the number of leaves per plant due to different levels of nitrogen in the early stages of plant growth. An increasing trend in the number of leaves per plant was recorded by the application of nitrogen upto n_4 level which was on par with n_5 level. However, at the n_5 level there occurred a slight reduction in the number of leaves per plant. There was no significant varietal influence on the number of leaves per plant. However, the variety v_5 produced the highest number of leaves per plant.

The effect due to interaction between variety and nitrogen was also not significant.

4.1.2.2. Forty days after sowing

During this stage, the different nitrogen levels exerted significant influence on leaf number, the n_4 level giving the maximum number of leaves which was on par with the highest level of nitrogen (n_5).

There was no significant varietal influence on the number of leaves per plant. The interaction effect was also not significant with respect to this character.

4.1.2.3. Sixty days after sowing

Nitrogen exerted significant effect on the number of leaves produced during the stage also. The lowest level of nitrogen recorded minimum number of leaves per plant.

The five varieties had not shown any significant influence on the number of leaves. However, the variety v[illegible] produced the highest number of leaves closely followed by v_5.

The effect due to variety X nitrogen interaction was not significant.

4.1.2.4. Harvest stage

At the harvest stage also leaf number differed significantly due to different levels of nitrogen. The effect of nitrogen on this character was linear upto n_4 level (140 kg. N/ha) after which a decline was observed. The minimum number was recorded by the lowest level of nitrogen which inturn was inferior to its immediate higher level. The effects of n_3 and n_4 were significantly different.

Varietal effect and interaction effect did not show any significant influence on leaf number at harvest stage.

4.1.3. Leaf Area Index.

The data on mean values of leaf area index are presented in Table 2(a) and (b) and the analysis of variance is given in Appendix IV.

4.1.3.1. Twenty days after sowing

During the early stage of plant growth, it was observed that different levels of nitrogen influenced the leaf area index significantly.

Maximum leaf area index (0.73) was associated with plants abundantly supplied with n_5 level while the lowest level of nitrogen recorded the minimum leaf area index (0.29). But the effects due to n_5 and n_4 were on par.

Data revealed that the varieties had no significant influence on leaf area index during the early stage. However, significant difference in leaf area index was observed due to different levels of nitrogen. Leaf area index was found to be increased progressively upto n_4 level.

Leaf area index was found to be unaffected by variety X nitrogen interaction.

4.1.3.2. Forty days after sowing

Unlike 20 days after sowing significant effect was observed due to the different varieties at this stage. The highest leaf area index of 2.52 was recorded by the variety v_5 followed by v_3 which differed significantly from v_5. v_5 was found to be significantlya superior to all other varieties.

Significant influence on the leaf area index due to different levels of nitrogen was also observed at this stage. Due to the increased application of nitrogen, leaf area index was also found to be increasing upto the highest (n_5) level of nitrogen and the maximum leaf area index of 2.23 was recorded at n_5 level.

Variety X nitrogen interaction did not show any significant influence on leaf area index at this stage.

4.1.3.3. Sixty days after sowing

During this stage, varietal effect resulted a significant difference in leaf area index. Among the different varieties, v_5 showed the highest leaf area index of 3.2 and v_1 recorded the lowest value of 1.75. The variety v_5 was found to be significantly superior to all other varieties.

During this stage also variety X nitrogen interaction did not show any significant influence on leaf area index.

4.1.3.4. Harvest stage

During the harvest stage significant difference in leaf area index was observed for different varieties and nitrogen levels.

Varietal influence was found to be significant. Among the different varieties, v_5 recorded the maximum leaf area index (2.74) which was found to be superior to all other varieties. The lowest leaf area index was recorded by v_1 (1.57).

Leaf area index was found to be increasing with increasing levels of nitrogen upto the highest level of nitrogen (n_5)application. Maximum leaf area index of 2.32 was noticed in n_5 which was on par with that in n_4 (2.19).

Leaf area index at the harvest stage was not affected by variety x nitrogen interaction.

4.1.4. Days to silking.

Data on this observations were statistically analysed and the mean values are presented in Table 3(a) and (b) and their respective analysis of variance in Appendix V.

The results revealed that the effects due to different varieties were significant on this character. Among the different varieties v_4 required the highest number of days to silking closely followed by v_3. Silking was found to be early in the variety v_2 (58.25 day).

A critical review of the mean table revealed that there were significant difference in this character with increasing levels of nitrogen. Silking was found to be early in plants receiving more nitrogen. At the lowest level of nitrogen, the number of days to silking was maximum. At n_5 level, plants were found to silk within 61.65 days while at the lowest level (n_1) it took 67.75 days.

The effects due to variety X nitrogen interaction were not significant.

4.1.5. Leaf-stem ratio at harvest.

The data on mean leaf-stem ratio of the crop at the harvest stage are presented in Table 3(a) and (b) and their analysis of variance in Appendix V.

It was found that the different varieties, levels of nitrogen and their interaction exerted significant influence on the leaf-stem ratio.

Among the varieties, v_5 recorded the maximum leaf-stem ratio at harvest while the least value was recorded by v_3. v_5 was found to be significantly different from other varieties.

An increasing response in leaf-stem ratio was recorded by graded application of nitrogen. The maximum value observed at n_5 level was 0.79, closely followed by 0.78 at n_4 level and the least value of 0.27 was observed at the lowest dose.

Among the treatment combination of variety X nitrogen, the maximum leaf- stem ratio was obtained by v_5n_4 which was on par with v_5 n_5. The treatment combination v_5n_4 was found to be significantly different from all other combinations and the least value (0.17) was recorded by v_2n_1 which was found to be statistically on par with the immediate higher levels.

4.1.6. Drymatter Production.

The data on drymatter production are given in Table 4(a) and (b) and the analysis of variance in Appendix V. The data revealed that the levels of nitrogen had significant effect on drymatter production. The nitrogen levels resulted in significant linear increase in drymatter production upto the highest level (n_5). The drymatter production at n_5 level was 3271 kg./ha.

Neither different varieties not their interaction with nitrogen levels exerted significant influence on drymatter production.

Table 3(a) Days to silking, Leaf stem ratio, Number of cobs per plant, Number of grains/cob, Girth of cob, weight of cob, 1000 grain weight

Treatments	Days to silking	Leaf-stem Ratio at Harvest	No. of cobs/ plant	No. of Grains/ cob	Length of cob (cm)	Girth of cob (cm)	Weight of cob (g)	1000 grain weight (g)
v_1	62.15	0.58	1.13	304.50	21.70	14.25	106.21	184.0
v_2	58.25	0.51	1.11	295.35	23.85	14.0	145.90	185.85
v_3	66.35	0.46	1.17	353.60	26.50	14.5	149.54	190.45
v_4	70.25	0.52	1.07	249.15	23.55	14.05	95.38	182.65
v_5	59.80	0.66	1.23	572.50	24.55	18.95	236.53	223.20
SE	2.18	0.02	0.02	11.25	0.65	0.43	11.56	4.05
CD	6.71	0.08	0.08	34.68	1.99	1.32	35.62	12.47
n_1	67.75	0.27	0.99	271.10	20.55	14.15	87.03	166.20
n_2	64.85	0.37	1.02	330.90	23.05	14.60	132.63	184.85
n_3	63.15	0.52	1.16	373.15	24.60	15.05	151.78	196.80
n_4	59.40	0.78	1.25	402.55	26.25	16.00	183.14	213.40
n_5	61.65	0.79	1.30	397.40	25.70	15.95	178.14	204.90
SE	0.74	0.01	0.03	6.15	0.46	0.27	5.08	2.73
CD	2.09	0.04	0.07	17.41	1.31	0.77	14.38	7.72

Table 3(b) Days to silking, Leaf stem ratio, Number of cobs per plant, Number of grains/cob, Girth of cob, weight of cob, 1000 grain weight

Treatments	Days to silking	Leaf-stem Ratio at Harvest	No. of cobs/plant	No. of Grains/ cob	Length of cob (cm)	Girth of cob (cm)	Weight of cob (g)	1000 grain weight (g)
v_1n_1	65.25	0.34	1.0	216.75	17.25	13.5	61.25	165.0
v_1n_2	64.75	0.40	1.02	263.75	20.50	13.25	94.63	182.50
v_1n_3	61.75	0.56	1.13	300.25	22.25	13.75	105.25	187.50
v_1n_4	58.0	0.82	1.25	376.75	24.25	15.25	136.50	200.0
v_1n_5	61.0	0.77	1.28	365.00	24.25	15.50	133.44	185.0
v_2n_1	65.25	0.17	1.0	203.50	22.25	12.50	72.50	150.0
v_2n_2	61.0	0.30	1.0	253.00	22.25	14.00	130.63	168.50
v_2n_3	59.25	0.49	1.14	334.50	22.75	14.00	153.00	195.0
v_2n_4	52.25	0.91	1.15	345.25	25.75	15.00	190.25	210.0
v_2n_5	53.50	0.79	1.26	348.50	26.25	14.50	183.13	205.75
v_3n_1	70.50	0.25	0.98	325.50	17.5	12.75	61.50	165.0
v_3n_2	66.25	0.34	1.02	330.00	26.0	14.50	124.25	183.25
v_3n_3	66.75	0.42	1.18	356.75	29.50	13.75	157.13	195.0
v_3n_4	63.0	0.54	1.37	377.00	31.00	15.75	204.06	209.0
v_3n_5	65.25	0.74	1.32	378.75	28.50	15.75	200.75	200.0

Table 3(b) Contd.

Treatments	Days to silking	Leaf-stem Ratio at Harvest	No. of cobs/plant	No. of Grains/cob	Length of cob (cm)	Girth of cob (cm)	Weight of cob (g)	1000 grain weight (g)
v_4n_1	72.75	0.24	0.96	175.00	22.50	13.50	67.0	164.0
v_4n_2	71.50	0.33	0.98	245.00	23.00	12.50	83.13	172.50
v_4n_3	69.25	0.50	1.06	263.75	23.75	14.75	98.50	180.0
v_4n_4	69.00	0.79	1.11	285.00	24.50	14.50	118.83	201.75
v_4n_5	68.75	0.74	1.24	277.00	24.00	15.0	109.38	195.0
v_5n_1	65.00	0.34	1.0	434.75	23.25	18.5	172.83	187.0
v_5n_2	60.75	0.47	1.10	562.75	23.50	18.75	230.50	217.5
v_5n_3	58.75	0.65	1.27	610.50	24.75	19.00	245.00	226.5
v_5n_4	54.75	0.93	1.37	628.75	25.75	19.50	266.00	246.25
v_5n_5	59.75	0.91	1.40	625.75	25.50	19.0	268.25	238.75
SE	1.65	0.03	0.06	13.76	1.03	0.61	11.37	6.10
CD	NS	0.08	NS	38.93	2.92	NS	32.16	NS

4.2. Yield Components

4.2.1. Number of cobs per plant.

The data on mean number of cobs per plant are presented in Table 3(a) and (b) and the analysis of variance in Appendix VI.

It is observed that the different varieties significantly affected the number of cobs per plant. v_5 recorded significantly higher number of cobs per plant when compared to other varieties. But v_5 and v_3 were statistically on par in this respect.

The different levels of nitrogen also showed significant influence on the number of cobs per plant and as such the number of cobs per plant increased with increasing levels of nitrogen. However, the effects of n_5 and n_4 were statistically on par while all the other nitrogen levels differed significantly.

