INVESTIGATIONS ON THE EFFECT OF FOLIAR APPLICATION OF NITROGENOUS FERTILIZERS ON CHEWING TOBACCO (*Nicotiana tabaccum Linn*)

BY

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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.M. Sukumaran 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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C O N T E N T S

PAGE

INTRODUCTION

It has long been known that plants are capable of absorbing nutrients through above-ground parts. The earliest published report on foliar absorption of mineral nutrients was by Gris (1844) and this was followed by those of Mayer (1874), Bohm (1877) and Hiltner (1909). Research on this subject has been greatly stimulated in recent years by the use of radioactive isotopes, by the availability of concentrated highly soluble fertilizers and by the development of suitable sprayers.

The spectrum of materials, known at present to be absorbed by plant foliage, is exceedingly broad. Anions such as nitrates, phosphates, sulphates, chlorides and iodides; monovalent cations like potassium, sodium and rubidium; divalent cations as calcium, magnesium, strontium and barium; and trace elements like iron, manganese, zinc, copper, molybdenum and cobalt, are all readily absorbed by plant foliage.

Experimental evidence is now available which establishes the positive response to foliar applied nutrients, of a variety of field crops, vogetable crops, fruit trees and plantation crops. Correction of trace element deficiencies by foliar spraying is at present prevalent on a commercial scale in the orchards of California and Florida. It is reported that seventy five to eighty percent of nitrogen currently applied to Hawaiian pineapple fields is in the form of urea sprays, while forty to fifty percent of the phosphorus and potassium fertilizer is applied to the foliage. Nutritional spraying of row crops and small grains with complete fertilizers has developed as an agricultural practice and has recently achieved considerable prominence abroad.

During the past two decades, intensive studies have been made on the use of foliar sprays as a means of furnishing a considerable part of the nitrogen needs of several crops. Thorne and Watson (1955) reported that in wheat urea sprays produced increases in yield and nitrogen content of grain. Jaurez, Applegate and Hamner (1957) obtained enhancement of yield and protein content of barley by foliar application of urea. Narayanan and Vasudevan (1959) reported that weight of maize cob increased by more than thirty percent over non-sprayed crop by spraying with urea and ammonium sulphate. Increases in tobacco crop yield to the extent of 13.3 per cent due to foliar application of macronutrients were reported by Minkov (1959).

The extensive foliage expanse of tobacco plants would at once suggest the feasibility of supplying nutrients through leaf sprays. An interrupted or irregular supply of nutrients has deleterious effect both on growth and yield of the tobacco crop. At times, it has been found difficult to maintain a regulated supply of available nutrients according to the needs of the crop during different phases of growth through soil application of solid fertilizers. A judicious control of nutrient levels in plants during critical periods of growth would appear to be more possible with foliar feeding.

Furthermore, there exists special problems in different tobacco soils, such as: (1) rapid fixation of nutrients in forms unavailable to the crop, (2) loss of nutrients due to leaching and (3) low moisture levels reducing the availability of nutrients. Under such situations efficiency of nutrient-uptake from foliar sprays may be expected to be greatest, in comparison with that from solid fertilizers applied to the soil.

Chewing tobacco (Nicotiana tabaccum L.) is an important cash crop in the Cannanore District of Kerala. It is grown on the littoral sandy soil as well as on laterite loam. Intensive manuring is practised by the growers. The crop receives on the average over three hundred kilograms of nitrogen per hectacre. It seems obvious from the nature of the soils and heavy precipitation received in the locality that losses of nutrients on account of fixation in unavailable forms and leaching are inevitable.

Little research work has been done on the nutritional aspect of this type of tobacco.

In contrast to the cigarette tobacco types, in the case of chewing tobacco, high yields are consistent with high quality and liberal nitrogenous manuring.

In view of the beneficial response to foliar spray of macronutrients, reported in other crops, it was felt worthwhile to investigate the feasibility of applying nitrogenous fertilizers through foliage in chewing tobacco.

The objects of the present investigation were:

(1) To study the effect of nitrogenous fertilizers on yield and allied economic characters of chewing tobacco.

(2) To find out the suitable quantity of nitrogen, applied as foliar spray which would produce high yield.

(3) To study the effect of foliar application of nitrogenous fertilizers on total nitrogen, nicotine, potassium and chlorine content of the cured leaf.

(4) To make a comparative study of two methods of supplying nutrient, viz: (1) foliar spray of fertilizer solutions and (2) soil application of solid fertilizers.

The results of the investigation conducted during 1962-63 are described and discussed in the following pages.

REVIEW OF LITERATURE

The phenomenon of foliar absorption of nutrients, or the associated agricultural practice, has been variously described as foliar feeding, nutrient absorption by above-ground plant parts, extra-radical feeding, non-root feeding and "Blattdumgung." The earliest published report on foliar absorption of mineral nutrients was by Griss (1844) and this was followed by reports of Mayer (1874), Bohm (1877) and Hiltner (1909). Research on this subject has been greatly stimulated during recent years by the utilisation of radioisotopes, by the availability of concentrated highly soluble fertilizers and by the development of suitable spraying equipment.

Mechanism of Foliar Absorption.

The evidence available at present is insufficient to define completely the mechanism involved in foliar absorption of individual nutrients.

The primary mechanism for urea absorption is probably diffusion, since it is absorbed and moved throughout the plant very rapidly, as was evident from the studies on absorption rates for nutrients applied to plant foliage, made by several research workers as Fisher and Walker (1955), Hilton and Shaw (1956), Bukovac and Wittwer (1956) and Sanford etc. al.(1958). Emmert and Klinker (1950) and Hilton and Shaw (1956) found that for urea uptake an energy source is apparently not required. It has been shown by

Kuykendall and Wallace (1954) that the temperature coefficient (Q_{10}) for absorption of urea is close to one.

The absorption of phosphate, sulphate and chloride appears to involve either an exchange or an active absorption process. This is evident from data presented on energy requirements by Yatazawa and Higashino (1953), on accumulation by Long, Sweet and Tukey (1956), and on sensitivity to exhibitors by Arisz (1958).

Factors affecting absorption.

(a) Contact angle and surface wetting.

Fogg (1947) found great differences in the contact angles of water on the leaves of different species, due to variations in age and water content of leaf. Hesse and Griggs (1950) observed differences in the degree of surface wetting of peach leaves of various varieties, which appeared to be due to the composition of the cuticle.

Studies by Guest and Chapman (1948) and Cook and Boynton (1952) indicated that wetting agents increased the efficiency of absorption by leaves.

Boynton (1954) emphasized the importance of contact angle of the applied solution droplets as well as surface wetting in foliar absorption.

Studies by Barrier and Loomis (1957) and Koontz and Beddulph (1957) showed that surfactants (wetting agents) seldom play a dominant role in mineral uptake.

(b) Paths of entry.

Cook and Boynton (1952) reported that the lower surfaces of apple leaves always absorbed a larger proportion of urea applied, than did the upper surfaces. They further stated that the shorter the time interval, the greater is the relative efficiency in absorption by lower leaf surfaces; the larger the time interval, the smaller is the advantage of the lower surface application, until ultimately it became non-existent. Skoss (1955) observed that stomates act as the major portal of entry of sprayed substances.

Orgell (1955) suggested that cracks and imperfections in the cuticle or an imbricated cuticle of small platelets cemented together by pectic materials, might result in ready penetration of foliar-applied polar substances. Data presented by several workers as Stewart and Leonard (1955), Frank (1957) and Gustafson (1957) indicated that passage through imperfection in the cuticular layer or through the cuticle itself is equally important as the entry through stomata.

(c) Temperature and humidity.

Cook and Boynton (1952) found that there were significant linear correlations both between air temperature and absorption and between relative humidity and absorption. When relative humidity and temperature combine to decrease the vapour pressure gradient at the leaf surface, greater absorption might be expected.

Sosa-Bourdouil and Lecat (1952) reported that for phosphorus absorption the Q_{10} value approximated to two. Same Q_{10} values were reported for potassium and rubidium by Teubner, Bukovac, Gaur and Wittwer (1958).

(d) Age and nitrogen status of absorbing leaves.

Cook and Boynton (1952) reported that older apple leaves were less efficient in short period absorption of urea nitrogen than younger leaves. Fisher and Walker (1955) and Koontz and Biddulph (1957) reported that foliar absorption rates for phosphorus were greater for young leaves than for old.

The studies of Cook and Boynton (1952) indicated that apple leaves which were grown under high nitrogen conditions were more efficient in absorption of urea nitrogen than were low nitrogen leaves. Higashino and Yatazawa (1952) reported that plants deficient in phosphorus absorbed foliar applied phosphorus more rapidly than those grown in phosphorus rich media.

(e) Chemical composition of the nutrient spray.

Parker (1934) reported that addition of lime to zinc sulphate alleviated the spray injury.

Emmert and Klinker (1950) working with tomato, Kuydendall and Wallace (1953) with citrus, and Cook and Boynton (1952) with apple found that the addition of sucrose to urea spray of injurious concentration, eliminated the leaf injury that occurred in the absence of the sucrose.

Montelaro, Hall and Jamison (1952) found that tomato leaves were less subject to injuries from epsom salts sprays of relatively high concentration, than from sprays of urea at comparable molar concentrations.

<u>Plant responses to sprays of nitrogenous fertilizers.</u>

Hamilton, Palmiter and Anderson (1943) reported significant increase of leaf chlorophyll and leaf total nitrogen in apple trees sprayed with urea at five pounds per hundred gallons plus one pound of lime.

Fisher and co-workers (1948, 1950, 1952) established that over a period of years application of three urea sprays at a rate of five pounds per 100 gallons at weekly intervals in the early post-bloom period gave nitrogen effects sufficient to keep apple trees moderately vigorous and productive. Comparing the effects of foliar application with those of soil application of urea in spring, they found that leaf sprays were as effective in promoting tree productivity and possibly a little more effective than soil application of the same amount of nitrogen. Beneficial effects in terms of yield and quality of apple fruit due to foliar application of nitrogen fertilizers were reported by Benson and Bullock (1951), Bould and Tolhurst (1951) and Blasberg (1953). Grappe (1958) found that four urea sprays at 0.7 per cent, increased yields of apple trees by 13.5 per cent. Van Lier (1960) reported that 0.5 per cent urea sprays on lightly pruned apple trees tended to improve fruit set and yield. Sako (1960) reported that urea sprays had marked effect on the nitrogen content of the leaves of apple trees. Oland (1960) observed that the amount of nitrogen absorbed by apple leaves from a single spray of urea was comparable to a net intake of 30-40 kilograms of nitrogen per hectacre.

Haas (1949) and Jones and Steinacker (1953) observed that the leaves of lemon and orange trees were efficient in absorption of urea sprays. Kuykendall and Wallace (1953) stated that urea nitrogen appeared to be readily assimilated in green leaves and did not affect juice quality in citrus.

Cannon (1950) reported significant results obtained by applying urea spray to pineapples.

Madera Bernal (1953) and Naundorf (1954, 1960) reported beneficial effects in cocoa plants by spraying with urea.

Robinson and Harcombe (1959) showed that in order to avoid leaf scorch in leaves of arabica coffee plants the strength of urea should not exceed one per cent by weight.

Burr and co-workers (1957, 1958) reported that high percentage of the required nitrogen could be supplied by foliage sprays of urea in sugarcane.

Kuthy, Fereez and Markus (1959) observed that calcium ammonium nitrate spray increased the yield and sugar content of sugar beet by 20 per cent. Yakushkina (1960) reported that spraying sugar beet with ammonium nitrate accelerated growth of the crop.

Pedas (1958) reported that tomato seedlings receiving urea spray made more rapid growth and produced 19.5 per cent increase in yield. Matskov and Ikonenko (1958) observed that phosphoric acid uptake by tomato plants sprayed with one per cent urea solution was greater than by control plants. Nitrogen content of leaves, stems and roots of the urea sprayed plants was greater.

Su and Kaung (1957) reported that spraying with urea at 0.5 per cent strength increased cotton yields by 140 pounds per acre.

Applegate and Hamner (1957) obtained enhancement of yield and protein content of barley by foliar application of urea.

Significant increases in yield and nitrogen content of grains in wheat were reported by Konovalov and Kolosha (1954) when urea spray was given at the beginning of ovary formation. Jaurez Gallano and Swanson (1955) found that pre-flowering spray of urea increased grain yields while post-flowering foliar application improved protein content of grain in wheat. Krzysch (1958) obtained significant increases in yield and protein content of grain of wheat by foliar spray of 1.7 per cent ammonium nitrate.

Fuleki and Nagymehaly (1956) noted that repeated application of urea spray at one per cent tended to delay maturity of maize crop. Narayanan and Vasudevan (1959) reported that weight of maize cob increased by more than

30 per cent by spraying with urea and ammonium sulphate.

Volk and Mc Auliffe (1954) demonstrated an extensive absorption and distribution throughout the plant, of urea nitrogen applied to tobacco as foliar spray. Mother and Trefftz (1954) found that spraying with 0.2 molar ammonium nitrate could take care of the full needs of the tobacco plant for nitrogen. Rammunni (1957, 1958) reported positive responses to foliar sprays of nitrogenous fertilizers in tobacco crop. Increases in tobacco crop yield to the extent of 13.3 per cent due to foliar application of macronutrients were reported by Hinkov (1959). Ivnovsky (1960) reported an increase of 12.9 per cent in the yield of tobacco sprayed with a solution containing nitrate of ammonia.

<u>Conditions determining the feasibility of nutrition by foliar application</u>

Boynton (1947) observed that on apple trees Epsom salts spray was resorted to as a solution to the problem of slow response to soil applied magnesium.

Boynton (1951) stated that urea spraying had been of particular interest to apple growers as a means of controlling the nitrogen effects on tree productivity and juice quality in so far as it furnished a means of adjusting the nitrogen level of the tree in accordance with the seasonal conditions.

Humbert and Hanson (1952) stated that the advantage of urea sprays in sugarcane resulted from the fact that it was impractical to make soil applications of nitrogenous fertilizers during the final period of growth of the crop when nitrogen supplements are some times needed.

Studies of Brasher, Wheatley and Ogle (1953) showed that beneficial results from foliar application of nutrients could be obtained in plants having low levels of nutrients.

Boynton (1954) stated that the usefulness of foliar application of nutrients depends on the following circumstances: (a) the existence of special problems that may not be coped with as well by application of the fertilizer to the soil (b) satisfactory plant responses to the nutrient spray.

Halliday (1961) observed that the efficiency of nutrient uptake from foliar sprays may be expected to be greatest, in comparison with that from fertilizers applied to the soil, when special limitations exist, for example, (1) when nutrients are rapidly fixed in the soil in forms unavailable to crop plants, (2) when there is need for a temporary method of control of nutrients in the period before the soil treatments take effect, (3) where there is competition for soil nutrients from weeds, ground cover, or shade plants.

Foliar versus soil application of nitrogenous fertilizers.

Humbert and Hanson (1952) presented evidence that a rapid increase of leaf total nitrogen and leaf chlorophyll followed spraying of sugarcane with concentrated urea solutions. This increase was much more rapid than that caused by comparable soil treatments.

Mortelaro, Hall and Jamison (1952) reported that in the early stagês of growth, tomato plants responded to nitrogen foliar sprays more slowly than to nitrogen applied to the soil at planting time.

Jones and Steinacker (1953), and Kuykendall and Wallace (1953) observed that the leaves of lemon and orange trees were efficient in absorption of urea sprays and that there was a more rapid increase of leaf nitrogen as a result of such sprays than as a result of comparable applications of nitrogen to the root medium.

Mortelaro (1952) observed that compared to side dressing of sodium nitrate, urea sprays did not increase total weight or number of fruit in tomatoes.

Jorissen (1955) found that sprays of ammonium sulphate were more effective on potato yield than broadcast application of equal amounts of the fertilizer.

Thorn and Watson (1955) reported that both topdressing of nitro-chalk and spraying 2 per cent ammonium nitrate solution produced similar increases of yield and nitrogen content of grain in wheat.

Walker and Fisher (1955) reported that in cherry trees urea sprays equivalent to half pound ammonium nitrate tended to produce greater increase of growth and fruit size than that procured from soil application of ammonium nitrate.

Buchner (1956) stated that urea spray was as effective as top-dressing of equivalent amounts of nitrate of lime and ammonia in cereals.

Thorne and Watson (1956) found that in the case of foliar sprays of ammonium nitrate and urea to sugar beet, the recovery of nitrogen in the whole plant was 70 and 40 per cent as compared with 40 or negligible amounts of recovery from similar applications to the soil.

Grappe (1958) reported that six urea sprays given to apple trees had a much more beneficial influence on vegetative growth than a similar amount of nitrogen applied entirely to soil.

Boguslawski and Vomel (1958) observed that foliar sprays of urea in oats produced yield equivalent to that which was procured from applying the fertiliser to the soil.

Experiments conducted with Mc Intosh apple, by Fisher (1958) revealed that yields from trees receiving foliage sprays of urea were as good as from trees given soil application of comparable amounts of nitrogen. He stated that the effect of leaf sprays was more rapid than that of soil applications, but was more temporary.

Stiles, Childers and Prusik (1959) reported that total nitrogen content of apple leaves sprayed with urea did not significantly differ from that of leaves from trees receiving an equal amount of nitrogen as ammonium nitrate through soil.

Narayanan and Vasudevan (1959) reported that in the case of maize, urea sprays produced more cob weight than what was obtained by application of an equal quantity of nitrogen to soil.

Many of the experimental results cited above show conclusively that nitrogen is readily absorbed by aerial plant parts, often several times more efficiently than from soil treatments. Yet, only few reports are available to show positive yield or growth responses to foliar spray, above those which could be procured by the most effective practices of soil application of fertilisers.

Nitrogen Nutrition of Tobacco

Nitrogen is of outstanding importance not only in its effects on the growth of tobacco but also in its influence on various elements of quality of cured leaf as was demonstrated by Garner (1934). Nitrogen has a specific action on leaf growth and consequently it is the nutrient which most influences the yield of leaf.

Garner et. al. (1934 and 1939) reported that application of nitrogen increased yield and leaf area of tobacco plants.

Brain (1937) found that a two-fold increase of nitrogen over that ordinarily used, that is from 14 to 28 pounds per acre, led to increased leaf yields.

According to investigations of Garner (1937), at least one third of the nitrogen applied to the crop should be in a slowly available organic form and one third in the form of urea and potassium nitrate.

Robert et. al. (1938) stated that tobacco crop requires a large supply of nitrogen for obtaining high yields; but the amount available at particular stages of growth tended to determine the quality of cured leaf.

According to Batchell (1938) maximum yield of tobacco was obtained when there was a liberal supply of nitrogen.

Garner (1947) stated that a high level of nitrogen assimilation favoured high water content or turgor in tissues which resulted in increased foliage expansion, enhanced accumulation of nitrogen in mature leaf and modified the ripening processes.

Garner (1947) also stated that nitrate forms of fertilisers were the most efficient in promoting rapid growth.

Swanback (1947) reported that the quantity of nitrogen absorbed by transplanted seedlings upto 30 days was always a little.

Swanback et. al. (1947) observed that the absorption of nitrogen by tobacco plants was usually in proportion to its availability in the soil.

Volodarsky (1948) reported that the application of an increased quantity of ammonium sulphate increased the thickness and area of the leaves.

Carr and Neas (1949) stated that urea is the most profitable form of nitrogenous fertiliser for tobacco crop.

The annual report of the Indian Central Tobacco Committee (1949-50) recorded that yield of tobacco enhanced significantly with increased levels of nitrogen supplied to soil. With the application of 90 pounds of nitrogen the yield was found to increase by 500 pounds over the control (no manure).

Results of manurial trials reported in the annual report of wrapper and Hookah Tobacco Research Station, Dinhatta, showed that with the addition of every 80 pounds of ammonium sulphate there was an increased yield of about 70 pounds of tobacco leaves.

Batra (1950) reported that a continuous supply of nitrogen throughout the growing period of the tobacco crop resulted in higher yield.

Russell (1950) stated that the photosynthetic acuivity was roughly proportional to the amount of nitrogen supplied.

Annual report of the Indian Central Tobacco Committee (1950-51) recorded that in all the manurial experiments conducted in flue-cured tobacco at Rajamundry, cheroot tobacco at Vedasandur, bidi tobacco at Anand and hookah tobacco at Ferosepur, nitrogenous manures were found to be distinctly superior to other manures in their effect on yield.

Kadam et. al. (1950) reported that the average yield of 620 pounds of tobacco per acre from nitrogen plots was significantly higher than the average of 547 pounds per acre from plots receiving no nitrogen.

Clark et. al. (1951) found that the potential nitrogen availability of water insoluble high grade inorganics had only half the efficiency of the water soluble nitrogen of ammonium sulphate.

Batra (1951) reported that Desi tobacco recorded highest yield when ammonium sulphate was applied in two equal instalments.

Tisdale, Woltz and Carr (1952) stated that difference in the effect of individual inorganic fertilisers on flue-cured tobacco was not very great.

Khemchandani, Kadam and Krishnan (1953) reported that highest yield was obtained with 80 pounds of nitrogen per acre and the lowest when no nitrogen was applied.

In an experiment conducted by Gilmore (1953) it was found that when the ratio of ammonium to nitrate nitrogen was high there was an increase in insoluble and soluble nitrogen, amide and alkaloid content.

Schmid (1953) stressed the particularly favourable effect of urea on tobacco plants.

Results recorded at the Hookah Tobacco Research Station, Bihar (1955-56) indicated that 50 pounds of nitrogen in any form gave an appreciable increase in cured leaf yield.

