EFFECT OF DATE OF SOWING AND NITROGEN FERTILISATION WITH MICRONUTRIENTS ON THE YIELD AND QUALITY OF HYBRID MAIZE (*Zea mays, L.*)

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri. K. Pushpangadan, under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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K. Pushpangadan.

LIST OF FIGURES

CONTENTS

INTRODUCTION

INTRODUCTION

Maize is grown in India as the poor man's crop. But in countries like the U. S. A. it is an agricultural crop of great importance. It constitutes a major part of the diet of the people in one form or another, and furnishes raw materials for a variety of industrial products.

Maize is one of the most ancient and important food plants. Even with the appearance of other cereals on the agricultural scene, its importance has not been in the least minimised. Instead it has taken a different and additional turn towards industrial use. The long list of the industrial uses of maize shows its importance in the economy of the advanced countries of the world. This also points to the role which hybrid maize is going to play in the future economy of our country.

Though maize figures as an all India Khariff crop with an acreage of 10.71 million, its yield per acre is extremely low and is only one third of that in the U.S.A. The present yields of maize in India are roughly comparable to those which were obtained in the south eastern part of the U. S. A. a generation ago. This is largely because of the great advances made in the science of Agriculture in western countries during the last 50 years have made little impact on the agricultural practices followed by the majority of our farmers.

The evolution of hybrid maize is an outstanding achievement in the practical application of the science of Genetics to agriculture. In India the first attempts in the improvement of maize were made at the Vivekananda Laboratory, Almora (U. P.). In 1947-48 maize breeding scheme was set up on an all India basis. The scheme started functioning with active collaboration between the I.A.R.I., the Rockfeller foundations and different state departments of Agriculture. In 1961 four double cross hybrids developed by the Co-ordinated Maize Breeding Scheme were released. These were Ganga Hybrid Makka 1 and Ganga Hybrid Makka 101 for the northern plains, Ranjid Hybrid Makka for southern parts of Rajasthan, Gujarat and Maharashtra and Deccan hybrid Makka for peninsular India. In Kerala preliminary trials have shown that the Deccan Hybrid Makka grow successfully.

Corn is unique among cereals in the enormous differences that exist among strains developed to meet the needs of diverse conditions of temperature, moisture, length of growing season and other environmental factors. Some strains grow less than 2' tall require 60 to 70 days to mature and have only 8 or 9 leaves, where as others require 10 to 11 months to mature grow more than 20' tall and have 42 to 44 leaves (Kuleshoe, 1933 as reported by Jenkins, 1941). Finch and Baker (1917) stated that practically no corn is grown where the mean summer temperature is less than 66^{o}F or where the average night temperature during the 3 summer months falls below 55^{o}F. For optimum growth and grain production corn requires a plentiful supply of moisture, well distributed throughout the growing season. In addition climate influences the chemical composition of corn, although the influence is less marked than in some other cereals (Reported by Jenkins, 1941). The soil and climatic conditions under which maize is grown in India differ materially from those in the principal maize growing areas of the U. S. A. and will require continued research to discover the best combination of practices for attaining high yields dependably and consistently.

It is not enough if farmers use hybrids for sowing. They must know that maize hybrids perform better under high fertility conditions and with proper agronomic practices. With hybrid maize having a higher yield potential it is possible to get attractive returns at much higher levels of investment, thus making it worth to put larger investment by way of better agronomic practices.

Nitrogen deficiency is very wide spread in the soils of Kerala as considerable loss of nitrogen occurs through drainage and leaching caused by heavy rains. With low organic content and comparatively rapid decomposition, nitrogen in the soil is low. The deficiency in phosphate is also experienced but to a comparatively lesser extent. Potassium deficiency is not keenly felt. Hybrid maize does not grow well if nitrogen is not available in adequate quantities. A number of experiments were conducted at I. A. R. I., New Delhi and other places where the response of hybrid maize to nitrogen was studied. It has been shown that 50 to 60% or even more increase in yields can be brought about by providing good soil fertility and judicial farm management. Preliminary investigations at Vellayani also proved responses of corn to nitrogen.

The establishment of essentiality of certain elements in minute quantities in the nutrition of plants led to an extensive study of micronutrients during the past few decades. As a consequence of recognising their importance, considerable attention was paid to their practical utility which promised great potentialities not only in the solution of problems of nutritional disorders in crops but also in the matter of increased production. Experiments conducted at I.A.R.I., New Delhi, indicated profitable response to zinc when applied to the soil, when the crop was well supplied with N, P, K. Combined application of zinc with manganese and magnesium along with N. P. K. also increased the grain yield by 5 to 6 quintals per hectare over N.P.K.

Since the date of sowing and fertility levels have been found to influence the yield and quality of maize, it was felt necessary to study these treatments under conditions prevailing in Kerala State where maize is a new introduction.

The objectives of the present investigation are stated below.

1. To find out an optimum date of sowing for hybrid maize crop under rainfed conditions.

2. To find out the optimum dose of nitrogen fertilization at different times of sowing on the yield and quality of the crop.

3. To find out the effect of a mixture of micronutrients containing zinc, copper and manganese on the yield and quality of the crop.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Corn is unique among the cereals in the enormous differences that exist among strains developed to meet the needs of diverse conditions of temperature, moisture, length of growing season and other environmental factors.

1) Effect of climate on growth and yield of corn.

Finch and Baker (1917) reported that practically no corn is grown where the mean summer temperature is less than 66°F or where the average night temperature during the three summer months falls below 55°F.

The results of a study of the average temperatures and yield during the 16 year period 1914-1929, Huntington et al (1933) concluded that corn which produce largest average yields had average summer temperatures for the months of June-July and August of 68° to 72°F.

Mattice (1931) studied the correlation between corn yields and numerous climatic factors and observed that in Minnesota high yields were associated with warm weather during the summer, while in Missouri high temperatures in July and August resulted in low yields.

In South Dakota and Kansas large yields were associated with high relative humidity.

Summarising the result of experiments in South America, Richey (1933) concluded that optimum stand of corn dependent upon size of the plant, moisture supply and soil fertility conditions, being heavier with more favourable conditions.

Martin and Leonard (1957) mentioned that in Western Kansas planting in June permits the corn to tassel and silk after the period of extreme mid summer drought and heat which results in higher yield.

Results of a study of climate within the maize growing areas of the west rift area of the Kenya high lands by Glover (1957) showed that rainfall is the major metereological variable. A further investigation showed that average yields of maize within the region are affected by changes in seasonal rainfall.

Runge and Odell (1959) concluded that precipitation above normal is especially beneficial when it occurs approximately one month before and during anthesis.

Denmead and Shaw (1960) reported that moisture stress during (1) the period between 30 and 60 days after sowing reduced plant height and dry matter production (2) from the on set of tassel emergence until 5 days after 75 percent of the plants had produced silks a period of 17 days and (3) for 30 days after silking reduced grain yields.

Hanke and Koss (1961) reported that high rainfall during sowing to emergence and during the 55 days after flowering inhibited development but increased the yield of dry matter.

Investigations conducted to find out a normal climate for a maize crop season in South Dakota, Darrold et al (1963) concluded that the normal season has a high rainfall in June and a temperature peak in July.

From trials over 13 years at 6 localities at 175-320 m. altitude Schwarzer (1963) showed that high yields were obtained only at localities below 250 metres altitude with a mean temperature of 15°C during the growing season.

Investigations carried out by Stannberry *et al* (1963) under various levels of Nitrogen and moisture revealed that the stage of development, at which supplementary irrigation most increased total ear weight was during pollination.

Colligado *et al* (1963) observed that drought retarded the growth of maize at the seedling stage, but the plants were able to recover and yielded as much as those given sufficient moisture throughout the growing period. Moisture deficit from tasseling to maturity was found to be most critical and significantly decreased the yield.

Dastane and Singlachar (1963) indicated that under excess water conditions that hybrids Ganga 1 and Ganga 101 gave significantly higher yield than the open pollinated variety K.T. 41. Flooding at the preflowering stage caused a significant reduction in the yield of maize crop gradually.

Rhoades and Nelson (1955) reported that a deficiency of moisture during tasseling and silking sharply lowers the yields. The greater need of corn for high moisture is during that period. Moisture deficiencies after silking have little effect on vegetative growth. Moisture deficiency through out the growing season results in stunted plants having short internodes, more root growth in relation to top growth, poor leaf growth, delayed silking and tasseling, delayed maturity and small poorly filled ears.

2) <u>Effect of date of sowing</u>

In South India Vittal Rao and Mahboob Ali (1961) suggested that sowings during Khariff season should be done around May 24 in order to get maximum yield of the maize crop. Maize cannot successfully raised when sown in January, March, April, August, September and early October. Sowings in July, late October and in December may give an average crop.

Relwanii (1962) observed that July was the optimum seeding date for open pollinated maize variety at Karnal. Sowing on first July consistently gave increased yield over 15th June and 15th July dates of sowing.

Gautam and Singh (1963) found that the yield of hybrid maize was significantly reduced as the sowing was delayed after June 25th.

Experiments conducted in Bihar (1964) showed that the response of hybrid varieties differed in Khariff and Rabi seasons. Hybrid Ganga 101 and Deccan were almost equally good in yield during khariff. The best time for sowing maize in Khariff was found in June 10 to 20 (Anon, 1964).

Agronomic investigations with hybrid maize by Gautam et al (1964) revealed that planting maize in June 24 significantly delayed tasseling as compared to plantings on July 5 and July 15. The differences between number of days to tasseling in July 5 and July 15 planting were not statistically significant. Planting maize on or about June 24 (pre monsoon) gave the maximum grain yield during 1961-62. Yields were progressively lowered with plantings on about July 5 and July 15. July 15 planting resulted in the lowest yield during both the season.

3) Effect of Nitrogen.

Vaidyanathan (1933) reported high response to nitrogeneous fertilization for maize from Kanke, Sepaya and Banka farms in Bihar.

Based on studies on corn fertilization, Grissom (1948) recommended that 100 lb. N per acre (112.1 Kg. per hectare) should be applied for a plant population of 8000 to 12000 per acre.

Results of experiments on yields and nitrogen content of corn by Viets and Domingo (1948) revealed that 90 lb. N per acre (100.890 Kg. per hectare) produced an average of 1 bushel of maize per 1.34 lb. of N. Nitrogen recovery in the grain was 48.6 percent.

Peterson et al (1948) obtained maize yields of 68, 91 and 97 bushels from application of 0, 40 and 80 lb. nitrogen per acre (0, 44.840, 89.680 Kg. per hectare) respectively.

Grissom (1948) reported that there was no significant response in yield of maize to phosphorus and potash application.

Calma and Castro (1950) found that application of sulphate of ammonia at the rate of 100 Kg. per hectare increased the yield of marketable grains in the dry season culture.

According to Miller et al (1950) that 17.8 lb. per acre N (19.954 Kg./ha.) was the most effective application for Central Mexico, further N application being equally efficient only when P was also applied.

Bondurant and Vice (1951) observed that about 213 lb. N per acre (238.77 Kg./ha.), 37 lb. P_2O_5 (41.477 Kg./ha.) and 96 lb. of K_2O per acre (107.616 Kg. per hectare) along with other plant nutrients was necessary to produce 100 bushels of corn per acre.

Dhesi (1953) recommended an economic dose of 1¼ md. per acre (114.903 Kg./ha.) of ammonium sulphate for richer soils and 4 md. per acre (367.688 Kg./ha.) for lighter soils to give a good maize yield return.

Fertilizer experiments carried out by Garderen (1953) revealed that in the presence of heavy applications of P, application of 100 lb. per morgen (1 morgen = 0.861 hectare) of ammonium sulphate significantly increased yields of maize provided the moisture supply was adequate and well supplied. Dressings of K tended to decrease rather than to increase yields.

Long (1953) observed that nitrogen is the plant food required in greatest abundance by corn crop. A 100 bushel crop of corn requires about 160 lb. of N (179.360 Kg. N/ha.), 55 lb. of P_2O_5 (61.655 Kg./ha.) and 110 lb. of K_2O (123.310 Kg./ha.) per acre.

According to Rhoades et al (1954) a dense stand (14000 to 19000 plants per acre) and dressings of 40-120 lb. N per acre (44.84 to 134.52 Kg. N/ha.) for maize can be recommended.

Based on experimental results Sen and Kavitkar (1956) reported highly significant response to nitrogen but not to phosphate.

Carby (1957) found that large increases in yield usually followed the use of upto 100 lb. N per acre (112.10 Kg./ha.).

Studies by Takur et al (1957) on the N requirements of maize in calcareous soils of Bihar indicated that increasing doses of N significantly raised the grain yield and the application of the maximum dose 100 lb. N per acre (112.10 Kg. per hectare) was found to be quite economical.

Summarising the results of experiments conducted during 1949, 50 and 51, Raheja et al (1957) reported that the yield response from doses of N was about 7.4 to 8.1 lb. of grain per pound of N with in the range of 20 to 60 lb. N per acre. The economics of fertilization has indicated that N would pay much more than phosphate application to maize crop.

Raheja et al (1957) concluded that response for doses of nitrogen was linear from 20 to 60 lb. N per acre (22.420 to 67.260 Kg./ha.).

Verma and Sharma (1958) found that with 3 doses of N - 20, 40 and 60 lb. per acre (22.420, 44.840 and 67.260 Kg./ha.) applied as ammonium sulphate the average yield showed a progressive and significant increase with each successive increase in dose of nitrogen.

According to Chela (1958) local flint type sown on 15th July at 1'x1' spacing gave high yield with N from the source of either ammonium sulphate or ammonium phosphate, but found super phosphate to be ineffective.

Studies by Galvez and Bruce (1958) recorded optimum yields from 45 to 90 Kg. N/ha. There was no response to P or K fertilization.

Sanchez and his co-workers (1958) obtained increases in yield with application of N from 60 Kg. N per hectare.

Nezamuddin and Prasad (1958) recommended 2' row spacing for north Bihar and 1.5' row spacing for South Bihar and hilly tracts of Chotnagpur, for Jaunpur variety of maize. The best spacing between plants was 12".

Based on trials Fielding (1959) reported that N applied as 250 lb. ammonium sulphate per acre (280.250 Kg. per hectare) increased yields by 1888 lb. per acre. A further 250 lb. per acre gave additional increase of 472 lb. per acre.

Thomas (1959) found that application of N, upto 40 lb. N per acre (44.84 Kg./ha.) significantly increased the yield of corn at all plant populations.

According to Harner _et al_ (1959) nitrogen application above 200 lb. per acre (224.200 Kg./ha.) did not produce significantly better yield even in dense population. It was not economic to apply above 100-130 lb. N per acre (112.10 to 145.730 Kg./ha.) for a population of 9000 to 13000 plants per acre.

Baird and Mason (1959) found increases in yield resulted from N application at all of the 23 locations on soils poor in organic matter and at 10 out of 17 locations on soils rich in organic matter.

Studies by Laird and Lizarrage (1959) reported that application of 80 Kg. N/ha. increased yields of ears by 1.43 to 2.86 tons per hectare in 13 localities. The additional increase in yield obtained by raising the application of N from 80 to 120 Kg./ha. was economical in 9 out of 10 localities and in 7 out of 10 applying half the N at sowing and half as side dressing at the time of last weeding was more effective than applying in all at sowing.

Wolfe <u>et al</u> (1959) found that grain and forage yields increased by N application at rates upto 80 lb. N per acre (89.68 Kg./ha.). Treatments with P alone depressed the yield.

According to Datta <u>et al</u> (1959) significant increases of 7.94 and 11.86 md. per acre were obtained with 40 and 80 lb. of N per acre (44.840 and 89.680 Kg. per hectare) respectively from the source of ammonium sulphate over control, giving a response of 16.33 and 12.33 lb. of maize grain per pound of N respectively.

It was also found that increasing doses of N gave increased yields and the difference in yield between any two levels was significant.

Agronomic investigations carried out by Lanza (1959) proved that the grain yield increased with increasing amounts of N applied upto 200 Kg./ha. with corresponding increases in the content of protein in the grain. N was generally more effective when applied late.

Rai (1959) reported yield of grain, straw, plant population, number of cobs, 1000 kernel weight and average number of grains per cob increased with increasing dosage of N. Nitrogen application accellerated early vegetative growth.

Based on field experiments Dow (1959) reported that 160, 240 and 360 lb. N per acre (179.36, 269.040 and 403.560 Kg. N/ha.) were required for maximum yields. No definite responses to P, K or Zn was observed.

Strang and Broue (1960) found that applications of 224 lb. ammonium sulphate per acre (251.104 Kg./ha.) at tasseling resulted in a higher grain nitrogen percentage (1.44) and grain yield.

Bruce and Tyner (1960) observed that for the wet season greatest response was obtained when a quarter of the N was applied in row at planting time, a half top-dressed four weeks later, and the remainder top dressed after a further 3 weeks.

Summarising the results of experiments Nandpuri (1960) concluded that high yield of grain can be obtained with 180 lb. N per acre (201.780 Kg./ha.) for a plant population of 26000 plants per acre.