The results revealed that the variety X nitrogen interaction had no direct influence on the cob number.

4.2.2. Number of grains per cob.

The data on mean number of grains per cob recorded are presented in Table 3(a) and (b) and the analysis of variance in Appendix VI.

Data revealed significant increase in the number of grains per cob with increasing levels of nitrogen and with different varieties.

Among the varieties, v_5 recorded the maximum number of grains per cob and v_4 recorded the minimum number. v_5 was found to be superior to all other varieties except v_3 with regard to number of grains per cob.

The level of nitrogen also had significant influence on the number of grains per cob. Number of grains increased progressively with increasing levels of nitrogen and the effect was linear upto n_4 level. However, the dose n_4 was statistically on par with the highest doses n_5.

The interaction between variety and nitrogen was also found to be significant. The treatment combinations v_5n_3, v_5n_4 and v_5n_5 were superior to the remaining ones. Number of grains per cob was maximum for the treatment combinations v_5n_4 while v_4n_1 recorded the minimum value.

4.2.3. <u>Length of cob.</u>

The data furnished in Table 3(a) and (b) represent the mean length of cob. Analysis of variance is presented in Appendix VI.

The varieties had significant influence on this character. Among the varieties, v_3 recorded maximum cob length which was on par with v_5. All the other three varieties differed significantly in this respect. v_5 and v_3 were found to be superior to other varieties.

The length of cob was influenced significantly by the levels of nitrogen also. The response was found to be linear upto n_4 beyond which nitrogen application resulted in a slight reduction in cob length. The maximum length of cob was 26.25 cm. recorded at n_4 level.

4.2.4. Girth of cob.

The data on mean value of girth of cobs are presented in Table 3(a) and (b) and the analysis of variance in Appendix VI.

Results revealed that varieties and nitrogen levels had significant influence on the girth of cobs. But the interaction effect was not significant.

Effects due to varieties were found to be significant. Among the varieties, v_5 recorded maximum girth and the lowest girth of 14 cm. was recorded by v_2. v_5 exhibited significantly greater cob girth as compared to all other varieties.

Applied nitrogen increased the girth of cobs significantly. The maximum girth of 16 cm. was recorded by 140 kg. N/h which was on par with 17? kg. N/ha. All the other nitrogen levels differed significantly in their responses.

Interaction effect between the varieties and nitrogen levels was not significant.

4.2.5. Weight of cob.

The analysis of variance is presented in Appendix VI and the mean values are given in Table 3(a) and (b)

It was observed that the varieties and nitrogen levels had significant effect on the weight of cobs. The interaction between varieties and levels of nitrogen was also significant.

Among the varieties, v_5 recorded the maximum weight of cobs which markedly differed from all the other varieties. The lowest weight of cob was recorded by the variety v_4.

Incremental doses of nitrogen also produced significant increase in the weight of cobs. From the mean table it is seen that the nitrogen fertilisation increased the weight of cob upto a level of n_4 level after which there was a decline. But both levels were only on par in this respect.

Interaction effect between the varieties and nitrogen levels also influenced significantly on the weight of cobs. Among the different combinations, v_5n_5 recorded the highest value which was on par with v_5n_4 and v_5n_3.

4.2.6. Thousand grain weight.

The data on mean values are presented in Table 3(a) and (b) and the analysis of variance is shown in Appendix VI.

Thousand grain weight was found to differ significantly due to different varieties and levels of nitrogen. Among the five varieties, v_5 recorded a remarkable increase in thousand grain weight which was superior to all the other varieties. The other four varieties were statistically on par with respect to this character.

Increasing levels of nitrogen increased the thousand grain weight considerably. This may be because of the fact that the heavier grains were resulted by increased application of nitrogen. There was a considerable increase in thousand grain weight upto n_4 level after which there was a significant decline in this character.

The thousand grain weight was not influenced by the interaction between variety and nitrogen.

4.3. Yield

4.3.1. Grain yield.

The mean values on grain yield are furnished in Table 4(a) and (b) and the analysis of variance in Appendix VII.

Results revealed that the grain yield was significantly influenced by the levels of nitrogen. The differences due to successive incremental doses of nitrogen were significant upto n_4 level and maximum yield was also recorded by this level. The minimum yield was recorded by the lowest dose of nitrogen. After n_4 level a decline in grain yield was observed although this difference was not significant. At n_4 level of nitrogen, the grain yield was 2340 kg./ha which was significantly higher than that at other levels except n_5 while it was only 1150 kg./ha at the lowest level of nitrogen.

The data revealed that the different varieties did not produce any significant effect on grain field. However, it was observed that v_5 produced the maximum grain yield followed by v_1.

Grain yield was not significantly influenced by the different treatment combinations also. However, the treatment combination v_5n_4 recorded the maximum grain yield.

4.3.2. Stover yield.

The data on mean stover yield are presented in Table 4(a) and (b) and the analysis of variance in Appendix VII.

Data revealed that the increasing rates of nitrogen had significant influences on stover yield. Stover yield progressively and significantly increased with each additional level of applied nitrogen. The maximum stover yield was recorded at n_4 level which was statistically on par with n_5.

Table 4(a) Grain yield, Stover yield, Harvest Index, Drymatter production, Protein content of grain

Treat-ments	Grain yield kg. ha^{-1}	Stover yield kg. ha^{-1}	Harvest Index	Drymatter production kg. ha^{-1}	Protein Content of grain (%)
v_1	1728	2973	0.38	2398	11.05
v_2	1485	3528	0.30	2480	10.26
v_3	1593	3561	0.31	3718	11.09
v_4	1407	3723	0.27	2422	10.98
v_5	2563	4330	0.35	3083	11.70
SE	3.30	4.27	2.28	205.05	0.17
CD	NS	NS	0.07	NS	0.54
n_1	1150	2665	0.31	1838	9.53
n_2	1399	3293	0.30	2298	10.23
n_3	1708	3755	0.32	2638	10.72
n_4	2340	4306	0.34	3057	12.47
n_5	2179	4096	0.35	3271	12.12
SE	1.07	1.09	0.0094	61.47	0.24
CD	3.01	3.09	0.03	173.87	0.67

Table 4(b) Grain yield, Stover yield, Harvest Index, Drymatter Production, Protein content of grain

Treat-ments	Grain yield kg. ha^{-1}	Stover yield kg. ha^{-1}	Harvest Index	Drymatter production kg. ha^{-1}	Protein Content of grain (%)
v_1n_1	1236	2214	0.38	1634	10.11
v_1n_2	1338	2522	0.35	1886	10.66
v_1n_3	1670	2851	0.39	2308	10.66
v_1n_4	2261	3662	0.38	2975	11.35
v_1n_5	2136	3618	0.42	3187	12.47
v_2n_1	857	2465	0.26	1796	9.01
v_2n_2	1145	3552	0.26	2230	9.91
v_2n_3	1542	3596	0.31	2497	10.12
v_2n_4	2032	4078	0.33	2835	10.75
v_2n_5	1848	3947	0.32	2994	11.52
v_3n_1	1239	2544	0.34	1817	9.10
v_3n_2	1338	3113	0.30	2364	10.07
v_3n_3	1567	3859	0.29	2804	10.78
v_3n_4	1958	4297	0.31	3195	13.16
v_3n_5	1862	3991	0.33	3412	12.36

Table 4(b) Contd.

Treatments	Grain yield	Stover yield	Harvest Index	Drymatter production	Protein Content
v_4n_1	850	2828	0.24	1684	9.32
v_4n_2	1248	3267	0.28	2180	9.83
v_4n_3	1518	3831	0.28	2506	10.57
v_4n_4	1753	4320	0.29	2730	13.18
v_4n_5	1669	4319	0.28	3010	12.00
v_5n_1	1566	3276	0.33	2259	10.11
v_5n_2	1925	4009	0.32	2830	10.69
v_5n_3	2241	4591	0.33	3076	11.49
v_5n_4	3699	5171	0.40	3499	13.92
v_5n_5	3383	4685	0.40	3752	12.28
SE	3.29	2.44	0.02	137.46	0.53
CD	NS	NS	NS	NS	NS

It was observed that the yield of stover was not significantly influenced by the different varieties. However, from the mean table it was observed that the variety v_5 produced the maximum quantity of stover followed by v_4. The different treatment combinations also did not significantly influence the stover yield.

4.3.3. Harvest Index.

The mean values of harvest index are presented in Table 4(a) and (b) and the analysis of variance in Appendix VII.

The results revealed that the different varieties and levels of nitrogen had significant influence on harvest index. However, the interaction effects did not show any significant influence on this character.

Among the different varieties, the highest value of harvest index was recorded by the variety v_1 which was on par with v_5 and v_3. The least value of 0.27 was recorded by the variety v_4.

Harvest index values increased linearly with increasing levels of nitrogen upto n_5 level. But the effects of n_5 level was statistically on par with n_4 level. All the other nitrogen levels were found to be quite inferior in this respect. The lowest value was obtained at 80 kg N/ha which was statistically similar to that of n_1 level.

It was further observed that nitrogen and variety interactions were not significant.

4.4. Quality Characters

4.4.1. Protein Content of Grain.

The data on the protein content of grain as influenced by various treatments are presented in Table 4(a, and (b, and the analysis of variance in Appendix. VIII.

It was observed that the effects due to varieties and levels of nitrogen were statistically significant. But the interaction effect was not significant.

Among the five varieties, v_5 had the highest protein content of 11.7 which was significantly different from the other four varieties. But v_1, v_3, v_4, were statistically on par.

The protein content of grain was significantly increasdd by the application of nitrogen upto n_4 level, beyond which there was a decline a in protein content although not statistically significant. Nitrogen at n_4 level recorded the highest protein content in grain which was superior to all the lower levels.

Interaction effect was not significant .

Table 5(a) Nitrogen, Phosphorus and Potash Content of plant and Grain at Harvest

Treatments	N Content of plant at Harvest (%)	N Content of grain (%)	P Content of grain (%)	P Content of plant at Harvest (%)	K Content of plant at Harvest (%)	K Content of grain (%)
v_1	1.43	1.77	1.23	1.13	0.53	0.50
v_2	1.43	1.64	1.20	1.01	0.60	0.60
v_3	1.33	1.77	1.06	0.97	0.56	0.55
v_4	1.45	1.76	1.20	1.01	0.58	0.48
v_5	1.59	1.87	1.11	1.11	0.57	0.51
SE	0.05	0.03	0.03	0.03	0.02	0.03
CD	0.16	0.09	0.08	0.11	NS	0.08
n_1	1.23	1.52	1.22	0.91	0.52	0.64
n_2	1.35	1.64	1.17	0.99	0.53	0.62
n_3	1.45	1.72	1.14	1.05	0.55	0.48
n_4	1.56	2.00	1.12	1.11	0.61	0.46
n_5	1.63	1.94	1.15	1.19	0.63	0.40
SE	0.03	0.04	0.03	0.05	0.02	0.02
CD	0.08	0.11	NS	0.058	0.07	0.05

Table 5(b) Nitrogen, Phosphorus and Potash Content of plant and Grain at Harvest

Treatments	N Content of plant at Harvest (%)	N Content of grain (%)	P Content of grain (%)	P Content of plant at Harvest (%)	K Content of plant at Harvest (%)	K Content of grain (%)
v_1n_1	1.26	1.62	1.22	1.01	0.48	0.71
v_1n_2	1.32	1.71	1.21	1.11	0.53	0.53
v_1n_3	1.43	1.71	1.16	1.14	0.48	0.55
v_1n_4	1.51	1.82	1.14	1.15	0.63	0.40
v_1n_5	1.60	1.99	1.43	1.25	0.55	0.30
v_2n_1	1.46	1.44	1.26	0.87	0.55	0.79
v_2n_2	1.35	1.59	1.28	0.90	0.61	0.68
v_2n_3	1.41	1.62	1.09	1.01	0.59	0.54
v_2n_4	1.47	1.72	1.15	1.07	0.59	0.55
v_2n_5	1.46	1.84	1.23	1.19	0.65	0.48
v_3n_1	1.07	1.46	1.20	0.85	0.53	0.65
v_3n_2	1.35	1.61	0.98	0.95	0.60	0.56
v_3n_3	1.38	1.72	1.17	1.01	0.50	0.63
v_3n_4	1.38	2.11	0.94	1.02	0.54	0.59
v_3n_5	1.46	1.98	0.98	1.05	0.61	0.30

Table 5(b) Contd.