Annual report of Cigar and Cheroot Tobacco Research Station, Vedasandur (1955-56) recorded an increase of about 55 per cent of first grade leaf yield with the application of 100 pounds of nitrogen.

Experiments conducted at Wrapper and Hookah Tobacco Research Station, Dinhata (1955-56) showed that yield of tobacco enhanced with increase in dose of nitrogen upto 150 pounds.

Sajnani and Bhyani (1955) reported that in hookah and chewing tobacco, nitrogen fertilisers effected increases both in growth and yield. The optimum requirement was found to be 50 pounds of nitrogen per acre.

Annual progress report (1957-58) of the Bidi Tobacco Research Station, Anand, stated that the differences in yield due to sources of nitrogen were significant. Ammonium sulphate was significantly superior in its effects to urea and chilean nitrates.

Results of experiments reported in the Annual Report (1957-58) of the Bidi Tobacco Research Station, Anand, revealed that groundnut cake and ammonium sulphate mixtures were in no way inferior to groundnut cake alone.

Progress Report (1957-58) of the Guntur Tobacco Research Station stated that flue-cured tobacco favourably responded to nitrogen at 20 pounds per acre.

Kurup and Tejwani (1960) reported that as far as growth, yield and production of good grade leaves were concerned, cigar tobacco responded to the application of nitrogen. Nitrogen from organic sources hastened growth more uniformly than no nitrogen or inorganic sources of nitrogen like ammonium sulphate.

Chandnani, Thomas and Reddi Babu (1960) found that application of nitrogenous fertilisers enhanced weight per unit area of leaf, yield of cured leaf and nicotine content.

Influence of nitrogenous fertilisers on the chemical content of the tobacco leaf.

Baily et. al. (1928) reported that liberal application of fertilisers to tobacco plant increased assimilation of nitrogen.

Anderson, Swanback and Street (1932) reported that tobacco heavily manured had a high content of potash.

Dawson (1938) stated that nitrogen assimilated as ammonia increased nicotine content of leaves.

Romer (1940) reported that increases in nicotine content could be obtained by application of nitrogen fertilisers. Ammonium sulphate was found to be better than urea in this respect.

Lacrose (1918) found that nicotine content of tobacco leaf increased with moderate application of nitrogen.

Woltz et. al. (1949) stated that nicotine content was positively correlated with nitrogen and carbohydrate content of leaf.

Mc Evoy (1951) observed that low nitrogen accelerated maturity and decreased the content of other macronutrients, except phosphorus in the leaf.

Gilmore (1953) reported that when the ratio of ammonium to nitrate nitrogen was high there was an increase in amide and alkaloid content of the leaf.

Gowarkar and Shaw (1961) reported that in bidi tobacco nitrogen significantly reduced the calcium, magnesium and chlorine content of the leaf while it increased the nitrogen, phosphoric acid, potash and nicotine content.

Materials and Methods

An experiment was conducted during 1962-63 to study the effect of foliar spray of nitrogenous fertilizers on chewing tobacco (Nicotiana tabaccum L.) and to compare the results with those of soil application of solid fertilizers.

Experimental site.

The experiment was conducted in earthern pots of 45 cm diameter, arranged on an open field of the Agricultural College and Research Institute, Vellayani. Care was taken so as to minimise the shade effect. Pots were filled with 40 kilograms of washed sand, collected from the Kovalam sea shore.

The variety of tobacco used in the investigation was 'Pannan', a local variety which is usually grown in sandy areas of the sea shore; hence the choice of the sea shore sand.

Seed material.

Pannan, a local chewing tobacco variety was selected for the investigation. Sukumaran and Thomas (1962) described the variety as follows: "This is a long duration variety, tall, height is about 180 cm, stem is about 4-5 cm near the base. Total number of modes is 31-38. Leaves are petiolate, margin is even, apex is pointed. Leaves droop heavily. Lamina is fine textured and thin in body. Flower is about 5.5 cm long, corolla is light pink in colour. Capsules are medium and bold."

It is observed that this variety responds well to heavy nitrogenous manuring.

This is the most popular variety grown in Kerala.

Seed material was obtained from the Tobacco Research Station, Kanhangad.

Manures and fertilizers.

Well-rotten farm yard manure at the rate of 2 kilograms per 40 kilograms of sand was mixed in the pots. Phosphoric acid (1 gram) and potash (6 grams) were applied in the form of super-phosphate and potassium sulphate, for every 40 kilograms of sand. The farm yard manure and fertilizers were mixed with the sand fifteen days earlier to planting the seedlings. Samples of the farm yard manure mixed with sand were analysed; the results are given below:

		Percent on oven-dry basis
N	-	0.65
$P_2 O_5$	-	0.34
$K_2 O$	-	0.53
Ca O	-	0.057
Mg O	-	0.04

Experimental technique.

Experimental lay-out.

Design - Split-plot experiment in randomised block.

Number of treatments - 3 x 2 x 5 = 30

Number of replication - 5

Total number of plants - 150.

There were 150 pots altogether, arranged in five blocks of 30 each.

Treatments.

The two methods of application of three forms of nitrogenous fertilizers and the different levels of nitrogen were connoted as follows.

A - Whole-plot treatments (forms of fertilizers)

(1) Urea - M_1

(2) Ammonium sulphate - M_2

(3) Ammonium nitrate - M_3

B - Sub-plot treatments (methods of application)

(1) Foliar spray - F_1

(2) Soil application - F_2

C - Sub-sub-plot treatments (levels of nitrogen)

(1) 0 gram per plant or per 40 kilograms of soil } L_o

(2) 1 gram -do- L_1

(3) 2 grams -do- L_2

(4) 3 grams -do- L_3

(5) 4 grams -do- L_4

Nursery.

Pots were filled with sand, mixed with farm yard manure (2 kilograms per 40 kilograms of sand).

superphosphate and potassium sulphate to supply 1 gram of phosphoric acid and 6 grams of potash respectively for every 40 kilograms of sand, were also added. The sand in the pots was well compacted and the surface levelled. On 23-8-1962 two grams of seed were mixed with fine sand and spread uniformly in six pots, the surface of the sand in the pots was then pressed evenly. The pots were covered with sraw, and watered daily. A protective spray of peronox against 'damping off' was given at the rate of 1 gram in 0.1 gallon of water. Seedlings were ready for transplanting in the second week of October 1962.

Planting of seedlings.

Vigorous seedlings of uniform size were selected for transplantation. The roots were washed with pure water. Planting of seedlings was done on 15th October 1962 in pots, arranged 90 centimeters, both ways.

Spraying of fertilizers.

One per cent solutions of pure fertilizer salts were prepared in distilled water and utilized for spraying the plants within six hours.

As a preliminary trial, a few young seedlings from the nursery were sprayed with 20 ml of 1 per cent solutions of urea, ammonium sulphate and ammonium nitrate at weekly intervals and it was observed that no scorching of leaves occurred.

Matskov and Ikonenko (1958) reported that one per cent urea spray did not produce any scorching effect on leaf of tomato.

Cannon (1960) stated that urea, one pound dissolved in one gallon of water did not produce any adverse effect on leaf of pineapple.

Krzysch (1958) observed that 1.73 per cent of ammonium nitrate solution sprayed on oats did not produce any scorching of leaves.

'Teepol' B-300 was added to the spray solutions which acted as a wetting agent. Two grams of 'Teepol' were mixed with one litre of spray solution.

Studies by Guest and Chapman (1948) and Cook and Boynton (1952) have indicated that wetting agents increased the efficiency of absorption of leaves.

Holmspray atomiser No.600 was used for spraying the fertilizer solutions. The spraying was done both on the upper and lower surfaces of the leaf. Cook and Boynton (1952) found that lower surface of apple leaves always absorbed a larger portion of the nutrient spray applied than did the upper surface.

The different doses of nitrogen namely 1 gram, 2 grams, 3 grams and 4 grams per plant were split up into four equal parts and sprayed at fortnightly intervals, beginning from the 30th day of planting the seedlings.

The quantity of the solution sprayed at any one time was divided into equal parts of 75 ml. each. Spraying was repeated at an interval of thirty minutes until the whole quantity of solution was used.

The plants were sprayed with fertilizer solution in the evening hours. Volk and Mc Auliffe (1954) and Freiberg and Payne (1957) have observed that foliage uptake of nutrients was most rapid at night and during early morning hours.

Tejwani, Kurup and Venkataraman (1958) reported that the period from 40 to 70 days after transplanting constituted the active phase of growth period in tobacco plants. Maximum growth and dry matter production occurred during this period. Hence, the spraying of nutrients was spread over the period, 30 to 75 days after transplanting, in order to coincide with the active phase of growth period of the plant.

The spraying of nutrients was done on the following dates:-

Date.	-	Days after transplanting.
12-11-1962	-	30
26-11-1962	-	45
10-12-1962	-	60
24-12-1962	-	75

Control plants were sprayed with 300 ml. of pure well water. Curtis and Clark (1950) have stated that distilled water is toxic to living plant cells; hence distilled water was not utilised for spraying the control plants.

Soil application of fertilizers.

As with spraying nutrients, the different doses of solid fertilizers applied to the soil were divided into four equal parts and applied at fortnightly intervals, beginning from the 30th day after transplanting. The soil application of fertilizers was done on the same dates as foliar sprays.

Irrigation.

The plants were watered daily, in the morning as well as in the evening with a hand sprinkler. The water used for irrigation was analysed; results obtained are furnished below:

Analysis of Irrigation water

p^H	-	3.2
Ec x 10^6	-	8760
T.S.S., ppm	-	640
Sulphates, ppm	-	520
Chloride, ppm	-	50
Iron, ppm	-	78

Topping and suckering.

Topping (removal of apical bud) was done on 3-1-1963.

Sukering (removal of axillary buds) was carried out on the following dates: 3-12-1962, 10-1-1963, 17-1-1963 and 24-1-1963.

Pest and diseases.

There were no pests or diseases of importance to need special mention.

Curing of tobacco.

After harvest of the plants, the leaves were removed and their weight recorded. The leaves and stem were spread on the ground for welting. The leaves from each plant were tied together and hung down from bamboo beams arranged in the open field. After 20 days of drying the bundles of loaf were stacked in rectangular heaps, weights were placed on the heaps. Every third day, the heaps were remade. Fermentation of leaves was completed after 15 days of stacking.

The cured leaves were exposed under shade for six hours and the weight of cured leaves was recorded.

Characters studied.

The following growth and yield characters were studied.

Character studied	Number of observations.	Days after transplanting.
(1) Height of plant	3	30, 60, 75, 90
(2) Number of leaves	3	30, 60, 90, 115.
(3) Leaf area	3	do.
(4) Girth of stem	1	at the time of harvest.
(5) Maturity study	1	do.

Post-harvest studies

(1) Green weight of leaves

(2) Cured weight of leaves

(3) Thickness of leaf

(4) Chemical analysis of cured leaf

(a) Nicotine content

(b) Nitrogen content

(c) Potassium content

(d) Chlorine

Procedure followed to study the characters

Observations were made for all the 150 experimental plants.

Height It was measured in centimeters from the base of the plant to the top of the stem.

Number of leaves Counts were taken of the functional leaves systematically in each plant.

Girth of stem A tape was wound around the middle of the stem and circumference read out in centimeters.

Leaf area The outline of leaves was marked on paper and the area was measured with the help of a planimeter.

Thickness of leaf.

This was expressed as weight of leaf per unit area. It was calculated from the formula:

$$\frac{\text{Weight of green leaves per plant in grams}}{\text{Total area of leaves in square centimeters}}$$

Estimation of chemical content of cured leaf.

Samples of cured leaves from all the 150 experimental plants were taken and analysis for nicotine, nitrogen, potassium and chlorine content was carried out. The procedure of analysis followed was as per A.O.A.C.

Analysis of experimental data.

The data pertaining to the different characters under study were subjected to statistical analysis.

The treatment comparisons were studied by using the analysis of variance technique suggested by Cochran and Cox (1959). The total sum of squares was split up into different components, as shown in the outline of the analysis of variance table given below.

Outline of analysis of variance table

Source	D.F.
Total	149
Whole-plot treatment (M)	2
Replication	4
Error (A)	8

Sub-plot treatments (F)	-	1
M x F Interaction	-	2
Error (B)	-	12
Sub-sub-plot treatment (L)		4
M x L Interaction	-	8
F x L Interaction	-	4
M x F x L Interaction	-	8
Error (C)	-	96

The interpretation of results was made on the basis of 'F' test and summary tables were prepared. Standard error and critical difference at 5% level were calculated. Graphical representation of results was made wherever necessary.

R E S U L T S

The results of the investigation on the effects of application of nitrogenous fertilizers by foliar spraying and soil application on chewing tobacco, Nicotiana tabaccum L. are described in the following pages.

Growth studies

Studies on the growth characters were carried out in respect of height of plant, number of leaves, leaf area and girth of stem at regular intervals of 30 days.

Height: The details of height data recorded are furnished in table Nos.1, 2, 3. The effect of the treatments on height is represented by bar diagram (fig. 2).

The effect of forms of fertilizers on height of plants is presented in table No. 1.

Table No.1

Average height of plants (in cms) as affected by forms of fertilizers.

Days after planting.	M_1	M_2	M_3	
30	13.15	13.06	13.05	'F' at 5% not sig
60	45.17	44.96	45.21	do.
75	65.65	65.74	65.52	do.
90	68.38	68.38	68.48	do.

The results summarized in the table show that there was no significant difference between the 3 forms of fertilizers in their effect on height of plants.

Data regarding the influence of methods of application of fertilizer on height of plants are furnished in table No.2.

Table No.2

Average height of plants (in cms) as influenced by method of application of fertilizer

Days after planting	F_1	F_2	
30	13.04	13.13	'F' at 5% not sig
40	45.09	45.13	do.
75	65.48	65.79	do.
90	68.42	68.40	do.

It is evident from table No.2 that the two methods of application of fertilizers did not affect the height of plants differently.

The effect of different levels of nitrogen on height of plants is presented in table No.3.

Table No. 3

Average height of plants (in cms) as affected by different levels of nitrogen.

Days after planting.	Levels of nitrogen					
	L_0	L_1	L_2	L_3	L_4	
30	12.85	12.76	12.83	13.51	13.50	'F' at 5% not sig
60	39.89	42.76	44.92	47.46	50.52	C.D. at 5% 0.064
75	58.86	61.90	65.97	69.03	72.40	C.D. at 5% 0.594
90	60.88	64.42	68.83	72.50	75.46	C.D. at 5% 0.444

Interence: Interactions - not significant
L_4 L_3 L_2 L_1 L_0

The influence of levels of nitrogen on height of plants was highly significant. There was progressive increase in height of plants with the increasing levels of nitrogen.

The effect of nitrogen persisted throughout the growth period.

The data show that height of plants increased with age. Rapid increase was noticed during 30 - 60 days after planting. Rate of increase during the period 60 - 90 days after planting was slower than that of the earlier periods of growth. Maximum height was recorded on the date of final observation. After

80 days of planting, the height remained constant as plants were topped on that day.

Number of leaves. Data regarding periodical production of number of leaves are given in table Nos.4, 5 and 6. Observations were recorded on different stage of growth viz. 30 days (S_1) 60 days (S_2) 90 days (S_3) 115 days (S_4) after transplanting.

Table No.4 furnishes the average number of leaves per plant as influenced by the three forms of fertilizers.

Table No. 4

Average number of leaves, as affected by forms of fertilizer

Stages	M_1	M_2	M_3	
S_1	5.30	5.32	5.20	'F' at 5% not sig
S_2	11.32	11.26	11.46	do.
S_3	14.90	14.82	14.94	do.
S_4	11.94	11.80	11.94	do.

There was no significant difference between the forms of in their influence on production of leaves.

Data with respect to the effect of methods of application of fertilizer on leaf number is presented in table No. 5.

Table No. 5

<u>Average number of leaves as influenced by methods of application of fertilizer.</u>

Stages	F_1	F_2	
S_1	5.24	5.28	'F' at 5% not sig
S_2	11.30	11.38	do.
S_3	14.85	14.91	do.
S_4	11.86	11.91	do.

The difference between the mean number of leaves corresponding to the two methods of application was not statistically significant.

Table No. 6 presents the data pertaining to the influence of different levels of nitrogen on production of leaf.

Table No. 6

<u>Average number of leaves as affected by different levels of nitrogen</u>

Stages	Levels of nitrogen					
	L_0	L_1	L_2	L_3	L_4	
S_1	5.30	5.30	5.20	5.20	5.26	'F' not sig
S_2	10.20	10.83	11.23	12.16	12.30	CD at 5% - 0.267
S_3	12.60	14.43	14.83	16.23	16.33	CD at 5% - 0.275
S_4	10.50	11.23	11.90	13.03	13.30	CD at 5% - 0.214

Inference:

S_2 $\overline{L_4\ L_3}$ L_2 L_1 L_0

S_3 $\overline{L_4\ L_3}$ L_2 L_1 L_0

S_4 L_4 L_3 L_2 L_1 L_0

The difference between levels of nitrogen in their influence on the number of leaves was statistically significant in 3 out of 4 stages of growth studied. However there was no marked difference between the mean number of leaves corresponding to the two higher levels, L_3 and L_4 during S_2 and S_3 stages.

There was progressive rise in the number of leaves with the increase in the age of plants. Compared with stage 2, the rate of increase of the leaf number in stage 1 was greater. There was a reduction in the number of leaves during the maturity phase of plant on account of shedding of lower most leaves.

Leaf area

The periodical data in respect of leaf area of plants are furnished in table Nos. 7, 8 and 9.

Data of leaf area per plant as influenced by the sources of nitrogen is furnished in table No.7 and graphically represented in figs. 3, 4 and 5.

Table No. 7

Leaf area per plant (in sq. cms) as affected by forms of fertilizers

Stages	M_1	M_2	M_3	
S_1	301.74	298.56	298.00	'F' at 5% not sig
S_2	1912.00	1605.40	1696.00	CD at 5% - 2.329
S_3	4831.64	3926.18	4169.50	CD at 5% - 26.85
S_4	4174.72	3391.54	3622.90	CD at 5% - 17.214

Inference: M_1 M_3 M_2

Results summarized in the table reveal a marked difference among M_1 M_2 and M_3 in their effects on leaf area. In periodical increment of leaf area, M_1 was significantly superior to M_3, while M_3 gave greater leaf area than M_2.

Table No. 8 gives the summary data of leaf area per plant during different stages of growth as affected by method of application of fertilizer (figs. 3, 4 and 5).

Table No. 8

Leaf area per plant (in sq. cms) as influenced by methods of application of fertilizer.

Stages	F_1	F_2	
S_1	299.38	299.42	'F' at 5% not sig
S_2	1628.90	1847.22	'F' at 5% sig
S_3	4000.62	4617.44	do.
S_4	3471.62	4120.54	do.
Inference:	F_2 F_1		

There was significant difference between the mean values of leaf area corresponding to F_1 and F_2 (figs. 6 and 7).

F_2 consistently produced greater leaf area than F_1.

Data regarding increment of leaf area produced by different levels of nitrogen is furnished in table No.9

Table No. 9

Leaf area per plant (in sq. cms) as affected by levels of nitrogen

Stages	Levels of nitrogen					
	L_0	L_1	L_2	L_3	L_4	
S_1	295.83	300.66	298.93	304.50	297.23	'F' at 5% not sig
S_2	1244.16	1476.33	1693.00	2015.83	2260.66	C.D.at 5% - 4.354
S_3	2838.33	3555.50	4243.33	5058.66	5849.73	C.D.at 5% - 102.40
S_4	2406.83	3035.66	3647.16	4460.40	5098.53	C.D.at 5% - 26.52

Inference: L_4 L_3 L_2 L_1 L_0

Results presented in the table show that levels of nitrogen had significant effect on the leaf area of plants. With the rise in dose of nitrogen, there was a corresponding increase in the leaf area; higher doses were always superior to lower ones.

Leaf area of plant was observed to increase with age of plant. The rate of increase was higher during stage S_1 than that of S_2 stage. A reduction in the total leaf area occurred in S_3 due to shedding of lower most leaves and drying of other leaves.

Girth of stem

The details of the data regarding the girth of stem at harvest stage as influenced by the treatments are furnished in table No.10.

Table No.10

Average girth of stem (in cms) as affected by the treatments

Fertilizer.	Level	Method of application of fertilizer: F_1	F_2	Average
M_1	L_0	5.22	5.21	5.21
	L_1	5.42	5.45	5.43
	L_2	5.52	5.53	5.52
	L_3	6.43	6.54	6.48
	L_4	6.46	6.58	6.52
Average		5.81	5.86	5.83
M_2	L_0	5.31	5.32	5.31
	L_1	5.20	5.32	5.26
	L_2	5.53	5.44	5.48
	L_3	6.27	6.37	6.32
	L_4	6.29	6.39	6.34
Average		5.72	5.76	5.74
M_3	L_0	5.11	5.11	5.11
	L_1	5.42	5.36	5.39
	L_2	5.52	5.51	5.51
	L_3	6.41	6.50	6.45
	L_4	6.45	6.57	6.51
Average		5.78	5.81	5.79
Mean of the data		5.77	5.81	5.79

'F' for method of application - significant at 5% level

C.D. (at 5%) for M means - 0.041.
C.D. (at 5%) for L means - 0.047.

Inference: (1) $\overline{M_1 M_3}\ M_2$ (2) $F_2\ F_1$ (3) $\overline{L_4 L_3}\ L_2\ L_1\ L_0$

Results summarised in the table show that the mean girth of stem was affected differently by sources of fertilizers. M_1 was found to be distinctly superior to M_2, but on par with M_3. M_3 produced greater girth than M_2.