Ramirez and Laird (1960) found that in the case of unirrigated maize, maximum yield was obtained from 60 Kg. of N per hectare and 1,48,300 plants per hectare.

Hinkle and Garrett (1961) arrived at the conclusion that the highest yield was obtained when 150 to 180 lb. N per acre (168.150 to 201.780 Kg./ha.) were applied. Phosphorus and potash were of limited or even negligible value.

According to Macgregor et al (1961) nitrogen fertilization increased the grain yields, concentration of protein in grains and protein production per acre.

In a fertilizer-spacing-variety studies Verma and Bhat Nagar (1962) observed that at 3 levels of N (40, 80 and 120 lb. N per acre) (44.840, 89.680 and 134.520 Kg. N/ha.) and at four spacings the highest yields were obtained from 120 lb. N per acre. Spacing of 2' between rows and 1' between plants was most profitable.

Arnon et al (1962) found that N in the form of ammonium sulphate resulted in substantial and consistent yield increases.

Relwanii (1962) reported that on an average 30 lb. of N as sulphate of ammonia produced a positive response of 5.52 md. per acre of grain. With additional unit of 30 lb. of N (33.620 Kg./ha.) there was a further significant increase of 3.45 md. of grain per acre over the initial level.

Shaw and Gautam (1963) reported that maize yielded highest when fertilized with 179 Kg. N/ha. but the increase in yield after application of 90 Kg. N/ha. was not statistically significant.

Long (1963) concluded that in most instances the suitable conditions were 12000 to 15000 plants per acre receiving 90 to 120 lb. N per acre (100.890 to 134.520 Kg. N/ha.).

According to Stanberry et al (1963) three or more nitrogen applications were better than two. Supplemental N increased yields predominently by increasing ears per plant and weight per ear.

Indications by Gautam and Singh (1963) showed that applications of N at 112 Kg./ha. in three splits proved significantly superior to application made in two splits or all applied in one lot at planting.

Investigations carried out by Shaw and Gautam (1964) revealed that the local variety K.T. 41 responded only upto 90 Kg./ha. where as hybrid maize Ganga 101 recorded increasingly higher yield upto 180 Kg. N/ha.

Amarjit Singh (1964) concluded that on an average the response to N was leniar upto 134 Kg. per ha. beyond which there was a slight though non-significant depression in yield.

Gautam et al (1964) reported that application of N to maize crop in three splits ie., at planting, at knee-high stage and at tasseling met the nitrogen requirement of the crop through out the season adequately and thus resulted in more efficient use of N, greater production of dry matter and grain as well as better quality of grain than the applications of nitrogen all at planting time.

4) Micronutrients on the growth and yield of corn

Results of experiments on the influence of copper compounds on the yield, growth pattern and composition of spring wheat and corn by Brown and Harmer (1951) showed that the absorption of applied copper by plants affected the assimilation of N, P, K, Ca, Mg, Si and Fe. Omission of copper application resulted in very large concentrations of the first 3 elements and considerable increase in content of the others in plants.

Pola and Supraptohardjo (1951) indicated that a satisfactory maize crop requiring ammonium sulphate at a rate exceeding 200 Kg./ha. benefitted from 50 Kg./ha. of copper sulphate.

Investigations carried out by Viets Jr et al (1953) on zinc deficiency in corn showed applications of $MnSO_4$, $CuSO_4$ and phosphate did not affect grain yields of maize.

Koehler and Albrecht (1953) showed that the nutritional efficiency of the legume was considerably improved by applying Mg together with wthe trace element mixture (Mn, Cu, B, Zn and Co) and that of the maize grains improved by dolometic lime stone or trace elements alone.

Bunting (1956) observed that when a solution of $ZnSO_4$ or of the chelate compound of Zn solution was applied in the funnel of the maize plants an increase in yield of grain was obtained.

Hiatt and Massey (1958) found that maize plants grown in a green house in Zn free culture solutions showed very severe deficiency symptoms when 38 days old and contained 18 ppm. Zn, when grown with 0.05 ppm. Zn plants showed mild deficiency symptoms and contained 9 ppm. Zn, with 0.14 ppm. Zn plants were apparently normal and contained 16 ppm. Zn. Similar relationships were observed in maize grown in the field.

Baheja <u>et al</u> (1959) indicated that micronutrients showed increase in yields with jowar, maize, Bajra, Barley, Oats, Ragi and other millet.

Results of studies of Manganous and other frits and their effect on the yields of agricultural crops by

Vlasyuk (1959) showed that application of frit containing Zn increased the yields of maize and cabbage by 25 percent.

Investigations on the effect of trace elements on maize by Klimora (1959) found that the effectiveness of trace elements in increasing the total yield and cob yield decreased in the order of Mo $>$ Cu $>$ Zn $>$ B $>$ Mn $>$ Co.

Ahuja and Gautam (1960) found Texas 26 maize grown in soil low in Zn gave significant grain yield but dry matter yield increased with Zn only in the presence of N, P, K which itself increased yields significantly.

Devidesco (1960) reported that the growth of Mn deficient plants was retarded and seed production was reduced or was nil.

Field experiments conducted by Igue and Gallo (1960) indicated that the Chlorotic symptoms could be dispersed or prevented by spraying with 0.05 percent $ZnSO_4$ band placing of 5 Kg. $ZnSO_4$/ha. mixed with the fertilizer at sowing or by seed treatment with ZnO_2 at about 2 Kg./ha. Yields were not always increased when symptoms generally of a low order.

Ahuja and Gautam (1961) reported that the responses to micronutrients were obtained only in the presence of N.P.K. Soil application of Zn increased the grain yield. The increase was however more when other micronutrients were also applied along with Zn.

Pumphery (1963) reported that 5 lb. of Zn (5.60 Kg. per hectare) as $ZnSO_4$ per acre broadcast and ploughed in before sowing maize increased early growth and yield of grain.

5) <u>Effect of fertility levels on the quality of maize.</u>

Results of experiments on the effect of nitrogen supply on yields and nitrogen content of corn by Viets and Domingo (1948) showed that nitrogen content of grain increased with nitrogen application. 90 lb. of nitrogen produced an average 1 bushel of maize per 1.34 lb. of nitrogen. Nitrogen recovery in the grain was 48.6 percent.

Nordon *et al.* (1951) were of the opinion that the soil N supply was adequate for good yield under some conditions but inadequate for maximum protein content. Apparently the maize plant used the available nitrogen first for the growth process related to maximum yield under the prevailing environment and excess nitrogen not needed for these processes was diverted to increase the grain protein.

Studies on the amino acid and protein content of corn as related to variety and nitrogen fertilization by Sauberlich et al (1953) revealed that amino acid and protein content of grains were significantly increased by nitrogen fertilization. Similar results were obtained by William F. Bennet et al (1953).

Zuber et al (1954) found that protein content in grain and stover increased with increasing application of nitrogen upto 250 lb. per acre (280.25 Kg./ha.).

Preliminary trials conducted by Prince (1954) on the effect of nitrogen fertilization, plant spacing and variety on the protein composition of corn showed that by increasing the application of nitrogen from 15 lb. to 135 lb. per acre, the crude protein content was increased from 7.81 to 9.53 percent.

Results of experiments on the yield and composition of corn by Nevens et al (1954) indicated that by annual application of 200-300 lb. per acre (224-336 Kg. per hectare) of 8:8:8 fertilizer at planting and 150 to

200 lb. ammonium sulphate per acre (168-224 Kg./ha.) as side dressing a gain in tonnage of forage was obtained. But there was only little change in ear protein content and fibre content of grain.

Gillford (1955) concluded that by increasing application from 0 to 600 pounds (0 to 672.60 Kg./ha.) per acre of sodium nitrate, nitrogen and phosphorus uptake was increased. Protein concentration was also increased.

Hunter and Youngen (1955) got maximum yield of maize grain by 100 lb. N (112.10 Kg./ha.) per acre. Protein content and total protein per acre in harvested grains increased with nitrogen application while percentage of applied nitrogen recovered in the grain decreased with increased nitrogen. No response to potash and phosphorus was found.

Galvez et al (1956) found that on nitrogen deficient loam soils yield and nitrogen content of grain increased with increasing application of nitrogen upto 135 Kg./ha. of nitrogen as sulphate of ammonia in addition to 90 Kg. each of P_2O_5 and K_2O per hectare. The maximum economic yield was at 45 Kg. of nitrogen per hectare.

Studies made by Genter et al (1956) concluded that highest yield of protein was obtained by using the higher plant stand and the heaviest application of nitrogen. Under drought conditions increased applications of nitrogen had no effect on protein content. Significant response was obtained to the application of phosphorus and potash for yield but they did not affect the protein content.

Long et al (1956) found that high nitrogen levels increased yield with high population while protein and oil content of the grain decreased with decrease in nitrogen level.

Results of experiments conducted by Thomas (1959) indicated that maize grown with 240 lb. N per acre (269.04 Kg./ha.) and 40 or 80 lb. SO_3 as sodium sulphate per acre (44.84 or 89.68 Kg./ha.) significantly increased the percentage of protein in the maize grains.

In trials with the maize hybrid Wisconsin 641 AA Lanza (1959) reported that the application of increasing amount of nitrogen upto 200 Kg./ha. increased the yield and protein content of grains.

Strang and Sroue (1960) found that application of 2 cwt. of ammonium sulphate per acre (251.10 Kg./ha.) at tasseling resulted in a higher grain nitrogen percentage (1.44) and grain yield.

Nandpuri (1960) concluded that high yield of grain can be obtained with 180 lb. N per acre (251.10 Kg./ha.) for a plant population of 26000 plants per acre. Protein content of grain also increased with high nitrogen application.

Studies on the effect of mineral fertilizers on physiological and biochemical processes in maize by Zemlyanukhin (1960) revealed that N, P and particularly NP, increased the percentage contents of N, starch, sugars and P in the grain.

Gupta and Das (1960) found that N, K and NP treatments increased crude protein content of grain while P reduced it. True protein behaved similarly to crude protein.

Mac George et al (1961) concluded that N fertilization increased the grain yields, concentration of protein in grains and protein production per acre.

Sharma (1961) found that nitrogen application to hybrid maize significantly increased the plant height, dry weight of plants, 500 kernel weight and protein content of grains and finally the yield of grain.

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigation was undertaken to determine the optimum date of sowing for maize and to study the effect of nitrogen and micronutrients on the yield and quality of maize under the soil and climatic conditions of Kerala. In this chapter the materials employed and the methods adopted are briefly dealt with.

I. EXPERIMENTAL SITE

The experiment was conducted in the dry lands of the farm attached to the Agricultural College and Research Institute, Vellayani during the period from June to November 1964. The site selected was topographically even and free from shade. The site for the experiment was carefully selected to have maximum uniformity in soil conditions in order to avoid variations due to soil heterogenity.

The soil of the area was red loam with the following chemical composition.

Total Nitrogen	-	0.0500%
Total Phosphoric acid	-	0.0430%

Available phosphoric acid	-	0.0021%
Total potash	-	0.0770%
Available Potash	-	0.0009%

The soil was well aerated with no problem of water stagnation during rainy season.

Cropping history of the field: The total area of the block was 2 hectares and that of the experimental site 0.25 hectare. The cropping history of the field for the previous three years is given in Table No. I.

Table No. I

Cropping history of the experimental field from 1960-61 to 1962-63

Year	Season	Crop	Yield in m. tons.	Remarks
1960-61	June - April	Cotton	..	
1961-62	June - March	Tapioca mixed with legumes	Less than 1 ton/acre (0.70 tons/acre)	Mixed cropping was practiced. 5 C.L. of F.Y.M. and 100 Kg. tapioca mixture/acre was applied. Variety used was kalikalan which is highly susceptible to Cassava mosaic.
1962-63	June - March	Tapioca mixed with legumes	2 tons/acre	

Fig. 1

Plan of the layout of field experiment

LAYOUT SPLIT PLOT DESIGN

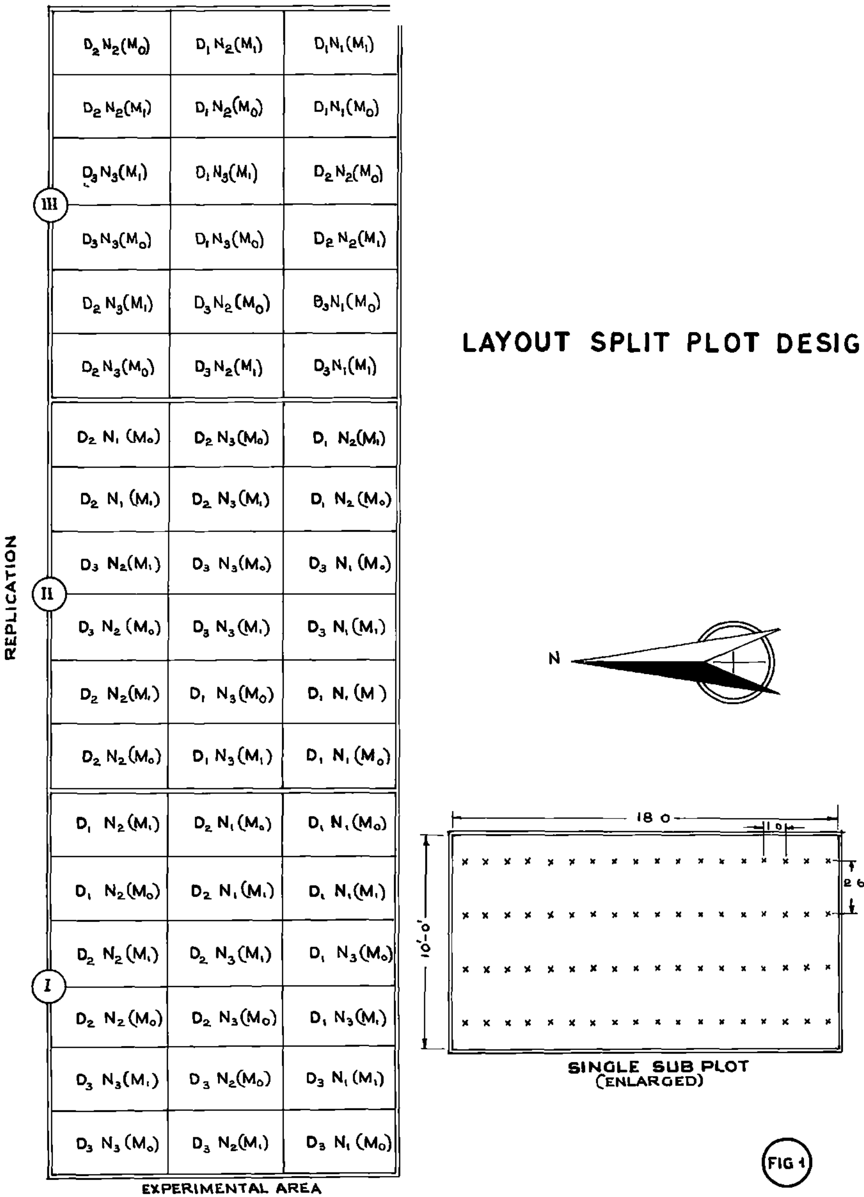

FIG 1

Climatic factors: The location of the experimental site lies between 8^{o} and 29^{o} latitudes and 76^{o} 57' longitudinally. The altitude of the locality is 64.3 metres.

The highest rain fall during the crop season was 433.00 mm. during the month of October. The maximum relative humidity prevailed during August and was 88.7%. The maximum and minimum temperature were 89^{o}F and 72^{o}F respectively.

The meteorological observations recorded by the College Farm during the periods from June to December 1964 are presented in Table No. II.

Season: The experiment was conducted during the Kharif season 1964 (June to November).

II. MATERIALS

1. Seed Material: Deccan Hybrid Makka.

The fact that hybrid maize yields higher than open pollinated local varieties has been proved in trials conducted under Indian conditions also. Deccan hybrid makka recommended for South India by the National Seeds Corporation has already been proved successful in this

Table No. II

Meteorological data recorded at the Agricultural College and Research Institute Farm during the Crop period

Period (weekly)		Rain fall in mm.	Temperature in °F		Relative Humidity %
			Maximum	Minimum	
June	1 - 7	40.00	82.0	78.0	78.85
	8 - 14	-	84.0	78.0	79.0
	15 - 21	30.20	84.0	82.0	79.30
	22 - 28	74.30	83.0	79.0	81.10
July	29th - 5	238.40	89.0	72.0	84.00
	6 - 12	55.20	80.0	72.0	76.50
	13 - 19	40.50	82.0	72.0	83.40
	20 - 26	10.00	82.0	73.0	84.10
	27 - 2nd Aug.	63.10	84.0	73.0	74.60
August	3 - 9	58.50	82.0	72.0	88.70
	10 - 16	21.20	82.0	73.0	82.20
	17 - 23	-	82.0	73.0	81.40
	24 - 30	-	82.0	74.0	80.40
September	31 - 6	15.20	84.0	74.0	79.30
	7 - 13	65.60	81.0	76.0	84.50
	14 - 20	82.20	82.0	74.0	82.00
	21 - 27	9.00	82.0	74.0	82.70
	28 - 4th Oct.	-	82.0	73.0	79.30
October	5 - 11	25.00	83.0	76.0	79.60
	12 - 18	433.00	81.0	76.0	84.50
	19 - 25	45.70	81.0	76.0	87.00
	26 - 1st Nov.	120.00	81.0	76.0	86.70
November	2 - 8	46.30	81.0	74.0	88.00
	9 - 15	33.40	81.0	74.0	86.40
	16 - 22	0.50	81.0	76.0	87.50
	23 - 29	-	82.0	78.0	84.00

Fig. 2

Rainfall, humidity percentages, minimum and maximum temperatures during the crop season.