Treat-ments	N Content of plant at Harvest (%)	N Content of grain (%)	P Content of grain (%)	P Content of plant at Harvest (%)	K Content of plant at Harvest (%)	K Content of grain (%)
v_4n_1	1.05	1.49	1.27	0.86	0.48	0.43
v_4n_2	1.35	1.57	1.25	0.93	0.44	0.68
v_4n_3	1.51	1.69	1.24	1.01	0.69	0.33
v_4n_4	1.63	2.11	1.18	1.13	0.70	0.49
v_4n_5	1.68	1.92	1.05	1.15	0.60	0.48
v_5n_1	1.31	1.62	1.16	0.94	0.55	0.63
v_5n_2	1.37	1.72	1.10	1.03	0.50	0.65
v_5n_3	1.50	1.84	1.02	1.10	0.50	0.38
v_5n_4	1.82	2.23	1.19	1.18	0.58	0.48
v_5n_5	1.63	1.96	1.06	1.30	0.73	0.43
SE	0.06	0.08	0.07	0.04	0.05	0.04
CD	0.18	NS	0.19	NS	NS	0.11

4.5. Uptake of Nutrients.

4.5.1. Uptake of nitrogen at harvest.

The mean values on the uptake of nitrogen at harvest are presented in Table 6(a) and (b) and the analysis variance in Appendix. X.

The results revealed that an increase in the application of nitrogen significantly increased the nitrogen uptake by plants. But higher uptake of nitrogen was observed only upto n_4 level beyond which a slight reduction was observed although this decrease was not statistically significant. It was also observed that the minimum uptake was recorded in the lowest level of nitrogen (n_1).

Varieties did not bring out any significant variation in nitrogen uptake by plants. The interaction effect was also not significant.

4.5.2. Uptake of phosphorus at harvest.

The mean values are presented in Table 6(a) and (b) and the analysis of variance in Appendix. X.

Results revealed significant differences in the phosphorus uptake due to different levels of nitrogen. Increased application of nitrogen resulted in an increase in phosphorus uptake by the plants upto n_4 level. Thereafter a slight reduction was observed in phosphorus uptake. Phosphorus uptake at n_4 level was significantly superior to all the other levels except n_5.

Varieties did not show any significant influence on phosphorus uptake. The effect due to variety and nitrogen interaction was also not significant in this case. v_5 recorded the maximum uptake of phosphorus as compared to all the other varieties.

4.5.3. <u>Uptake of potassium at harvest.</u>

The mean values are presented in Table 6(a) and (b) and the analysis of variance in Appendix. X.

Results indicated that potassium uptake was significantly influenced by increasing levels of nitrogen. This significant increase in potassium uptake was observed only upto n_4 level after which there occured a decreasing trend which was not significant.

Different varieties of maize failed to show any significant influence on the uptake of potassium. None of the variety x nitrogen interaction was also found to be significant in this respect.

Table 6(a) Uptake of Nitrogen, Phosphorus and Potash and Total Nitrogen, Available Phosphorus and Potassium Content in soil

Treatments	Uptake of Nitrogen kg. ha^{-1}	Uptake of Phosphorus kg. ha^{-1}	Uptake of Potash kg. ha^{-1}	Total N Content in soil kg. ha^{-1}	Available P_2O_5 content in soil kg. ha^{-1}	Available K_2O content in soil kg. ha^{-1}
v_1	73.47	54.26	23.47	2725	12.12	216
v_2	75.22	53.41	29.40	2754	17.24	311
v_3	77.17	52.95	28.33	2919	15.19	258
v_4	80.21	55.09	32.40	2880	19.81	257
v_5	122.41	77.65	36.97	3373	15.68	257
SE	12.60	7.07	3.74	343.23	0.55	24.07
CD	N	NS	NS	NS	1.69	NS
n_1	50.92	37.49	23.74	1629	11.44	197
n_2	68.65	48.80	28.41	2240	13.44	225
n_3	84.36	58.57	27.83	2550	15.63	254
n_4	115.48	74.11	37.00	3500	16.91	273
n_5	109.07	72.80	33.35	4732	16.63	330
SE	3.83	2.23	1.32	175.36	0.42	22.625
CD	10.97	6.31	3.75	495.98	1.18	64.07

Table 6(b) Uptake of N P and K and Total Nitrogen content, Available P_2O_5 and K_2O content in the soil after the experiment

Treatments	Uptake of N kg. ha^{-1}	Uptake of P kg. ha^{-1}	Uptake of K kg. ha^{-1}	Total N Content in soil kg. ha^{-1}	Av. P_2O_5 content in soil kg. ha^{-1}	Av. K_2O content in soil kg. ha^{-1}
v_1n_1	47.11	33.86	17.54	1657	9.06	190
v_1n_2	56.05	44.04	20.94	2217	10.31	202
v_1n_3	69.54	51.57	21.27	2611	12.81	206
v_1n_4	95.37	67.29	30.58	3057	15.63	231
v_1n_5	99.30	74.54	26.33	4085	12.81	250
v_2n_1	48.82	32.50	20.80	1699	12.50	213
v_2n_2	65.72	45.89	29.47	1965	17.50	244
v_2n_3	75.42	53.21	30.07	2273	18.13	274
v_2n_4	95.00	66.32	35.12	3603	17.75	288
v_2n_5	91.11	69.16	31.57	4233	20.31	538
v_3n_1	46.68	37.01	21.41	1580	12.50	173
v_3n_2	63.92	45.85	27.23	2147	13.75	206
v_3n_3	79.89	57.53	29.23	2406	16.25	254
v_3n_4	101.19	64.47	34.28	3498	13.75	269
v_3n_5	94.16	59.88	29.51	4968	14.69	283

Table 6(b) Contd.

Treatments	Uptake of N kg. ha^{-1}	Uptake of P kg. ha^{-1}	Uptake of K kg. ha^{-1}	Total N Content in soil kg. ha^{-1}	Av. P_2O_5 content in soil kg. ha^{-1}	Av. K_2O Content in soil kg. ha^{-1}
v_4n_1	42.89	35.00	31.69	1536	13.13	199
v_4n_2	63.47	46.22	31.87	2462	11.56	238
v_4n_3	84.46	57.84	27.39	2693	14.38	271
v_4n_4	106.06	69.47	38.72	3582	14.06	288
v_4n_5	104.23	66.93	32.33	4380	15.94	288
v_5n_1	69.69	49.06	27.24	1923	10.00	209
v_5n_2	94.09	62.0	32.55	2413	14.06	235
v_5n_3	112.53	72.69	31.44	2770	16.56	264
v_5n_4	179.77	103.00	46.33	3763	18.38	283
v_5n_5	156.55	98.50	47.30	5997	19.38	283
SE	8.67	4.99	2.96	392.11	0.93	50.65
CD	NS	NS	NS	NS	2.63	NS

4.6. Soil Analysis

4.6.1. Total nitrogen content in the soil after the experiment.

The mean values of nitrogen content in the soil after the experiment are presented in Table 6(a) and (b) and analysis of variance in Appendix. X.

Statistical analysis of the data revealed significant difference in the total nitrogen content of the soil due to levels of nitrogen application. Varieties and interaction effect did not show any significant influence in the total nitrogen content of the soil.

Increased levels of nitrogen increased the total nitrogen content of the soil upto the highest level of n_5 which was significantly superior to all the other nitrogen levels.

4.6.2. Available phosphorus content in the soil.

Data furnished in Table 6(a) and (b) represent the mean value of available P_2O_5 in the soil after the experiment. Analysis of variance is given in Appendix. X.

Data revealed that nitrogen and varieties had significant influence on the available phosphorus content of soil. The effect due to interaction between nitrogen levels and varieties on this character was also significant. But the increasing trend was observed only upto n_4 level which recorded 16.91 kg P_2O_5/ha which recorded was on par with n_5 level.

The effect due to varieties was also significant. Variety v_2 recorded increase in the available phosphorus content in the soil followed by v_5 which was on par with the former.

Interaction effects were also found to be significant the variety x nitrogen interaction the highest value was recorded by the v_2n_5 treatment which wase on par with the treatment combinations v_5n_5, v_5n_4, v_5n_4, v_2n_3, and v_2n_4. The treatment combination v_1n_1 recorded the minimum phosphorus content in the soil.

4.6.3. <u>Exchangeable potash content in the soil.</u>

The mean values of available potash in the soil after the experiment are furnished in Table 6(a) and (b) and the analysis of variance in Appendix. X.

Results indicated that the levels of nitrogen had significant influence on the potash content in the soil. Increasing levels of nitrogen also increased the potash content of the soil upto n_5 level. But n_4 and n_5 levels were statistically on par. The highest value recorded by the n_5 level was 330 kg potash and the lowest value recorded by n_1 level was 197 kg potash.

There was no significant influence by the different varieties and their combination with nitrogen levels.

4.7. Response of maize to nitrogen

Results of analysis presented in Appendix XI. revealed that the varieties V_1, V_3 and V_5 responded linearly towards the application of nitrogen and as such the physical and economic optimum nitrogen rates could not be found out. Response function of grain yield and nitrogen levels in variety V_4 was explained by the quadratic function, $Y = 194.820 \quad 24.586\,N \quad 0.0793\,N^2$.

The physical and economic optimum nitrogen rates for this variety were found to be 155 kg and 144.44 kg/ha respectively. The relationship between the grain yield and levels of nitrogen in variety V_2 was explained by cubic polynomial function. $Y = 2140.75 - 55.926\,N \quad 0.738\,N^2 - 0.0024\,N^3$. The physical and economic optimum nitrogen rates for this variety were found to be 156.5 kg and 147.57 kg/ha respectively.

4.8. Economics of production

The economics of production of different varieties for the estimated yields at various levels of nitrogen are given in Table 7 and the analysis of variance furnished in Appendix.XII.

The results revealed that V_5 recorded the maximum profit of Rs. 6,510/ha which was found to be higher than that for all the other four varieties.