With regard to the effect of methods of application of fertilizer, results reveal that influence of F_2 on girth character was significantly greater than F_1.

Influence of levels of nitrogen on girth of stem was statistically significant. Higher levels, L_4 and L_3 produced greater girth of stem than the lower levels, L_2 and L_1 and the control. However, the difference between L_4 and L_3 was not much marked.

Among the second order interactions, those of M L and F L were found to be statistically significant. The third order interaction was not evident.

The interactional effect between F and L is presented in table No.11.

Table No. 11.

Interactional effect of methods of application and levels of nitrogen on average girth of stem (in cms).

Levels	-	F_1	-	F_2	
L_0	-	5.21	-	5.21	
L_1	-	5.38	-	5.37	*
L_2	-	5.52	-	5.49	*
L_3	-	6.37	-	6.47	*
L_4	-	6.40	-	6.51	*

C.D. at 5% - 0.022
* Significant at 5% level.

The F L combinations were significant only for the higher levels of nitrogen, L_4 and L_3. The treatment combination F_2 L_4 produced the greatest girth, closely followed by F_2 L_3.

Studies on yield and allied characters

Total weight of green leaf per plant.

Data with respect to total weight of green leaf recorded at the time of harvest were analysed to find out the effect of treatments on the yield; the results are summarised in table 12 and graphically represented in figures 8, 9 and 10.

Table No.12
Total green weight of leaf per plant in grams.

Ferti- lizer	Level	Method of application of fertilizer		
		F_1	F_2	Average
N_1	L_0	149.0	147.0	148.0
	L_1	198.0	238.0	218.0
	L_2	245.0	285.0	265.0
	L_3	342.0	398.0	370.0
	L_4	397.0	468.0	432.5
Average		266.2	307.2	286.7
M_2	L_0	152.0	154.0	153.0
	L_1	169.0	181.0	175.0
	L_2	198.0	220.0	209.0
	L_3	266.0	308.0	287.0
	L_4	309.0	356.0	332.5
Average		218.8	243.8	231.3
N_3	L_0	148.0	146.0	147.0
	L_1	167.0	198.0	182.5
	L_2	204.0	266.0	235.0
	L_3	284.0	337.0	310.5
	L_4	333.0	397.0	365.0
Average		227.2	268.8	248.0
Mean of data		237.40	273.28	255.33

contd...

'F' (at 5%) for F highly significant - 4.75
C.D. for M means - 0.960
C.D. for L means - 1.240
Inference: M_1 M_3 M_2 F_2 F_1 L_4 L_3 L_2 L_1

The influence of the three sources of fertilisers, M_1 M_2 and M_3 on yield of green leaf was distinctly significant. The effect of the three fertilizers in increasing the yield was of the order $M_1 > M_3 > M_2$.

Comparison of the effects of the two methods of application of fertilizer F_1 and F_2 on yield of green leaf revealed that F_2 was markedly superior to F_1.

There was significant difference in the mean yield values corresponding to different levels of nitrogen. The yield increased with the rise in dose of fertilisers.

The interactional effect of F and L on yield of green leaf, found significant is given in Table No. 13.

Table No. 13

Average yield of green leaf as affected by the interactional effect between method of application and level of fertiliser.

Levels	F_1	F_2	
L_0	149.66	149.00	C.D. at 5%
L_1	178.00	205.66	-2.281
L_2	215.66	257.00	
L_3	297.33	347.66	
L_4	346.33	407.00	

Except in the case of the control, all the F_2 L combinations were superior to F_1 L combinations. The highest mean green leaf yield was obtained for F_2 L_4.

Yield of cured leaf per plant

The details of the data regarding the weight of cured leaf as influenced by the treatments, are presented in Table No.14 (Figs 8, 9, 10 and 11) furnish the graphical summary of the results.

Table No. 14

Total weight of cured leaf per plant in grams

Fertiliser	Level	Method of application of fertiliser		
		F_1	F_2	Average
M_1	L_0	31.68	31.68	31.79
	L_1	41.60	49.60	45.60
	L_2	51.00	58.80	54.90
	L_3	70.44	79.60	75.02
	L_4	81.40	95.50	88.45
Average		55.224	63.08	59.152
M_2	L_0	32.40	32.40	32.40
	L_1	35.80	38.20	37.00
	L_2	41.60	46.00	43.80
	L_3	55.20	63.48	59.34
	L_4	63.80	73.20	68.50
Average		45.760	50.656	48.208
M_3	L_0	31.60	31.32	31.46
	L_1	35.40	41.60	38.50
	L_2	42.80	55.20	49.00
	L_3	58.80	69.20	64.00
	L_4	68.80	82.30	75.55
Average		47.480	55.924	51.702
Mean of data		49.488	56.550	53.019

'F' at 5% for F sig - 4.76
C.D. for M means - 0.523
C.D. for L means - 0.750

Inference - M_1 M_3 M_2 F_2 F_1 L_4 L_3 L_2 L_1

Results summarized in Table No.14 show that the yield of cured leaf is affected markedly by the three forms of fertilizers, N_1 N_2 and N_3. The influence of the three sources of fertilizer in the increment of yield of cured leaf was in the order: $N_1 > N_3 > N_2$.

F_2 treatment was significantly superior to F_1 in effecting increase in cured leaf yield.

The mean yield values were found to increase progressively with the rise in the doses of nitrogen, applied.

The interactional effect of F and L on cured leaf yield, found significant is presented in Table No.15.

Table No. 15

Average cured leaf weight as influenced by the interactional effect of method of application and level of nitrogen (in grams)

Level	F_1	F_2	
L_0	31.89	31.67	Not sig.
L_1	37.60	43.13	C.D. at 5%
L_2	45.13	53.33	- 1.316
L_3	61.48	70.73	"
L_4	71.33	83.06	"

F_2 L combinations were at all levels superior to F_1 L except in the case of control. F_2 L_4 recorded the highest value of mean yield of cured leaf.

Ratio of cured leaf to green leaf

The ratio of the weight of cured leaf to that of green leaf was calculated with respect to all the treatment combinations, the result is presented in Table No.16 and graphically represented in figures 12 - 14.

Table No.16

Ratio of cured leaf yield to weight of green leaf.

Levels	N_1		N_2		N_3		Average
	F_1	F_2	F_1	F_2	F_1	F_2	
L_0	0.200	0.214	0.214	0.213	0.214	0.215	0.211
L_1	0.210	0.200	0.212	0.211	0.212	0.210	0.209
L_2	0.209	0.207	0.210	0.209	0.212	0.207	0.209
L_3	0.206	0.200	0.207	0.206	0.206	0.205	0.205
L_4	0.205	0.204	0.206	0.206	0.207	0.205	0.205
Average	0.206	0.205	0.210	0.209	0.210	0.208	0.208

None of the treatments appeared to have influenced significantly the cured leaf to green leaf ratio, which was observed to be 0.208. The cured leaf yield was about 21 per cent of the total weight of green leaf. It was observed that the ratio was slightly higher in the case of control plants than those of the treated plants.

Thickness of leaf:

The thickness of leaf was expressed as weight per unit area. This was worked out by dividing the total green leaf weight per plant by its corresponding area. Mean values of the weight in gms per sq. cms of leaf as influenced by the treatment are presented in Table No. 17.

Table No. 17

Average weight of leaves in gms per square cm

Fertiliser	Level	F_1	F_2	Average
	L_0	0.06174	0.06202	0.06183
	L_1	0.06314	0.06308	0.06311
M_1	L_2	0.06490	0.06500	0.06495
	L_3	0.07196	0.07188	0.07192
	L_4	0.07406	0.07400	0.07403
Average		0.06716	0.06719	0.06717
	L_0	0.06184	0.06173	0.06178
	L_1	0.06288	0.06314	0.06301
M_2	L_2	0.06474	0.06506	0.06490
	L_3	0.07168	0.07222	0.07205
	L_4	0.07390	0.07430	0.07429
Average		0.06705	0.06925	0.06708
	L_0	0.06264	0.06204	0.06244
	L_1	0.06292	0.06314	0.06303
M_3	L_2	0.06510	0.06452	0.06481
	L_3	0.07210	0.07202	0.07206
	L_4	0.07300	0.07400	0.07350
Average		0.06715	0.06714	0.06716
Data Mean		0.06690	0.07720	0.07200

'F' ratio (at 5%) for F mean - 4.94 sig.
C.D. (at 5%) for L means - 0.0032
Inference: F_2 F_1 L_4 L_3 L_2 L_1 L_0

Results given in the Table indicate that the three sources of nitrogen did not differ in their influence on the thickness of leaf.

The difference between the methods of application on their effect on leaf thickness was slightly significant. The superiority of F_2 over F_1 was evident to some extent.

Mean values of leaf thickness corresponding to different levels of nitrogen were markedly different. A progressive increase of this character of the leaf with increased levels of nitrogen was discernible.

Studies of the chemical contents of cured leaf

Total nitrogen

Samples of cured leaf from five replications, each comprising of 30 treatments, were analysed. Average values of total nitrogen content are furnished in Table No.18. The effect of various treatments on the total nitrogen of leaves is diagrammatically represented in Fig. 15.

Table No. 18

Total nitrogen content of cured leaf (dry) in percentage as influenced by the treatments.

Fertilizer.	Level.	F_1	F_2	Average
	L_0	2.20	2.21	2.20
	L_1	2.48	2.30	2.39
M_1	L_2	2.53	2.42	2.47
	L_3	2.91	2.83	2.87
	L_4	3.25	2.86	3.05
Average		2.67	2.52	2.60
	L_0	2.22	2.20	2.21
	L_1	2.40	2.27	2.33
M_2	L_2	2.46	2.34	2.40
	L_3	2.60	2.79	2.69
	L_4	2.65	2.77	2.71
Average		2.46	2.47	2.47
	L_0	2.20	2.20	2.20
	L_1	2.50	2.32	2.41
M_3	L_2	2.50	2.41	2.45
	L_3	2.86	2.81	2.83
	L_4	3.11	2.84	2.97
Average		2.63	2.52	2.57
Data Mean		2.59	2.50	2.55

C.D. at 5% for M means - 0.0124
do. F " - 0.0101
do. L " - 0.0153

Inference: M_1 M_3 M_2 F_1 F_2 L_4 L_3 L_2 L_1 L_0

The results summarized in the table show that there was significant difference in the mean values of total nitrogen as affected by the three forms of fertilisers (M_1, M_2, and M_3). M_1 tended to increase the nitrogen content of leaves more than M_3 and M_2, while M_3 was superior to M_2 in its effect on nitrogen content.

Regarding the influence of the methods of application of fertilizer, the data revealed that the two methods (F_1 and F_2) differed distinctly in their effect on nitrogen content of leaf. F_1 was superior to F_2 in this respect.

The mean values of nitrogen content corresponding to the different levels of fertilisor were significantly different. The nitrogen content of leaves increased progressively with the rise in dose of fertilizer.

Table No. 19

Interactional effect of methods of application and doses of fertiliser on the percentage nitrogen content of cured leaf

Level	F_1	F_2
L_0	2.212	2.208
L_1	2.462	2.300
L_2	2.503	2.392
L_3	2.793	2.807
L_4	3.005	2.829

C.D. at 5% - 0.0217

The treatment combination F_1 L_4 registered the highest value of percentage nitrogen content of leaf closely followed by F_2 L_4.

Percentage of nitrogen recovery

These data were deduced from the percentage of nitrogen content of the cured leaf and total weight of cured leaf. The values, thus obtained are given in table No. 20.

Table No. 20

Percentage of nitrogen recovery in leaves

Levels	F_1	F_2	Average
L_1	14.00	28.10	21.05
L_2	17.14	27.82	22.48
L_3	25.51	32.38	28.94
L_4	25.50	32.36	28.93
Average	20.54	30.17	25.35

Results furnished in the table show that the average recovery of nitrogen in leaves was about 25 per cent. The mean values for F_1 and F_2 were 20.5 and 30.2 respectively. It was observed that the recovery of nitrogen increased with the rise in dose of fertilizer upto L_3. There was no difference in the mean value of recovery of nitrogen between the higher levels L_3 and L_4.

Nicotine content of leaves

Samples of cured leaf from five replications, each comprising of 30 treatments were analysed. Average values of the nicotine content as percentage of dry cured leaf, are presented in Table No.21. The influence of treatment combinations on the percentage of nicotine content of leaves is represented by bar diagram (figure 15).

Table No. 21

Nicotine content as percentage of dry cured leaf.

Fertilizer	Level	F_1	F_2	Average
M_1	L_0	1.928	1.960	1.944
	L_1	1.924	2.210	2.067
	L_2	1.928	2.250	2.089
	L_3	1.946	2.484	2.215
	L_4	1.946	2.720	2.333
Average		1.934	2.325	2.130
M_2	L_0	1.906	1.905	1.905
	L_1	1.914	2.280	2.097
	L_2	1.906	2.610	2.280
	L_3	1.900	2.680	2.325
	L_4	1.970	2.680	2.325
Average		1.944	2.431	2.188
M_3	L_0	1.902	1.920	1.911
	L_1	1.902	1.924	1.913
	L_2	1.950	1.956	1.953
	L_3	1.968	1.970	1.969
	L_4	1.974	1.974	1.974
Average		1.940	1.948	1.944
Data mean		1.939	2.235	2.087

C.D. at 5% for M means - 0.0348
" F " - 0.0284
" L " - 0.0160

Inference M_2 M_1 M_3 F_2 F_1 L_4 L_3 L_2 L_1 L_0

The results summarized in the table show that the mean values of nicotine content corresponding to the sources of nitrogen (M_1, M_2 and M_3) vary significantly. The highest nicotine percentage was obtained for M_2, followed in decreasing order by M_1 and M_3.

Regarding the effect of the methods of application of fertilizer, it was found that soil application (F_2) procured more nicotine content of leaf than foliar spraying (F_1).

The influence of the different levels of nitrogen on the percentage content of nicotine of leaf was highly significant. The higher values of nicotine invariably corresponded with increasing levels of nitrogen.

Potash content as percentage of dry cured leaf

Samples of cured leaf from five replications, each constituting 30 treatment combinations were analysed. Average values of potash content as percentage of dry cured leaf are furnished in table No.22. Results are represented in graph (figure 16 - 18).

Table No. 22

Potash content as percentage of dry cured leaf

Fertiliser	Level	F_1	F_2	Average
	L_0	3.508	3.482	3.495
	L_1	3.598	3.604	3.601
M_1	L_2	3.634	3.616	3.625
	L_3	3.714	3.720	3.717
	L_4	3.722	3.842	3.782
Average		3.635	3.652	3.644
	L_0	3.516	3.470	3.493
	L_1	3.504	3.618	3.561
M_2	L_2	3.512	3.652	3.582
	L_3	3.550	3.760	3.655
	L_4	3.602	3.768	3.685
Average		3.536	3.653	3.594
	L_0	3.432	3.454	3.443
	L_1	3.558	3.548	3.569
M_3	L_2	3.632	3.636	3.634
	L_3	3.670	3.778	3.724
	L_4	3.690	3.836	3.763
Average		3.596	3.656	3.626
Data Mean		3.589	3.653	3.621

C.D. (5%) for M means - 0.017
" for L " - 0.018
Inference M_1 M_3 M_2 F_2 F_1

The three sources of nitrogen differ markedly in their influence on the potash content of leaves. The increment in the average potash content of leaves was lowest in the case of N_2; N_1 and N_3 did not differ significantly in their effect on potash content of leaves.

With regard to methods of application, it was indicated that F_1 and F_2 did not statistically differ in their effect on potash content.

The potash content of leaves was found to increase with rise in dose of nitrogen. Higher percentage content of potash was consistently obtained in the case of increased levels of nitrogen (L_4 and L_3).

Chlorine content of cured leaf

Samples of cured leaf from five replications, each comprising of 30 treatment combinations, were analysed. The chlorine content was expressed as percentage of dry cured leaf. Graphical representation of the influence of the treatments was made (figures 16 to 18).

Mean values of chlorine content as percentages are presented in Table No.23.

Table No. 23

<u>Chlorine content as percentage of dry cured leaf</u>

Fertilizer	Level	F_1	F_2	Average
	L_0	2.544	2.492	2.518
	L_1	2.540	2.562	2.551
M_1	L_2	2.550	2.564	2.557
	L_3	2.870	2.424	2.647
	L_4	2.974	2.040	2.507
Average		2.695	2.416	2.556
	L_0	2.528	2.484	2.506
	L_1	2.622	2.566	2.594
M_2	L_2	2.636	2.514	2.575
	L_3	2.682	2.396	2.539
	L_4	2.780	2.404	2.592
Average		2.649	2.472	2.561
	L_0	2.518	2.466	2.492
	L_1	2.612	2.556	2.584
M_3	L_2	2.620	2.414	2.517
	L_3	2.780	2.214	2.497
	L_4	2.818	2.108	2.463
Average		2.669	2.351	2.510
Data Mean		2.671	2.413	2.542

C.D. for M means - 0.038
C.D. for F means - 0.259
C.D. for L means - 0.191

Inference: $\overline{M_2}$ M_1 M_3 F_1 F_2 $\overline{L_1\ L_3}$ $\overline{L_3\ L_2}$ L_4 L_0

Results summarised in the table show that there was marked difference between the sources of nitrogen in their influence on chlorine content of leaf. The increase in the chlorine content on account of N_2 was significantly greater than N_3, but was on par with N_1.

Foliar application of fertilisers (F_1) tended to produce significantly higher percentage of chlorine than soil application (F_2).

Influence of the different levels of nitrogen on the chlorine content of leaf was distinctly significant.

The chlorine content of leaves tended to increase with the higher levels of nitrogen when applied through foliage, while the opposite was the trend noticed in the case of soil application of nitrogen.

The interactional effect of methods of application and levels of nitrogen on the percentage content of chlorine in leaf found significant is presented in Table No. 24.

Table No. 24

Interactional effect of methods of application and levels of nitrogen on the percentage chlorine content of cured leaf

Level	F_1	F_2
L_0	2.530	2.487
L_1	2.591	2.554
L_2	2.601	2.497
L_3	2.777	2.347
L_4	2.857	2.184

C.D. at 5% 0.061

The treatment combination, F_1 L_4 corresponded to the highest value for chlorine and was statistically superior to all other treatment combinations.

DISCUSSION

Results of investigations on the response of chewing tobacco to foliar application of nitrogenous fertilizers are discussed in the following pages.

(1) Height and number of leaves.

Results summarized in table Nos. 3 and 6 show that foliar application of nitrogenous fertilizers at 4 grams of nitrogen per plant increased the height of plants by about 23 per cent and number of leaves by about 30 per cent over the control (figure No.2).

Data regarding the effect of different levels of nitrogen (table Nos. 3 and 6) indicate that both height and number of leaves increased progressivly with increasing levels of nitrogen.

The effect of nitrogen was manifest 60 days after transplanting and persisted through the growth period of the plant. It was also seen that neither the three sources of nitrogen, viz. urea, ammonium sulphate and ammonium nitrate, nor the methods of supplying the nutrient, (foliar spraying and soil application of solid fertilizers) differed significantly in their influence on the height and number of leaves of the plant (figuro No.2).

(2) Leaf area.

Observations (table No.9) on leaf area showed that the leaf area per plant increased on the average by about 95 per cent over the control on account of foliar spray of nitrogenous fertilizers at 4 gms. of nitrogen per plant. A high level of nitrogen assimilation consequent on foliar spray favours high water content and turgor in the tissues which result in increased foliage expansion.

Results presented in table No.7 indicate that of the three fertilizer sprays, urea induced greater increment of leaf area than ammonium nitrate (figures 3 to 5). The lowest leaf area was obtained in plants receiving ammonium sulphate sprays. The differential influence of three fertilizers was discernible when they were applied to the soil also.

A study of the data (table No.9) regarding the influence of different levels of nitrogen indicates that, irrespective of the method of application, rise in the dose of nitrogen produced a corresponding increase in leaf area.

A comparative study of the effect of two methods of application, (foliar and soil application) (table No.8) reveals that there was a significant difference between the two methods in their influence on increasing leaf area (figures 6 and 7).

(3) Girth of stem.

Results presented in table No.10 indicate that foliar application of nitrogen resulted in significant increase in girth of stem. The increase was to the extent of 22 per cent over the control in the case of the higher level, 4 gms. of nitrogen per plant. However, the increase caused was lesser than which was obtained by soil application.

While comparing the effects of three sources of nitrogen, it was found that urea spray was distinctly superior to ammonium sulphate but on par with ammonium nitrate in increasing the girth of stem.

It was also noticed that increasing levels of nitrogen (3 and 4 gms. per plant) applied as foliar spray tended to produce greater girth of stem than the lower doses, viz. 1 and 2 gms. However, no distinct difference was observed between 3 and 4 gms. doses. It appeared that 3 gms. per plant was the optimum dose as far as increment of girth of stem is concerned. Comparative results were obtained with the application of fertilizer to the soil.

It was further observed (table No.11) that the interactional effect of methods of application and level of nitrogen was significant. The treatment combination F_2 L_4 produced the greatest girth of stem, closely followed by F_2 L_3.

Thus it is seen that foliar sprays of nitrogen fertilizers had marked influence on height, leaf number, girth and leaf area of the plants. Foliar application of nitrogen at the rate of 4 grams per plant produced on the average about 23 per cent, 30 per cent, 22 per cent and 95 per cent increment in height, number of leaves, girth of stem and leaf area respectively. The findings in the present investigation are in conformity with those reported by several workers in other crops. Narayanan and Vasudevan (1959) recorded marked improvement of height in maize, by foliar spray of urea. Schneider and Synder (1960) obtained highly significant effect on shoot length in azaleas by urea sprays. Venkataramani (1957) recorded that N P K foliar sprays increased girth of tender branches in tea bushes. Thorne and Watson (1955) reported significant increase in leaf area in wheat plants sprayed with ammonium sulphate. Yakushkina (1960) reported that spraying sugar beet with ammonium nitrate accelerated vegetative growth of the crop.