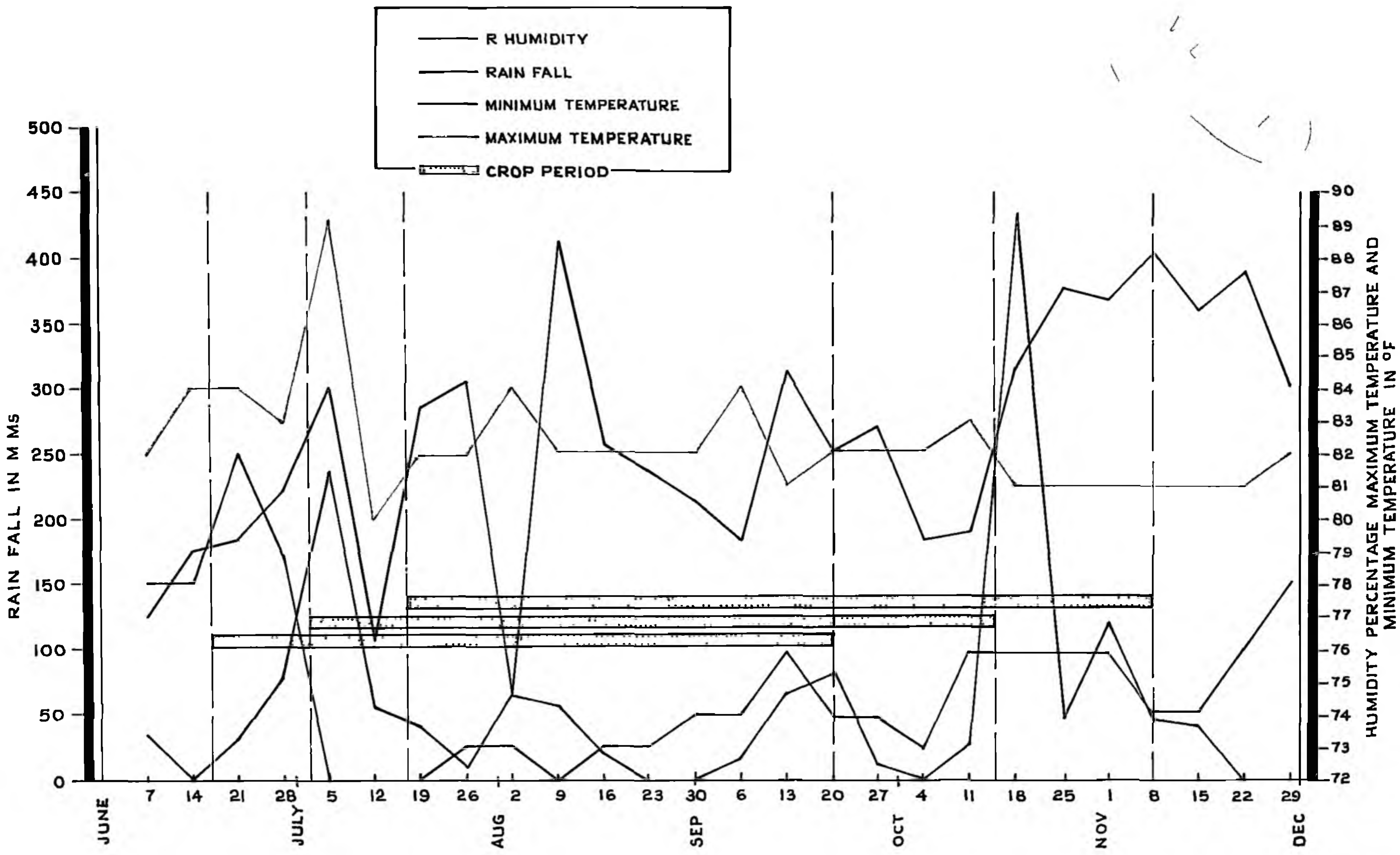
R HUMIDITY
RAIN FALL
MINIMUM TEMPERATURE
MAXIMUM TEMPERATURE
CROP PERIOD
RAIN FALL IN M MS
500
450
400
350
300
250
200
150
100
50
0
7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29
JUNE
JULY
AUG
SEP
OCT
NOV
DEC
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
HUMIDITY PERCENTAGE MAXIMUM TEMPERATURE AND MINIMUM TEMPERATURE IN °F

FIG 2

area and therefore was selected for the present investigation. Seed certified by the National Seeds Corporation, New Delhi and supplied by The Telengana Hybrid Seed Production and Sales Co-operative Society, Warangal, Andhra Pradesh was used in this investigation. The seeds were treated against seed borne diseases. The duration of this variety is from 80 to 100 days. It is vigorously growing, high yielding with good grain quality and taste, late maturing, resistant to leaf blight and other pests. This hybrid variety has the ability to respond to high levels of fertility. The hybrid has more vigorous plants with more of leafy growth, fewer barren stalks and cobs with a good husk cover. This hybrid has another advantage in that they are more leafy and remain some what green at the time of grain harvest and thus produce more fodder of better quality.

2. Seed rate: The seed rate used in this experiment was 12 Kg. per hectare. The germination capacity of the seed was found to be 98 percent.

3. Manures and fertilizers: Farm Yard Manure: Well decomposed farm yard manure with the following analysis was used for the experiment.

Nitrogen (Total)	-	0.65%
Phosphoric acid (Total)	-	0.32%
Potash (Total)	-	0.49%

Major fertilizer nutrients: Nitrogen, Phosphorus and Potash were applied in the form of Ammonium sulphate, Super phosphate and Muriate of Potash respectively.

Micronutrients: A mixture of Zinc, Copper and Manganese was used in the form of their salts viz., Zinc sulphate, Copper sulphate and Manganese sulphate with the following analysis.

Zinc sulphate	-	22.75% Zinc
Copper sulphate	-	25.45% Copper
Manganese sulphate	-	32.54% Manganese

III. TREATMENTS AND LAYOUT

The experiment included three dates of sowing, three levels of nitrogen and two levels of micronutrient mixture. Thus there were altogether 18 treatment combinations as given below.

a) Treatments:

(i) Whole plot treatments

Date of sowing and Nitrogen combinations

D_1 - 17th June, 1964
D_2 - 2nd July, 1964
D_3 - 17th July, 1964

N_1 - 111.00 Kg./ha.
N_2 - 148.00 Kg./ha.
N_3 - 185.00 Kg./ha.

Treatment combinations

D_1N_1	D_2N_1	D_3N_1
D_1N_2	D_2N_2	D_3N_2
D_1N_3	D_2N_3	D_3N_3

(ii) Sub plot treatments: A mixture of three micronutrients - Zinc, Copper and Manganese.

M_0 - No mixture
M_1 - Mixture containing

Zinc - 6.38 Kg./ha.
Copper - 7.12 Kg./ha.
Manganese - 18.23 Kg./ha.

Total treatment combination - 18 as given

$D_1\ N_1\ (M_0)$	$D_2\ N_1\ (M_0)$	$D_3\ N_1\ (M_0)$
$D_1\ N_1\ (M_1)$	$D_2\ N_1\ (M_1)$	$D_3\ N_1\ (M_1)$
$D_1\ N_2\ (M_0)$	$D_2\ N_2\ (M_0)$	$D_3\ N_2\ (M_0)$
$D_1\ N_2\ (M_1)$	$D_2\ N_2\ (M_1)$	$D_3\ N_2\ (M_1)$
$D_1\ N_3\ (M_0)$	$D_2\ N_3\ (M_0)$	$D_3\ N_3\ (M_0)$
$D_1\ N_3\ (M_1)$	$D_2\ N_3\ (M_1)$	$D_3\ N_3\ (M_1)$

b) Layout and Design

The trial was laid out as a split plot experiment in randomised block design, with three replications. The total number of plots were 54.

Layout plan is given in Fig. 1.

c) Size of plot.

(i) Whole plot (gross) - 6.1 x 5.5 Sq. metres

,, (Net) - 4.6 x 4.9 Sq. metres

(ii) Sub plot (gross) - 3.04 x 5.5 ,,

,, (Net) - 1.52 x 4.9 ,,

d) Spacing: Rectangular planting - 76 cm. between rows and 30 cm. between plants.

e) Experimental plants

Number of rows (sub plot)		- 4
Number of plants (sub plot)	Gross	- 72
	Net	- 32

IV. CULTIVATION

1) Preparation of land:

The land was dug 3 times soon after the first rains in June. It was levelled and the area was demarcated for each replication with 60 cm. wide bunds.

Each replication was then divided into whole plots and they in turn were sub divided into sub plots.

2) Application of manures and fertilizers:

Farm yard manure was applied prior to the last digging of the plots at the rate of 3360 Kg./ha. and was incorporated with the soil by digging. Then the field was levelled.

Super phosphate at the rate of 612 Kg./ha. to supply 98 Kg. P_2O_5 per Hectare and Muriate of potash at the rate of 125 Kg./ha. to supply 75 Kg. K_2O/ha. were applied as basal dressing in furrows made 76 cm. apart and were covered with a thin layer of soil. Ammonium sulphate at the rate of 550 Kg., 750 Kg., 925 Kg./ha. to supply 111 Kg., 148 Kg. and 185 Kg. N/ha. respectively were applied in three split doses. It has been reported by Gautam et al (1964) that application of nitrogen to maize crop in three splits ie., at planting, at knee high stage and at tasseling met the nitrogen requirement of the crop throughout the season adequately and thus resulted in more efficient use of nitrogen, greater production of dry matter and grain as well as better quality of grain than the applications of nitrogen all at planting time. In this investigation half of the nitrogen was applied at planting and the remaining split into two equal doses and side dressed at knee high and tasseling stages (ie., 35 days and 55 days after sowing).

Soil application of the mixture containing Zinc, Copper and Manganese at the rate of 28 Kg., 28 Kg., and 56 Kg./ha. respectively of $ZnSO_4$:$CuSO_4$ and $MnSO_4$ was given along with the basal application of other fertilizers to supply 6.38 Kg. Zn, 7.12 Kg. Cu and 18.23 Kg. Mn/ha.

The quantities of major and micronutrients applied in each sub plot (3.04 x 5.5 Sq. metres) at different stages of plant growth are presented in Table No. III.

Table No. III

Quantities of major and micronutrients applied (in gm) in each sub plot of 3.04 x 5.50 Sq. metres at different stages of plant growth

Name of fertilizer and quantity of nutrient supply Kg./Hectare	Quantity applied per sub-plot in gm	Planting stage	Knee high stage	Tasseling stage
a) Ammonium sulphate				
111 Kg. N/ha.	930.00	465.00	235.00	230.00
148 ,,	1240.00	620.00	310.00	310.00
185 ,,	1550.00	775.00	390.00	385.00
b) Super phosphate				
98 Kg. P_2O_5/ha	920.00	920.00	-	-
c) Muriate of potash				
75 Kg. K_2O/ha.	250.00	250.00	-	-
d) Micronutrients				
6.38 Kg. Zn/ha.	47 gm of $ZnSO_4$	47.00	-	-
7.12 Kg. Cu/ha.	47 gm of $CuSO_4$	47.00	-	-
18.23 Kg. Mn/ha.	94 gm of $MnSO_4$	94.00	-	-

3) Sowing:

The seeds were sown in furrows 3 to 4 cm. above the fertilizers already applied at the rate of 2 seeds per hill. The distance between 2 rows was 76 cm. and that from seed to seed 30 cm. The seeds were covered with a layer of top soil and the field was levelled. The first date of sowing was 17-6-64 and the second and third were 2-7-64 and 17-7-64 respectively keeping a span of 15 days between each date of sowing. Since the study was proposed to be carried out under rainfed conditions no irrigation was given.

4) Post sowing operations

a) Thinning and gap filling: The stand of the crop was observed a week after sowing and the percentage of germination was found to be about 97. The plots were thinned and the gaps filled maintaining one plant per hill.

b) Weeding: Three hand weedings were given. The first weeding was given a fortnight after sowing and the second and third weedings along with the top dressing of ammonium sulphate viz., at the knee high (35 days after sowing) and at the tasseling (55 days after sowing) stages respectively.

c) Top dressing: Sulphate of ammonia was applied on either side of the maize rows 10 to 12 cm. away from the base of the plants. Shallow trenches 3 to 4 cm. were made on both sides of the row without injuring the roots and the fertilizer applied uniformly in the trenches and earthed up. Top dressing with ammonium sulphate was done at two stages - one at the knee high stage and the other at tasseling stage.

d) Harvest: Harvesting of the cobs was done when the cobs were fully ripened. The dates of sowing and the dates of harvesting are given below.

Date of sowing	Date of harvest
17-6-64	22-9-64
2-7-64	17-10-64
17-7-64	6-11-64

The border plants were rejected and the cobs from the inner rows were harvested for yield. Cobs from the observation plants were bagged separately for further cob studies.

V. BIOMETRIC OBSERVATIONS

The following biometric observations on the following characters were made.

Four plants were selected at random using random numbers (Panse and Sukhatme) from each sub plot and tagged. The plants were studied throughout the life period of the crop for plant characters. The harvested cobs from these plants were kept separately and a representative sample was taken to study the moisture percentage and for chemical analysis.

a) Height of the plant. The height of the plants was measured from the base of the stem to the base of the fully opened leaf. This measurement on height was taken at four stages of plant growth viz., on the 35th, 50th, 65th and 80th day respectively after sowing, keeping an interval of 15 days between each measurement. On the basis of this the cumulative growth rate and the absolute growth rates were determined.

i) The cumulative growth rate: It was taken as the total elongation in the plant height from the date of germination to the date of cessation of increase in growth.

ii) Absolute growth rate: It was calculated by taking the difference in height of the plant from one date of observation to the next divided by the total number of days in the interval.

It was the cumulative growth rate that was utilised for statistical analysis of this experiment.

b) Earliness to tasseling. Observations were taken on earliness to tasseling in each treatment and the number of plants tasseled were observed on alternate days. The fully exposed tassels were only taken into account. This observation was continued until all the plants were tasseled.

c) Earliness to cobbing. The date of cobbing and the number of plants cobbed were recorded simultaneously with the observations on tasseling. This observation was also continued until all the plants were cobbed.

d) Weight of cob. The weight of cob was taken after drying (moisture percentage below 12%) in the sun and average weight taken.

e) Length of cob. The length of cobs were measured and the average length calculated.

f) Girth of cob. The girth at both ends and the middle of the cobs was measured by using calipers and the average girth of cobs found out.

g) Yield of grains per plant. The grains were separated by manual labour and the grains weighed and the average yield per plant calculated.

h) Grain:Heart ratio. The heart and grains were weighed separately and the grain:heart ratio was worked out.

i) Yield per plot. Yield per sub plot at 12% moisture was calculated on the basis of the inner rows excluding the outer plants. Yield contribution by the second and third cobs was also recorded.

j) Stover yield. After the harvest of cobs, stover was left in the field for drying. After complete driage in the field they were cut at the base and weighed in the field.

k) Grain to Stover ratio. The weight of grains and stover taken separately for each sub plot was utilised for calculating the grain to stover ratio.

I) Quality studies.

i) Test weight of grains: A representative sample of the maize grains from each treatment was taken and from it 1000 grains were counted and weighed at 12% moisture. Mean of such determinations was recorded.

ii) Crude protein: The nitrogen content of the grains were analysed by Kjeldahl's method. Crude protein content was worked out by multiplying the nitrogen content by the factor 6.25.

VII. STATISTICAL ANALYSIS AND INTERPRETATION OF DATE

The experimental data were subjected to statistical analysis suited to the design adopted to find out which of the treatments varied significantly in various plant characters and yield attributes studied as suggested by Cochrn and Cox (1958). Usual analysis of variance was followed. The interpretation of the results was made on the basis of F test and summary tables have been prepared. Standard error and Critical difference at 5% level were also calculated.

VIII. ECONOMICS DOSE OF NITROGEN

From the levels of nitrogen tried in this study, the optimum and the economic doses of nitrogen were calculated.

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

Details of weather conditions during the growth period of the crop was recorded every week and are presented in Table No. II. The weather factors are represented graphically in Fig. No. 2.

I. Growth and weather conditions

The growth period and rainfall conditions

The rainfall gradually increased from the second week of June to the first week of July. A maximum of 238.40 mm. of rainfall was recorded in the first week of July. The rain later receded during the rest of the month. As such the rainfall did not adversely affect the germination percentage and stand of the crop sown on the first and second dates of sowing (D_1 and D_2). The third date of sowing (D_3) was on 17-7-1964, when the rainfall ranged between 40 and 50 mm. which favoured germination and stand of the crop.