Table 7. Economics of maize production

('000 rupees/ha)

Treat-ments	Cost of production excluding treatment	Extra treatment cost	Total expendi-ture	Net Return
n_1	3.043	0.080	3.123	1.534
n_2	3.043	0.133	3.176	2.707
n_3	3.043	0.180	3.223	3.590
n_4	3.043	0.227	3.270	5.627
n_5	3.043	0.280	3.323	5.023
SE	-	-	-	0.347
CD	-	-	-	0.983

Cost of inputs

1. Nitrogen : Rs.4.85/kg.
2. Price of grain : Rs.2.89/kg.
3. Price of stover: Rs.0.50/kg.

Labour charge

Men @ Rs.20/-

Women @ Rs.15/-

The different levels of nitrogen markedly influenced the production of maize. It is seen that increasing levels of nitrogen increased the net profit considerably. The increase in profit was linear upto n_4 level after which there was a decrease in the net profit although not significant.

4.9. Correlation Studies

The values of simple correlation coefficients worked out between the yield of grain and other characters are presented in Table. 8.

Grain yield of the crop was positively and significantly correlated with number of cobs per plant, number of grains per cob, length of cob, girth of cob, weight of cob, weight of thousand grains, weight of stover etc... These yield attributes were positively correlated with grain yield and the 'r' values were 0.519[illegible], 0.5954, 0.2731, 0.4661, 0.63[illegible]3, 0.6385, [illegible].7[illegible] respectively.

The uptake of nitrogen, phosphorus and potash by the crops at harvest was also positively and significantly correlated with grain yield and the correlation coefficients were 0.926[illegible], [illegible].9169 and 0.76[illegible]7 respectively.

It was further noticed that the uptake of nitrogen, phosphorus and potash was positively and significantly correlated with the grain protein content.

Table 8 Simple linear correlation coefficients between grain yield and certain biometric characters

Sl.No.	Characters correlated with grain yield	Correlation Coefficient
1.	No. of cobs per plant	0.5190*
2.	No. of grains per cob	0.5954*
3.	Length of cob	0.2731*
4.	Girth of cob	0.4661*
5.	Weight of cob	0.6343*
6.	Thousand grain weight	0.6385*
7.	Weight of stover	0.7040*
8.	Protein content	0.4399*
9.	Nitrogen uptake	0.9260*
10.	Phosphorus uptake	0.9169*
11.	Potash uptake	0.7607*

* Significant at 5% level.

DISCUSSION

5. DISCUSSION

The present investigation is an attempt to select the most suitable variety of maize for rice fallows and also to findout an optimum level of nitrogen for the variety. The data collected on various growth characters, yield attributes and yield and quality parameters were statistically analysed and the results of experiment are discussed here under.

5.1. Growth Characters

5.1.1. Height of Plants.

It is seen from the Table 2 (a) and (b) that there was significant increase in plant height at various stages of growth due to the application of nitrogen. The fact that the lower level nitrogen recorded lesser height at all stages of growth as compared to higher levels clearly indicates the superiority of nitrogen in increasing the plant height.

The maximum height was recorded by the highest level of 170 kg N/ha at all stages of growth except at harvest wherein it was on par with its immediate lower level of 140 kg N/ha. Height being a character dependent on nutrition, increased application of fertilisers would have encouraged the root growth which inturn resulted in higher rate of nutrient absorption which was manifested in the increase in plant height. Nair et al. (1966) Mati and Panda (1970), Rajput et al. (1970), Mandloi et al.(1972), Rajgopal and Morachan (1974), Gangre (1978) Salem and Aly (1979) and Muthukrishnan and Subramanian (1980) observed similar increase in plant height by the application of higher doses of nitrogen in maize.

Varieties recorded significant influence in plant height at harvest stage only. The maximum height of 180.35 cm was recorded by the variety Ganga-5 closely followed by Agothi-76. However, Vijay recorded the minimum height of 139.43 cm. In the later stages variety Ganga-5 and Agothi-76 might have responded well to the added fertilisers resulting in increased plant height.

The interaction effect between varieties and nitrogen levels was also significant only in the beginning and at harvest. While v_5n_4 has recorded the maximum height (69.25 cm) at 20 DAS, it was v_2n_4 which recorded the maximum height (201.32) cm) at harvest followed by v_5n_4 (196.36 cm).

5.1.2. Number of leaves per plant.

The results presented in Table 2 (a) revealed that in all the stages, higher nitrogen levels recorded significant influence on the number of leaves per plant. However, varietal variation was not significant during any of the growth stages.

Eventhough there was significant increase in the number of leaves per plant with increasing levels of nitrogen, this increase was significant only upto 140 kg N/ha and as such 140 kg N and 170 kg N/ha could be economically used for increased leaf production. Several workers reported that the nutrients especially nitrogen influenced all the growth parameters especially leaf number (Rajput <u>et al</u>., 1970; Gangro (1977), Yahya and Andrew (1981). Adetiloye <u>et al</u>.(1984) also reported the influence of higher levels of nutrients in increasing the number of leaves in maize.

It is seen that varieties could not influence the leaf number in the present experiment. However, Ganga-5 recorded the maximum number of leaves in all the stages of growth.

5.1.3. <u>Leaf Area Index</u>

It is seen that LAI was significantly influenced by the different nitrogen levels at all the stages of growth of maize plants. This might be due to the favourable effect of nitrogen on leaf growth. Higher levels of nitrogen increased the number of functioning leaves (Table 2 a). Increase in LAI with increased levels of nitrogen was reported by

Rajgopal and Morachan (1974), Krishnamurthy et al. (1974), Gangre (1977), Mikhail and Shalaby (1979), El-Hattab et al. (1980), and Sales et al. (1982). The highest nitrogen level was found to be giving the maximum LAI at all stages except 60 DA which was on par with its immediate lower levels. Another observation made in the present study was that the maximum LAI was recorded at 60 DA. Krishnamurthy (1978) indicated that summer planting exhibited faster growth of crop enabling early achievement of larger LAI to intercept and utilise higher amount of radiation than observed from Kharif and Rabi plantings.

Increase in LAI at higher doses of nitrogen might be due to the higher number of leaves produced by the application of nitrogen as indicated earlier. Increased nitrogen application might have also increased the metabolic activity of plants and this inturn might have increased the LAI. Studies conducted by Cangwar and Kalra (1981) found that LAI of rainfed maize increased with increase in nitrogen rates from 40 to 120 kg N/ha.

Varietal effect on this character was also significant at all stages except at 20 DA. Among the different Varieties, Ganga-5 showed the highest LAI of 3.2. Thus it is seen that Ganga-5 could produce the highest LAI during summer season, thus exhibiting its superiority in this very important growth function.

The fact that interaction effect was not significant is a clear indication that different varieties did not interact with nitrogen levels.

5.1.4. Days to silking.

The results (Table 3(a) and (b), revealed that different varieties and levels of nitrogen significantly influenced the number of days to silking. Sharma et al. (1969) found that the days to silking was decreased with increasing rates of nitrogen upto 200 kg N/ha. Nandlal et al. (1972) also reported early silking with the application of nitrogen at higher doses. In the present study also the plants were found to silk earlier with higher levels of nitrogen and the earliness continued upto 140 kg N/ha. Thus the mean number of days to silking was significantly reduced from 67.75 to 61.65. Generally nitrogen is expected to lengthen the vegetative phase and as such delayed process of maturity. But in the present study because of the luxuriant supply of sunshine due to summer season the photo synthetic activity could have been started earlier in the presence of abundant supply of nitrogen resulting in earlier attainment of higher LAI (Table 2) and earlier silking. The results of the present investigations are in agreement with the findings of Gupta (1968), Rathore et al. (1976), Athar (1979), El-Hattab et al. (1980) and Yadav et al. (1983).

Varieties also recorded significant difference in the number of days taken for silking. Among the varieties, Agothi-76 required the lowest number of 58.25 days for silking followed by Ganga-5 with 59.8. The maximum number of 7[illegible].25 days was recorded by the variety Vijay.

5.1.5. Leaf-stem ratio at harvest.

There were significant effects in the leaf-stem ratio of maize at harvest due to different varieties, different levels of nitrogen and their interaction.

A linear increase in leaf stem-ratio was recorded by nitrogen application upto 140 kg N/ha. This might be due to the higher rate of leaf production in proportion to stem in the monocrop of maize under adequate nutrition. Although the highest value of 0.79 was recorded at 170 kg N/ha, it was on par with that of 140 kg N/ha.

Different varieties varied significantly in leaf-stem ratio. Among the five varieties, Ganga-5 has recorded the highest value of 0.66 followed by Ganga safed-2 and the lowest value of 0.46 was recorded by Hi-starch. The data presented in Table 2(a) revealed that the above two varieties have produced comparatively higher number of leaves per plant and as such they could very well record higher values of leaf-stem ratio. The superiority of Ganga-5 variety has been further reflected in the case of leaf area index also.

5.1.6. Drymatter production.

It is evident from the Table 4(a) and (b) that nitrogen application had significant influence on the drymatter production, upto the highest level tried (170 kg N/ha). The treatments which received higher doses of nitrogenous fertilisers

(170 kg N/ha registered higher drymatter yield than those with lower fertiliser levels. The influence of nitrogen in promoting the vegetative growth of plants is a well established fact. Increase in drymatter yield with increasing levels of nitrogen was reported by Shanmughasundaram et al. (1974), Kumaraswamy et al. (1975), Elias et al. (1979), Singh and Chand (1980), Muthukrishnan and Subramanian (1980).

A positive linear response was observed with increasing levels of nitrogen. Higher levels of nitrogen application increased the growth of maize crop significantly (Table 2 (a) and (b). The growth attributing characters like height of plants, number of leaves per plant and the leaf area index were maximum at higher levels of nitrogen application. The results in Table 6 (a) and (b) clearly indicated that the uptake of major nutrients might have increased the production of growth attributing characters and finally resulted in the higher drymatter yield. The uptake of major nutrients was maximum at higher levels of nitrogen application. The increased uptake of major nutrients would have resulted in higher drymatter yield. Similar results showing the influence of increased dose of nutrients in increasing the yield of maize was reported by Krishnamurthy et al. (1974) and Mikhail and Shalaby (1979a). According to Ahlawat et al. (1975), nitrogen fertilisation increased the drymatter accumulation and the rate of drymatter accumulation was faster in nitrogen fertilised plants and the per plant dry weight increased continuously upto 9 -95 days. Stoyanov (1983) also observed the beneficial effect of nitrogen in increasing the drymatter production in maize and explained, that the increasing nitrogen rates increased the chlorophyll content which is correlated with drymatter accumulation.

Eventhough there was no significant difference in drymatter yield due to different varieties, the maximum drymatter yield was recorded by the variety Ganga-5 and minimum by Ganga Safed-2.

5.2. Yield Components

5.2.1. Number of cobs per plant.

The data furnished in Table 3 (a) revealed that the application of nitrogen at different levels had significant effect on the number of cobs per plant. The highest number of cobs was recorded by the highest level of nitrogen (17. kg N/ha) which was on par with its immediate lower level (14. kg N/ha). This finding is in conformity with the results obtained by Sharma (1973), Rathore et al. (1976), Bran and Chohra (1977), Short et al. (1982), Karim et al. (1983) and Akotiloye et al. (1984).

Varieties also recorded significant difference in the number of cobs per plant. Ganga-5 recorded the highest number of cobs per plant which was on par with Hi-starch in this regard.