<u>Yield.</u>

<u>Green leaf yield.</u>

In proportion to the increase procured in the growth characters as leaf number and leaf area, the sprays of nitrogen enhanced the weight of green leaves also (figures 8 to 10). Data presented in table No.12 show that foliar spraying at the rate of 4 grams of nitrogen per plant increased weight of green leaf by 132 per cent over the control. It was evident that nitrogen applied as foliar spray was effectively assimilated and induced increase in weight of leaves.

The findings in the present investigation is in agreement with those reported for other crops by several workers. Pedas (1958) reported that tomato seedlings receiving urea spray made more rapid growth and produced 19.5 per cent increase in yield. Kraysh (1958) obtained significant increases in yield in wheat by foliar spray of 1.7 per cent ammonium nitrate. Kuthy, Fereez and Markus (1959) observed that calcium ammonium nitrate spray increased the yield of sugar beet by 20 per cent.

It was also found (table No.12) that the different levels of nitrogen employed in spraying significantly influenced the yield of green leaf. Higher mean values of weight of green leaf invariably corresponded with increasing levels of nitrogen.

A comparative study of the three forms (table No.12) reveals that urea, ammonium sulphate and ammonium nitrate differed among themselves significantly in their influence on green leaf yield.

It was also observed that soil application of fertilizers (figures 8 to 10) tended to increase yield than foliar spraying with respect to all the three forms of fertilizers and all levels of nitrogen studied.

Cured leaf yield.

As already noted foliar feeding of nitrogen tended to enhance leaf area and weight of green leaves over control. A proportionate increase in yield of cured leaf was also observed.

Results summarized in table No.14 show that foliar application of nitrogenous fertilizer at the rate of 4 grams of nitrogen per plant increased the weight of cured leaf per plant by 123 per cent over the control (figures 8 to 11). It was quite evident that nitrogen applied through foliage had been effectively absorbed and utilized resulting in increase in the dry weight of plant.

The result of the present experiment is in agreement with those reported in tobacco by many workers. Mothes and Trefftz (1954) observed that spraying with 0.2 molar ammonium nitrate could take care of the full needs of the tobacco plant for nitrogen. Increases in tobacco crop yield to the extent of 13.3 per cent resulting from foliar application of macronutrients were reported by

Hinkov (1959). Ivanosky (1960) also recorded an increase of 12.9 per cent in the yield of tobacco crop sprayed with a solution containing nitrate of ammonia.

It may be noted that there is a wide disparity in the increase in yield, viz. 123 per cent over controls, obtained in the present experiment and those reported by Hinkov (1959) and Imosky (1960). This variation appears to be on account of the difference in the experimental technique employed. While in the present investigation spraying of fertilizers was conducted on potted plants, Hinkov and Ivanosky worked with plants grown in the field. Moreover, in the present investigation plants of a chewing type of tobacco which was known to respond remarkably to nitrogen were grown in littoral sand, while Ivanosky (1960) experimented with plants of the smoking type of tobacco, which did not usually show much response to nitrogenous fertilizers, grown on chernozom soil. Ivnosky's experimental crop received usual basal manuring.

Results presented in table No.14 also reveal that the effect of different levels of nitrogen employed in spraying, on yield of cured leaf, was distinctly significant. There was a progressive increase in yield with the rise in the dose of fertilizer.

It was noticed (figure 14) that urea, ammonium sulphate and ammonium nitrate exhibited distinct differences among themselves in their influence on increment of yield. The relative efficiency of the fertilizers in increasing leaf yield was in the decreasing order, $M_1 > M_3 > M_2$.

The data further showed that soil application of the same fertilizers in comparable quantities produced greater yield than which was obtained with foliar spraying of the fertilizer. It was observed that the mean yield of cured leaves from plants receiving soil applied nitrogen was 162 per cent over the control plants.

Foliar versus soil applied fertilizer.

In the present investigation it was observed that all the growth and yield characters of tobacco plant except height and number of leaves were influenced more effectively by the application of solid fertilizers to soil than the foliar spray of the fertilizers.

This finding is supported by those of many workers in various crops. Fortelaro, Hall and Jamison (1952) observed that compared to side dressing of sodium nitrate, urea sprays did not increase total weight or number of fruits in tomatoes.

Brasher, Weatley and Ogle (1953) did find significant increases in tomato yields from eleven sprays of urea, but they obtained greater yield increases at less cost from plots in which nitrogenous fertilizer was applied to the soil.

Differential effect of the fertilizers.

It was seen from the results of the present study that in influencing the vegetative growth aspects like leaf area, girth of stem and the yield potentiality of the plants, the three sources of nitrogen, viz., urea, ammonium sulphate and ammonium nitrate exhibited marked variation among themselves. Urea sprays were found to be invariably superior to ammonium nitrate and ammonium sulphate, while ammonium nitrate produced better results than ammonium sulphate.

The beneficial effect of urea, may be due to the fact that it is highly soluble and is least toxic to leaf tissue. Hamilton, Palmiter and Anderson (1943) showed that urea at 5 pounds per 100 gallons of water did not cause any leaf injury, while ammonium sulphate at 8 pounds in 100 gallons of water resulted in leaf injury in apple. Furthermore, urea nitrogen is found to be absorbed and metabolized more rapidly. Volk and Mc Auliffe (1954) demonstrated extensive absorption and distribution of urea nitrogen throughout the plant within 24 hours in tobacco.

In the present experiment it was further observed that urea applied to soil also had more beneficial influence on growth and yield of tobacco than ammonium nitrate and ammonium sulphace. This result is also supported by the findings of Sen Gupta and Das (1962) who reported that wheat crop responds better to urea than ammonium sulphate. It was explained that the beneficial effect of urea resulted from the fact that the conversion to nitrate in soil was more rapid in the case of urea in tropical and sub tropical climatic conditions. In the present investigation, tobacco plants, grown in littoral sand and watered daily with irrigation water of low P^H value responded better to urea than to ammonium nitrate and ammonium sulphate which were physiologically acid fertilizers.

Weight per unit area of leaf.

Results given in table No.17 indicated that foliar sprays of nitrogen profoundly influenced the weight per unit area of the tobacco leaf. A progressive increase of this character of the leaf with increased levels of nitrogen upto 4 grams per plant was evident.

The same trend was also seen in the case of application of the fertilizers to the soil.

Increases in thickness of leaf resulting from nitrogenous manuring have been reported by Volodarsky (1948) Batra (1950) Chandnani et. al.(1956), and Chandnani, Thomas and Reddi Babu (1960).

Total nitrogen content of cured leaves.

Results presented in the preceding chapter (table No.18) show that foliar application of nitrogenous fertilizer tended to increase the percentage of total nitrogen content of dry cured leaves. The nitrogen content of leaves was observed to increase progressively with corresponding rise in dose of nitrogenous fertilizers upto 4 grams per plant. The increase of nitrogen content in leaves was greater when the fertilizers were applied as foliar sprays than as soil application (table No.19). Urea sprays tended to increase the nitrogen content of leaves more than ammonium nitrate and ammonium sulphate (figure 15).

The tendency of the nitrogen content to increase in leaves consequent on foliar spraying of nitrogenous fertilizers has been reported by various workers. Sako (1960) observed that urea sprays had a marked effect on the nitrogen content of apple leaves; the difference between the leaves of treated and control trees was 0.62 - 1.19 per cent nitrogen. Oland (1950) reported that 4 per cent urea spray increased the total organic nitrogen content of leaves by 51 per cent within two days.

The increase in nitrogen content of leaves consequent on nutrient sprays occurs not only because of direct absorption of the applied solution through leaves, but also indirectly, by enhancing the uptake of nitrogen through roots. This phenomenon has been demonstrated by Thorne (1957) in sugar beet; he found that ammonium nitrate solution applied to leaves increased the uptake of nitrogen by the roots.

Jones and Steinacker (1953) and Kuykendall and Wallace (1953) observed that in the leaves of lemon and orange trees there was a more rapid increase of leaf nitrogen as a result of urea sprays than which was consequent on a comparable application of nitrogen to the root medium.

Percentage of nitrogen recovery.

Results furnished in table No.20 indicate that the average percentage recovery of nitrogen obtained with foliar sprays of nitrogenous fertilizers was 20.5, while the mean value with respect to the solid application of fertilizers to soil was found to be 30.2. It was further observed that in both cases the recovery of nitrogen increased with rise in the dose of fertilizers upto 3 grams of nitrogen per plant. No difference in the mean values of recovery of nitrogen between the higher levels of nitrogen viz., 3 grams and 4 grams per plant was discernible. It was thus seen that the percentage of recovery of nitrogen decreased with the increase in dose of nitrogen applied through foliage as well as by soil application.

Nicotine content of leaves.

Results presented in the preceding chapter (table No. 21) show that foliar spray of nitrogenous fertilizer had significant influence in increasing the percentage content of nicotine in leaves. The increment of nicotine content in leaves corresponded to the rise in the dose of nitrogen applied. It was observed that the increase in nicotine content of leaves was greater when the fertilizers were applied through soil than as foliar spray (figure 15).

A comparison of the differential influence of the three sources of nitrogen (table No.21), ignoring the effect of methods of application showed that Ammonium sulphate caused higher percentage of nicotine than urea and ammonium nitrate. It appeared that the efficiency of the three fertilizers (Ammonium sulphate, Urea and Ammonium nitrate) in influencing the percentage content of nicotine was in the order $M_2 > M_1 > M_3$. But taking into consideration the influence of methods of application it could be seen that in the case of foliar spray, ammonium sulphate gave higher percentage content of nicotine than ammonium nitrate and urea; urea sprays produced the least nicotine content. While with soil application ammonium sulphate was found superior to urea, and urea gave better results than ammonium nitrate.

The finding in the present study is in conformity with those reported in the case of soil application of fertilizers by several workers. Dawson (1938) stated that nitrogen assimilated as ammonia increased nicotine content of leaves. Romer (1940) reported that increases in nicotine content could be obtained by soil application of nitrogenous fertilizers in sufficient quantity. He found that ammonium sulphate was better than urea in this respect. Chandnani, Thomas and Reddi Babu (1960) found that application of nitrogenous fertilizers to soil enhanced nicotine content of leaf in hookah tobacco.

Potash content of leaves.

Results given in the preceding chapter (table No.22) reveal that foliar sprays as well as soil application of nitrogenous fertilizers increased the percentage content of potash in cured leaves, there being no significant difference between them. The potash content was observed to increase progressively with corresponding rise in doses of nitrogenous fertilizers upto 4 grams per plant. Urea sprays tended to increase the potash content of leaves more than ammonium nitrate and ammonium sulphate.

The tendency of the potash content of leaves to increase as a result of foliar application of nutrients has been reported by Golikova (1959).

he observed that NPK sprays in straw berries increased potash uptake from the soil.

The influence of soil application of nitrogenous fertilizers in enhancing the potash content in tobacco leaves has been reported by Anderson, Swanback and Street (1932). Gowarkar and Shaw (1961) reported that in bidi tobacco soil applied nitrogen significantly increased the potash content of leaves.

Chlorine content of leaves.

Results presented in the preceding chapter (table No.23) show that foliar application of nitrogenous fertilizers tended to increase the percentage content of chlorine in cured leaves. The chlorine content of leaves was seen to increase progressively with rise in nitrogen doses of the sprays upto 4 grams per plant (figures 16 to 18). This cannot be easily explained. Thorne (1957) has demonstrated that the increment of nitrogen level in leaves resulting from foliar sprays of nitrogenous fertilizers to sugar beet might also be due to an enhancement in the uptake of nitrogen by roots, of the sprayed plants. The increase of chlorine content in leaves of the tobacco plant receiving foliar sprays obtained in the present investigation may also perhaps be explained as due to some such mechanisms.

With regard to the effect of soil application of fertilizers on chlorine content of leaves, it was observed that with lower doses of fertilizer viz., 1 gram and 2 grams per plant, there was an increase in chlorine content of leaves; while at higher levels of nitrogen fertilizers as 3 grams and 4 grams per plant, the chlorine content appeared to record a reduction.

However, it may be noted that the increment in percentage chlorine content obtained in the present investigation was well within the tolerance limit of tobacco plants; the maximum increase observed was only 2.97 per cent. Garner (1954) has stated that chlorine assimilation increases turgor, leaf area and hygroscopicity in tobacco. Considering the fact that leaf size and hygroscopicity are desirable qualities in chewing tobacco, the phenomenon of increased chlorine content of leaves observed in the present investigation appeared to be beneficial.

S U M M A R Y

In order to study the effects of foliar application of nitrogenous fertilizers on chewing tobacco (*Nicotiana tabaccum* L.) and compare them with those of soil application of solid forms of fertilizers, an experiment was conducted during 1961-63 at the Agricultural College and Research Institute, Vellayani. The experimental lay-out was of split-plot design in randomised block, with five replications consisting of 30 treatments each. Three forms of fertilizers (urea, ammonium sulphate and ammonium nitrate) at five levels of nitrogen (0, 1, 2, 3 and 4 grams per plant or per 40 kilograms of soil) were investigated. Spraying of nutrient solution was carried out at fortnightly intervals, beginning from 30 days of transplanting the seedlings. One per cent solutions of pure fertilizer salts were used for spraying. Observations were recorded on all important growth and yield characters.

I. Growth characters.

(1) Height and number of leaves.

(a) Foliar application of nitrogenous fertilizers (urea, ammonium sulphate and ammonium nitrate) at 4 grams of nitrogen per plant increased the height of plants by 23 per cent and the number of leaves by 30 per cent over the control.

(b) Neither the three sources of nitrogen nor the methods of application differed significantly in their influence on height and number of leaves per plant.

(2) Leaf area.

(a) Foliar spray at 4 grams of nitrogen per plant enhanced on the average the leaf area by 95 per cent over the control.

(b) Of the three fertilizer sprays, urea induced greater increment of leaf area than ammonium nitrate; the lowest value of the leaf area was obtained in plants receiving ammonium sulphate sprays.

(c) Irrespective of the method of application and form of fertilizer, rise in the dose of nitrogen produced a corresponding increase in leaf area.

(d) Soil applied fertilizers were significantly better than foliar sprays in their effect on leaf area.

(e) Third order interactional effect among forms of fertilizers, method of application and levels of nitrogen was evident.

(3) Girth of stem.

(a) Foliar sprays at 4 grams of nitrogen per plant increased the girth of stem to the extent of 22 per cent over the control.

(b) Urea spray was distinctly superior to ammonium sulphate, but on par with ammonium nitrate in increasing the girth of stem.

(c) Increasing the levels of nitrogen (3 and 4 grams per plant) tended to produce greater girth of stem than the lower doses (1 and 2 grams per plant).

(d) Interactional effect between methods of application and levels of nitrogen was significant. Soil application of 4 grams of nitrogen per plant produced the greatest girth of stem, closely followed by soil application of 3 grams of nitrogen per plant.

II. Yield characters.

(1) Green leaf yield.

(a) Foliar spraying at the rate of 4 grams of nitrogen per plant increased the weight of green leaf per plant by 132 per cent over the control.

(b) Higher mean values of weight of green leaf invariably corresponded with increasing levels of nitrogen.

(c) Urea sprays gave green leaf yield significantly greater than what was obtained with ammonium nitrate and ammonium sulphate.

(d) Soil application of fertilizers tended to give greater yield of green leaf than foliar sprays.

(2) Cured leaf yield.

(a) Foliar sprays of fertilizers at 4 grams per plant increased the weight of cured leaf per plant by 123 per cent over the control.

(b) The relative efficiency of the three fertilizers (urea, ammonium sulphate and ammonium nitrate) in increasing cured leaf yield was in the decreasing order $M_1 > M_3 > M_2$.

(c) There was a progressive increase in yield with the rise in the doses of fertilizers.

(d) Soil application of the same fertilizers in comparable quantities produced greater yield of cured leaf than which was obtained with foliar spray of the fertilizers.

(3) Weight per unit area of leaf.

(a) Foliar sprays of nitrogen profoundly influenced the weight per unit area of leaves. A progressive increase of this character of the leaf with increased levels of nitrogen upto 4 grams per plant was evident.

(b) Soil applied fertilizers induced slightly more increase in the weight per unit area of leaf than comparable fertilizer sprays.

III. Chemical contents of the leaf.

(1) Total nitrogen content of cured leaves.

(a) Foliar application of nitrogen increased the total nitrogen content of dry cured leaf.

(b) Urea sprays increased the nitrogen content of leaves more than ammonium nitrate and ammonium sulphate.

(c) The increase of nitrogen content in leaves was greater when the fertilizers were applied as foliar sprays than as soil application.

(2) <u>Percentage of nitrogen recovery</u>.

(a) The average percentage recovery of nitrogen obtained with foliar sprays of nitrogenous fertilizers was 20.5; while the mean value with respect to the soil application was 30.2.

(b) Recovery of nitrogen increased with rise in the dose of fertilizers upto 4 grams of nitrogen per plant. But the mean values of recovery of nitrogen corresponding to the higher levels (3 and 4 grams per plant) did not differ greatly.

(3) <u>Nicotine content of leaves</u>.

(a) Foliar sprays of nitrogen had significant influence in increasing the content of nicotine in leaves.

(b) Increase in nicotine content was greater when the fertilizers were applied to the soil than as foliar spray.

(c) In the case of foliar spray, ammonium sulphate gave higher content of nicotine than ammonium nitrate, while ammonium nitrate produced greater increase than the urea.

(d) With soil application, ammonium sulphate was superior to urea and urea gave higher results than ammonium nitrate.

(4) <u>Potash content of leaves.</u>

(a) Foliar sprays of nitrogenous fertilizers increased the percentage content of potash in cured leaf.

(b) Potash content increased progressively with corresponding rise in dose of nitrogen upto 4 grams per plant.

(c) The increase in potash content was greater when the fertilizers were applied to soil than as foliar sprays.

(d) Urea sprays tended to increase the potash content of leaves more than ammonium nitrate and ammonium sulphate.

(5) <u>Chlorine content of leaves.</u>

(a) Foliar application of nitrogen tended to increase the content of chlorine in leaves.

(b) The chlorine content of leaves increased progressively with the rise in nitrogen dose of the spray solution upto 4 grams per plant.

(c) With soil application of fertilizers, lower doses of nitrogen (1 and 2 grams per plant) showed an increase in chlorine content of leaves, while at higher levels of nitrogen (3 grams and 4 grams per plant) the chlorine content of leaves recorded a reduction.

CONCLUSIONS.

The following broad conclusions may be drawn from the results obtained in the present investigation:-

(1) Foliar spray of nitrogenous fertilizers increases the vegetative aspects of chewing tobacco, like height of plants, number of leaves, leaf area and girth of stem.

(2) Foliar application of nitrogen favourably influences the yield characters in chewing tobacco such as weight per unit area of leaf, green leaf yield and cured leaf yield.

(3) Foliar feeding of nitrogen increases the total nitrogen, nicotine, potash and chlorine content of leaf.

(4) Urea is the ideal spray material.

(5) The percentage of recovery of nitrogen is higher in plants receiving nitrogen through soil than in those which are sprayed with nutrient solutions.

(6) As compared with foliar sprays, soil application of solid fertilizers produces greater increase in vegetative as well as yield characters in chewing tobacco.

REFERENCES

ARISZ, W.H., (1952) Ann. Rev. Plant Physiol., 3, 109-30.

BIDDULPH, O., (1954) Plant Analysis and Fertilizer Problems, 7-17 (Institut de Recherches pour les Huiles et Oleagineux, Paris, France, 263 pp., Annual Review of Plant Physiology, 10 , 1959.

BOYNTON, D., (1954) Ann. Rev. Plant Physiol., 5, 31-54

BRASHER, E. P., WHEATLEY, J. R., and OGLE, W.L., (1953), Delaware, Univ., Agr. Expt. Sta. Bull., No.295 Ann. Rev. Plant Physiol., 10, 1959.

BOHM, J., (1957) Landwirtsch. Vers. Sta., 20, 51-59 Ann. Rev. Plant Physiol., 10, 1959.

BUKOVAC, M.J., and WITTWER, S.H., (1957) Plant Physiol., 32, 428-35, Ann. Rev. Plant Physiol., 10, 1959.

BARRIER, G.H., and LOOMIS, W.E., P (1957) Plant Physiol. 32, 225-31.

BENSON, N.R., and BULLOCK, R.M., (1951), Proc. Wash. Sta. Hort. Abs., 47, 113.

BOULD, C., and TOLHURST, J., (1951) Rep. Agric. Hort. Res. Sta. Bristoll.
Halliday, D.J., Out look on Agriculture. 3 (3), 1961.

BOGUSLAWSKI, E.V., and VOMEL, A. (1955) Foliar Fertilizing of Oats with singe nutrients and complete fertilizer, Landw. Forsche Sondreth, 9, 83-94.
Halliday, D.J., Out look on Agriculture. 3 (3), 1961.

COOK, J.A., and BOYNTON, D., (1952) Proc. Am. Soc. Hort. Sci., 59, 82-90.

EMMERT, E.M., and KLINKER, J.E., (1950) Kentucky Agr. Expt. Sta., Univ. Kentucky, Bull. No. 550. Ann. Rev. Plant Physiol., 10, 1959.