The total rainfall received during the crop growth is given in Table No. IV.

Table No. IV

Total rainfall recorded during the different stages of growth of maize crop for the different dates of sowing

No.	Period	Rainfall in mm.		
		D_1	D_2	D_3
1	Period from planting to tasseling	570.20	486.90	274.10
2	Period from planting to maturity	763.40	1116.90	1035.30
3	Period from tasseling to maturity	193.20	630.00	761.20

The relative humidity, maximum and minimum temperatures varied between 74 and 88%, 81 and 89°F and 72 and 81°F respectively during the growth period of the crop, sown in the different dates of sowing (D_1, D_2 and D_3).

II. Height of plants and the cumulative growth rate

Table No. V presents the height of plants at the different stages of growth. It is also represented in Fig. No. 3.

Fig. 3

Graph showing height of plants at different stages of growth

MEAN HEIGHT OF MAIZE PLANTS AT DIFFERENT STAGES OF GROWTH

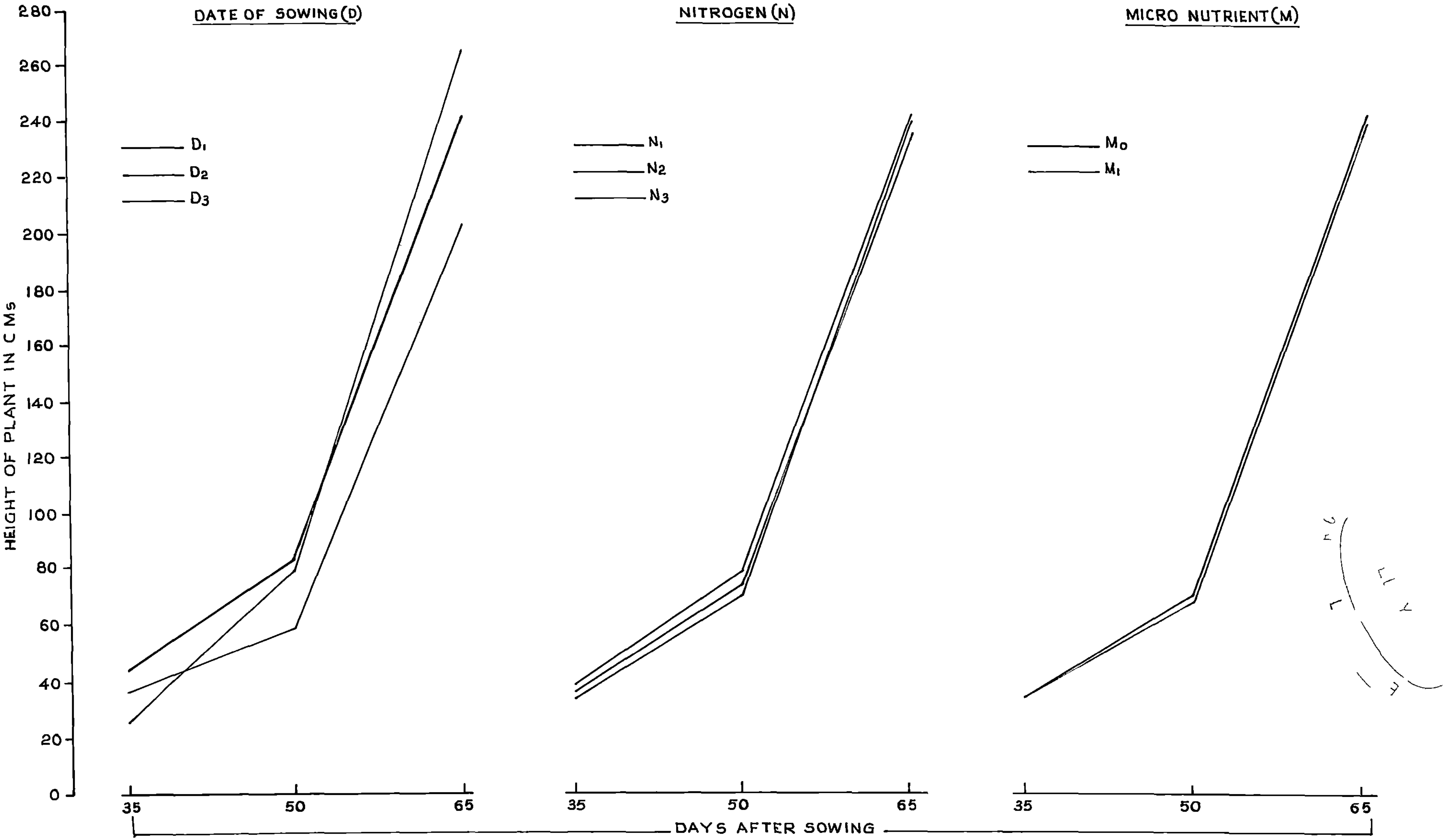

FIG 3

Table No. V

Mean height of plants at different stages of growth (in cm.)

Treatments	Days after sowing		
	35.00	50.00	65.00
Dates of sowing			
D_1	26.22	78.90	263.09
D_2	44.35	83.57	239.53
D_3	37.14	58.51	221.77
F. test	sig.	sig.	sig.
S.E.	1.3	2.065	3.76
C.D. at 5% level	2.756	4.378	7.97
	$D_2D_3D_1$	$D_2D_1D_3$	$D_1D_2D_3$
Nitrogen			
N_1	33.24	69.05	241.42
N_2	36.50	74.62	239.07
N_3	37.97	77.30	243.98
F. test	sig.	sig.	N.S.
S.E.	1.3	2.065	--
C.D. at 5% level	2.756	4.378	--
	$\overline{N_3N_2}N_1$	$\overline{N_3N_2}N_1$	
Micronutrient			
M_0	35.92	74.02	241.81
M_1	35.87	73.30	241.17
F. test	N.S.	N.S.	N.S.

It is seen from the table that the effect of date of sowing on the height of plants at all stages is significant. In the first and second stages of growth ie., 35th and 50th days after sowing, the cumulative growth was significantly maximum for the second date of sowing (D_2) while at the third stage (65th day after sowing) when the growth was almost ceased it was significantly higher for the first date of sowing (D_1) than D_2 and D_3 dates of sowings. A fourth observation on the 80th day after sowing did not show any appreciable difference in the height of plants and hence discarded for the purposes of analysis. It can also be seen from the table that the growth rate was of the highest order, during the period of tasseling.

The second part of the table summarises the effect of nitrogen at different stages of growth. The difference in height at the different nitrogen levels showed significance in the first and second stages only while at the final stage of growth, the levels of nitrogen did not influence the height of plants. Between the levels of nitrogen the N_2 and N_3 levels of N favourably influenced the height of plants at the first and second stages. But the increase was not significant.

With regard to the application of micronutrients, the mean height of plants did not show any significant difference at any of the growth stages of the crop.

III. Earliness to tasseling

The average number of days taken for 50 percent tasseling are presented in Table No. VI.

Table No. VI

Effect of date of sowing and manurial levels on earliness in tasseling treatments

Date of sowing	No. of days
D_1	53.40
D_2	53.80
D_3	56.00
F. test	sig.
S.E.	0.5376
C.D. at 5% level	1.13
	$\overline{D_1 D_2} D_3$
Nitrogen	
N_1	54.40
N_2	54.40
N_3	54.20
F. test	N.S.

Micronutrient	
M_0	54.00
M_1	54.70
F. test	sig.
S.E.	0.327
C.D. at 5% level	0.687
	M_0M_1

1. Effect of date of sowing: As evident from the data the earlier dates of sowing (D_1 and D_2) were significantly earlier for uniform tasseling than the D_3 date of sowing. Between the D_1 and D_2 dates of sowing there was no significance.

2. Effect of nitrogen: It is seen from the data that increased levels of nitrogen had no significant effect in earliness to tasseling.

3. Effect of micronutrient: Micronutrient application significantly affect the earliness to tasseling.

IV. Cob studies

A. Length of cob: The data on the length of cob under different treatments are presented in Table No. VII and represented graphically in Fig. No. 4.

Fig. 4

Bar diagram showing length, weight and girth of maize cob.

LENGTH WEIGHT AND GIRTH OF MAIZE COB

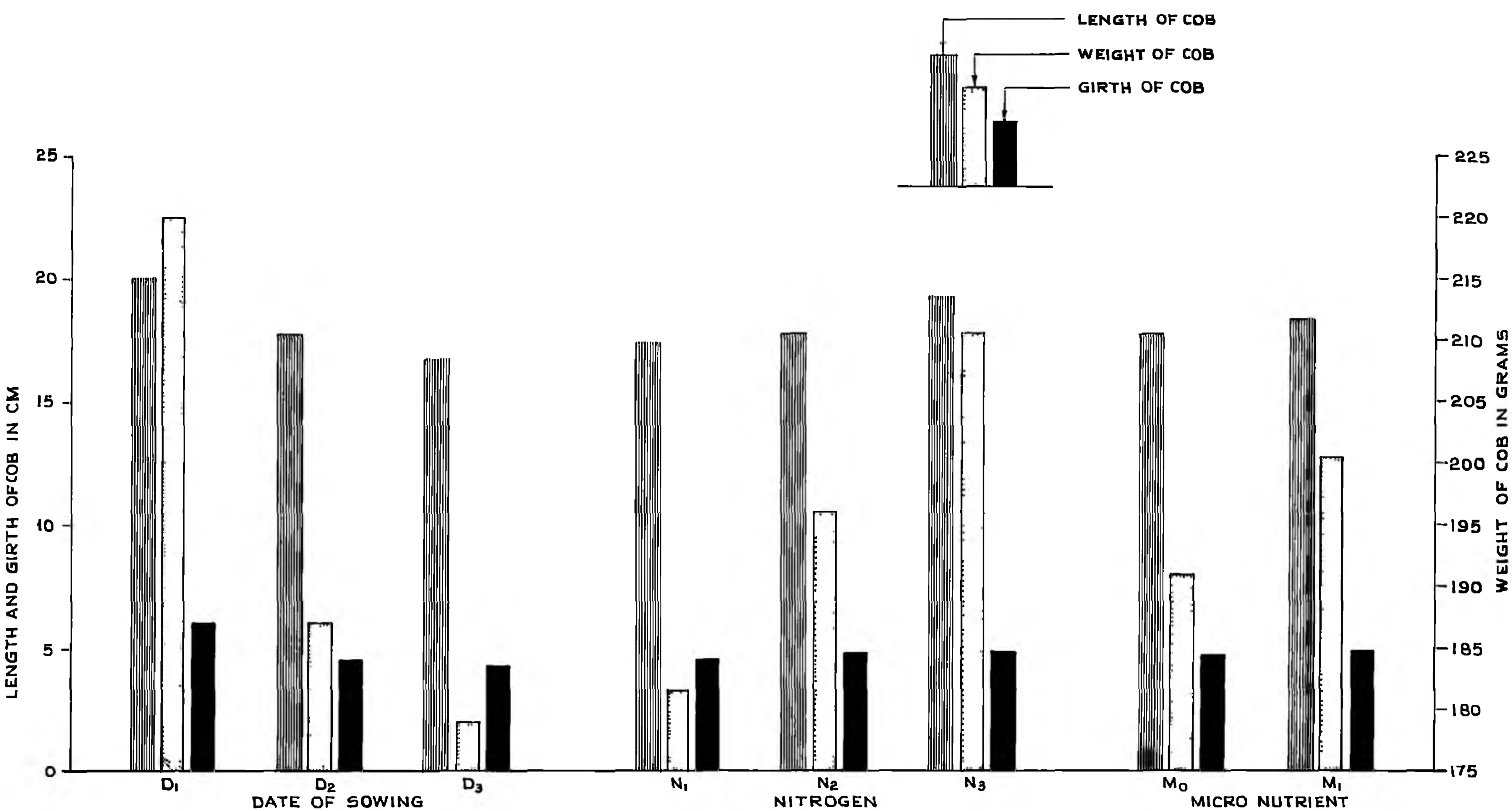

FIG 4

Table No. VII

Length of cob as affected by various treatments (in cm.)

Treatment	Length	Treatment	Length	Treatment	Length
Date of sowing		Nitrogen		Micronutrient	
D_1	20.08	N_1	17.48	M_0	17.79
D_2	17.62	N_2	17.79	M_1	18.39
D_3	16.84	N_3	19.27		
F. test	sig.		sig.		N.S.
S.E.	0.809		0.809		-
C.D.	1.175		1.175		
	$D_1\overline{D_2D_3}$		$N_3\overline{N_1N_2}$		

1. Effect of date of sowing: The data given in Table No. VII shows that the length of cob significantly increased in the first date of sowing (D_1). The influence of the date of sowing on the length of cob was not significant for the second and third dates of sowings (D_2 & D_3). However the cob length increased appreciably for the second date of sowing than the last date of sowing.

2. <u>Effect of nitrogen:</u> As evident from the data the highest level of nitrogen (N_3) had significantly increased the length of cob. The differences between N_1 and N_2 levels of nitrogen were not statistically significant.

3. <u>Effect of micronutrient:</u> The effect of micronutrients was not statistically significant.

B. <u>Weight of cob.</u>

Table No. VIII presents the weight of cob as affected by the different treatments. It is also represented graphically in Fig. No. 4.

1. <u>Effect of date of sowing:</u> Earlier sowing (D_1) recorded significantly maximum cob weight. The differences between D_2 and D_3 were not significant.

2. <u>Effect of nitrogen:</u> The data show that none of the treatment effects was significantly different. But there was a general trend of increase for increased levels of N application.

3. <u>Effect of micronutrients:</u> It is also evident from the data that no significant differences in weight were noted for micronutrient application.

Table No. VIII

Weight of cob as affected by the different treatments (in gm.)

Treatment	Weight	Treatment	Weight	Treatment	Weight
Date of sowing		Nitrogen		Micronutrient	
D_1	221.68	N_1	181.50	M_0	191.35
D_2	187.43	N_2	196.00	M_1	200.58
D_3	178.80	N_3	210.44		
F. test	sig.		N.S.		N.S.
S.E.	15.61		-		-
C.D. at 5% level	33.0932				
	$D_1 \overline{D_2 D_3}$				

C. Girth of cob.

The data on the girth of cob under different treatments are presented in Table No. IX and represented graphically in Fig. No. 4. It is found that on an average the girth of cobs was 4.52 cm. and it ranged between 4.31 cm. to 4.78 cm.

Table No. IX

Girth of cob as affected by different treatments (in cm.)

Treatment	Girth	Treatment	Girth	Treatment	Girth
Date of sowing		Nitrogen		Micronutrient	
D_1	4.78	N_1	4.45	M_0	4.49
D_2	4.36	N_2	4.57	M_1	4.60
D_3	4.31	N_3	4.62		
F. test	sig.		N.S.		N.S.
S.E.	0.1148				
C.D. at 5% level	0.2433				
	$D_1 \overline{D_2 D_3}$				

1. Effect of date of sowing: It is seen from the data given in Table No. IX that the maximum girth of cob was obtained for the first date of sowing (D_1) and was significantly higher than cobs obtained for the second and third dates of sowings (D_2 and D_3). The difference in the girth of cobs for the second and third dates of sowings (D_2 and D_3) did not show significance.

2. Effect of Nitrogen: Nitrogen in its various levels do not seem to have any significant effect on the girth of cobs. However, there was an increasing trend noted as the level of nitrogen was increased.

3. Effect of micronutrients: Micronutrients did not show any significant effect on the girth of cobs.

D. Grain heart ratio

The data on the grain heart ratio of the cob is presented in Table No. X. The average grain heart ratio is 4.395 and it ranged between 3.94 to 4.69.

1. Effect of date of sowing: It is evident from the table that the first date of sowing was significantly different from the second and third dates of sowing and that the ratio was less for the first date. The ratio for the second and third dates of sowing was not statistically significant.

2. Effect of nitrogen: None of the treatments has any significant effect in the grain heart ratio.

3. Micronutrient: The effect of micronutrients influenced the grain heart ratio and the ratio was maximum

for the micronutrient applied plants. None of the interactions was significant.

Table No. X

Grain heart ratio as affected by different treatments

Treatment	Ratio	Treatment	Ratio	Treatment	Ratio
Date of sowing		Nitrogen		Micronutrient	
D_1	3.94	N_1	4.26	M_0	4.52
D_2	4.56	N_2	4.56	M_1	4.26
D_3	4.69	N_3	4.37		
F. test			N.S.		sig.
S.E.	$\pm$ 0.2046				0.1466
C.D. at 5% level	0.4337				0.3080
	$\overline{D_3 D_2} D_1$				

V. Yield attributes

A. Stover yield

The data on stover yield per plot is presented in Table No. XI and graphically represented in Fig. No. 5.