The data on LAI and leaf-stem ratio also revealed that Ganga-5 stood first in both characters. The fact that Ganga-5 could produce the highest LAI of 5.2 clearly indicates its superiority in the carbohydrate synthesis which reflected in the number of cobs and ultimately on the yield.

It was observed that the number of cobs per plant is a character influenced by both nutrient status and varietal character individually as their interactions were not significant.

5.2.2. Number of Grains per cob.

Table 3 (a) and (b) showed that the different varieties, levels of nitrogen and its interaction effects significantly influenced the number of grains per cob. Number of grains increased linearly with increasing levels of nitrogen upto 140 kg/ha which was on par with its higher level of 170 kg N/ha. Sattar et al. (1975) observed higher number of grains per ear with 120 kg N/ha. But Rathore et al. (1976) observed linear increase in the number of grains per cob with increasing levels of nitrogen upto 160 kg/ha.

The effect of varieties significantly influenced this character. Among the different varieties Ganga-5 recorded the maximum number of grains per cob and Vijay recorded the minimum number of grains per cob. The interaction between nitrogen and variety also was found to be significant.

FIG.3. NUMBER OF GRAINS / COB AS INFLUENCED BY VARIETIES AND LEVELS OF NITROGEN

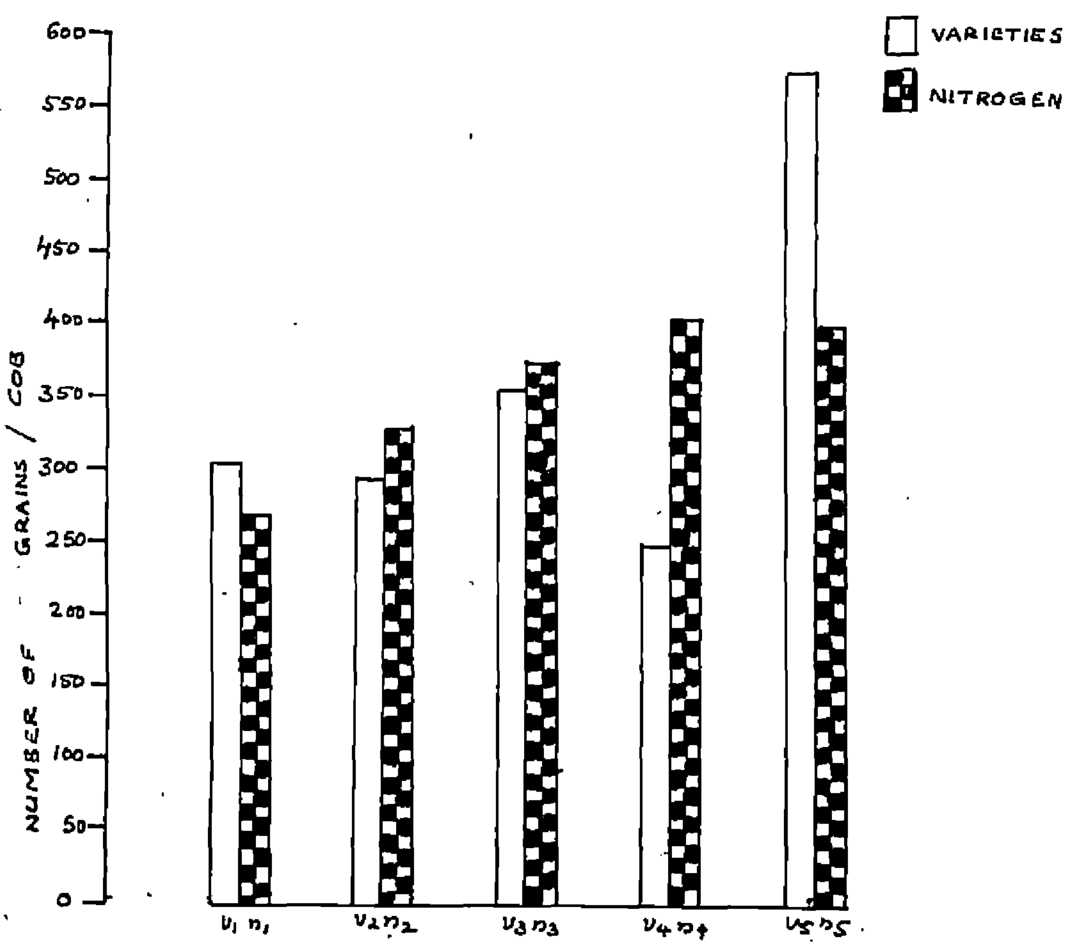
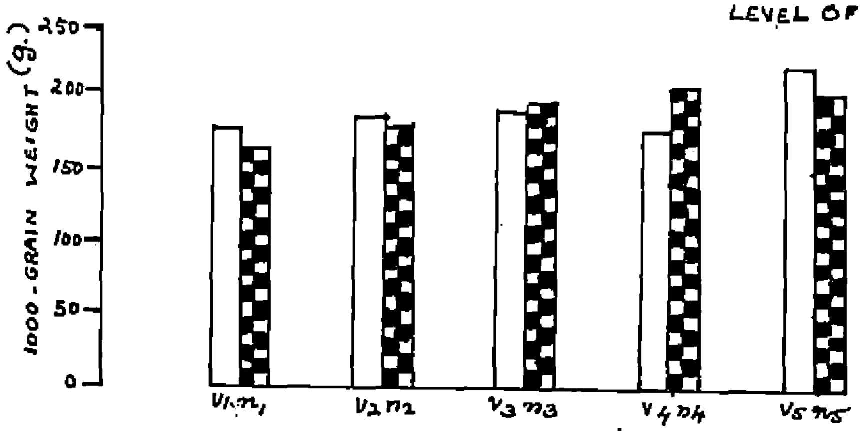


FIG.4. 1000 GRAIN WEIGHT AS INFLUENCED BY VARIETIES AND LEVEL OF NITROGEN.



Krishnamurthy et al. (1977), Al-Rudha and Al-Younis (1978) and Muthukrishnan and Subramonian (1980) observed an increasing trend in the number of grains per cob with increasing rates of nitrogen. Rajput et al. (1978) also observed linear significant increase upto 160 kg N/ha. The higher level of nitrogen treated plots produced marked increase in the number of grains per cob compared to lower level nitrogen treated plots. Thus it is revealed that the application of nitrogen is definitely beneficial in this character.

The fact that the interactions were also significant clearly indicated the fact that the varietal variation in this character can be fully exploited by high level of nitrogen management. Ganga-5 when supplied with 140 kg N/ha could produce the maximum number of grains per cob.

5.2.3. Length of cob.

The data revealed that the different varieties and nitrogen levels influenced the length of cob significantly. Among the varieties, Hi-starch recorded maximum length of cob followed by Ganga-5. The result of the present investigation was in conformity with the findings of Muthukrishnan and Subramonian (1980). The minimum length of 21.70 cm was recorded by Ganga Safed-2.

Length of cob was influenced significantly by levels of nitrogen. The response was linear upto 140 kg N/ha beyond which a slight reduction in length was observed. Increase in length of cob with increasing levels of nitrogen was reported by several workers like Hati and Panda (1970), Gangro (1978), Shalaby and Mikhail (1979), Sciput et al. (1979), Subramonian et al.(1982), Adetiloye et al.(1984) and Russel (1984).

It is seen that the interaction effects was also significant. Hi-starch at 140 kg N/ha has recorded the maximum length of 31.5 cm followed by 29.5 cm recorded by the same variety at 110 kg N/ha, thus proving that the same variety of maize and the same level of nitrogen both individually and collectively exhibited their superiority in this character.

5.2.4. Girth of cob.

Results revealed that applied nitrogen increased the girth of cobs significantly. Maximum girth of 16 cm was recorded by 140 kg N/ha which was on par with 170 kg N/ha. Thus it is seen that there was significant linear response only upto 140 kg N/ha and thereafter a slight reduction in the girth of cobs was observed. These findings are in confirmity with the results of Kharkar (1980), who found a linear increase in girth of cobs upto 160 kg N/ha. Subramonian et al. (1982) and Russel (1984) also reported significant linear response in the girth of cobs with different levels of nitrogen.

Varietal effect also influenced significantly on the girth of cobs. Among the varieties, Ganga-5 recorded the maximum girth which was found to be superior to other varieties.

5.2.5. Weight of cob.

The different varieties, nitrogen levels and its interaction effects recorded significant influence on the weight of cobs. Among the varieties, Ganga-5 recorded the maximum weight of cobs which markedly differed from all the other varieties. The data presented in Table 3 (a) clearly indicated that the length of cobs and girth of cobs were significantly superior in the variety Ganga-5. Therefore, it is quite natural that this variety recorded significantly higher weight of cobs.

Incremental doses of nitrogen also produced significant and linear increase in the weight of cobs upto 14. kg N/ha. In the case of length of cobs and girth of cobs it is seen that the nitrogen level of 14 kg/ha was superior and as such the same level would record the higher weight of cobs also. According to Rathore et al. (1976) and Shankar (193-) a linear increase in cob weight was recorded upto 16. kg N/ha.

5.2.6. Thousand Grain weight.

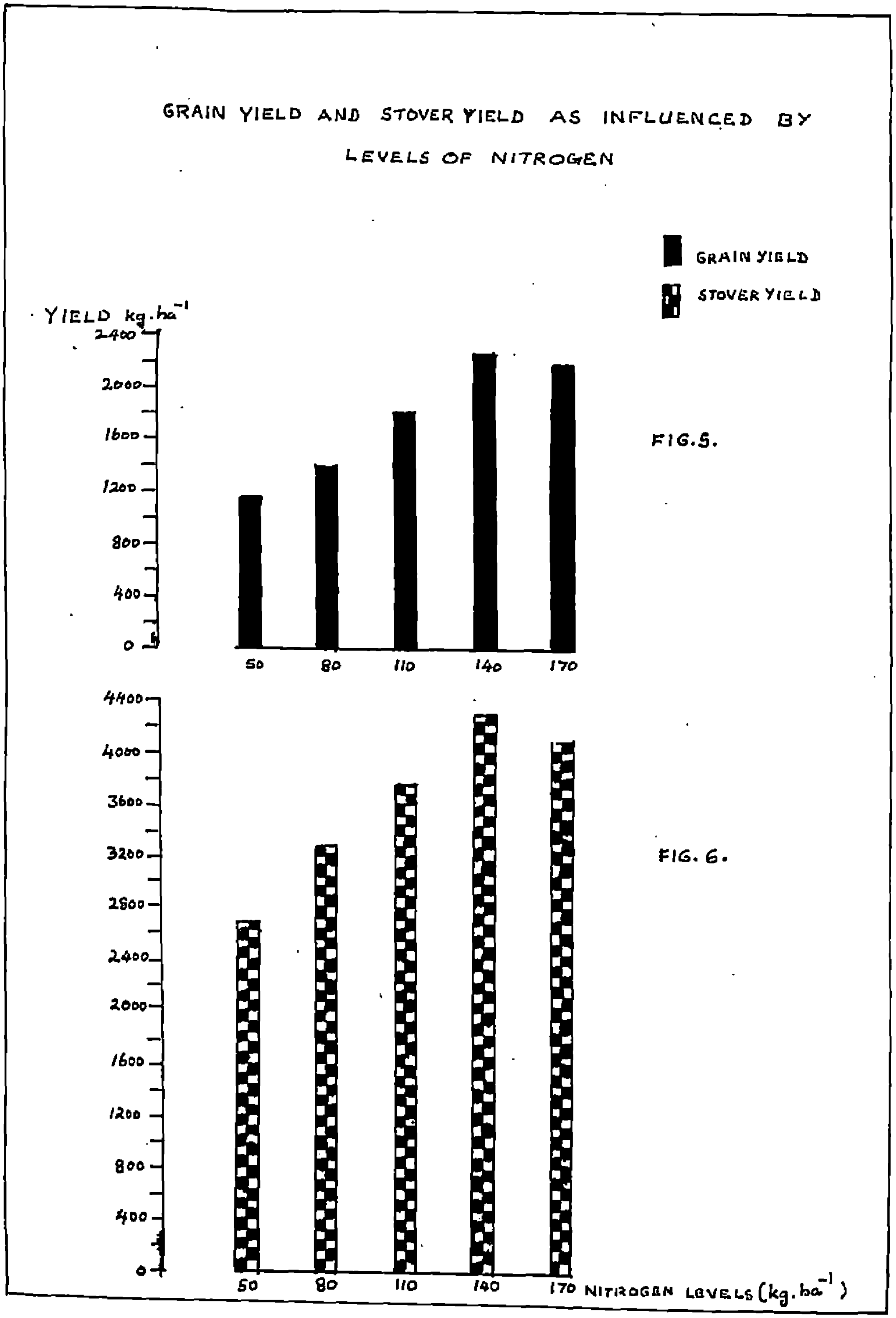
Data furnished in Table 3 (a) revealed that different fertilizer levels and different varieties recorded significant influence on the thousand grain weight. The significant effect of nitrogen has been utilized not only for vegetative growth and development, but also for increasing the size of seeds by proper filling up of the grains and thereby contributing to a higher thousand grain weight. Increasing levels of nitrogen increased the thousand grain weight upto 140 kg N/ha. Similar increasing trend in thousand grain weight with incremental levels of nitrogen was observed by Tripathi (1971), Sharma (1973), Rajan and Sankaran (1974), Krishnamurthy *et al.* (1977) Shalaby and Mikhail (1979), Subramanian *et al.* (1982), Russel (1984) and Krishnaveni and Ramaswamy (1985). Rathore *et al.* (1976) and Kharkar (1980) recorded linear response upto 160 kg/ha.