FISHER, E.G., (1952) The Principles Underlying Foliage Application of urea for Nitrogen fertilization of the Mac Intosh Apple. Proc. Amer. Soc. Hort. Sci. 59, 91-98, Cornell Univ. Ithaca, N.Y. Soils and Fertilizers, 16, (1953)

FISHER, E.G., and WALKER, D.R., (1955) Proc. Am. Sco. Hort. Sci., 65, 17-24.
Ann. Rev. Plant Physiol. 10, 1959.

FOGG, G.E. (1947) Proc. Roy. Soc. (London), B.J., 134, 503-22.

GRIS, E., (1844) Compt. rend., 19, 1118-19, Ann. Rev. Plant Physiol. 10, 1959.

GUEST, P.L., CHAPMAN, H.D., (1949) PROC. Am. Soc. Hort. Sci. 54, 11-21.
Ann. Rev. Plant Physiol, 5, 1954.

GRAPPE, W., Gartenbauwiss (1958), 23: 494-506
Hort. Abst. 30 (2), 1960.

COLIKOVA, N.A., (1959) The effect of Extra root top dressing on the Physiological and biochemical Processes in Strawbaeries, Irv. Timiryazev. S. Kh. Akad Nauk No.3.
Soils and Fertilizers, 23, 1960.

GOWARKAR, A.S. and SHAW, C.C. (1961) Effect of N.P.K. on bidi tobacco. Ind. Tob. Vol. VIII No.4.

GUSTAFSON, F.G., (1957) Plant Physiol., 32, 141-42.

GEISSELER (1954)Arch. Gartenbau, 2, 311-18
Ann. Rev. Plant Physiol., 10, 1959.

HILTNER, L, (1909) Prakt. Bl. Pfl. Bau U. Schutz, 7, n.8. Halliday, D.J., (1961) Out look on Agric. 3 (3) 1961.

HINKOV, T.P., (1959) Foliar Nutrition of Tobacco Plant (Russian), Tabak, 1959, 20 (4), 44-45,
Hort. Abst. 30(2), 1960.

HILTON, R.J., and SHAW, D.A. (1958) Can. J. Agr. Sci. 36, 27-35, 10, 1959.
Ann. Rev. Plant Physiol., 10, 1959.

HESSE, C.O., and GRIGGS, W.H., (1950) Proc. Am. Soc. Hort. Sci., 56, 173-80

HIGASHINO, S., and Yatazawa, M., Sci. Repts. Shiga Agr. Coll. Ser. II, No.1, 39-41 (1952)

IVANOVSKY, M., (1960) Foliar Nutrition of Tobacco. Rev. Ind. Tabacs., 35, 43-44.
Hort. Abst. 30, No.2, 1960.

INDENKO, I.F., (1960) Extra root top dressing of Black currant and the possibility of combining it with treatme with fungicides. Fiziol. Rast. 7, 198-206.
Soils and Fertilizers 23, 1960.

JAUREZ, L., APPLEGATE, H.G., and HAMNER, L., (1957), New Phytologist, 56, 301-304.

JORISSEN, J., (1955) Spraying with nitrogen fertilizers M.M. dtsch. Londiv. Ges. 70, 956, Soils and Fertilizers 19, 1956.

JUARES GALLANO, L., SWANSON, A. (1955). Foliar Fertilizing of Wheat with urea. Inf. Estac., Agric. La. Molina 29, Soils and Fertilizers 19, 1956.

KOONTZ, H., and BIDDULPH, O., (1959) Plant Physiol., 32, 463-70.

KUTHY, S., FEREEZ, V., MARKUS, L., (1953) The effect of Foliar Spray on Sugar Beat. Agrokan. Talgat 1, 425-30. Soils and Fertilizers 16,(1953).

KUYKENDALL, J.R., and WALLACE,A.,(1953) Urea Nitrogen as Foliar spray Calif. Agric. 7. Soils and Fertilizers 16, 1953.

KRZYSCH, G., (1958), The effect of increasing Salt concentration and of the time of Application on the efficiency of Foliar Fertilizing, Soils and Fertilizers, 16, 1953.

LONG, W.G., SWEET, D.V., and TUKEY, H.B., (1956), Science 123, 1039-40. Ann. Plant Physiol. 10, 1959.

LECAT, P., (1955) Compt, rend. accd. agr. France, 41, 712-13. Ann. Plant Physiol. 10, 1959.

MAYER,A., (1874), Landwrtsch. Vers. Sta., 17, 329-40 Ann. Rev. Plant Physiol., 10, (1959)

MATSKOV, F.F., and IKONENKO, T.K., (1958), The relationship between extra root nutrition, Photosynthesis and the root nutrition of plants Dokl. Akad. Nank. 118, 601-603. Soils and Fertilizers 21, (1958)

MORTELARO, J., Fall, C.V., JAMISON, F.S., (1952) Studies on the Nitrogen Nutrition of Tomatoes with Foliar sprays Proc. Amer. Soc. hort. Sci. 59, 361-66. Agric. Exptl. Stat. Gamseville Fla. Soils and Fertilizers 16, 1953.

NARAYANAN, T.R., and VASUDEVAN, V., (1959) Studies on foliar nutrition of crops - 3 Madras Agric. J. 46, 225-29 (1959) Ann. Res. Plant Physiol., 10, 1959.

ORGELL, W.H., Plant Physiol. 30, 78-80,(1955)

OLAND, K., (1960) Nitrogen feeding of Apple Trees by Post-harvest urea sprays - Nature 185-87, bull. 6.

PEDAS, F.I., (1958) (Russian), Bjull. Clav. Bot. Sada., (1958) Hort. Abst. 30, 1960

PETINOV, N.S., and PAVLOV, A.N., (1960) The participation of the spikelet glooms of wheat in the Absorption of Nitrogen during extra root top dressing. Dokl. Akad. Nauk. 130, 929-931. Soils and Fertilizers, 23, 1960.

SANDFORD, W.G., NIGHTINGALE, G., STEWART, W.S., Gowing, O.P., SIDERIS, C., LEEPER, R.W., YOUNG, H.Y., KRAUSS, B., and FO. J., (1958) Pinapple Research Institute, Honolulu, Hawaii, Ann. Res. Plant Physiol, 10, 1959.

SKOSS, J.D. (1955) BOTAN. Gaz., 117, 55-72.

STEWRT, I., and LENORD, C.D., (1956) Radio Active Isotopes in Agriculture, 245-51 (AEC. TID 7512 Washington D.C.) 416.

SAKO, J., (1960) The effect of urea sprays on Nitrogen Content of Apple leaves, Agric. Res. Centre, Dept. Hort. Pukio, Hort.Abst. 30 (2) 1961.

SILBERSTEIN, O., and WITTWER, S.H., (1951) Foliar Application of Phosphatic nutrients to vegetable crops. Proc. Amer. Soc. Hort. Sci., 58, 179-90. Soils and Fertilizers, 16 (1963).

STILES, W.C., CHILDERS, N.F., and PRUSIK, M.J. (1959) Effect of urea sprays and pesticides on russeting and craking of stamen Apple. Proc. Amer. Soc. Hort. Sci. 74, 25-29, Soils and Fertilizers, 23, (1960)

SCHNEIDER, E.F., and SNYDER, W.E., (1960) Effects of urea sprays on grouth and flowering of Azaileas Proc. Amer. Soc. Hort. Sci. 75, 658-662. Soils and Fertilizers, 24, (1961).

SEN GUPTA AND DAS, J., (1962) Fertilizing Wheat with urea. ..a Agri. J. 11, 1960.

THORNE, G.N., and WATSON, D.J., (1955) Field expts. on uptake of Nitrogen from leaf sprays by sugar beaf. J. Agric. Sci. 46, 449-56, Soils and Fertilizers (19) (1956)

THORNE, G.N., (1957), The effect of applying nutrient in leaf sprays on the absorption of same nutrient by the roots. Soils and Fertilizers, 21, (1958).

VAN LIER, P., (1960) Urea - Magnessium sprays in Limburg. (Fruittelt 50, 568-70, Hort. Abst. 30, (1960).

VENKATARAMANI, K.S.,(1957) Fertilite, 1, 17-21 Ann. Res. Plant Physiol., 10, 1959.

VOLK, R., and McAULIFFE, C., Soil Sci.Soc. Am., Proc., 18, 308-12 (1954) Ann. Res. Plant Physiol., 10, 1959.

WALKER, D.R., and FISHER, E.G., (1955) Foliar sprays of urea on sour cherry trees, Proc. Amer. Soc. Hort. Sci. 66, 21-27, Soils and Fertilizers 19, (1956).

YATAZAWA, M., and HIGASHINO, S., (1952) Sci. Rept. Shiga, Agr. Coll. 2, 31-39.

YAKUSHKINA, (1960) Extra root top dressing and Physiological processes in sugar beat Vestn. S. Qh. Nauki. No.11, 36-40. Soils and Fertilizers, 24, 1961.

Appendix - II

Table No.

Height of plant on 30, 60, 75 and 90 days after transplanting

(Analysis of variance)

Factor	D.F.	30	65	75	90
		M.S.S.	M.S.S.	M.S.S.	M.S.S.
Total	149	81.76	2265.55	3801.71	4296.87
Block	4	1.67	5.28	9.75	1.83
Forms (M)	2	0.32	1.79	1.29	0.35
Error-A	8	4.59	32.65	19.04	7.97
Methods (F)	1	0.32	0.05	3.50	0.00
M x F	2	0.25	1.54	0.95	0.81
Error-B	12	3.77	16.98	29.24	16.95
Levels (L)	4	17.26	2032.41 *	3529.15 *	4179.64 *
M x L	8	7.81	7.77	24.90	8.44
F x L	4	1.67	2.51	1.97	6.28
M x F x L	8	10.91	19.49	25.64	2.11
Error-C	96	33.19	145.08	156.28	72.49

* Significant at 5 per cent level.

Appendix - III

Table No.

Number of Leaves per plant on 30, 60, 90 and 115 days after transplanting.

(Analysis of variance)

Factor	D.F.	30	60	90	115
		M.S.S.	M.S.S.	M.S.S.	M.S.S
Total	149	33.79	137.97	323.07	250.294
Block	4	0.16	2.44	2.64	1.761
Forms (M)	2	0.41	1.05	0.37	0.654
Error-A	8	0.72	2.28	1.96	2.525
Method (F)	1	0.05	0.14	0.16	0.100
M x F	2	0.13	0.94	0.38	0.656
Error-B	12	2.32	7.52	3.16	2.298
Levels (L)	4	0.22	95.17 *	280.30 *	218.964 *
M x L	8	1.26	1.55	2.30	1.676
F x L	4	0.19	0.93	0.74	0.006
M x F x L	8	1.53	2.59	3.22	4.740
Error-C	96	26.80	25.80	27.84	16.914 *

* Significant at 5 per cent level.

Appendix - IV

Table No.

Leaf area on 30, 60, 90 and 115 days after transplanting

(Analysis of variance)

Factor	D.F.	30	60	90	115
		M.S.S.	M.S.S.	M.S.S.	M.S.S.
Total	149				
Block	4	228.46	30.577	32609.94	2014.9
Forms (M)	2	203.95*	2123918*	10979095*	8095029*
Error-A	8	9.47	25.536	33790.0	1393.5
Method (F)	1	0.01	1790880*	14270285*	9988720*
M x F	2	93.92	81570.66*	3336916*	329341*
Error-B	12	27.00	93.11	5606.25	2172.2
Levels (L)	4	139.31	4985532*	42530988*	34845730*
M x L	8	158.74	139252.58*	1020190.3*	7346282*
F x L	4	125.19	135748.54*	772021.6	762526*
M x F x L	8	204.26	11181.08*	119368.0*	59942.2*
Error-C	96	79.00	72.5	40014.9	2690.4*

* Significant at 5 per cent level.

Appendix - V.

Table No.

Girth of stem

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	44.49			
Block	4	0.04	0.01	1.11	3.84
Forms (M)	2	0.178	0.089	9.82 *	4.46
Error-A	8	0.072	0.009		
Methods (F)	1	0.05	0.05	12.50 *	4.75
M x F	2	0.00	0.00	0.00	3.88
Error-B	12	0.05	0.004		
Levels (L)	4	42.66	10.67	1333.75 *	2.48
M x L	8	0.48	0.06	7.26 *	2.06
F x L	4	0.12	0.03	3.61 *	2.48
M F x L	8	0.04	0.005	0.60	2.06
Error-C	96	0.80	0.0083		

* Significant at 5 per cent level.

Appendix - VI

Table No.

Green weight of leaf

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	1230751.34			
Block	4	40.80	10.24	1.87	3.84
Forms (M)	2	81874.37	40937.17	682.83	* 4.46
Error-A	8	43.60	5.45		
Methods (F)	1	48240.68	48240.68	3015.06	* 4.75
M x F	2	2380.32	1190.16	743.86	* 3.88
Error-B	12	19.60	1.633		
Levels (L)	4	1045871.68	261467.92	40854.23	* 2.48
M x L	8	33157.32	4144.665	647.51	* 2.06
F x L	4	16920.98	4230.245	640.73	* 2.48
M F x L	8	1688.02	211.0025	33.53	* 2.06
Error-C	96	618.00	6.4365		

* Significant at 5 per cent level.

Appendix - VII

Table No.

Weight of cured leaves

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	49039.59			
Block	4	7.020	1.755	1.35	3.84
Forms (M)	2	3124.70	1562.35	1201.55 *	4.46
Error-A	8	10.33	1.291		
Methods (F)	1	1871.96	1871.96	2078.97 *	4.75
M x F	2	90.40	45.20	50.12 *	3.88
Error-B	12	11.01	0.0175		
Levels (L)	4	41762.55	10440.6375	5556.37 *	2.48
M x L	8	1262.56	157.82	83.54 *	2.06
F x L	4	648.69	162.1725	86.15 *	2.48
M F x L	8	69.77	8.721	4.53 *	2.06
Error-C	96	180.60	1.881		

* Significant at 5 per cent level.

Appendix - VIII

Table No.

Weight per unit area of leaf

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	0.003569026			
Block	4	0.000001356	0.000000339	2.029	3.84
Forms (M)	2	0.000000291	0.000000145	0.86	4.46
Error-A	8	0.000001342	0.000000167		
Methods (F)	1	0.000000851	0.000000851	4.948*	4.75
M x F	2	0.000001885	0.000000942	5.47 *	3.88
Error-B	12	0.000002064	0.000000172		
Levels (L)	4	0.003526747	0.000881686	4081.88 *	2.48
M x L	8	0.000005925	0.000000741	3.43 *	2.06
F x L	4	0.000001633	0.000000408	1.88 *	2.48
M F x L	8	0.000006177	0.000000772	3.57 *	2.06
Error-C	96	0.00020755	0.000000216		

* Significant at 5% level.

Appendix - IA

Table No.
Nitrogen content of leaves
[illegible]

(Analysis of variance)

Source	S.S.	D.F.	M.S.S.	Variance ratio
Total	13.7427	149		
Whole plot	2.1541	29		
Replication R	1.1981	2	0.08285	94.1477 *
Forms (M)	0.4824	2	0.24120	274.0909 *
Methods (F)	0.2904	1	0.29040	330.0000 *
M x F	0.1657	2	0.08285	94.1477 *
Error (A)	0.0175	20	0.00088	
Sub-plot				
Levels (L)	10.5633	4	2.64082	2967.2130 *
L x M	0.4223	8	0.05279	59.3146 *
L x F	0.2336	4	0.05840	65.6179 *
L x M x F	0.2843	8	0.03554	
Error (B)	0.0851	96	0.00089	

* Significant at 5 per cent level.

Appendix - X

Table No.

Nicotine content of leaves

(Analysis of variance)

Source	S.S.	D.F.	M.S.S.	Variance ratio
Total	11.2655	149		
Whole plot	7.1737	29		
Replication R	0.5420	4		
Forms (M)	1.6191	2	0.80955	116.148 *
Methods (F)	3.2737	1	3.27370	469.684 *
M x F	1.5995	2	0.79975	114.742 *
Error (A)	0.1394	20	0.00697	
Sub-plot				
Levels (L)	1.6245	4	0.40613	419.984 *
L x M	0.6465	8	0.08081	83.570 *
L x F	1.0330	4	0.25825	267.063 *
L x M x F	0.6950	8	0.86875	898.397 *
Error (B)	0.0928	96	0.000967	

* Significant at 5 per cent level.

Appendix - XI

Table No.

Potash content of leaves

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	2.1579			
Block	4	0.7570	0.1892		3.84
Forms (M)	2	0.0249	0.1245		4.46
Error-A	8	0.0107	0.0013		
Methods (F)	1	0.0015	0.0015		4.75
M x F	2	0.1149	0.0574		3.88
Error-B	12	0.0115	0.0095		
Levels (L)	4	0.0197	0.0049	*	2.48
M x L	8	0.1329	0.0166		2.06
F x L	4	0.9410	0.2352		2.48
M x F x L	8	0.0168	0.0021		2.06
Error-C	96	0.1269	0.00132		

* Significant at 5 per cent level.

Appendix - XII.

Table No.

Chlorine content of leaves.

(Analysis of variance)

Factor	D.F.	S.S.	M.S.S.	Variance ratio	'F' from table 5%
Total	149	6.6787			
Block	4	0.6157	0.1539	22.65 *	3.84
Forms (M)	2	0.0768	0.0384	5.64 *	4.46
Error-A	8	0.0546	0.00682		
Methods (F)	1	2.5298	2.5298	1264.9 *	4.75
M x F	2	0.1370	0.0685	34.2 *	3.88
Error-B	12	0.0249	0.00207		
Levels (L)	4	0.1075	0.0268	20.42 *	2.48
M x L	8	0.1567	0.0195	15.06 *	2.06
F x L	4	2.3348	0.5837	429.2 *	2.48
M F x L	8	0.4307	0.538	39.6 *	2.06
Error-C	96	0.1312	0.00136		

* Significant at 5 per cent level.