Fig. 5

Bar diagram showing grain and stover yield per hectare and grain yield per plant

GRAIN AND STOVER YIELD PER HECTARE AND GRAIN YIELD PER MAIZE PLANT

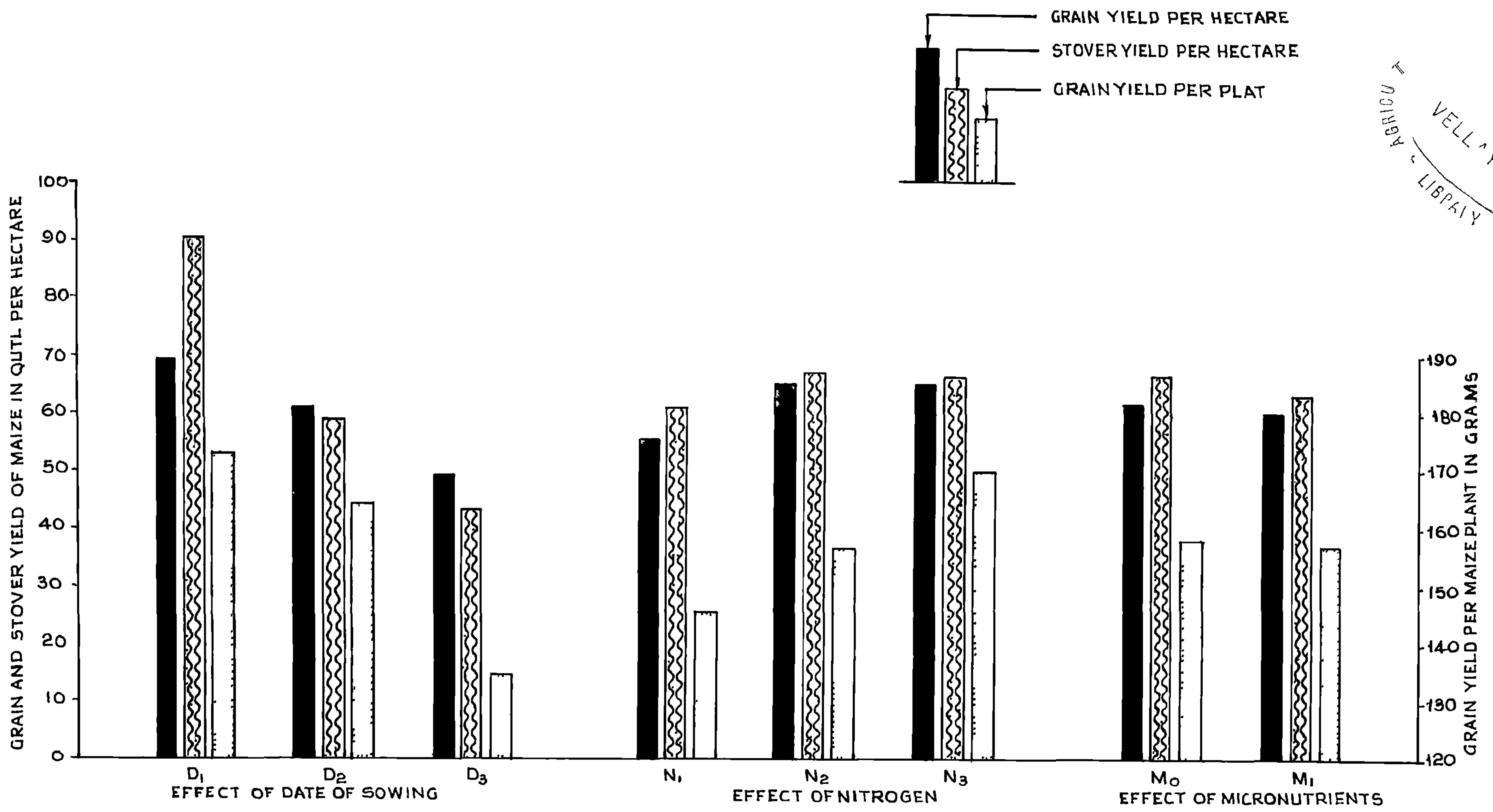

FIG 5

Table No. XI

Yield of stover per plot as affected by the different treatments (in Kg.)

Treatment	Weight (in Kg.)
Date of sowing	
D_1	6.68
D_2	4.43
D_3	3.17
F. test	sig.
S.E.	$\pm$ 0.426
C.D. at 5% level	0.903
	$D_1D_2D_3$
Nitrogen	
N_1	4.47
N_2	4.98
N_3	4.84
F. test	N.S.
Micronutrient	
M_0	4.87
M_1	4.65
F. test	N.S.

1. Effect of date of sowing: The stover yield was significantly different for the three dates of sowing (D_1, D_2 and D_3). The maximum stover yield was for the first date of sowing and the second date of sowing had significantly lesser yield than the D_1 date of sowing and the late sown crop (D_3) gave the lowest yield. The first date of sowing had 3.51 kg. (110.7%) higher stover yield than the last date of sowing.

2. Effect of nitrogen: None of the treatments was significant in the yield of stover.

3. Effect of micronutrients: It is also evident from the data that the micronutrients did not affect the stover yield significantly.

B. Yield of grains per plant

Table No. XII presents the yield of grains per plant and also represented graphically in Fig. No. 5.

1. Effect of date of sowing: It is seen from the Table No. XII that the date of sowing had statistically significant influence on the yield of grains. The yields obtained on the first and second dates (D_1 and D_2) were

not significantly different from each other. Similar results were obtained for the second and third dates of sowing also (D_2 and D_3). But the yield obtained for the first date of sowing (D_1) was statistically significant over the last date of sowing (D_3) and the increase was 28.28%.

Table No. XII

Weight of grains per plant as affected by the different treatments (in gm.)

Treatment	Weight	Treatment	Weight	Treatment	Weight
Date of sowing		Nitrogen		Micronutrient	
D_1	172.27	N_1	144.40	M_0	156.91
D_2	164.20	N_2	156.30	M_1	156.91
D_3	134.15	N_3	169.80		
F. test	sig.		N.S.		N.S.
S.E.	$\pm$ 16.36				
C.D.	34.68				
	$\underline{D_1}\,\overline{D_2 D_3}$				

2. Effect of nitrogen: It is evident from the table that the successive increases in the dose of nitrogen did not influence the yield significantly. However, it was observed that the yield showed an increasing trend as the doses were enhanced. The percentage of increases were 8.3% and 17% respectively for the N_2 and N_3 levels of nitrogen over the N_1 level.

3. Effect of micronutrients: Application of micronutrients did not show any significant effect on the yield of grains per plant.

C. Yield of grain per plot

The yield of grains per plot as affected by the various treatments are presented in Table No. XIII and also graphically represented in Fig. No. 5.

The yield data on Table No. XIII shows that the date of sowing treatment only is statistically significant over the others.

1. Effect of date of sowing: It is seen that the premonsoon sowing ie., the first date of sowing D_1 increased the yield by 12.21% and 37.85% over the second (D_2) and third (D_3) dates of sowings respectively.

However, the differences in yield between the D_1 and D_2 sowings and between D_2 and D_3 sowings were not statistically significant.

Table No. XIII

Weight of maize grains per plot as affected by the different treatments (in gm.)

Treatment	Weight	Treatment	Weight	Treatment	Weight
Date of sowing		Nitrogen		Micronutrient	
D_1	5095.61	N_1	4054.00	M_0	4508.2
D_2	4541.05	N_2	4483.00	M_1	4380.5
D_3	3696.33	N_3	4796.00		
F. test	sig.		N.S.		N.S.
S.E.	$\pm$ 433.095	+	-		-
C.D.	918.17	+	-		-
	$\overline{D_1}\ \overline{D_2 D_3}$				

2. Effect of nitrogen: None of the levels of nitrogen was statistically significant over the other. However, it was observed that the highest level N_3 enhanced

the yield by 7% and 18.3% over the N_2 and N_1 levels of N respectively. The yield increases for N_2 level of N over the N_1 level was found to be 10.58%.

3. Effect of micronutrients: The yield of maize grains obtained for the micronutrient applied plots showed a depressing trend over the control. However the yield difference was not statistically significant.

VI. Grain to stover ratio

The grain to stover ratio as affected by the various treatments are presented in Table No. XIV and graphically represented in Fig. No. 6.

1. Effect of date of sowing: It is evident from the Table No. XIV that the D_1 date of sowing was statistically significant over the D_2 and D_3 dates of sowings and that it was lower for the D_1 date of sowing. The difference between D_2 and D_3 dates of sowing was not significant.

2. Effect of nitrogen: None of the treatments was significant in the grain to stover ratio.

Fig. 6

Bar diagram showing grain to stover ratio

Fig. 7

Bar diagram showing percentage of protein in maize grains

GRAIN TO STOVER RATIO

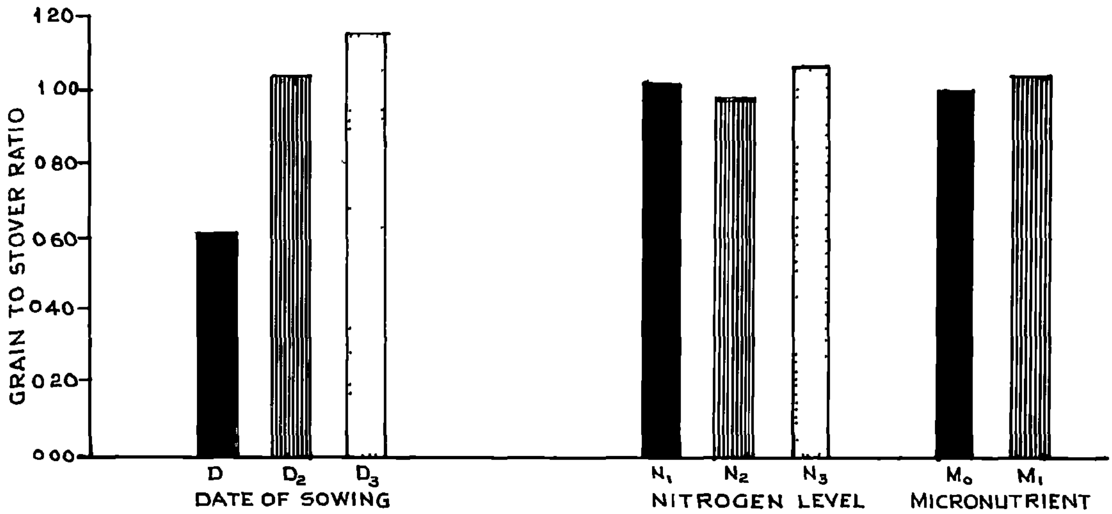

FIG 6

PROTEIN PERCENTAGE OF GRAINS

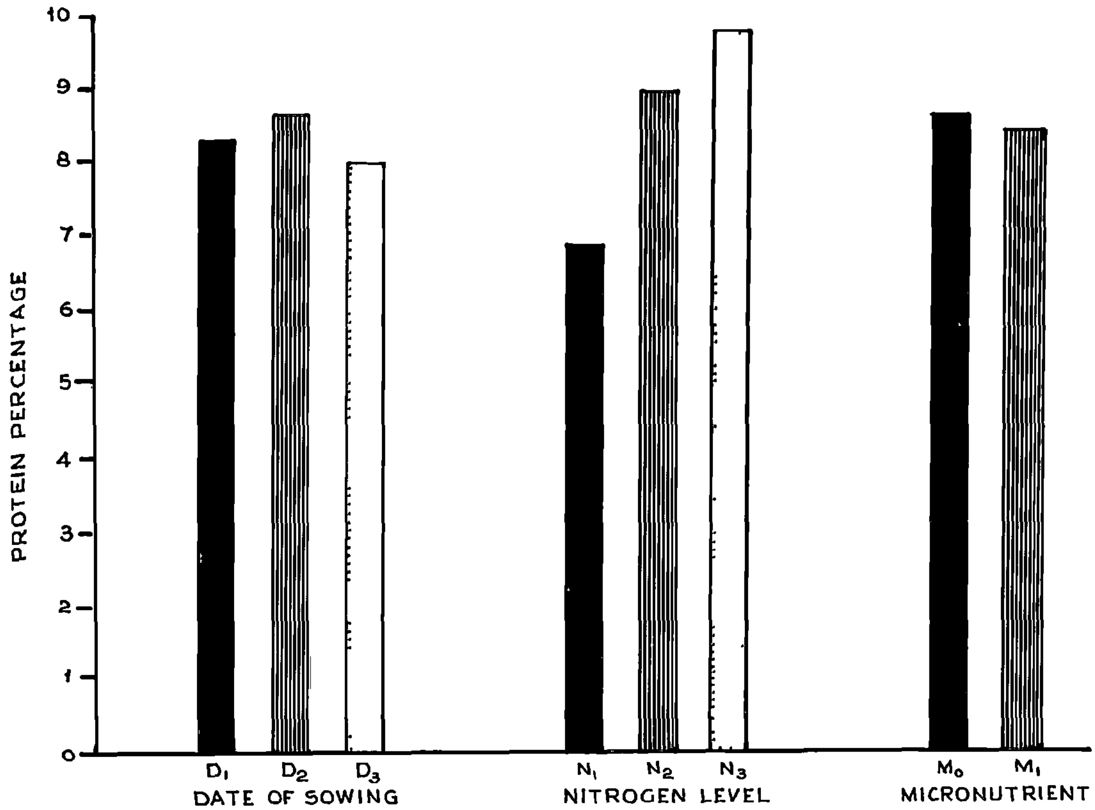

FIG 7

Table No. XIV

Grain to stover ratio as affected by the various treatments

Treatment	Ratio	Treatment	Ratio	Treatment	Ratio
Date of sowing		Nitrogen		Micronutrient	
D_1	0.604	N_1	1.012	M_0	0.99
D_2	1.056	N_2	0.96	M_1	1.02
D_3	1.150	N_3	1.045		
F. test	Sig.		N.S.		N.S.
S.E.	0.1613				
C.D. at 5% level	0.341				
	$\overline{D_2 D_3} D_1$				

3. <u>Effect of micronutrients:</u> It is also evident from the data that the micronutrients did not affect the grain to stover ratio.

VII. Protein content of maize grains

Table No. XV shows the protein content of maize grains as affected by the various treatmnts and graphically represented in Fig. No. 7.

Table No. XV

Percentage of protein of maize grains as affected by the various treatments ([illegible])

Treatment	Protein %age	Treatment	Protein %age	Treatment	Protein %age
Date of sowing		Nitrogen		Micronutrient	
D_1	8.44	N_1	7.07	M_0	8.79
D_2	8.73	N_2	9.05	M_1	8.53
D_3	8.1	N_3	9.87		
F. test	N.S.		sig.		N.S.
C.D.			2.08		
S.E.			0.984		
			$\overline{N_3 \overline{N_2 N_1}}$		

1. Effect of date of sowing: Dates of sowing D_1, D_2 and D_3 did not influence the protein percentage of corn grains.

2. Effect of nitrogen: It is evident from the table that the highest level of Nitrogen (N_3) influenced the protein percentage of the grain significantly by 39.6 percent over the N_1 level of nitrogen. Percentage of protein between N_1 and N_2 and also between N_2 and N_3 did not show statistically significant improvement. However the increase in percentage of proteins between N_1 and N_2 levels was 28 percent and between N_2 and N_3 was 9.06 percent.

3. Effect of micronutrient: The effect of micronutrient was not statistically significant.

DISCUSSION

DISCUSSION

Growing hybrid maize is not merely a matter of sowing a new kind of seed. To get high yields from hybrid maize, it is imperative to adopt improved production methods. Hybrid maize varieties are high yielding and respond much more profitably than open-pollinated maize to good cultural practices. In view of the importance of improved cultural practices for the realization of maximum yield potential of the newly evolved hybrids, work on improved cultural practices was initiated almost simultaneously with their release for general cultivation. Agronomic trials have been under way in various regions to work out most suitable production practices for growing these hybrid maize.

Hybrid maize is a new introduction to Kerala and it is found to do well under Kerala climatic conditions. No systematic work has ever been done in Kerala on cultural as well as manurial requirements of this crop.

The present investigation is one of the pioneer works conducted at the Agricultural College and Research Institute, Vellayani with the object of finding out a suitable time of sowing combined with adequate fertilization.

The results obtained regarding the time of planting and the effect of fertilizers particularly of Nitrogen on the plant as adjudged by plant characters, grain and stover yield and quality are discussed in the following pages.

I. Growth Studies as related to Climate

a) Germination and stand of the crop

The observation made on the percentage of germination showed that the period of plant emergence ranged between 4 to 5 days and that the percentage was 97% in the field. The high rate and early germination can be attributed to the good quality of seed and warm moist conditions prevailed during the periods of sowing.

b) Height of plants

The analysis of data on the cumulative growth rate of plants indicated that during the first and second observations made on the 35th and 50th days after sowing respectively, the second date of sowing influenced the height of plants significantly over the other two dates of sowing (D_1 and D_3). The fall in vegetative growth was more for D_1 date of sowing than the D_3 date of sowing in the first observation and in the second observation the fall in vegetative growth was significant for the D_3 date of sowing over the D_1 date of sowing.