Among the five varieties tried only Ganga-5 could record significantly higher thousand grain weight which clearly indicated the fact that only Ganga-5 could utilise the higher levels of nitrogen for increasing the size of grains and thereby exhibiting higher thousand grain weight.

5.3. Yield

5.3.1. Grain yield.

The results furnished in Table 4 (a) revealed that the application of nitrogen exerted a significant influence on the total grain yield. A positive linear increase in grain yield was observed upto 140 kg N/ha and the differences due to


GRAIN YIELD AND STOVER YIELD AS INFLUENCED BY LEVELS OF NITROGEN
GRAIN YIELD
STOVER YIELD
YIELD kg.ha^{-1}
2400
2000
1600
1200
800
400
0
50
80
110
140
170
FIG.5.
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
50
80
110
140
170
NITROGEN LEVELS (kg.ha^{-1})
FIG. 6.

successive incremental doses of nitrogen were significant upto 140 kg N/ha. It was already seen (Tables 2(a,b) and 3(a,b) that many of the growth promoting and yield attributing characters like LAI at critical stages, leaf stem ratio, number of cobs per plant, number of grains per cob, weight of cobs, thousand grain weight etc.,. were progressively increased with incremental levels of nitrogen. Therefore it is clear that the influence of all these characters have been finally expressed in the grain yield.

When the level of nitrogen increased from 100 kg to 140 kg N/ha, grain yield increased from 1708 kg 2340 kg/ha. Thus it is seen that an increase of 30 kg N/ha could produce a very high increase in grain yield. The number of cobs per unit area, number of grains per cob and higher grain weight were mainly responsible for this increase in yield. Arora et al. (1973) found that the increase in grain yield with increasing levels of nitrogen may be attributed to the favourable effect of nitrogen on grain yield per ear. The influence of higher dose of fertilizers on the growth of maize crop is well known. A perusal of the data (Table 4a) in respect of grain yield indicated that different levels of nitrogen had significant effect on grain yield.

The data in Table 6(a) in respect of the uptake of total N, P and K by maize also clearly indicate that the higher uptake of the major nutrients might have substantially improved the yield attributing characters which might have finally resulted in higher yields. Similar results showing the influence of increased dose of nutrients in increasing yield of maize was reported by several workers alike Pushpangadan and George (1965) Sasidhar and Sadanandan (1972), Meenakshi et al. (1975), Khan and Singh (1976), Sathyanarayana (1978) and Kumar et al. (1984).

The results discussed above clearly revealed that the hybrid maize crop economically responded to 140 kg N/ha which produced the maximum yield while the lowest yield was under 50 kg N/ha. Grainyield increased significantly with each additional level of applied nitrogen. The favourable effect of nitrogen in increasing the total grain yield has been reported by many workers like Tripathi and Singh (1982), [illegible]alen et al. and Yadav et al. (1985), Brar and Bhajan Singh (1984) and Patel et al. (1985). In the present study, the higher grain yield under increased nitrogen levels were mainly due to corresponding increase in yield contributing characters like length of cob, girth of cob, number of grains per cob and thousand grain weight. Moreover the uptake of major nutrients viz., N, P and K were higher with increasing levels of nitrogen resulting in higher grainyield as already stated. Similar linear response in grain yield to maize upto 140 kg N/ha was reported by Palacios (1979) and Mihajlovic (1982).

According to Tripathi (1978), Gangwar and Kalra (1981), Yadav et al.(1985) and Patel et al.(1985), application of nitrogenous fertilisers exerted a linear increase in grain yield upto 120 kg N/ha. Workers like Brar and Khehra (1977) and Bhushan et al. (1977), Prasad (1978), Halemani et al. (1980) and Dev et al. (1980) reported linear increase in grainyield with increasing levels of nitrogen upto 150 kg/ha. The results of trials conducted by Bharthakur et al. (1975) and Mehta and Kothari (1975) revealed that nitrogen at the rate of 160 kg/ha resulted maximum increase in grain yield during summer season.

Eventhough the effect of varieties on grainyield was not significant, Ganga-5 produced the maximum grainyield which may be ascribed by hybrid vigour in Ganga-5 and also that it may be an efficient user of available plant nutrients. In otherwords, the higher grain yield of Ganga-5 may be attributed to higher number of ear bearing plants and superior ear characters. Decreased grain yield of Vijay even with higher dose of 170 kg N/ha appears to be due to less productive efficiency of Vijay as compared to Ganga-5. Sharma (1970) observed that the hybrid Ganga-5 out yielded Vijay and the economic optimum dose of nitrogen was between 145 and 164 kg N/ha.

5.3.2. Stover yield.

The results revealed that nitrogen had a significant influence on stover yield. Increasing rates of nitrogen significantly influenced the stover yield. As in the case of grain yield maximum stover yield was recorded at 140 kg N/ha which was on par with 170 kg N/ha. It is seen that the vegetative characters like height of plants, number of leaves per plant etc., increased with increasing levels of nitrogen and as such increased stover yield is only a reflection of the favourable influence of these characters. Stover yield progressively and significantly increased with each additional levels of applied nitrogen. Shanmugasundaram et al. (1974) observed considerable increase in straw yield with every increment of nitrogen. The present investigation is in conformity with the findings of several workers like El-Sharkawy et al. (1976), Santos and Olsen (1977), Singh and Sheoprasad (1978), Ranjodh Singh et al. (1980) and Singh et al. (1982).

The effect of varieties was found to be non-significant in the case of stover yield indicating that no variety could significantly influence this character. However the variety Ganga-5 produced the highest grain yield and the lowest yield was recorded by Ganga Safed-2. It is already seen that the highest grain yield was produced by Ganga-5 variety. The fact that the important vegetative characters like height of plant, number of leaves were higher in the case of Ganga-5 variety clearly illustrates the reasons for the highest stover yield in this variety.

5.3.3. Harvest Index

In the present study it is seen that nitrogen had significant influence on the harvest index. The maximum harvest index was obtained at 175 kg N/ha which was on par with its immediate lower level of 140 kg N/ha, showing that this lower dose could be s economically used for higher harvest index. A relatively higher harvest index at higher levels of nitrogen is a clear indication that the varieties tried respond well to the application of nitrogen. This result is in confirmity with the finding of Mikhail and Shalaby (1979b) and Elias *et al.* (1979).

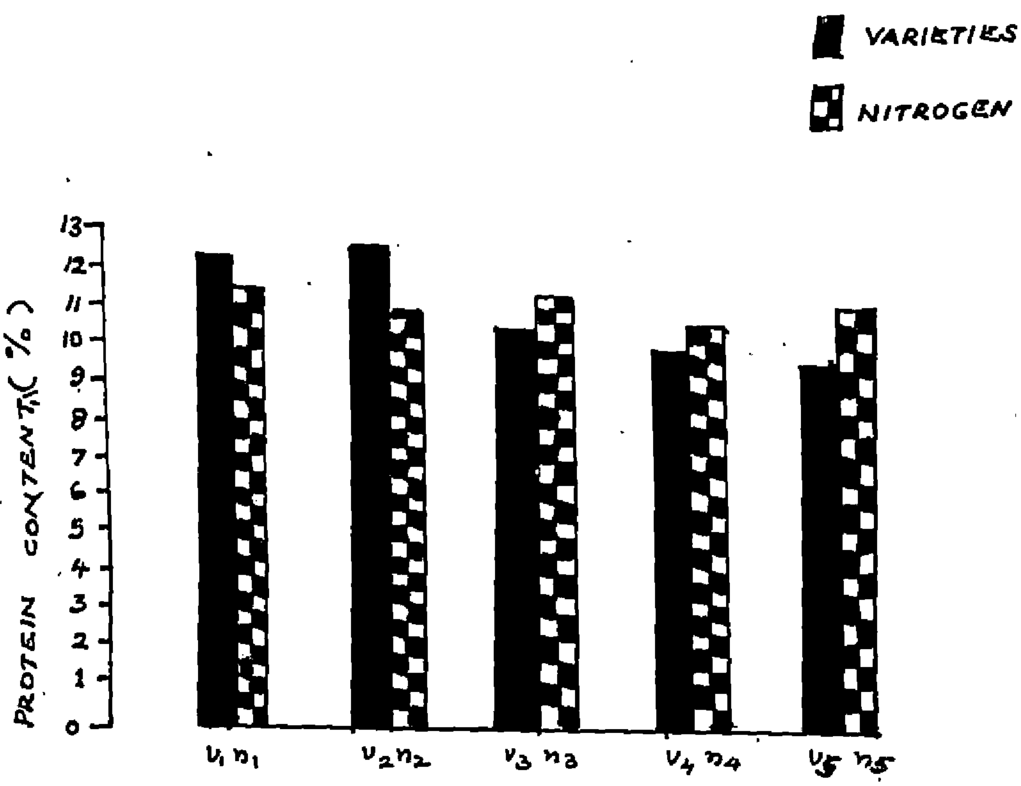
Varieties also had significant influence on harvest index. It is seen that the variety Ganga safed-2 recorded the highest harvest index which was on par with the values recorded by Ganga-5 and Hi-starch. From the early discussion it is clear that Ganga-5 produced the highest grain yield and therefore it is quite natural to get relatively high harvest index values of this variety. It is also observed that Vijay recorded the lowest harvest index which produced the second highest stover yield next to Ganga-5, but recorded only the lowest grain yield. Although Ganga-5 produced the highest stover yield, because of its relatively higher grainyield it could produced higher harvest index also.