PLAN OF LAY-OUT

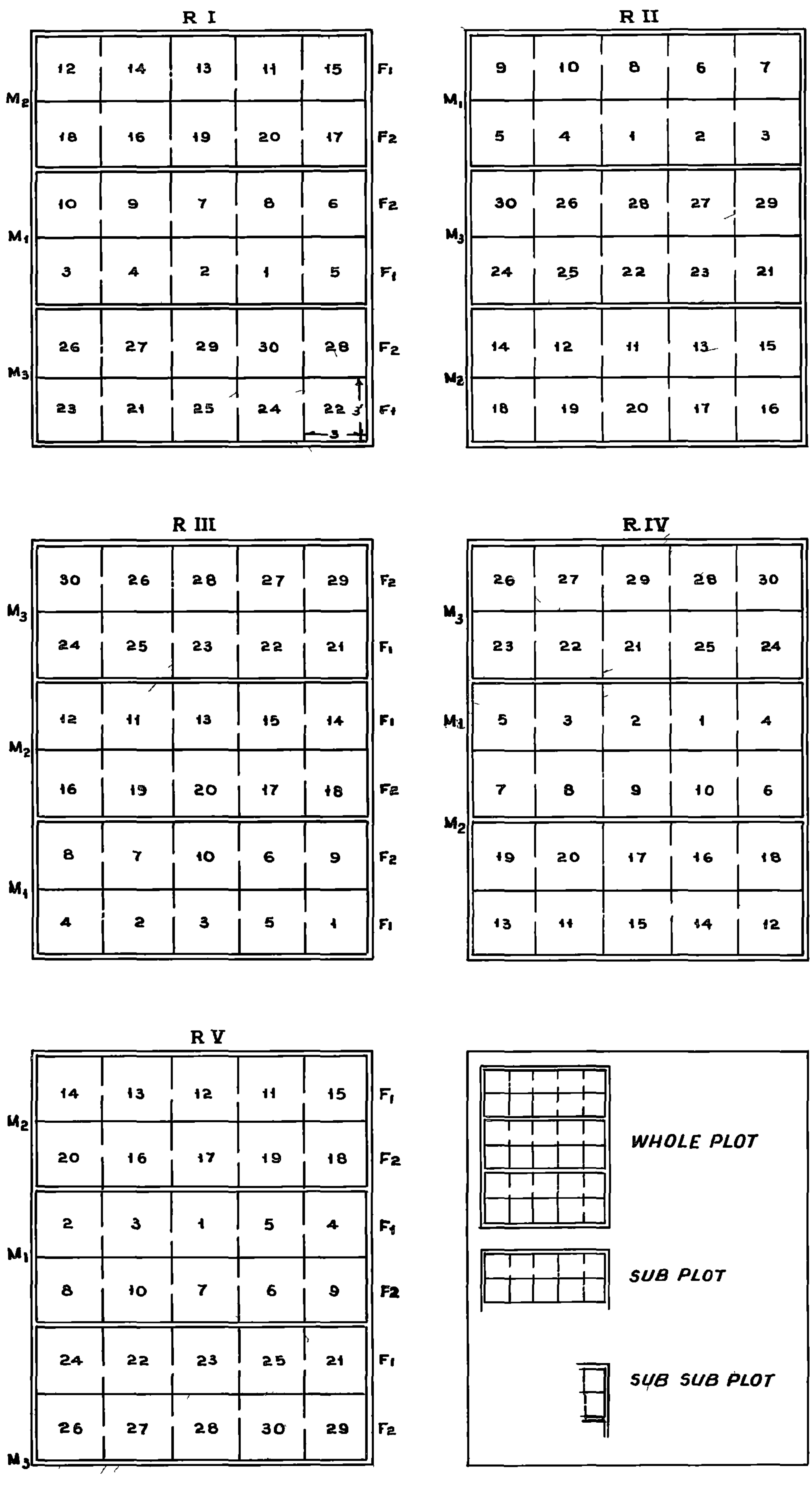


FIG 1

HEIGHT OF PLANTS (IN Cms) AT DIFFERENT GROWTH STAGES

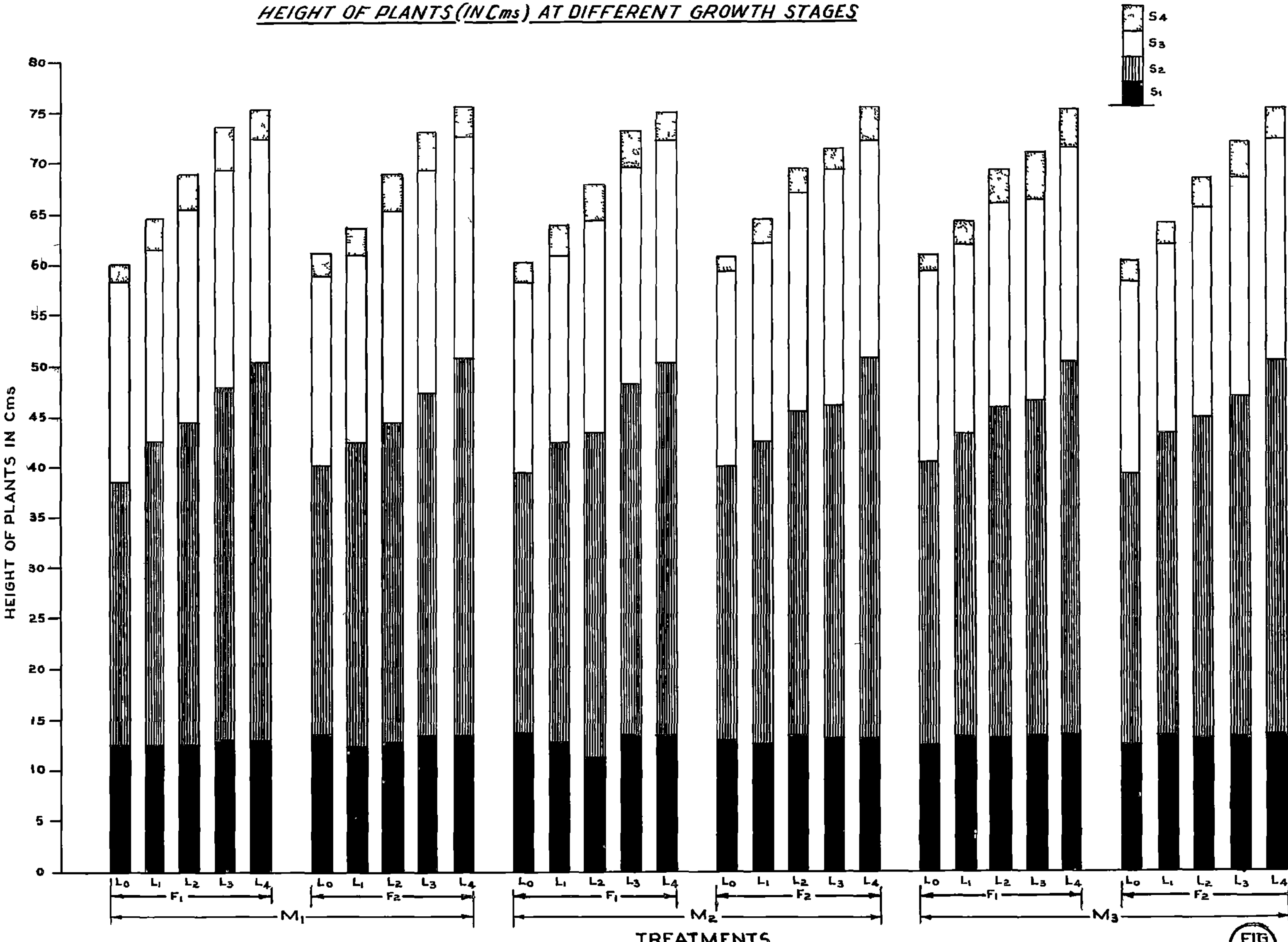


FIG 2

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (UREA) ON LEAF AREA PER PLANT (sq cms)

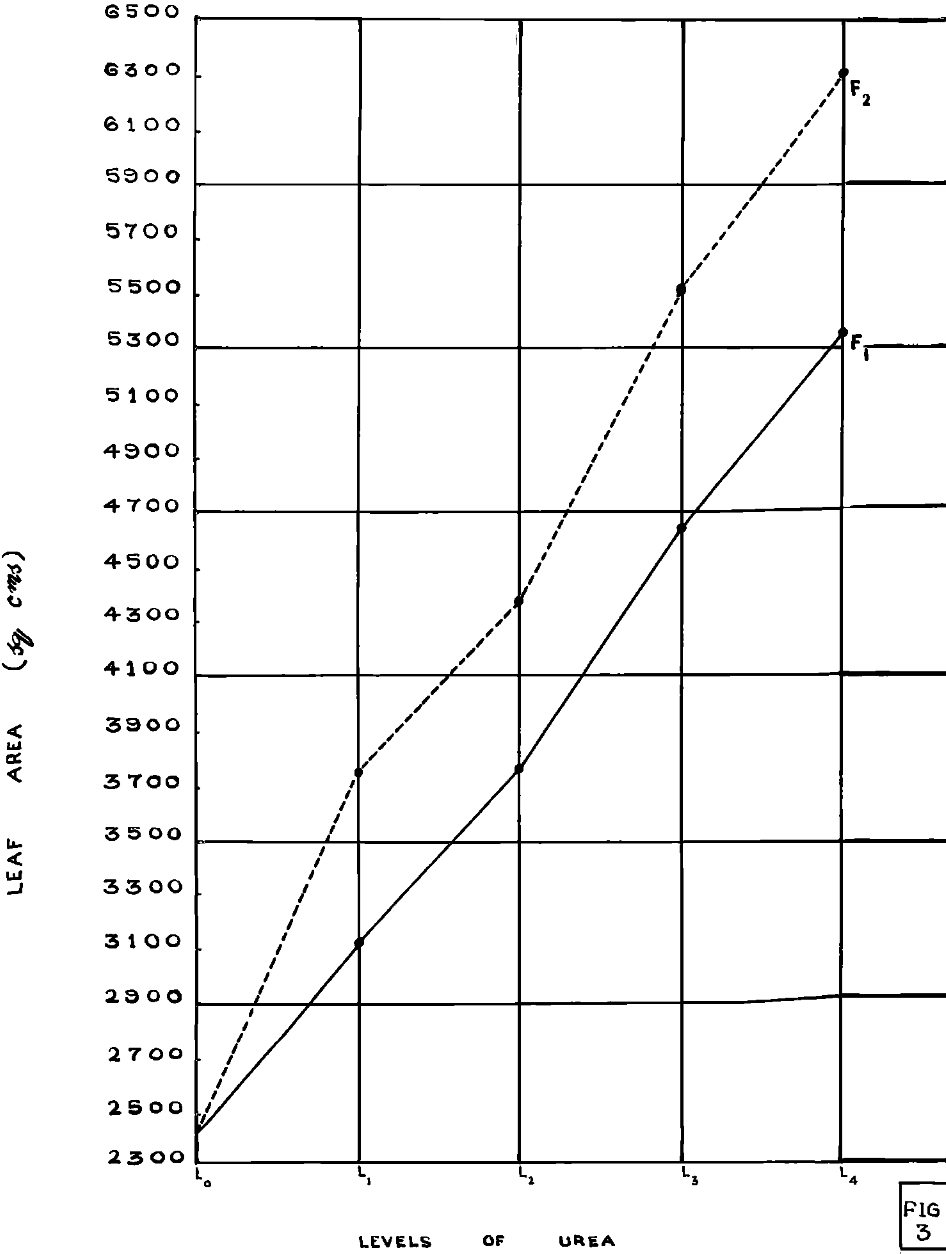


FIG 3

EFFECT OF METHODS OF APPLICATION OF FERTILIZER

(AMMONIUM SULPHATE) ON LEAF AREA PER PLANT (sq. cms)

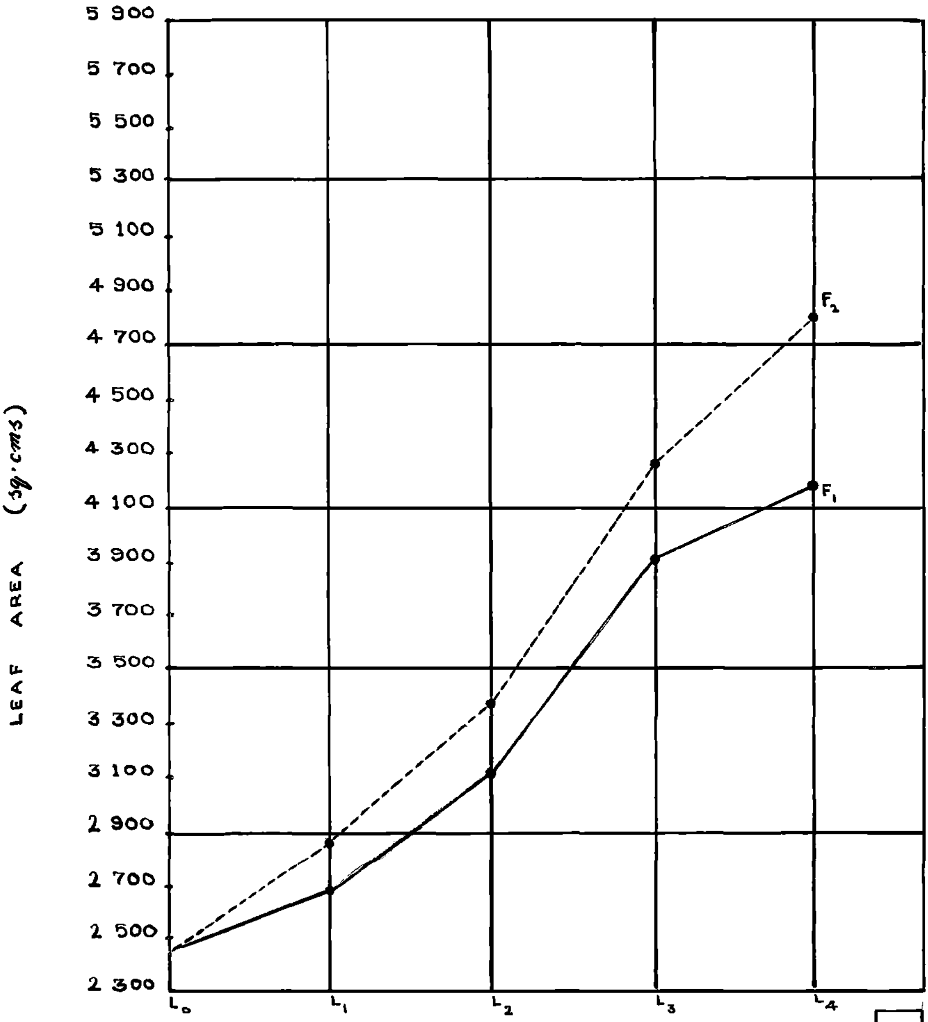


FIG 4

EFFECT OF METHODS OF APPLICATION OF FERTILIZER

(AMMONIUM NITRATE) ON LEAF AREA PER PLANT (sq. cms)

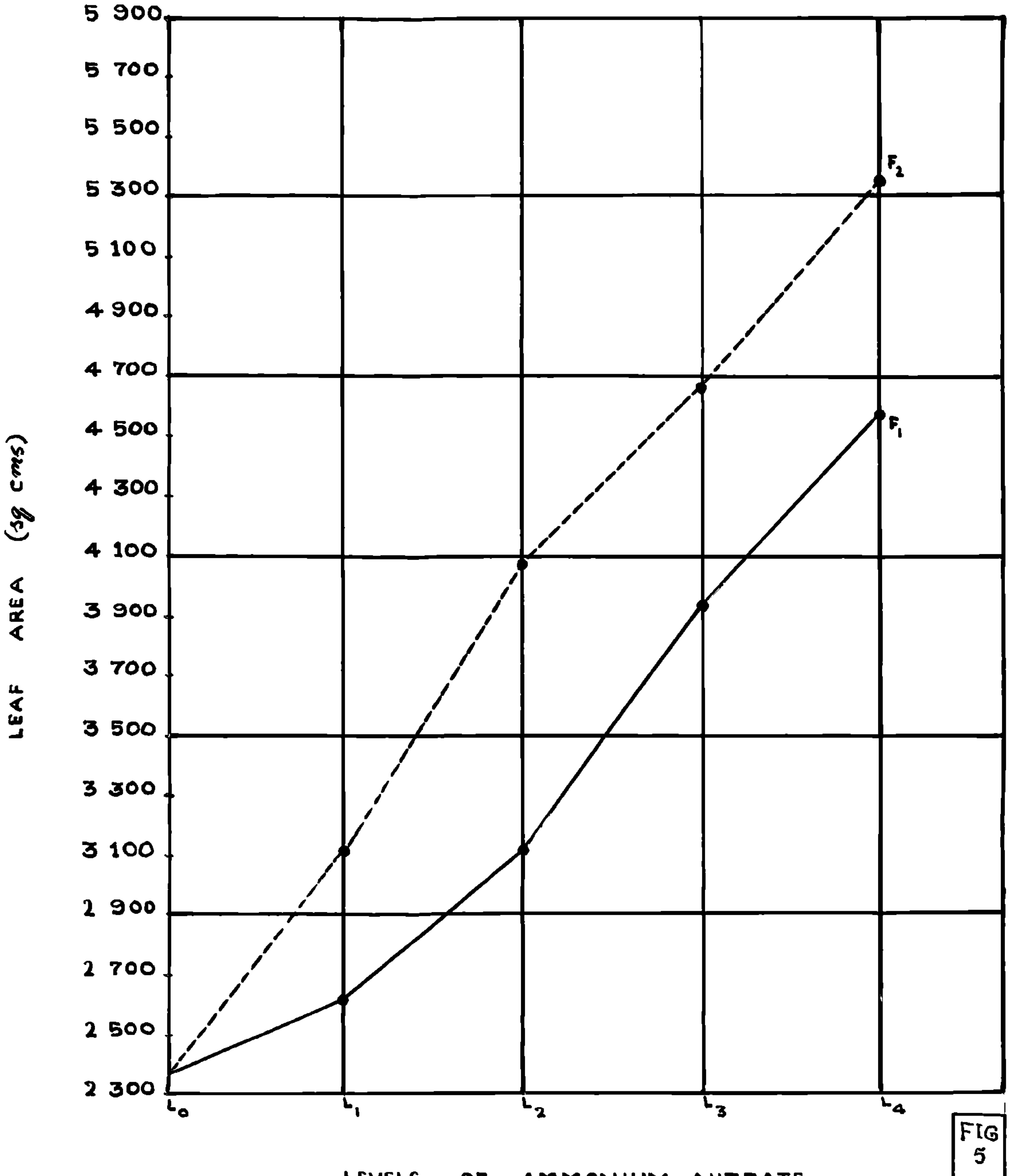


FIG 5

EFFECT OF FORMS OF FERTILIZER
ON LEAF AREA PER PLANT
(FOLIAR APPLICATION)

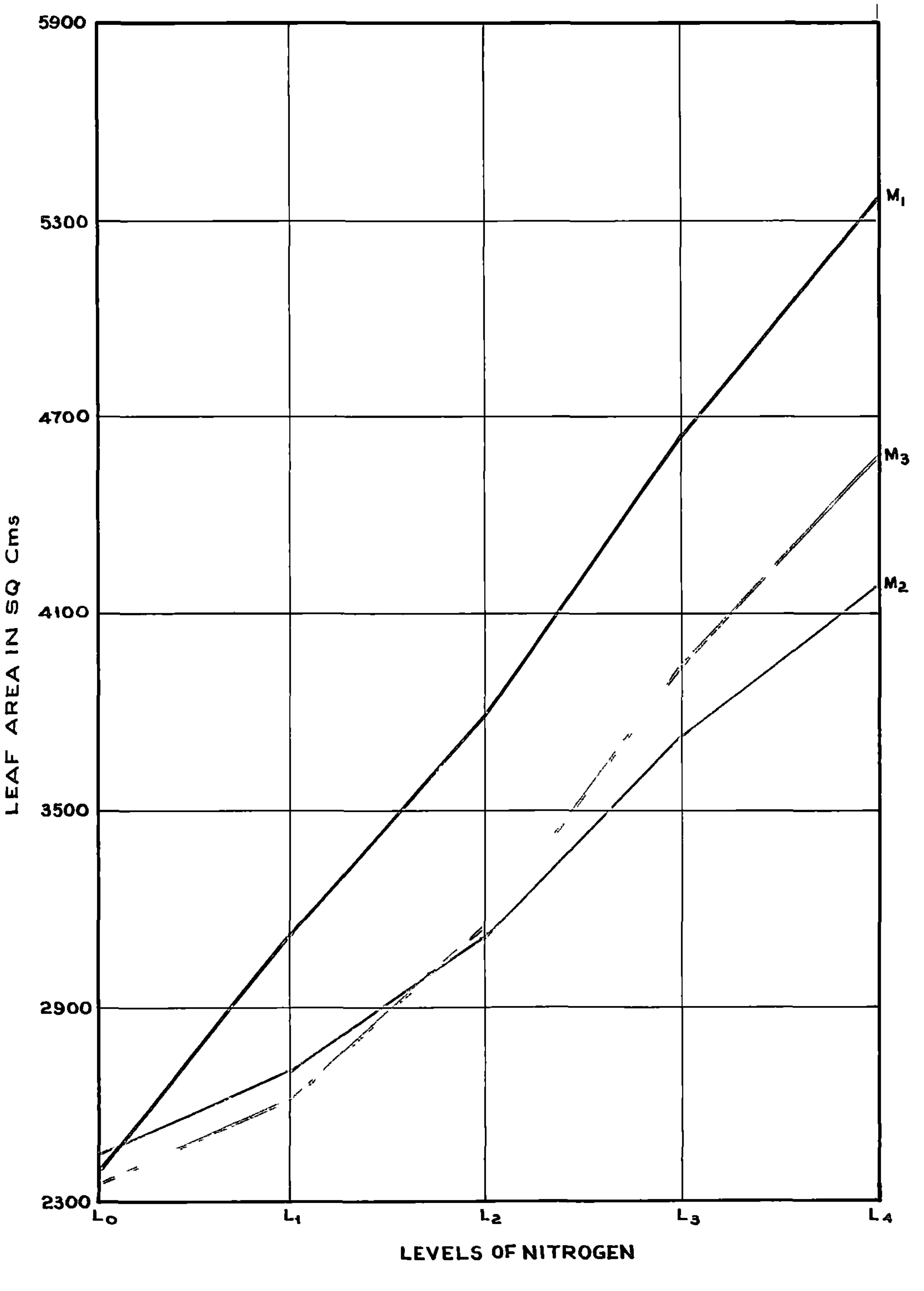


FIG 6

EFFECT OF FORMS OF FERTILIZER
ON LEAF AREA PER PLANT
(SOIL APPLICATION)