This fall in vegetative growth in the early stages may be attributed to the rainfall received during the 1st stage of plant growth ie., 14 days after plant emergence as recognised by Hanway (1959). The rainfall during this period was in the order of 104.50 mm., 336.50 mm. and 113.60 mm. for the D_1, D_2 and D_3 dates of sowings. The high rainfall during this period for the July 2 sowings (D_2) might have resulted in increased vegetative growth and plant height followed by D_3 and D_1 dates of sowings. In the second observation ie., 50th day after sowing the plant height for the D_1 date of sowing increased considerably over the D_3 date of sowing but not over the D_2 sowings. This may again be attributed to the rainfall conditions prevailed during the second and third growth stages of the plant as recognised by Hanway (1959). The total precipitation during these stage of plant growth was 511.70 mm., 486.90 mm. and 193.30 mm. for the D_1, D_2 and D_3 dates of sowings respectively. Thus it is clear that with increase in rainfall the vegetative growth and plant height of the June 17 sowings (D_1) accelerated over the D_3 sowings. The initially high level of moisture followed by sufficiently good rains at this stage maintained the already high growth rate of the D_2 sowings during this period.

Early workers like Rhoades and Nelson (1955) observed that a deficiency of moisture in the soil during early growth stages slows down vegetative growth, delays tasseling and silking and also the maturity of the crop. It was also reported by Denmead and Shaw (1960) that moisture stress between 30 and 60 days after sowing ie., until tassel emergence reduced plant height and dry matter production. Colligado and Alibert (1964) have also found that a single period of moisture stress had the greatest retarding effect on growth when applied during the period from 30 days after sowing to beginning of tasseling.

But the observation on the cumulative growth on the 65th day after sowing indicated that the height of plants considerably increased and that it was statistically significant for the June 17 sowing (D_1) and with subsequent sowing (D_2 and D_3) the height was progressively reduced. The premonsoon sowing (D_1) recorded 10% and 19% more height over the D_2 and D_3 dates of sowings done after the break of the monsoon.

The rainfall received during this growth period was 591.40 mm., 502.10 mm. and 356.30 mm. respectively for D_1, D_2 and D_3 dates of sowings. Thus it is clear that the crop sown during the premonsoon period receiving uniform increase in rainfall at the early stages of plant growth showed significant increase in height over the others. This may be due to the fact that the premonsoon planting followed by increasing rains at the early stages ensured uniform growth of the crop. The plants have all established, well before the rains and could better withstand excessive moisture conditions in the root zone at the later stages of growth. Early root growth would have been better in premonsoon planting and the premonsoon interculture of the crop would have enabled better control of weeds during early growth phase when maize suffers most due to weed competition. On the other hand the delay in sowing ie., after the break of the monsoon (D_2 and D_3) might have resulted in slower growth at this period. Similar result have been reported by Raheja <u>et al</u> (1964) in their agronomic investigations with maize wherein it was indicated that the premonsoon planting with slight irrigation had several definite advantages as compared to planting after break of monsoon in the first week of July or later and that a delay in planting till the onset of the rains may result in poor plant stand, a slower growth, higher borer damage or higher percentages of barren plants and more damage from water logging resulting in lower grain yield.

It is also interesting to note that the high total precipitation for the D_1 date of sowing during approximately one month before anthesis when compared to the later dates of sowings might have induced higher vegetative growth during tasseling. This finding is in agreement with those reported by Runge and Odell (1959) wherein it was concluded that precipitation above normal is especially beneficial when it occurs approximately one month before and during anthesis and that the greatest need of corn for high soil moisture is during that period. The comparatively better precipitation during the above period for D_2 date of sowing over the D_3 date of sowing might have been the reason for increased plant height in the July 2 (D_2) sowing.

II. Climate and tasseling

Table VI shows the data regarding the number of days to tasseling under three planting dates in this study. Sowing maize on July 17 (D_3) significantly delayed tasseling compared to sowings on July 2 (D_2) or June 17 sowings (D_1). The number of days taken to tasseling for the three dates of sowing (D_1, D_2 and D_3) were 53.40, 53.80 and 56 days respectively. The delay to tasseling may be attributed to deficiency of soil moisture during the growth phase nearing to tasseling. Tahir (1956-57) as reported by Rai (1961) found at Tozi that tasseling and silking in maize occur just before the time when the rains decrease and the relative humidity begin to fall. In the present investigation also tasseling occurred for D_1 date of sowing when this critical period influencing earliness to tasseling coincided with the period of tasseling. For the D_1 sowing, tasseling occurred just before the time the rains decreased and stopped thereafter for three weeks from 10th August to 30th August 1964 and the relative humidity declined from 88.70 to 81.40 percent.

It was also found by Rhodes and Nelson (1955) that a deficiency of moisture during early growth slows down vegetative growth, delays tasseling and silking and delays maturity. In the present investigation also the total precipitation during the early stages of growth upto tasseling gradually decreased for the three dates D_1, D_2 and D_3 in the order of 570.20 mm., 486.90 mm. and 208.0 mm. respectively, thus causing moisture deficit for the D_3 sown crop at this stage. This might be the reason for the delayed tasseling for D_3 sowing. The difference between the number of days to tasseling in June 17 and July 2 sowings (D_1 and D_2) were not statistically significant.

III. Cob Studies

a) Climate and length of cob.

Studies on the length of cob revealed that the length was significantly higher for the D_1 date of sowing. However the differences between the length of cob in July 2 (D_2) and July 17 (D_3) sowings were not statistically significant (Table VII). The effect of date of sowing on length of cob may be due to the optimum moisture conditions maintained through out the growing period of the D_1 sowing. Length of cob - a contributing factor to yield might be affected by total rainfall during the growing season (Glover, 1957), deficiency of soil moisture during tasseling and silking (Rhoades and Nelson, 1955). Robins and Domingo (1960) reported that depletion of available moisture to wilting percentage reduce the yield of corn. Apart from the favourable climatic conditions for the D_1 sowings, fertilisation also significantly enhanced the length of cob.

b) Climate and weight of cob.

The first date of sowing (D_1) recorded significant increase in weight of cobs. This finding is in partial agreement with the result obtained by Stannberry et al (1963) wherein it was found that the stage at which supplimentary irrigation most increased total ear weight was during pollination. In the present investigation also, after the emergence of tassels there was slight rains which might have favoured the total ear weight of corn. For the D_2 sowing there was no rains after the emergence of tasseling which might have inhibited the development of cob and hence resulted in lesser ear weight. In July 17 sowing (D_3) the ear weight did not differ significantly from the July 2 sowing (D_2). In this case though a period of 2 weeks with no rains preceded anthesis, as it was alleviated by rainfall during the period of anthesis the ear weight did not reduce significantly from the D_2 sowings. This finding is in partial agreement with the report made by Rhodes and Nelson (1958) wherein it was found that if the deficient moisture supply during early growth is alleviated by tasseling time and optimum moisture is maintained throughout the rest of the growing season yields are likely to be good.

c) Climate and girth of cob

The girth of cob-another contributing factor to yield improved significantly in the first date of sowing (D_1). The girth of cob under the second and third dates of sowing (D_2 and D_3) did not differ significantly from each other. The favourable climatic conditions prevailed at the various stages of plant growth for the June 17 sowing (D_1) might have influenced the development of cob and thereby the girth.

d) Climate and grain to heart ratio

The results of grain to heart ratio indicated that premonsoon sowing (D_1) resulted in production of greater amount of heart per unit of grain as compared to plantings after the onset of the monsoon (D_2 and D_3). The differences between the July 2 and July 17 sowings (D_2 and D_3) were not statistically significant.

IV. Yield attributes

a) Climate as related to yield per plant and per plot

Sowing maize on June 17 (D_1) gave the maximum grain yield during the cropping season under investigation. Yields were progressively lowered with sowings in July 2 and July 17 (D_2 and D_3). July 17 sowing resulted in the lowest yield during the season under study. However, differences between yields from June 17 and July 2 (D_1 and D_2) and from July 2 and July 17 (D_2 and D_3) sowings were not statistically significant.

Satisfactory levels of soil moisture during the early growth stages of corn increased the vegetative growth, induced early tasseling and silking. It can be seen from the metereological data that the amount of rainfall received till 50 days after sowing was 570.20 mm. for June 17 sowing (D_1) while it was only 486.90 mm. and 208.50 mm. for the D_2 and D_3 dates of sowing respectively. The well distributed high precipitation favoured early tasseling and silking and the higher yields for the D_1 date of sowing. Runge and Odell (1959) observed that maize yields were influenced most markedly by precipitation preceding anthesis and by maximum temperature during anthesis. The temperature recorded for the D_1 sowing at the time of anthesis was 82°F while for the D_2 and D_3 sowings were 82°F and 81°F respectively. Thus it can be postulated that the precipitation above normal one month before and during anthesis with high temperature were the limiting factors to high yields.

It would also be attributed that the delay in tasseling and silking might have adversely affected the yield of maize in D_2 and D_3 dates of sowings. This observation is "agreement with those obtained by Tahir (1956-57) as reported by Rai (1961).

Adequate moisture during tasseling and silking for the D_1 over the D_2 and D_3 dates of sowings might have also contributed to the high yields obtained for the D_1 date of sowing.

The increasing total rainfall received during the growing season in one of the major contributing factors for increased yields. Glover (1957) found that the yield of maize rises with increasing total rainfall upto a maximum only, thereafter as rain fall totals further increase, yield decreases. In the present investigation the total rainfall recorded during the growing season of the D_1, D_2 and D_3 dates of sowings were 763.40 mm., 1116.90 mm. and 1035.30 mm. respectively. From the yield data obtained, it could be inferred that the total rainfall of about 763.40 mm. might have been the critical limit for increased grain production under Vellayani conditions beyond which the increase in total rainfall might have decreased the grain yields.

The depression of yield under excessive rainfall also needs experimentation for elucidation. The causes may in part consist if any or all of the following, Leaching of soil nutrients, reduced light and heat, increased diseases, increased competition from weeds etc.

Moisture depletion at the time of tasseling and pollination might have been the reason for low yields for the second and third dates of sowing (D_2 and D_3).

b) Climate and stover yield

June 17 planting (D_1) resulted in the maximum stover yield and with subsequent delay in planting the stover yield was progressively lowered. The quantity of stover produced was 50.79% and 110.7% for the D_1 date of sowing over D_2 and D_3 dates of sowings respectively. The increase in stover yield for D_2 date of sowing over D_3 was 39.75%. This could be attributed to the favourable climatic conditions prevailed during the growing seasons of the June 17 (D_1) and July 2 (D_2) sowings over the July 17 (D_3) sowing. This finding is in agreement with those obtained by Gautam and Shaw (1964) in their agronomic investigations with hybrid maize. The increased plant height also helped in increasing the stover yields for D_1 and D_2 dates of sowings.

c) Grain to stover ratio as affected by climate

The results of grain to stover ratio indicated that premonsoon planting resulted in production of greater amount of stover per unit of grain as compared to plantings after the onset of monsoon. This finding is in agreement with those obtained by Gautam and Shaw (1964) in their agronomic investigations with hybrid maize.

V. Quality factors

Climate and crude protein percentage

The crude protein percentage of maize grain was not significantly affected by the dates of sowing treatments. Similar results have been obtained by Gautam and Shaw (1964) in their agronomic investigations with hybrid maize.

VI. Effect of fertility levels

A number of experiments were conducted at the I.A.R.I., New Delhi, wherein the response of hybrid maize to nitrogen was studied. Maximum yield of grain in most of the experiments was obtained when N was applied at 134 or 179 Kg./ha. However the response to N application beyond 134 Kg. per hectare was relatively low and sometimes even uneconomic. The response curves developed with data obtained during 1960 and 1961 revealed that for the best economic returns nitrogen should be applied at a level between 67 and 134 Kg./ha. depending upon the soil fertility and seasonal conditions - low soil fertility and adverse conditions like water logging etc., requiring higher doses within this range.

Earlier investigators like Bondurant and Vice (1951), Dhosi (1953), Leng (1953), Fielding (1959), Dow (1959), Nandpuri (1960) and Hingle and Garret (1961) reported response to high doses of nitrogen upto 403.5 Kg. N/ha. But Liard et al (1959), Takur and Sharma (1958), Shaw and Gautam (1963) and Stanberry (1963) recommended doses upto 120 Kg. N/ha. to be economic and optimum dose for maize.

In the present investigation Nitrogen was tried at three levels 111 Kg., 148 Kg. and 185 Kg. per hectare respectively. The high levels utilised in this experiment were on the basis of high responses reported by earlier workers.

High fertility level treatment had significantly affected the height of plants, length of cob and the protein content of grains. But there was no significant effect on earliness to tasseling, weight of cob, girth of cob, grain to heart ratio, yield per plant, per plot yield, stover yield and grain to stover ratio.

Higher N level treatment helped the maize plants to accelerate early vegetative growth. This was in line with the findings reported by Rai (1961) and Sharma (1961). In the present investigation also, higher N level (N_2 & N_3) considerably accelerated the height of plants over N_1 though the difference between them was not significant. However, at the 65th day (third) observation there was no significant effect for the different levels of N tried in this experiment.

The length of cob was significantly increased by the higher dose of N (N_3). This may be due to the direct effect of N on the linear growth of the cob.

Protein content was also significantly increased from 7.07 to 9.87 percent due to higher fertility levels. Investigators like Viets and Domingo (1948), Nordon et al (1951), Sauberlich et al (1953), Zuber et al (1954), Prince (1954), Nevens et al (1954), Gillfard (1955), Hunter and Youngen (1955), Galvez et al (1956), Genter et al (1956), Lang et al (1956), Thomas (1959), Lanza (1959), Strang and Broue (1960), Nandpuri (1960), MacGeorge et al (1960) and Sharma (1961) concluded that higher doses of N application increased the protein content significantly in maize grains.

The response of higher doses of N on factors, such as weight of cob, yield per plant, per plot yield, grain heart ratio, grain stover ratio etc. was not significant at all levels tried in the present investigation. This lack of response may be due to the accumulative effect of one or more of the following reasons. Low plant population, loss of soil nutrients either by leaching or volatilization, higher doses of N tried in the experiment, increased competition from weeds and reduced light and heat associated with increased cloud.

Proper adjustment of plant populations and rate of N seem to be very important for grain production in corn. High rates of N might have decreased grain yield with low plant population of approximately 43250 per ha. (17500 plants per acre) used in this experiment. This appears to support the idea of Willcox (1954) that nutrient which is in excess in the soil solution will also be in excess in plant juices, where it will disturb normal metabolism and may not produce the desired results.

In the present investigation the plant population used was low ie., approximately 43250 plants per hectare (17500 plants per acre) and the doses of N tried were high viz., 111 Kg., 148 Kg. and 185 Kg. (N_1, N_2 and N_3) per hectare respectively. The initially higher doses of N did not show any marked difference between them though the yield increased by 18.3% and 7% with N_3 dose of N over N_1 and N_2 levels. Thus the high levels of N with low plant population might have disturbed the normal metabolism of the plants and decreased the yields.

A second reason that could be attributed to the low response with high doses of N is that even the low level of N tried in this study would have been sufficient enough to promote the economic yield of corn with the low plant densities used. The extra available N in the soil might have been utilised for increasing the protein content of the grains. This finding is in agreement with those obtained by Karam Singh and Nandpari (1960) wherein it was found that higher rates of N than those used would be necessary to obtain the maximum content of proteins. It was also reported that the yield of shelled corn decreased with high plant population and low rates of N. From this it could be inferred that with low plant populations as used in this investigation a low dose of N would have been sufficient or the high doses of N as tried in this study should have a dense stand of the crop to promote grain yields but not protein percentage.

A third reason that could be attributed to the low response of N to yield might be due to the loss of nutrients either by leaching or by volatilisation in the well drained soil used in the present investigation. In the present study N was applied at three stages viz., at sowing, 35 days after sowing (knee high stage) and 20 days after the second application (tasseling stage). The amount of precipitation recorded during and the week followed the application of fertilizers are given in Table No. XVI.

Table No. XVI

Rain fall data during and the week followed fertilizer applications

Date of sowing	Rain fall in mm.		
	Sowing stage	Knee high stage	Tasseling stage
D_1	104.50	50.50	79.70
D_2	293.60	79.70	-
D_3	50.50	-	147.80

The above table indicates the possibility of loss of N either by leaching or by volatilisation.

VII. Effect of micronutrients

Micronutrients did not show significant effect to any of the plant characters other then grain heart ratio studied in the present investigation. This finding is in partial agreement with those obtained by Viets (Jr) et al (1953) wherein it was found that applications of $MnSO_4$, $CuSO_4$ and phosphate did not affect grain yields of maize.

Some of the early investigators like Bunting (1956), Hiatt and Massey (1958), Vlasyuk (1959), Ahuja and Gautam (1961), Pumphery (1963) concluded that application of zinc either soil application or foliar spray helped in increasing yield of maize. But Fuehring and Soofi (1964) concluded that the application of zinc, Fe, Mn and Cu resulted in a decrease in grain yield of corn. It was reported that the relationship between the Zn nutrition of corn and the yield of grain is a very complex one requiring further study. In particular there was no definite critical level of Zn. The optimum Zn level was affected to the greatest extent by the level of Mn, low Mn in the leaves resulting in a low Zn requirement for maximum grain yields while high Mn in the leaves resulted in a high Zn requirement for both grain and stover yields. The contention for a balance between the amounts of Zn and Mn requires further investigation.