5.4. Quality Characters

5.4.1. Protein content of grain.

Nitrogen had a pronounced effect in increasing the protein

FIG. 7 . PROTEIN CONTENT OF GRAIN AS INFLUENCED BY VARIETIES AND LEVELS OF NITROGEN



per cent of grain as revealed in the proof study. Nitrogen at the rate of 140 kg/ha recorded the highest protein per cent in grain after which there was a decline in protein content although not statistically significant. Reddy and Kaliappa (1974) reported that the quality of grain in respect of protein was less at higher population, but if we a take into consideration the total yield per hectare, the loss will be compensated by higher yields at thicker population. They also reported that grain protein content in maize increased with increase in applied nitrogen upto 150 kg/ha. Increased application of nitrogen increased the crude protein per cent indicating the importance of nitrogen in achieving high protein yields with no adverse effect on protein quality. The increased protein per cent was the result of increased nitrogen application as the nitrogen is the most important component of protein.

Increased protein content may be due to higher rates of absorption of nitrogen by the plants at adequate nitrogen level which ultimately resulted in higher protein content. There was significant linear increase in grain protein content with increasing levels of nitrogen. Nitrogen level of 140 kg N/ha produced the maximum grain protein content of 12.47%. Saad et al. (1981) reported a similar increasing trend in grain protein content from 11.75 to 15.5% with increasing nitrogen rate. The prevailing high temperature and low humidity during summer season help in quick drying of seed and thereby better quality of seed is obtained.

The role of nitrogen in increasing the grain protein content was reported by Tripathi (1971), Singh (1976), Gangro (1978) and Yahya and Andrew (1981).

Varieties also differed significantly in their grain protein content. Ganga-5 recorded the highest protein content of 11.7%. The data on nitrogen uptake by different varieties (Table 6(a)) also revealed the fact that the highest nitrogen uptake was recorded by the variety Ganga-5. This higher nitrogen uptake would have helped this variety to record higher per cent of protein also.

5.5. Nutrient contents of plant parts

5.5.1. Nitrogen content of grain and stover.

It is seen that the highest level of nitrogen gave the highest content of nitrogen in grain and stover. Nitrogen content at lowest level was significantly inferior to all other levels of nitrogen. It is clear from the results that the increased supply of nutrients had increased the nitrogen contents of grain and stover significantly. The effect of nitrogen nutrition in increasing the nitrogen content of maize plant has been reported by many workers. (Gangro 1978, Russel and Lorso 198 and Rouf and Islam 1983). Grove et al. (198 found that nitrogen content of above ground drymatter yield was 1.18% and nitrogen content in the grain ranged from 1.45 to 2.27%. According to Mora and Michalis (1981), the grain contained 1.15 to 1.41% nitrogen with nitrogen fertilization upto 160 kg/ha The high content of nitrogen observed with higher levels of nitrogen may be due to the enhanced growth of vegetative (Table 2(a) and (b) and reproductive (Table 3(a) and (b) parts of plants which facilitated higher rate of absorption of this nutrient. The increased nitrogen content with enhanced rates of nitrogen application noticed in this study is inline with the findings of many workers, viz., Rajan and Sankaran (1974), Al-Rudha and Al-Younis (1978), Nayyar and Sawarkar (1980), Chao et al.(1982), Singh et al.(1982) and Salem et al. (1983). According to Khera and Tyagi (1972) maize crop varieties differ in their nutrient removal and therefore in their fertiliser requirements. Nemeth and Below et al.(1984) observed increase in the nitrogen concentration in plants in response to different nitrogen concentration. The application of nitrogen might have produced more roots which inturn might have facilitated more absorption of nutrients. The supply of phosphorus and potash might have also led to the proper uptake of nitrogen.

5.5.2. Phosphorus content of grain and stover.

Table 5(a) and (b) showed clearly the effect of different levels of nitrogen in increasing the phosphorus content in plants. The higher levels of phosphorus content might probably be due to the favourable effect of balanced fertilization. The increase in plant phosphorus content with higher doses of nitrogen supply observed in this study is in line with the findings of Subramonian et al.(1982). The availability of nitrogen at knee heigh stage might have stimulated the vegetative growth which inturn led to better absorption of phosphorus.

5.5.3. Potassium content of grain and stover.

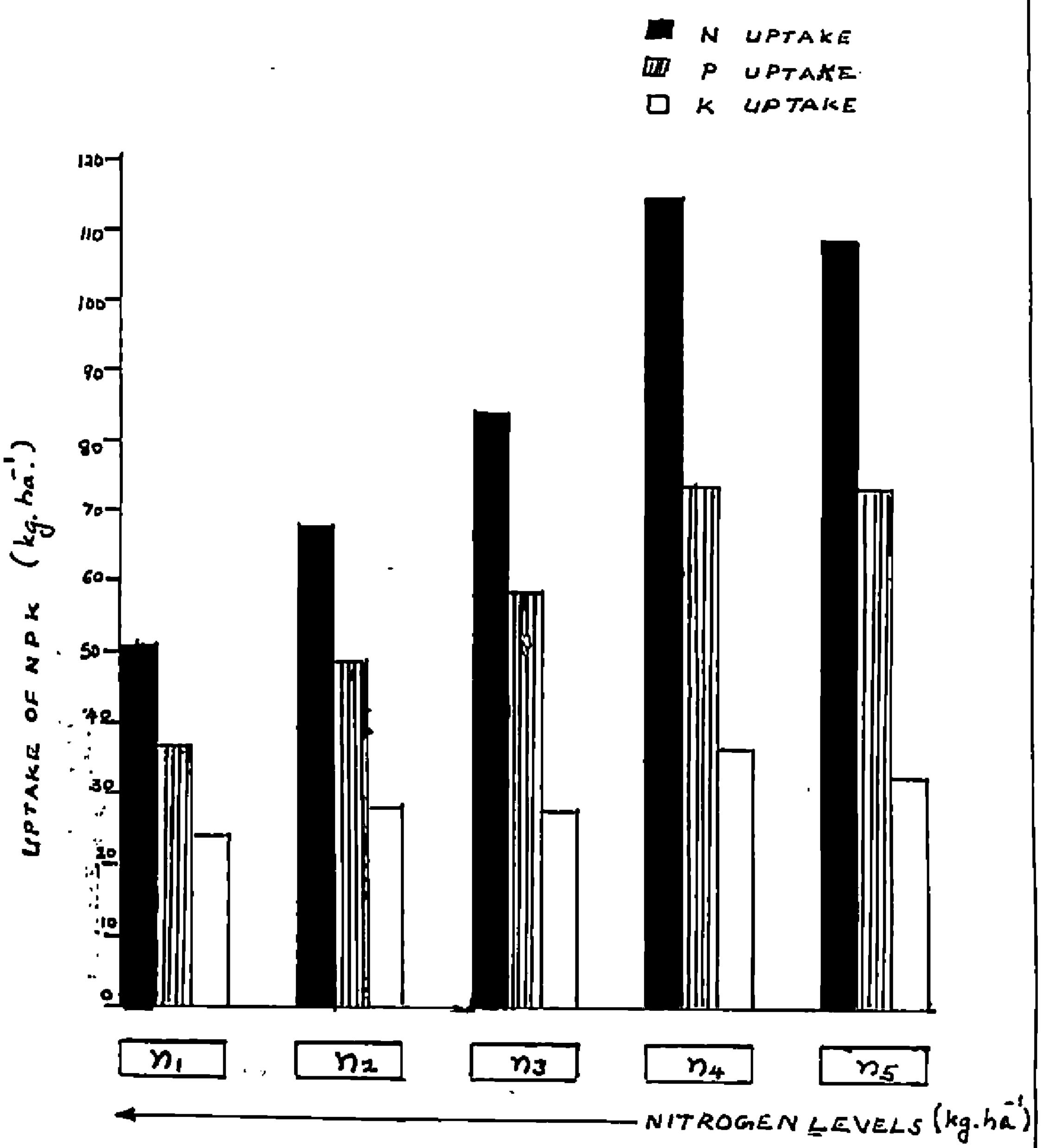
The significant effect of different levels of nitrogen on the potassium content of grain and stover was very clearly revealed in the Tables 5(a) and (b). The higher levels of nitrogen gave significantly lower values for the potassium content of grain and higher values for potassium content of stover. Naturally the higher doses of N,P,K might have led to a better absorption of potassium by stover and hence registering lower potassium content in this treatment. Due to the better absorption of potassium by the stover, the content of it in grain might have decreased.

5.6. Uptake of major nutrients

5.6.1. Nitrogen.

It is seen that the effect of nitrogen was significant was on the uptake of nitrogen by plant. There was progressive

FIG. 8. UPTAKE OF N. P AND K AS INFLUENCED BY LEVELS OF NITROGEN



increase in nitrogen uptake with increasing levels of nitrogen upto 14. kg N/ha. A reference to the Table 5(a) and (b) on the nitrogen content of grain and stover also revealed that the nitrogen content increased with higher levels of nitrogen. Data on drymatter production (Table 4 a and b) also recorded higher values with higher levels of nitrogen. Therefore it is natural that the uptake of nitrogen which was computed from these values also showed the higher values with higher levels of nitrogen. Trials conducted by Rajan and Sankaran (1974) revealed that uptake of nitrogen was higher with higher levels of nitrogen.

There was an appreciable increase in the uptake of nitrogen by maize crop with increasing levels of nitrogen. Application of the 14. kg N/ha resulted in the maximum uptake of 115.48 kg/ha. The effect of nitrogen application on the uptake of nitrogen had been reported by many workers. Sharma et al. (1975), Al-Rudha and Al-Younis (1978), Tripathi (1978) Gangro (1978), Dass and Ranjodh Singh (1979), Rouf and Islam (1983) Martin et al. (1984) and Bolow et al. (1984) reported that increasing levels of nitrogen resulted in higher per cent of plant nitrogen resulting in increased nitrogen uptake.

5.6.2. Phosphorus.

Increased application of nitrogen resulted in an increase in phosphorus uptake by plants upto 14. kg N/ha. Phosphorus uptake at this levels of nitrogen was significantly superior when compared to other lower levels. Virmani (1970) and Pathak and Tewari (1972) revealed that the uptake of phosphorus was higher with higher levels of nitrogen. Nitrogen was thus found to have a pronounced influence on the uptake and translocation of phosphorus. A reference tothe data on drymatter production (Table 4 a and b) revealed that the higher values were obtained with higher levels of nitrogen. Therefore the higher uptake of phosphorus observed in the treatment may be due to the cumulative and complementary effect of this treatment.