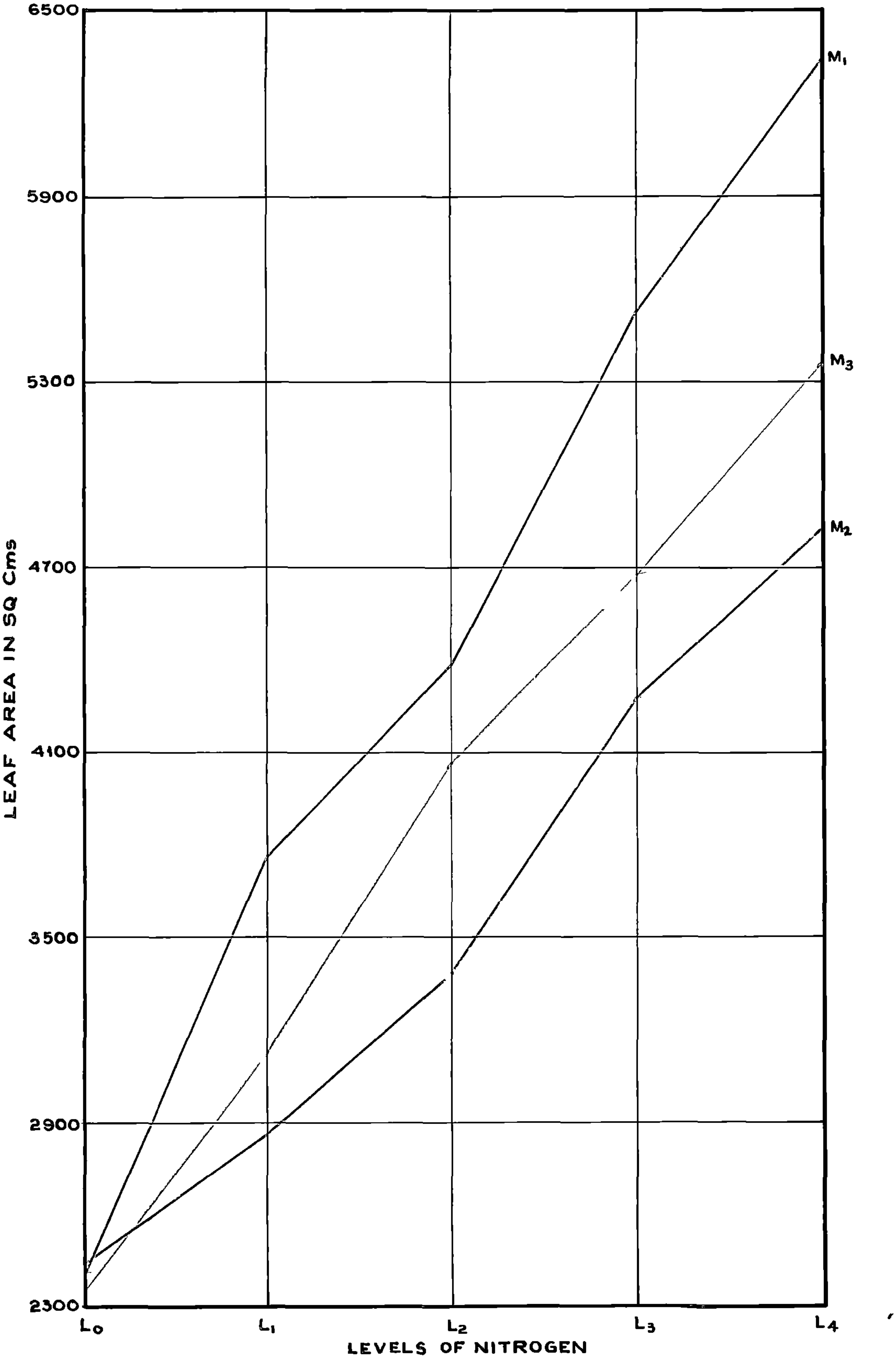


FIG 7

EFFECT OF METHODS OF APPLICATION OF FERTILIZER
(UREA)
ON WEIGHT OF GREEN LEAF AND CURED LEAF

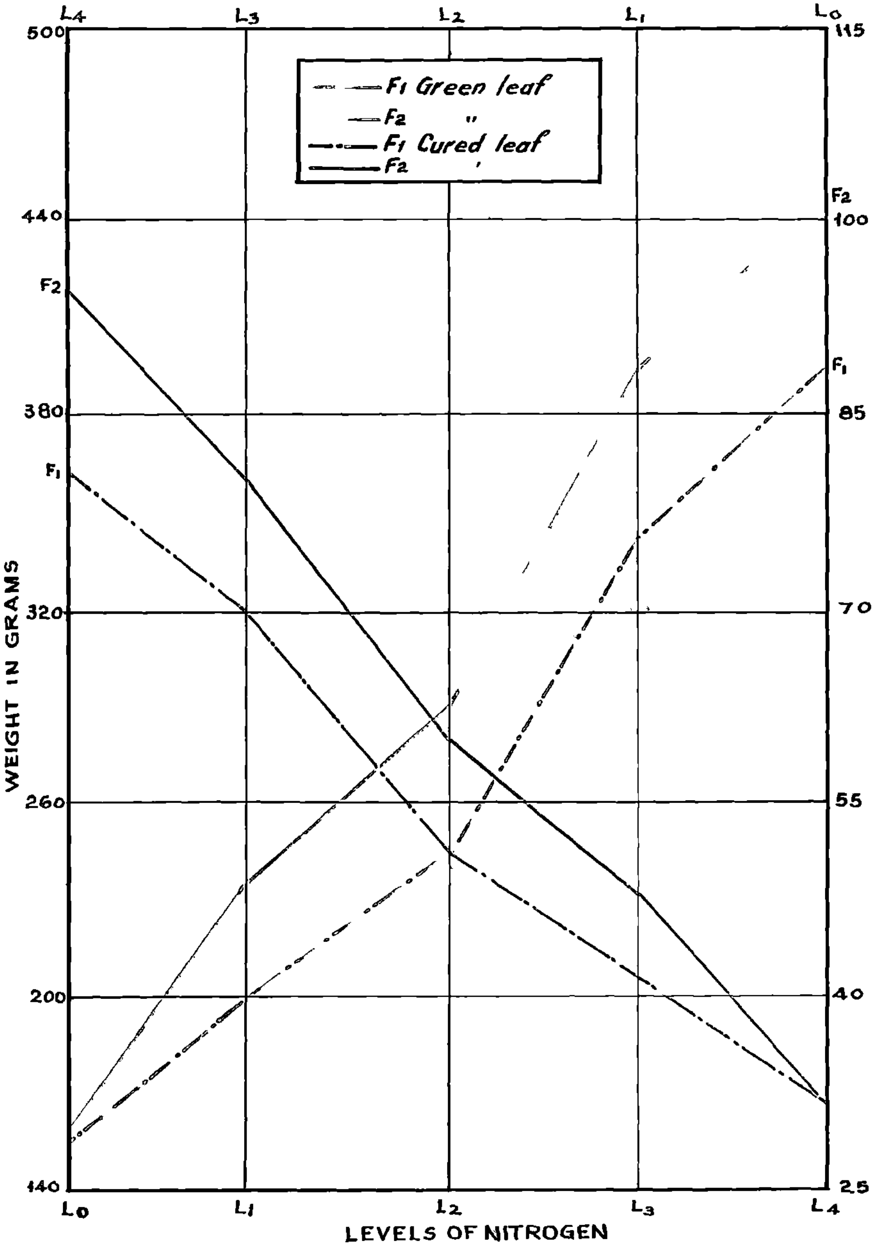


FIG 8

EFFECT OF METHODS OF APPLICATION OF FERTILIZER
(AMMONIUM SULPHATE)
ON WEIGHT OF GREEN LEAF AND CURED LEAF

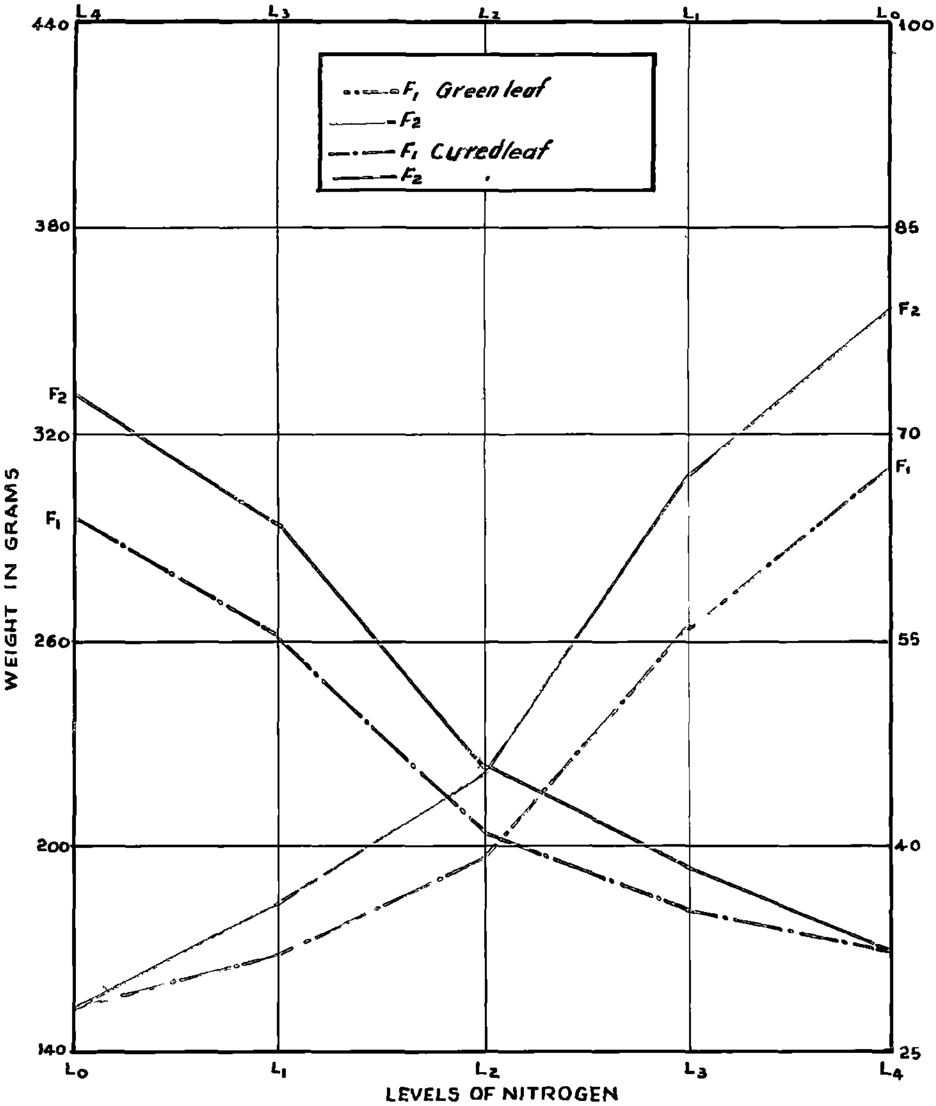


FIG 9

EFFECT OF METHODS OF APPLICATION OF FERTILIZER

(AMMONIUM NITRATE)

ON WEIGHT OF GREEN LEAF AND CURED LEAF

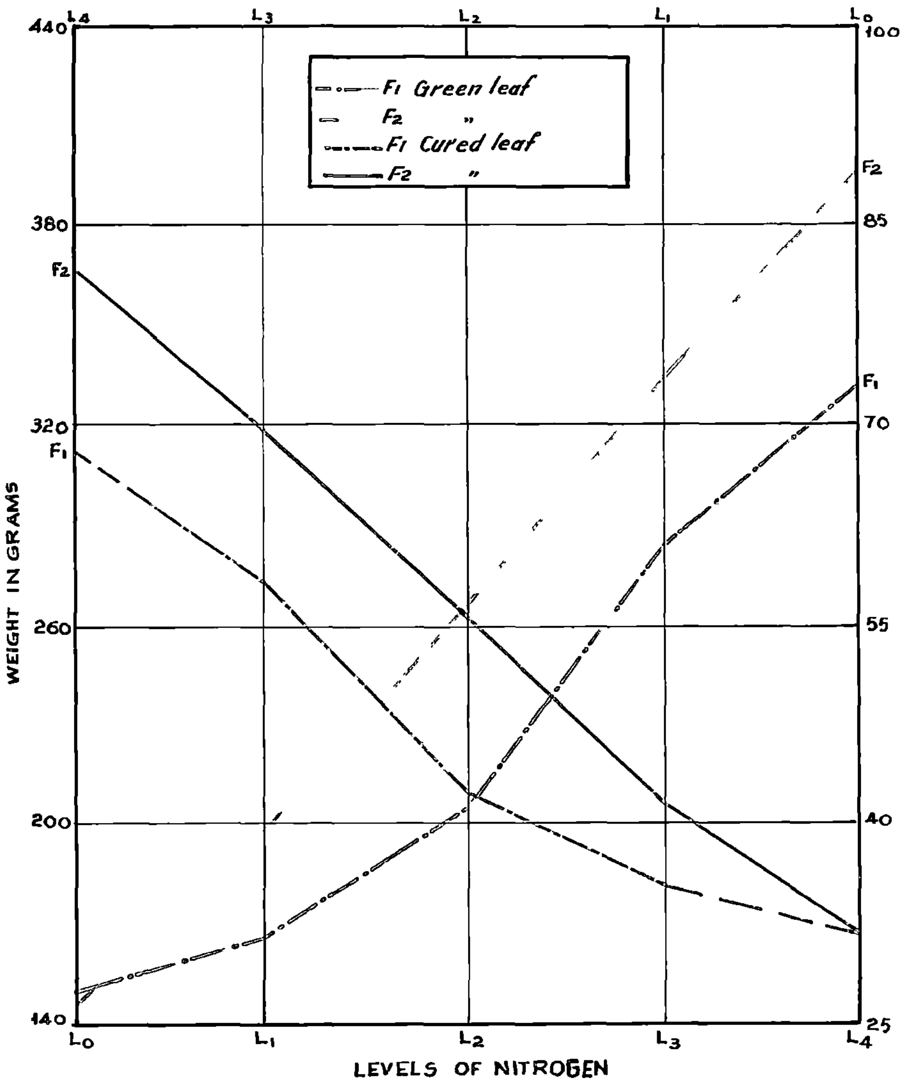
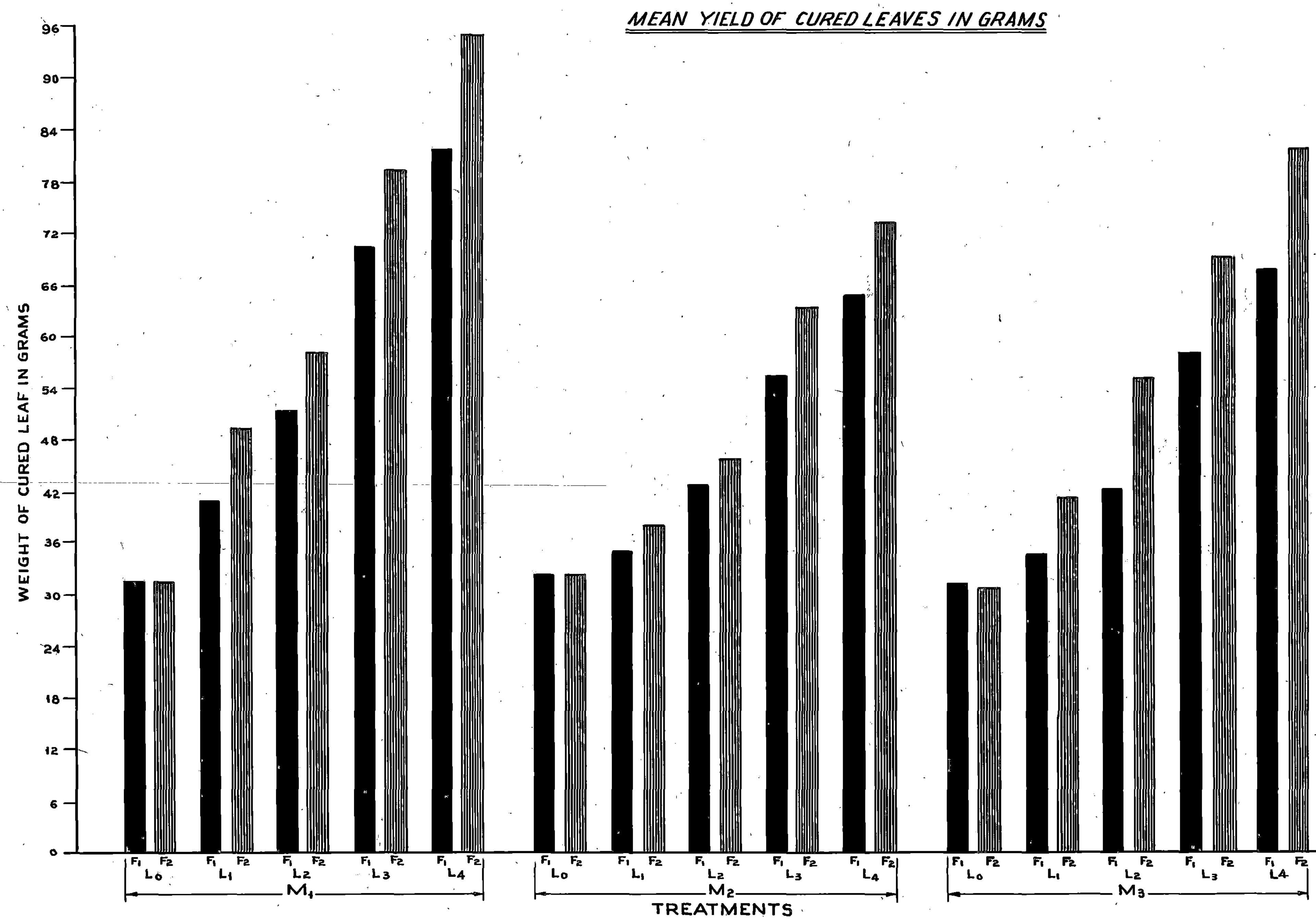


FIG 10



MEAN YIELD OF CURED LEAVES IN GRAMS
WEIGHT OF CURED LEAF IN GRAMS
0
6
12
18
24
30
36
42
48
54
60
66
72
78
84
90
96
F1 F2
L0 L1 L2 L3 L4
M1
M2
M3
TREATMENTS

FIG. 11

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (UREA)

ON RATIO OF GREEN LEAF WEIGHT TO CURED LEAF WEIGHT

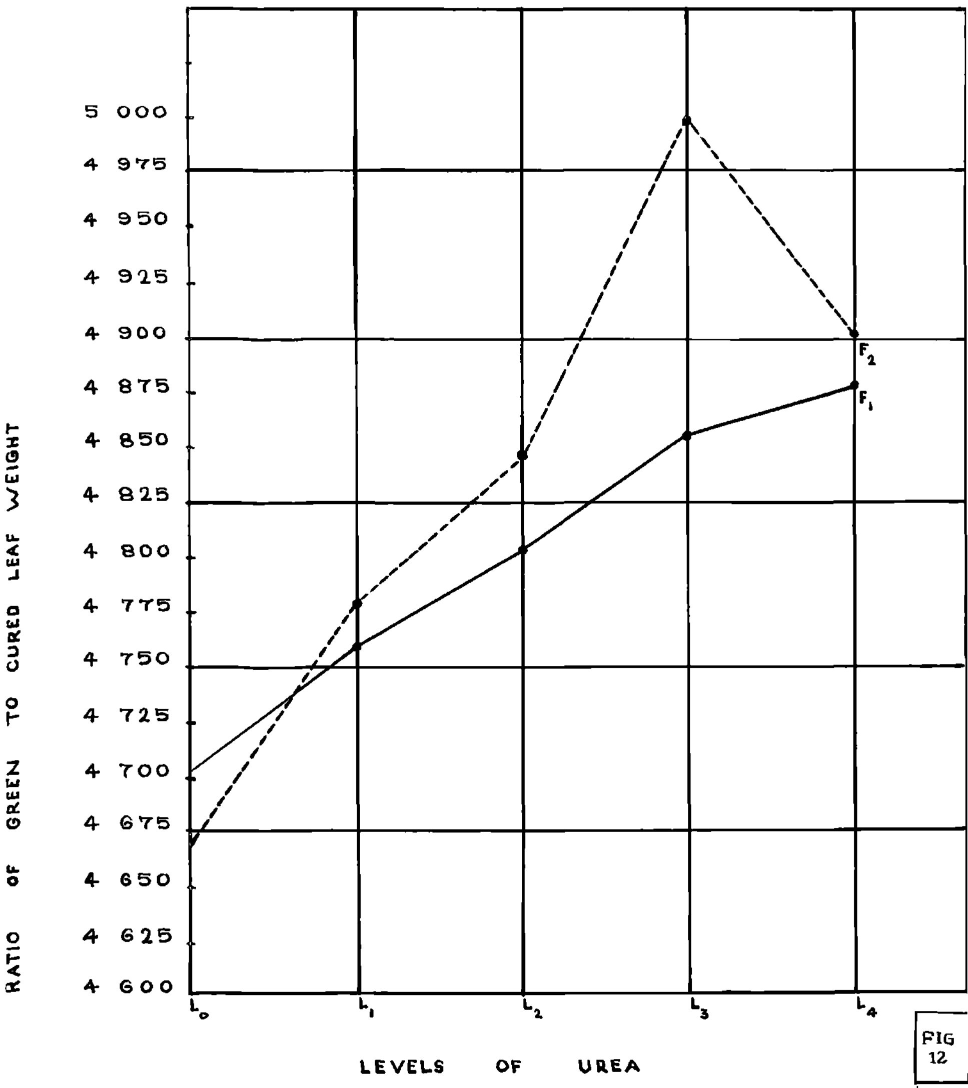


FIG 12

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (AMMONIUM SULPHATE) ON RATIO OF GREEN LEAF WEIGHT TO CURED LEAF WEIGHT

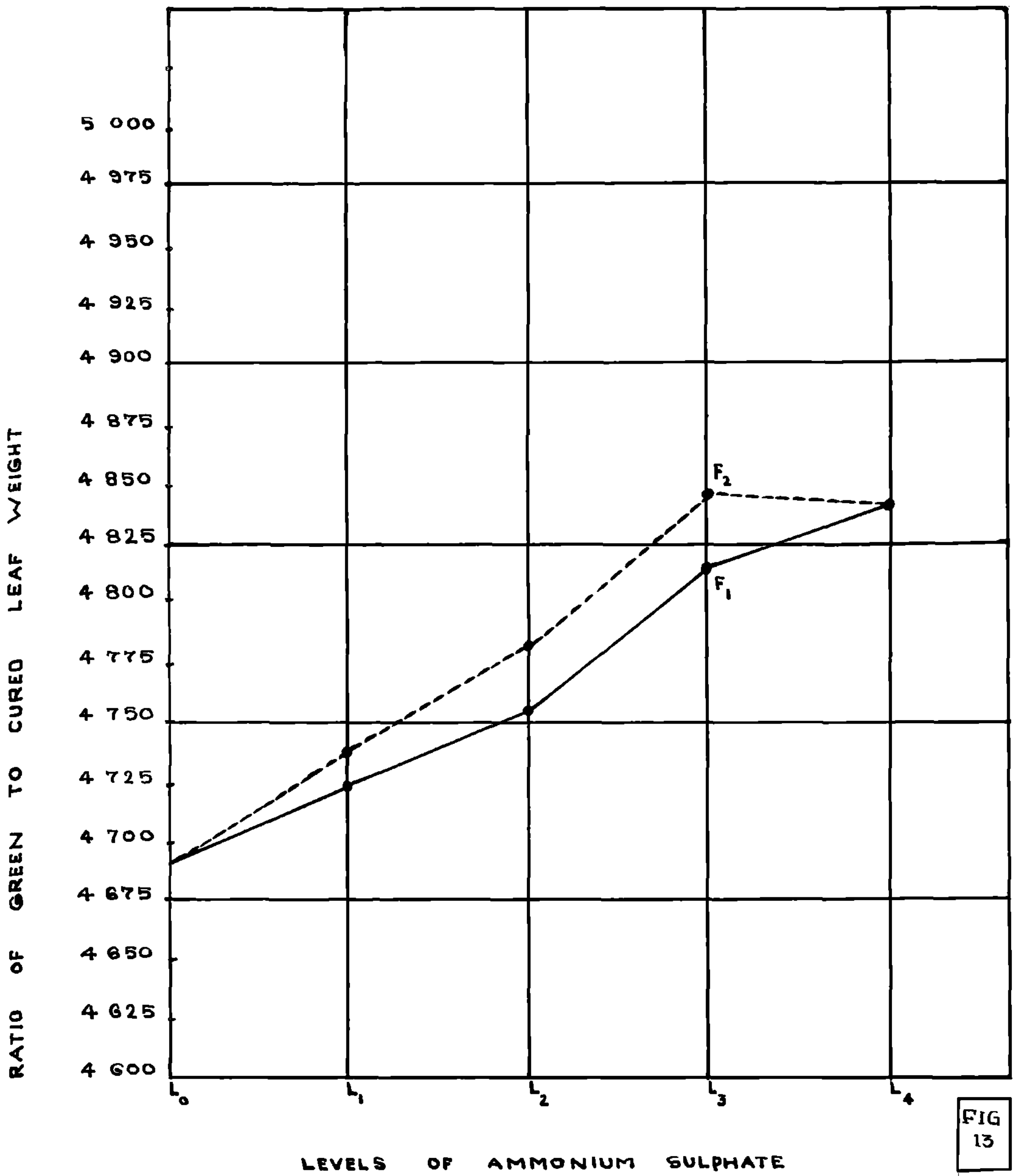


FIG 13

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (AMMONIUM NITRATE)