VIII. Economics of Nitrogen fertilization

Even though the levels of nitrogen used in this study did not show significance over the other it was found that the response of corn to different levels of nitrogen (111 Kg., 148 Kg. and 185 Kg./ha.) behave in a linear fashion except for the premonsoon planting (D_1) which was found to be the most suitable date of sowing as adjudged by the various plant characters studied. (Fig. 8). The response curve developed for the D_1 date of sowing stood at steady level beyond the N_2 dose of nitrogen (148 Kg. N/ha.). As such the theoretical optimum and economic doses of nitrogen for the D_1 date of sowing was worked out. It was found that the optimum level of nitrogen for the D_1 date of sowing would be 186.82 Kg./ha. while the economic dose would be only 169 Kg./ha. In calculating the economic dose, the price of input ie., N in the form of ammonium sulphate was taken to be Rs.360/- per ton of ammonium sulphate and the price of out put ie., maize grains at Rs.30/- per quintal.

Fig. 8

Curve showing response of corn to different levels of Nitrogen

RESPONSE OF CORN TO DIFFERENT LEVELS OF NITROGEN

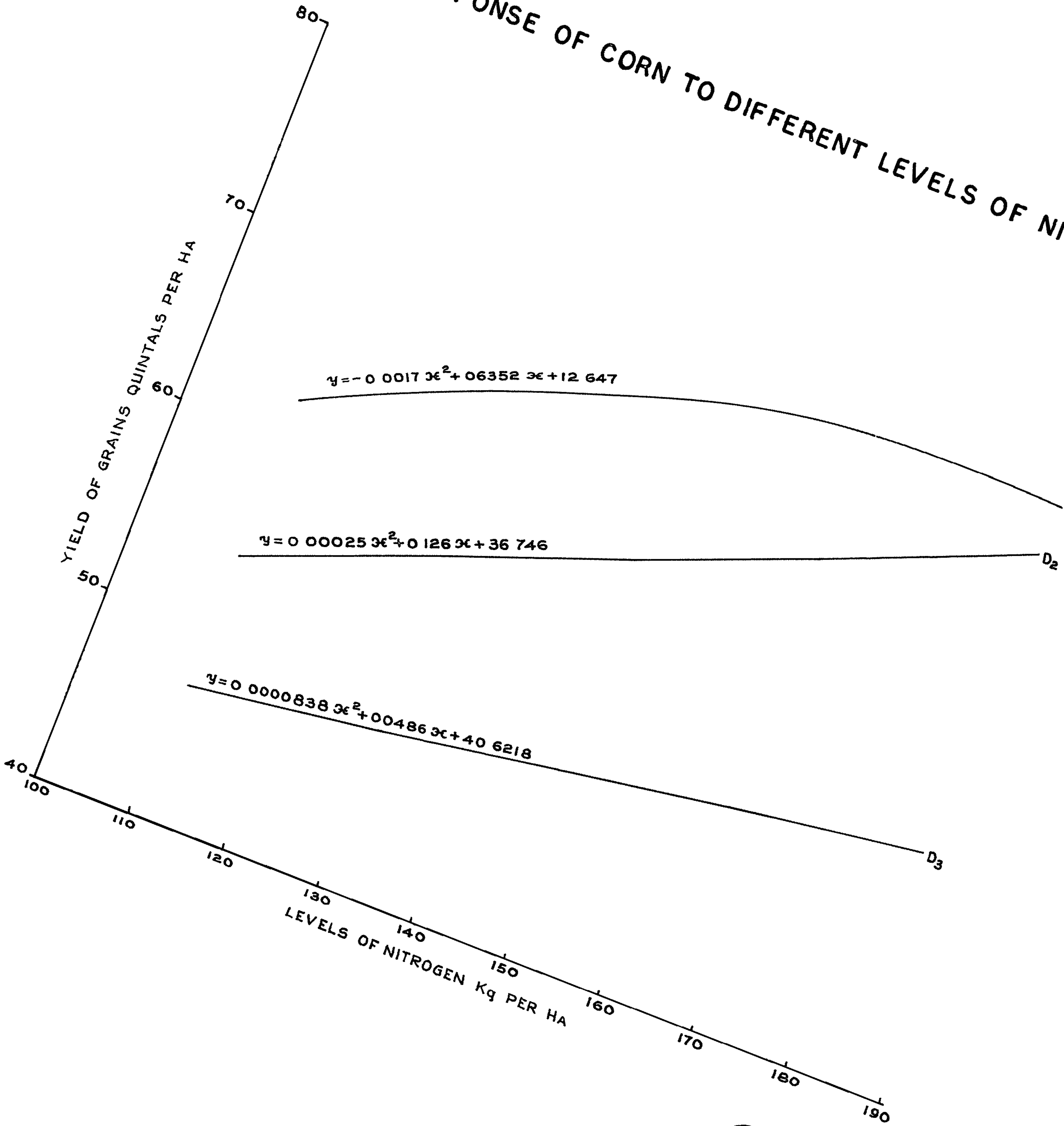

FIG 8

The relationship of extra doses of N to the additional yields obtained at higher levels of N was also worked out. It was found that for every rupee invested to N over the initial level of 111 Kg. N per hectare the extra income would be Rs.1.60 upto 148 Kg. N/ha., beyond which it reduced to Rs.0.89 upto 185 Kg. N/ha.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSIONS

An investigation was carried out to study the effect of date of sowing and Nitrogen fertilization combined with a mixture of micronutrients with hybrid maize variety-Deccan hybrid Makka-during Khariff 1964 in the Farm of the Agricultural College and Research Institute, Vellayani. The soil of the field is red loam of medium fertility. The experiment was laid out in a split plot design with combinations of date of sowing and nitrogen as the main treatment and micronutrient mixture as sub treatment. Farm yard manure, phosphoric acid and potash were applied to all the plots uniformly.

Three sowing dates were tried in the present study viz., June 17, July 2 and July 17 with 15 days interval. Three levels of nitrogen 111 Kg., 148 Kg. and 185 Kg. per hectare with a mixture of 6.38 Kg. Zn, 18.23 Kg. Mn and 7.12 Kg. Cu per hectare were also tried to determine a suitable combination of these nutrients for the Vellayani region.

Growth characters like the germination percentage, height of plants, earliness to tasseling were studied.

Yield and allied characters namely length of cob, weight of cob, girth of cob, grain heart ratio, stover yield, grain yield and grain to stover ratio were investigated. Quality character mainly percentage of crude protein was also studied. Results of the investigations are summarised below.

1. Premonsoon planting viz., June 17 planting was found to increase the height of plants significantly as compared to the sowings after the break of the monsoon and that the maximum vegetative growth occurred during the period of tasseling.

2. The higher levels of nitrogen enhanced the height of plants when compared to the lowest level of nitrogen tried in this study.

3. Early sowings upto July 2 were conducive to stimulate earliness to tasseling. The moisture conditions and himidity favoured the early tasseling in maize. The nitrogen fertilization did not have any marked influence at any of the levels tried in inducing early tasseling.

4. Premonsoon sowing on June 17 significantly increased the length of cob. The highest level of

nitrogen (N_3) also considerably enhanced the length of cob.

5. While the premonsoon planting D_1 favourably affect the weight of cobs, none of the nitrogen levels are found to be effective in increasing the total ear weight.

6. Sowing on June 17 significantly increased the girth of cob. Fertility levels had no significant effect on the girth of cob.

7. The grain heart ratio is the highest for the late sown crop (D_3). This would suggest that as the grain weight was increased the heart weight also increased proportionately in the early sown crop (D_1). No discernable difference is observed among the different levels of nitrogen.

8. Early sowing D_1 increased the yield of grains by 12.21% and 37.85% over the later sowings D_2 and D_3 respectively. However, the yield differences between D_1 and D_2 sowings and between D_2 and D_3 sowings were not statistically significant. There is definite advantage of premonsoon sowings over sowings after the onset of

monsoon. The distribution of rain fall at various stages of plant development being the major factor contributing to higher grain yields.

Higher fertility levels tried, though increased the grain yields, the increase was not significant at any of the levels. This would suggest that with a plant population used in this experiment the N requirement would also be proportionately lower for higher grain yields.

9. The stover yields obtained for the three dates of sowings (D_1, D_2 and D_3) were significantly different from each other and it was maximum for the June 17 planting (D_1) followed by July 2 and July 17 sowings. But the stover yields were not affected by higher fertility levels.

10. The grain to stover ratio is low for the early sown crop (D_1) when compared to D_2 and D_3 sowing dates. This would suggest that sowing early in the season improves both the grain and stover yield considerably. No remarkable effect was observed for the higher levels of nitrogen.

11. While the time of sowing did not materially affect the crude protein content of grain, higher fertility level increased the crude protein content from 7.07 to 9.87 percent over low fertility level.

12. Application of micronutrient mixture did not influence any of the plant characters other than grain - heart-ratio studied under the present investigation.

It is evident from the results of the present investigation that when Zea mays is grown as a field crop under the agro-climatic conditions of Vellayani, the most suitable sowing date would be before the onset of south west monsoon round about June 10th and June 20th provided there is adequate showers prior to the date of sowing for early agricultural operations.

With the present plant population used in this experiment a higher level of N beyond 111 Kg./ha. does not seem to be advantageous though there is an increasing trend upto 185 Kg. N/ha.

Application of micronutrient mixture does not seem to influence the growth and yield attributes of corn.

however, it requires further investigation with individual micronutrients and their combinations.

The optimum and economic doses of N for the D_1 date of sowing as estimated by regression equations revealed that the optimum and economic doses of N for the D_1 date of sowing would be 186.82 Kg./ha. and 169 Kg./ha. respectively.

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* Originals not seen.

APPENDIX

Appendix I

Height of plants at different stages of growth
(Analysis of variance)

Source	D.F.	Variance		
		35 days after sowing	50 days after sowing	65 days after sowing
Total	53			
Block	2	16.8889	21.81	64.02
M.P.T.				
D	2	1498.9479*	3195.796*	7738.54*
N	2	105.7534*	318.7995*	108.83
DN	4	16.8888	22.70975	45.29
Error 1	16	15.2873	38.3924	127.71
S.P.T.				
M	1	0.0290	6.863	5.64
DM	2	0.9525	28.226	6.14
NM	2	2.6816	2.509	78.95
DNM	4	18.0741	33.809	272.35
Error 2	18	15.4236	37.508	140.831

*Significant at 5% level.

$F_{2,16}$=98.4	$F_{2,16}$=83.2	$F_{2,16}$=60.60
$F_{2,16}$= 6.9	$F_{2,16}$= 8.3	

Appendix II

Earliness to tasseling - (Analysis of variance)

Source	D.F.	Variance Earliness to tasseling
Total	53	
Block	2	1.68
W.P.T.		
D	2	31.63*
N	2	0.300
DN	4	5.185
Error 1	16	2.602
S.P.T.		
M	1	6.00*
NM	2	0.850
DM	2	0.670
DNM	4	0.905
Error 2	18	0.963

*Significant at 5% level.

$F_{2,16}$=12.156

$F_{1,18}$= 6.231

Appendix III

Length, weight and girth of cob

Source	D.F.	Variance		
		Length	Weight	Girth
Total	53			
Block	2	18.5939*	14310.395	0.18735
W.P.T.				
D	2	51.4436*	9258.70*	2.5363
N	2	16.3939*	3771.31	0.1347
DN	4	6.0363	573.51	0.1115
Error 1	16	5.9031	2191.85	0.1191
S.P.T.				
M	1	2.4831	1148.99	0.1546
DM	2	9.8349	2586.15	0.162
NM	2	4.0189	690.46	0.0062
DNM	4	2.2158	861.89	0.0204
Error 2	18	3.5849	1519.47	0.1357

*Significant at 5% level

F2,16=3.19 F2,16=6.53 52,16=21.3
F2,16=8.71 F2,16=4.22
F2,16=2.78

Appendix IV

Grain yield per plant and per plot

Source	D.F.	Variance	
		Per plant	Per plot
Total	53		
Block	2	14139.95*	12857.86*
W.P.T.			
D	2	7278.79*	8937197.5*
N	2	2883.90	2502337.0
DN	4	376.44	215426.0
Error 1	16	2408.34	1688166.0
S.P.T.			
M	1	0.07	220075.0
DM	2	733.88	1105726.5
NM	2	2468.06	460158.0
DNM	4	672.49	469360.25
Error 2	18	1291.38	389135.6

Significant at 5% level.

$F_{2,16}$=5.87 $F_{2,16}$=7.61

$F_{2,16}$=3.022 $F_{2,16}$=5.294

Appendix V

Stover yield per plot - (Analysis of variance)

Source	D.F.	Variance Stover yield
Total	53	
Block	2	5.5253
W.P.T.		
D	2	56.9315*
N	2	1.2812
DN	4	0.2890
Error 1	16	1.6307
S.P.T.		
M	1	0.6622
DM	2	0.3226
NM	2	0.2303
DNM	4	2.6308
Error 2	18	0.4980

*Significant at 5% level

$F_{2,16}$=34.9123

Appendix VI

Grain to heart ratio and grain to stover ratio

(Analysis of variance)

Source	D.F.	Variance	
		Grain to heart ratio	Grain to stover ratio
Total	53		
Block	2	0.4490	0.6300
W.P.T.			
D	2	2.9248*	0.5775*
N	2	0.3998	0.0378
DN	4	0.8961	0.0209
Error 1	16	0.3779	0.2340
S.P.T.			
M	1	0.9178*	0.0085
DM	2	0.1140	0.0325
NM	2	0.0371	0.0519
DNM	4	0.0529	0.0360
Error 2	18	0.2927	0.0373

*Significant at 5% level

$F_{2,16}$=7.7396 $F_{2,16}$=2.468

$F_{1,18}$=4.49

Appendix VII

Protein percentage of maize grains

(Analysis of variance)

Source	D.F.	Variance Protein percentage
Total	53	
Block	2	1.905
W.P.T.		
D	2	0.71
N	2	37.28*
DN	4	1.66
Error 1		
S.P.T.		
M	1	0.91
DM	2	0.08
NM	2	0.07
DNM	4	1.29
Error 2	18	0.40

*Significant at 5% level

F2,#6=42.85

PLATES

PLATE I
A General View of the standing crop

PLATE II
Relative Height of plants with 111 Kg.N/ha.
and micronutrients under D_1 date of sowing
D_1 17-6-64 N_1 111 KgN/ha

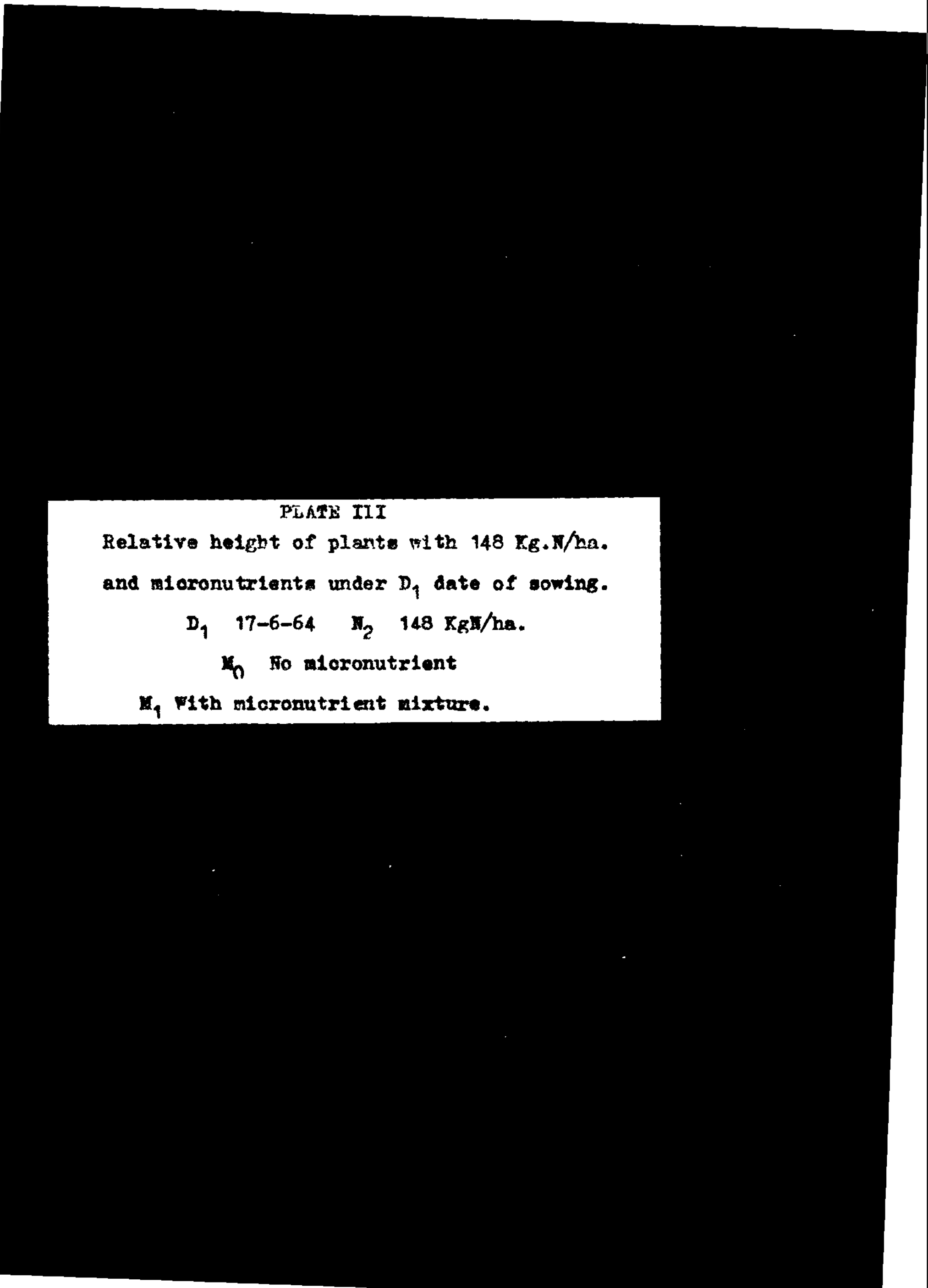


PLATE III

Relative height of plants with 148 Kg.N/ha. and micronutrients under D_1 date of sowing.