5.6.3. Potassium.

The data on the uptake of potassium revealed that 14. 1[illegible] kg N/ha produced highest uptake values which was on par with 17. kg N/ha. The Table 4(a) and (b) and 5(a) and (b) on dry matter production and potassium content of plant revealed that the highest values were obtained with higher levels of nitrogen. Consequently the highest values of uptake of potassium in this treatment may be due to the additive effect of all these. Bajwa and Paul (1978) reported that the total removal of potash increased appreciably with the application of nitrogen alone and also nitrogen in combination with phosphorus, which was associated with increased drymatter production. The effect of nitrogen and phosphorus was largely because of higher grain yield while that of potassium was due to greater availability of this element to the plant. (Deol et al., 1985). According to them, the rate of application of fertilisers influenced the potassium uptake and this too was mainly the contribution of the improvement in grain and total drymatter production.

5.7. Soil analysis

5.7.1. Total nitrogen content of the soil.

The results presented in Table 6(a) and (b) showed that total nitrogen content of soil after cropping was influenced by levels of nitrogen. The soil is rated as high with respect to nitrogen status. Compared to the initial status of soil nitrogen (Table 1) an increase was observed in the content of total nitrogen after cropping. The increase may be due to the mineralisation of the organic matter available in the soil, microbial action etc.... However the residual analysis of soil from higher level nitrogen treated plots showed significant increase in the content of total nitrogen when compared to lower level nitrogen treated plots. The results clearly showed a trend of depletion of total nitrogen with lower levels of nitrogen as compared to initial status of soil nitrogen. But for the highest level of nitrogen, there was no depletion of nutrient status of soil even after the experiment. This reveals the fact that the lower to levels are not adequate to maintain soil fertility status after meeting the crop demands.

Varieties did not differ in their effect on residual of soil nitrogen. However, the variety Ganga-5 extracted the maximum content of nitrogen from the soil.

5.7.2. Available phosphorus content of the soil.

Results presented in Table 6(a and (b showed that the available phosphorus content of the soil after harvest was influenced by levels of nitrogen, varieties and their interaction effect. The available phosphorus status of the soil was low (Table 1.). The data showed that there was depletion of available phosphorus content of the soil with increasing levels of nitrogen. This shows that there was depletion of phosphorus after plant uptake with the lower levels of nitrogen. Thus the data clearly showed the need for application of high levels of nitrogen for the maintenance of nutrient status of soil Among the different varieties Ganga-5 extracted the maximum amount of phosphorus from the soil.

5.7.3. Exchangeable potash content of the soil.

The data on the avilable potassium content of soil after the experiment (Table 6 a and b, revealed that there was significant difference in the potassium content with levels of nitrogen. The results showed that the potassium content increased in the soil after experiment with higher rates of nitrogen. application. It may be noted . that there was no significant difference between nitrogen levels on the uptake of potash by the maize crop (Table 5 (a) and (b)) thus indicating the possibility for the availability of higher quantity of potash in the soil in treatments in which higher levels of potash were applied.

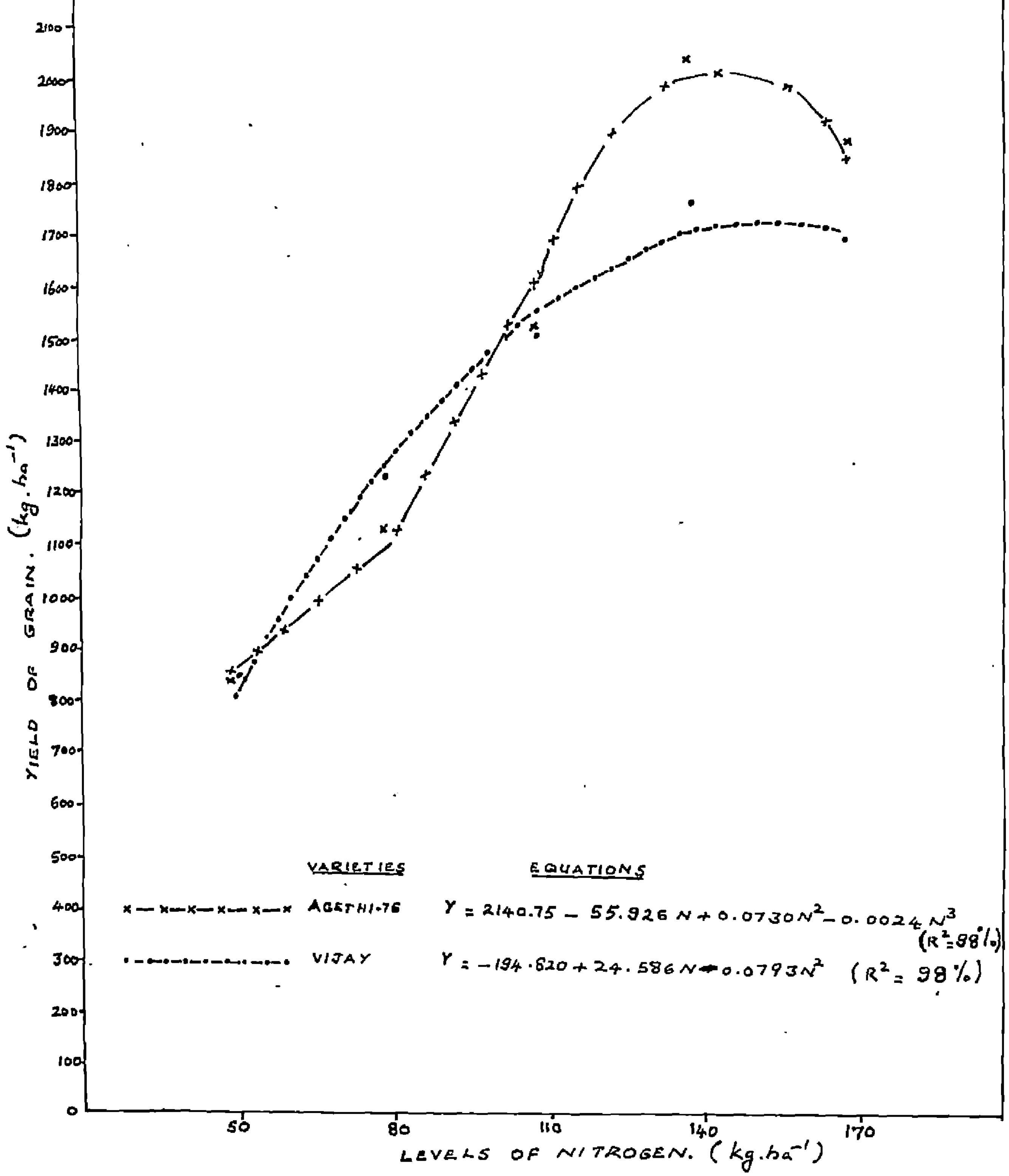
5.3. Response of maize to nitrogen

The results of trend analysis presented in Appendix XI clearly revealed that the varieties Ganga Safed-2 (V_1), Hi-starch (V_3) and Ganga-5 (V_5) responded linearly towards the application of nitrogen and as such theoretically the yield maximising levels could not be worked out. A class of non linear models tried on these varieties also failed oto indicate the anticipated optimum. Although the following models were tried to study the response pattern, none of them were found to fit the data satisfactorily.

1. Quadratic model
2. Inverse polynomial model
3. Logarithmic linear model
4. Square root polynomial model
5. Cubic polynomial model
6. Mitscherlich function

However, from the ANOVA of these varieties it could be seen that the doses 14 kg. and 17 kg. were statistically on par and were significantly superior to all of the lower doses. Thus practically no significant response could be gained by increasing

FIG. 9. RESPONSE OF MAIZE VARIETIES TO NITROGEN.



the level of nitrogen beyond 14[illegible] kg/ha. Thus 14[illegible] kg N/ha could be recommended for adoption in the case of these varieties.

The quadratic model was found to be the best fit for one variety Vijay (V_4) and Cubic polynomial model yielded promising results for another variety Agothi-76 (V_2). Response function of grain yield and nitrogen levels in variety Vijay (Fig. 9) was explained by the quadratic function $Y = 194.0265 + 24.5034\ N - .0791\ N^2$. The physical and economic optimum nitrogen rates for this variety were found to be 155 kg and 144.44 kg/ha respectively. The relationship between the grain yield and levels of nitrogen in a variety Agothi-76 could be explained by cubic polynomial function $Y = 214.75 - 55.926$ [illegible]$.72$[illegible] N^2 - [illegible]$.024\ N^3$. The physical and economic optimum nitrogen rates for this variety were found to be 15[illegible].5 kg and 177.57 kg/ha respectively. The coefficient of determination (R^2) of these models were as high as 90[illegible] which exhibited the high amount of predictability of the models in describing the response pattern.

[illegible]harma (1973) observed that the economic optimum dose of nitrogen for maize was in between 145 and 164 kg/ha. But recent investigations conducted by Negrila *et al.* (1984) revealed that the most economic nitrogen rate for grain production was 143 kg N/ha.

5.9. Economics of maize production.

The crelative economic of nitrogen fertilisation in maize cultivation in rice fallows during summer in terms of grain and stover production worked out on the basis of expenditure and returns are presented in Table.7.

The results showed significant increase in net return when the level of nitrogen was enhanced from 50 to 140 kg N/ha. The net return increased from Rs. 1,534/- to Rs. 5,627/-, when the nitrogen dose was increased from 5. kg N/ha to 140 kg N/ha. This works out to a net return of Rs. 45.48 per kg of nitrogen. In this connection it may also be noted that the economic optimum levels of nitrogen for Vijay and Agothi-76 were also worked out to be around 140 kg/ha, that is 144.44 kg/ha for Vijay and 147.57 kg/ha for Agothi/76.

The economic analysis revealed that the varieties did not differ significantly in this respect although the net return ranged from Rs. 2,706/- to Rs. 6,5.9/-. This is in agreement with the earlier findings that there was no significant difference between varieties in the case of grain and stover yield.

5.10. Correlation studies

The results presented in Table 9 clearly revealed that the grain yield of the crop was positively and significantly correlated with the various yield components, viz., number of cobs per plant, number of grains per cob, length of cob, girth of cob, weight of cob, weight of thousand grains, weight of stover. Similar result was obtained by Pande et al.(197 . Studies conducted by Singh (197) revealed that grain yields showed the highest postive correlation with ear girth followed by ear length. Singh and Verma (1977) also reported that the grain yield as per plant was positively and significantly correlated with number of cobs per plant, girth of cobs, number of rows per ear and 2.0 grain weight. According to Geerts et al.(1978) there was a highly positive correlation between grain yield and number of ears per plant.

It is also seen from the Table 7 that the uptake of nitrogen, phosphorus and potassium by the crops at harvest was also positively and significantly correlated with grain yields as well as protein content of grain. These results are in confirmity with the findings of Geerts et al.(1978 .

SUMMARY

6. SUMMARY

An experiment was conducted at the Instructional farm, College of Agriculture, Vellayani during summer season 1985-86 to find out the response of five maize varieties viz. Ganga safed-2, Agethi-76, Hi-starch, Vijay and Ganga-5 to graded levels of nitrogen in rice fallows. The different levels of nitrogen tried were 50, 80, 110, 140 and 170 kg/ha. The experiment was laid out in split-plot design with four 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. The maximum height was recorded by 170 kg N/ha at all stages of growth except at harvest wherein it was on par with its immediate lower level of 140 kg N/ha. Varieties recorded significant influence in plant height at harvest stage only. The variety Ganga-5 recorded the maximum height and Vijay recorded the minimum height.

2. Number of leaves increased significantly with increasing levels of nitrogen upto 140 kg/ha. Varieties had no significant influence on the number of leaves at any stage.