ON RATIO OF GREEN LEAF WEIGHT TO CURED LEAF WEIGHT

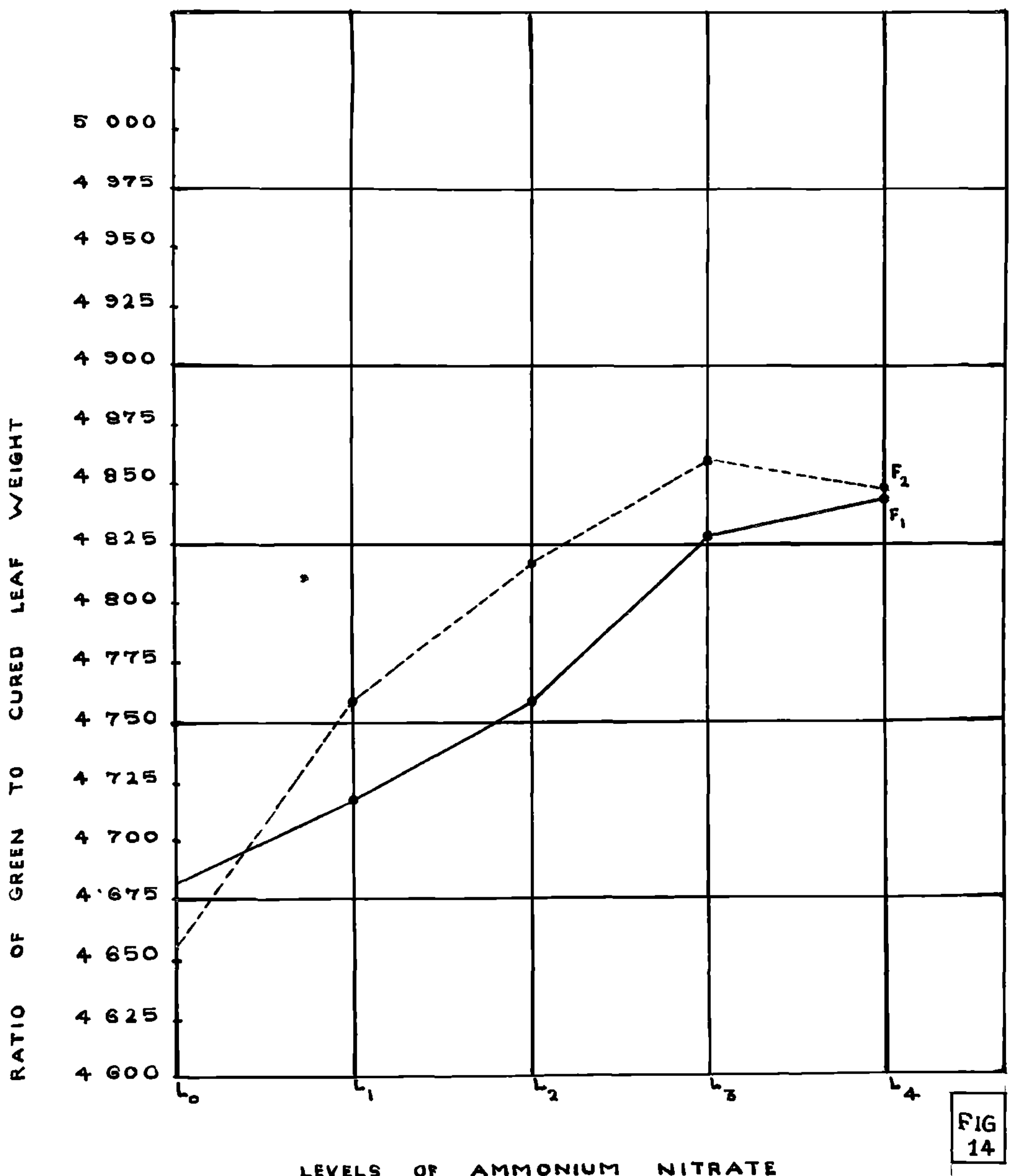


FIG 14

EFFECT OF METHODS OF APPLICATION OF FERTILIZERS
ON NICOTINE AND NITROGEN CONTENT OF CURED LEAF (PERCENTAGES)

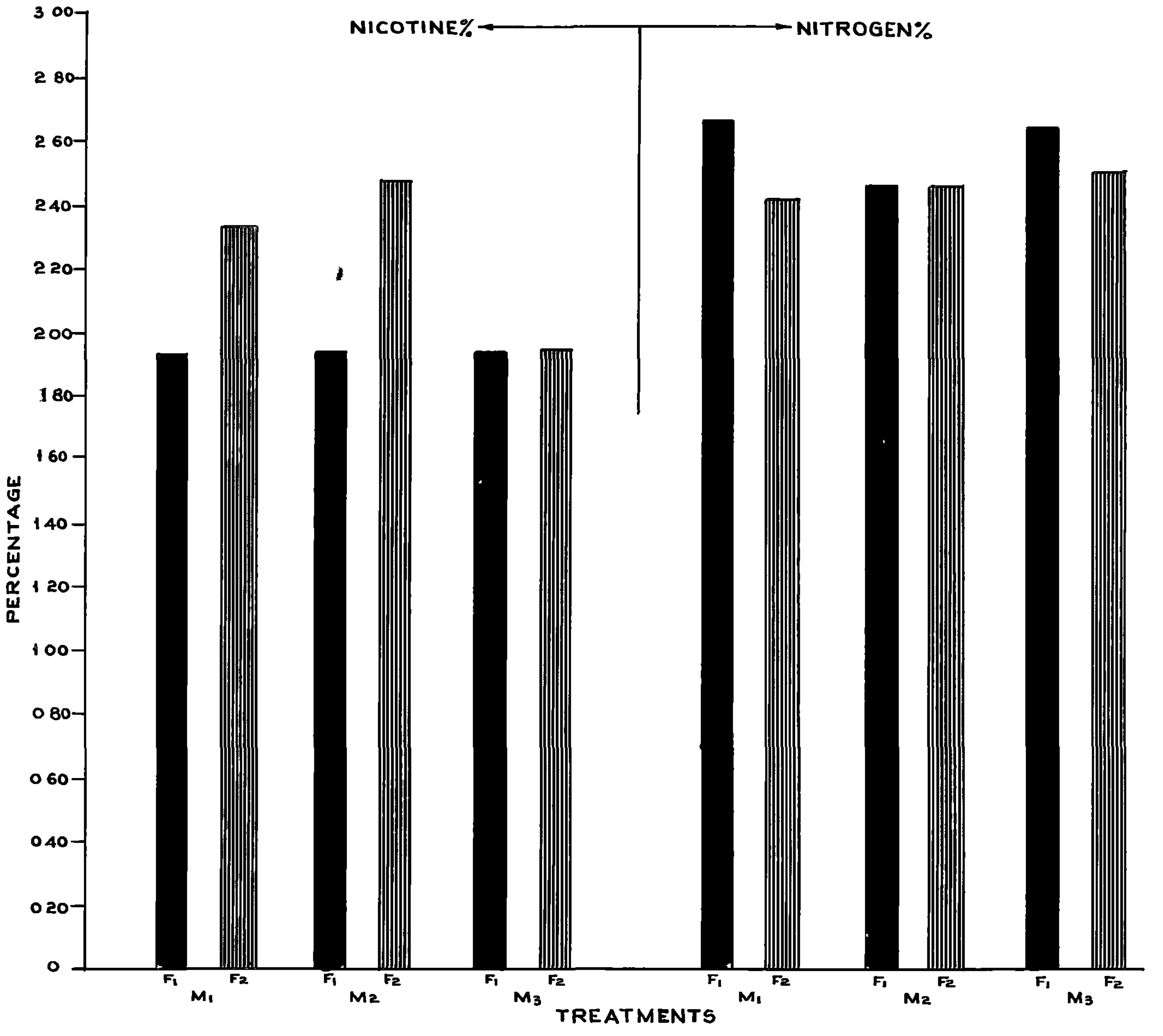


FIG 15

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (UREA)

ON POTASH AND CHLORINE CONTENT OF CURED LEAF (PERCENTAGE)

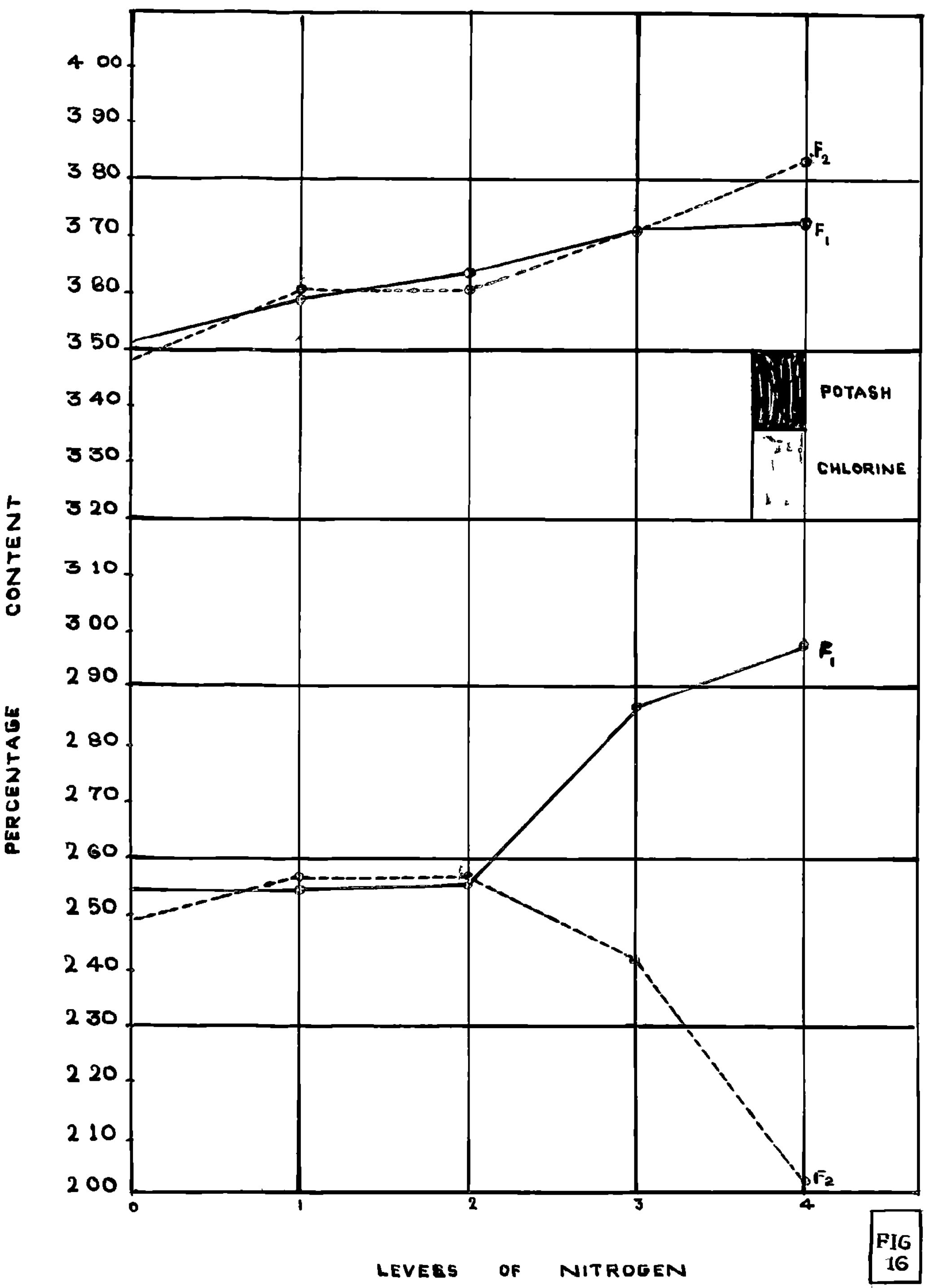


FIG 16

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (AMMONIUM SULPHATE)

ON POTASH AND CHLORINE CONTENT OF CURED LEAF (PERCENTAGE)

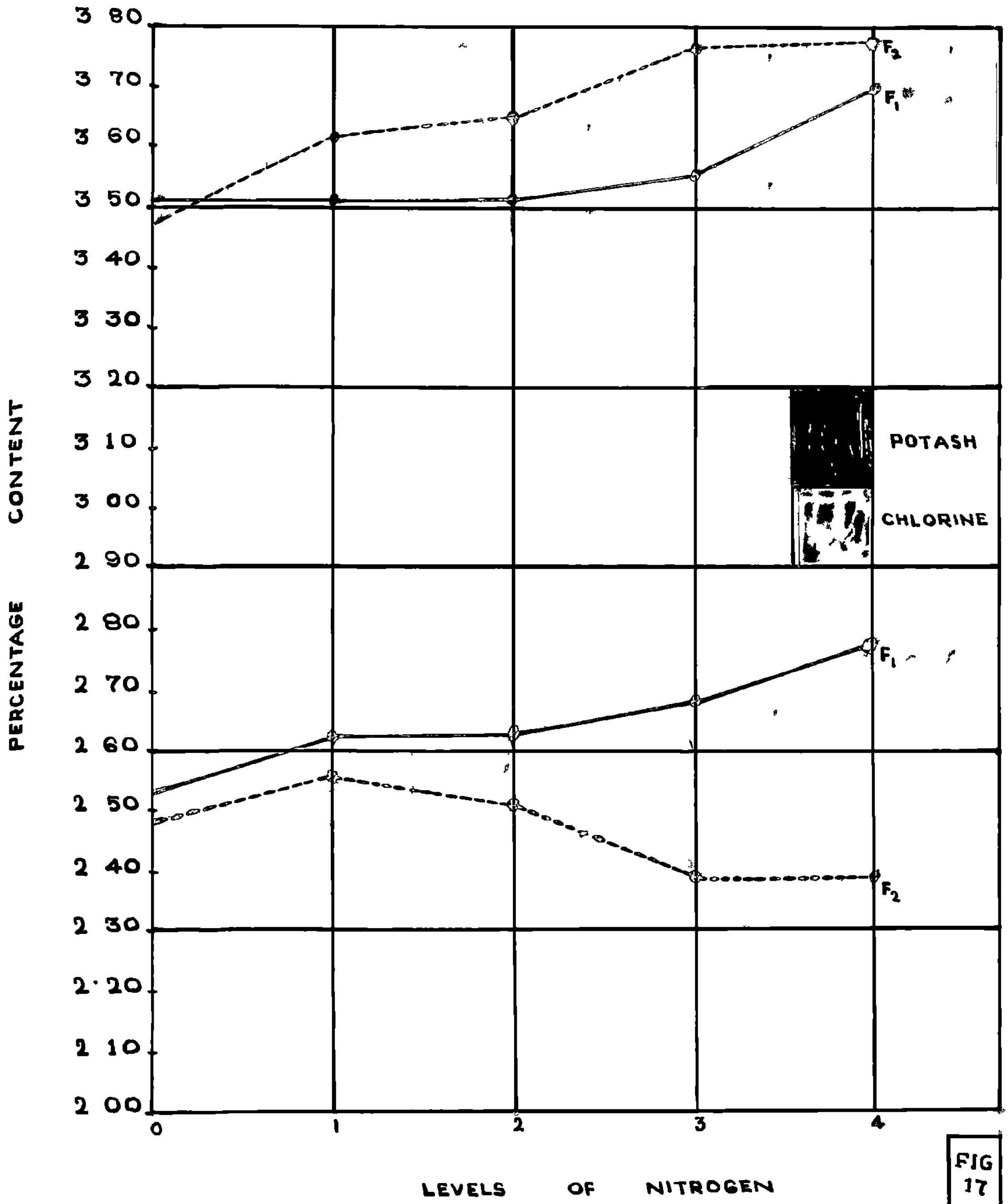


FIG 17

EFFECT OF METHODS OF APPLICATION OF FERTILIZER (AMMONIUM NITRATE) ON POTASH AND CHLORINE CONTENT OF CURED LEAF (PERCENTAGE)

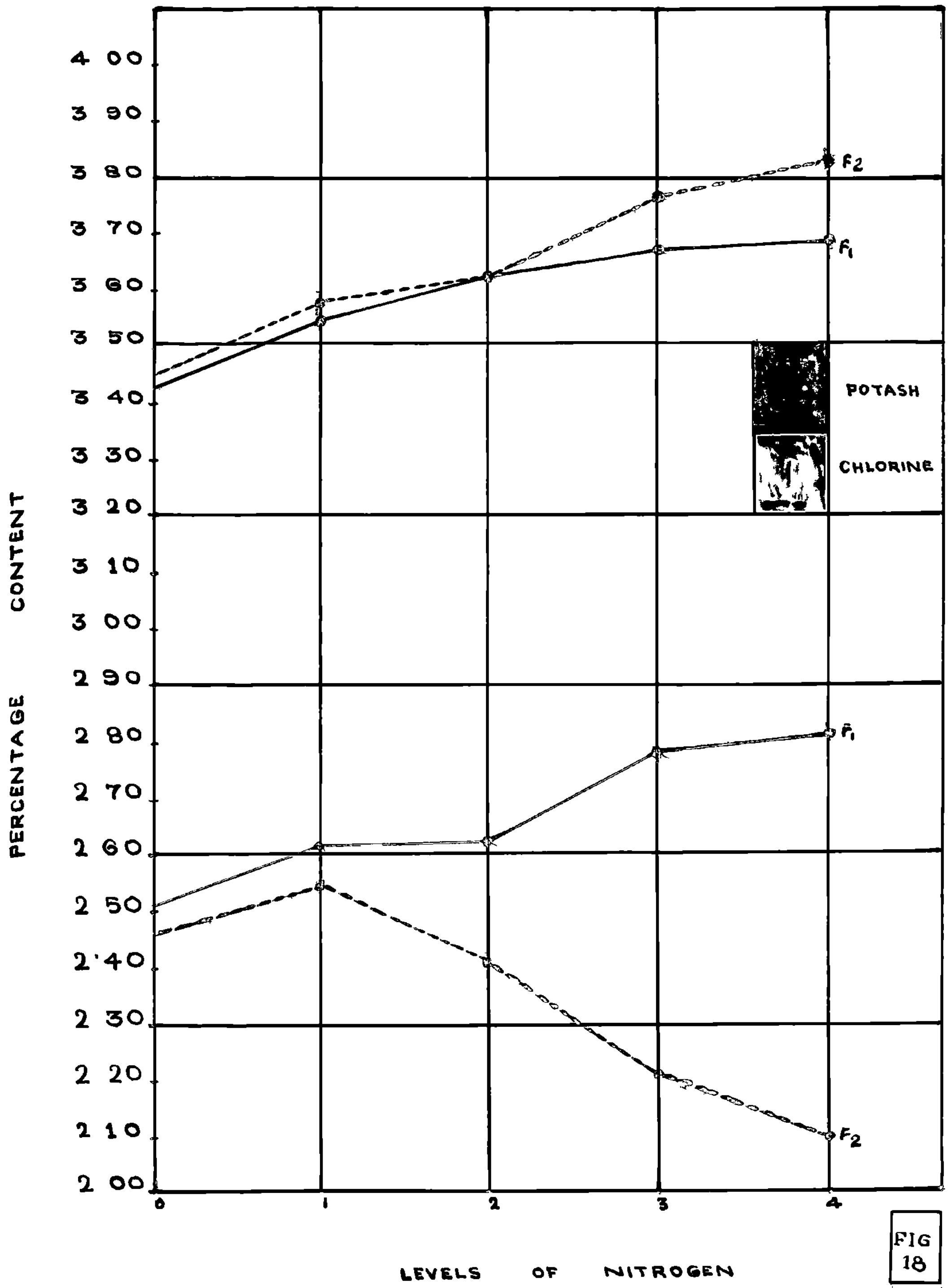


FIG 18


IV/2
IV/15
IV/16
IV/17
IV/18


IV/2
IV/22


IV/25


Y
14