D_1 17-6-64 N_2 148 KgN/ha.

M_0 No micronutrient

M_1 With micronutrient mixture.

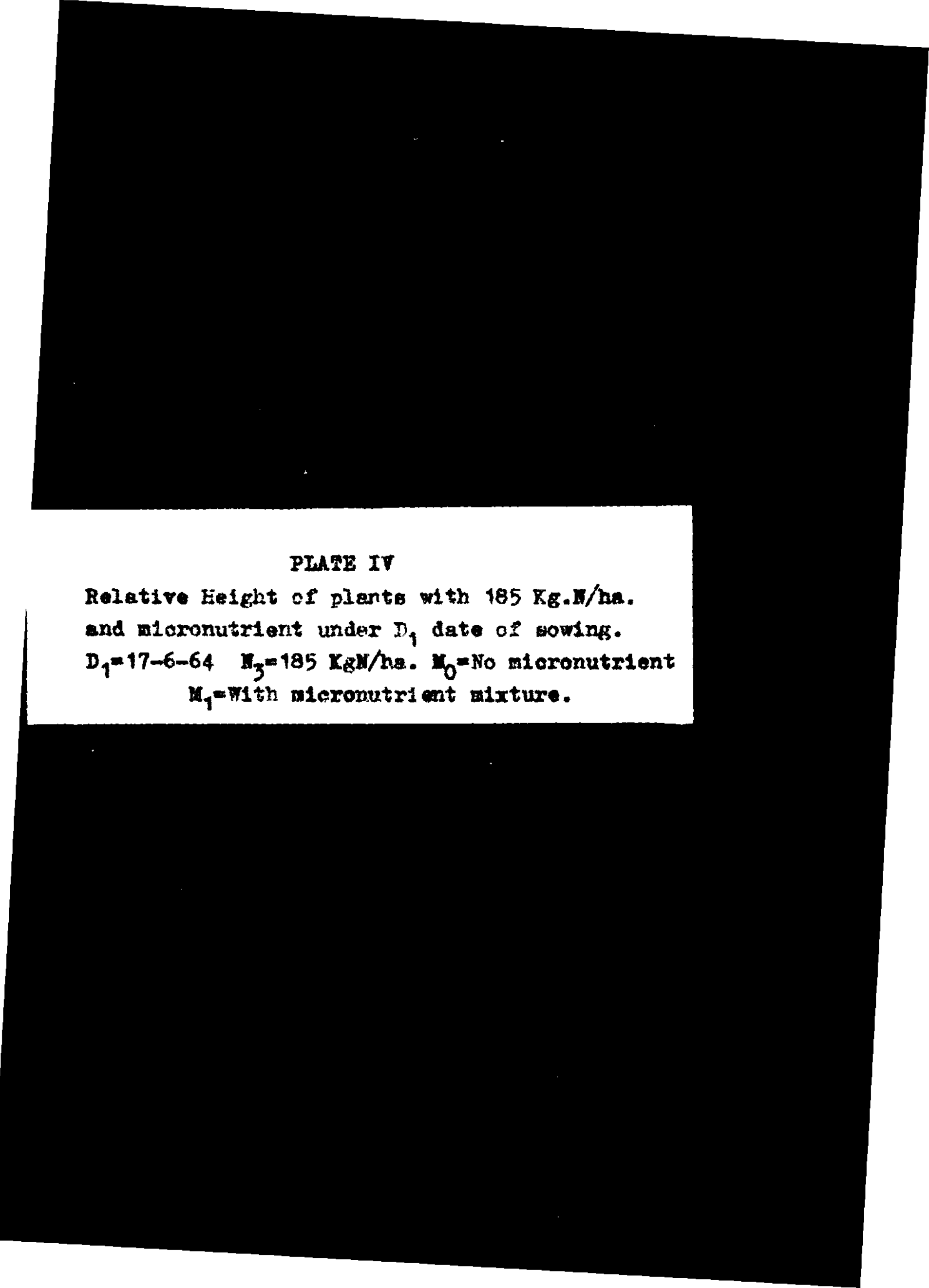


PLATE IV

Relative Height of plants with 185 Kg.N/ha. and micronutrient under D_1 date of sowing.

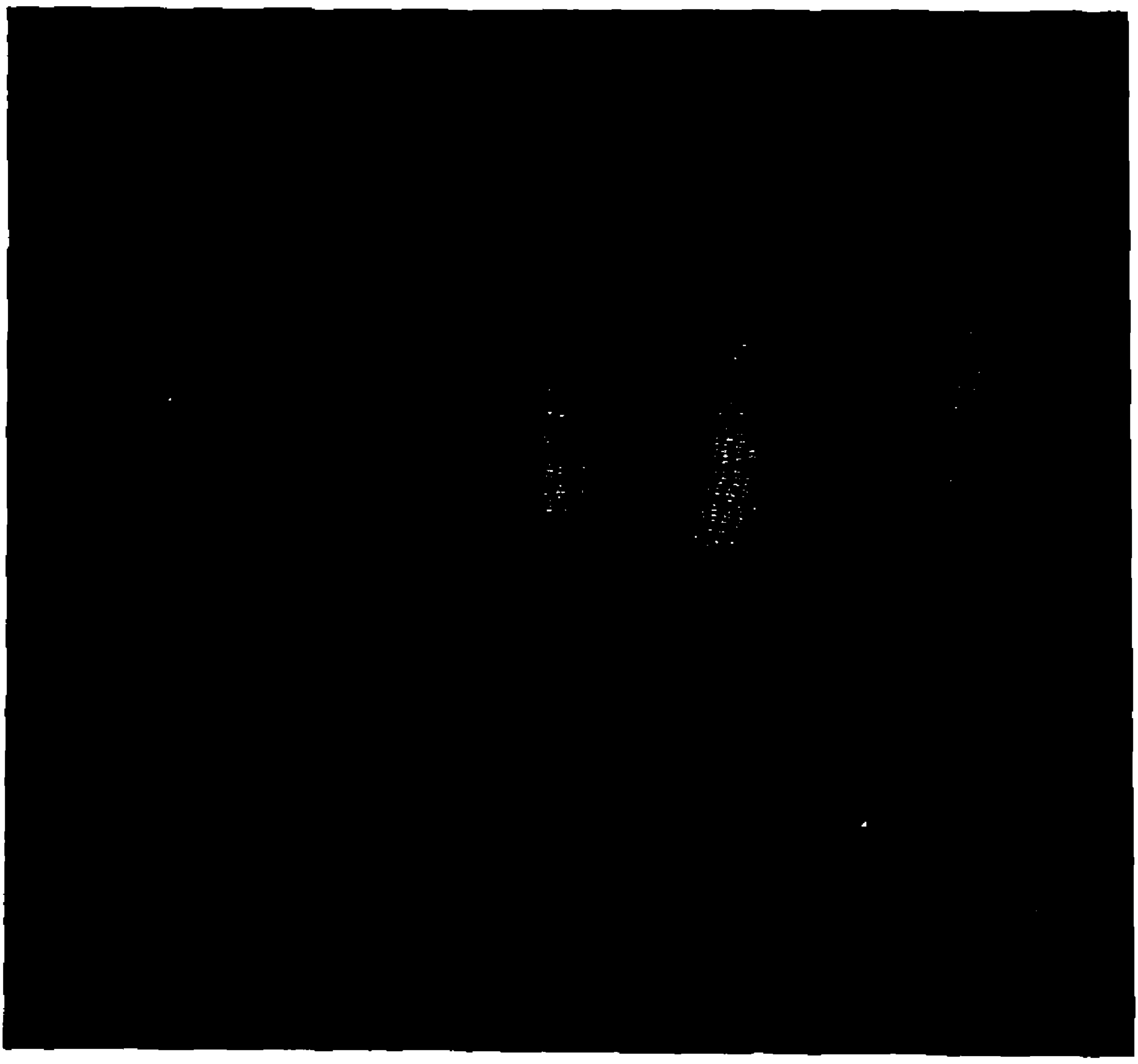
D_1=17-6-64 N_3=185 KgN/ha. M_0=No micronutrient M_1=With micronutrient mixture.

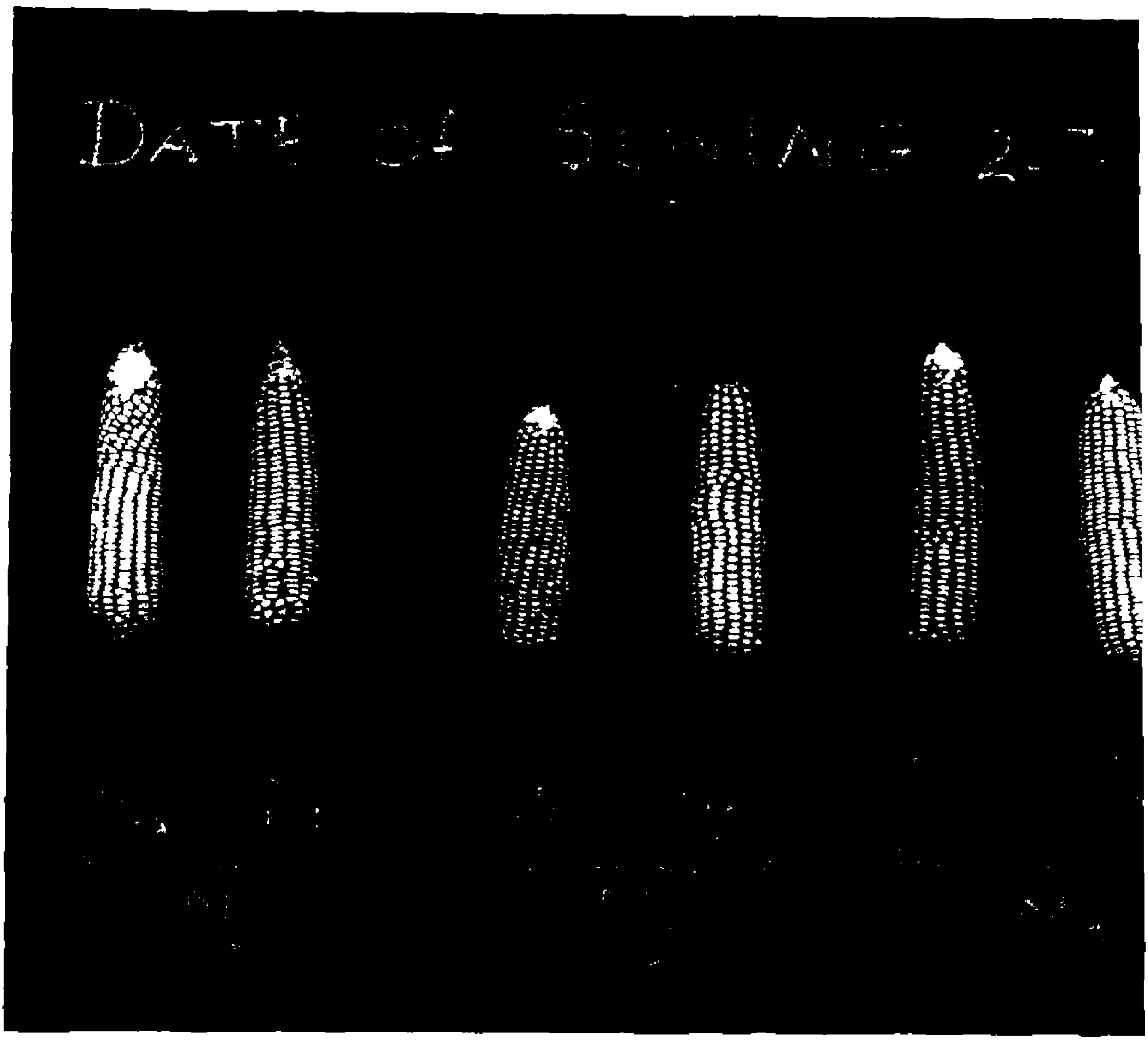
PLATE V

Representative ears of the crop produced under different treatments in the D_1 (17-6-64) date of sowing.

PLATE VI

Representative Ears of the crop produced under different treatments in the D_2 (2-7-64) date of sowing.




DATE OF SOWING

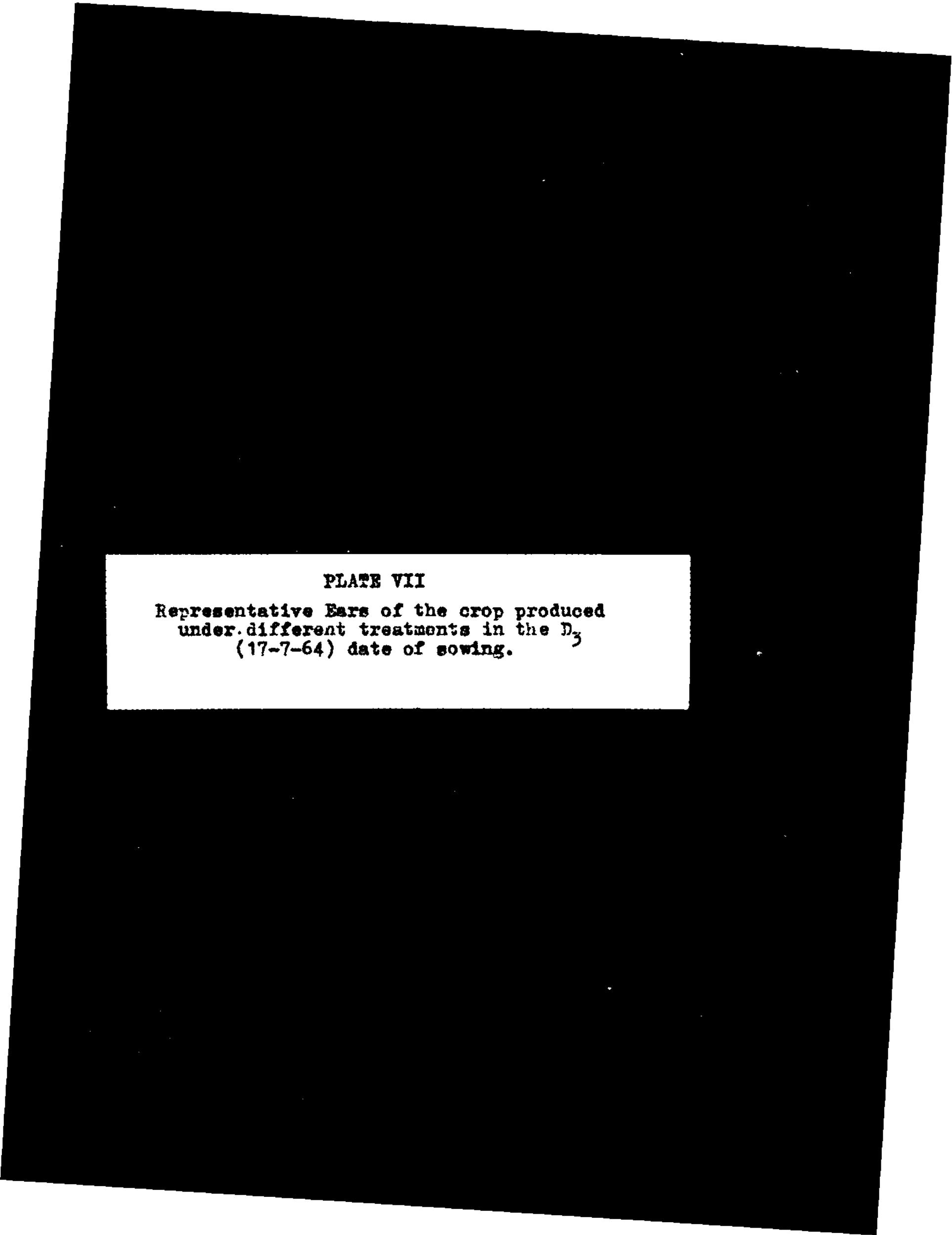


PLATE VII

Representative Ears of the crop produced under different treatments in the D_3 (17-7-64) date of sowing.