THE TIME AND RATE OF PLANT NUTRIENT ABSORPTION BY BRIGHT TOBACCO

by

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TITLE.

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INTRODUCTION.

In the production of most farm crops, emphasis is placed on yield per acre. Other things being equal, the higher the yield per acre the lower the per unit cost of production. But in the case of flue-cured tobacco, emphasis is placed primarily on quality. Yield per acre is, of course important, but it must be sacrificed if and when it is obtained at the expense of quality. In the production of flue-cured tobacco both yield and quality play equally important roles. The better the quality of the crop the higher the price per pound, and the higher the yield of good quality tobacco the greater the value per acre.

The removal of soluble plant nutrients through prolonged periods of extremely heavy rainfall, following the fertilization and transplanting of the crop have resulted in decreased yield because of the lack of adequate nutrients in the soil to facilitate maximum absorption and growth at some critical period. In attempts to eliminate such effects and to provide a fertilizer that will supply nitrogen to feed the plants continuously from the early stages of growth to maturity it has been the common practice to include in the fertilizer considerable nitrate nitrogen as well as a large quantity of water insoluble nitrogen derived from natural organic sources. Both of these types of nitrogen add to the cost of the fertilizer and the latter is especially expensive. Also, prolonged periods of dry weather, following fertilization and transplanting of the crop have resulted in decreased yields because of injury from the fertilizer being placed in contact with the plant roots. However, this condition is eliminated when the fertilizer is machine placed to each side and slightly below the root crown of the plant.

The tobacco plant is very responsive to climatic changes, soil conditions, and the kinds and forms of plant nutrients supplied them in fertilizers. Many thorough investigations have been conducted in the flue-cured regions of the tobacco producing states on many problems relating to the production of this crop. These problems have dealt with the kinds and quantity of nitrogen required, the quantity of phosphoric acid, the quantity and sources of potash, the quantity of magnesia, sulfur, calcium, chlorine, and boron and the placement of fertilizer.

In the fertilization of a crop like flue-cured tobacco, which is very exacting in its plant food requirements and which requires a special and complicated fertilizer formula there are many problems concerning nutrition which have not been investigated. Some of the many questions to consider are: (1) How efficient is the crop in utilizing applied nutrients; (2) At what stage or stages during its growth does maximum absorption and utilization of nutrients occur; (3) What is the effect of different forms of nitrogen on nitrogen absorption: (4) What is the effect of different sources of magnesia on magnesia absorption;

and (5) What are the effects of split applications as well as fertilizer placement on nutrient absorption?

The object of this study was to seek information on, and to try and answer these questions in so far as they are related to the production of flue-cured tobacco.

REVIEW OF LITERATURE.

Thomas and Mack (17) in their work with Zea Mays in nutrient solutions state that: "The validity of the procedure in which plant tissue is analyzed to give some indication of the nutrients available and utilized by the plant is based on the experimental fact that; two morphologically homologous leaves of the same species and variety are the seat of identical physiological processes when the medium is identical and of different physiological processes when the mediums are different. Second, whenever a fertilizer element, whether N, P or K is effective as determined by response to that element, the response is invariably associated with an increase of that element in the dried material of the leaf. Third, the foliar diagnosis of plants of the same species grown on the same homogenous medium but receiving different fertilizer treatments are correlated with this development and also with the nature of the fertilizer applied".

Thomas and Mack (17) reported also from their work with Zea Mays that a relationship exists between the content of nitrogen in the leaf and the percentage of nitrogen in the fertilizer used, but no relationship was found to exist between the percentage of nitrogen in the fertilizer applied and the yield of the crop except when accompanied by additions of phosphoric acid and potash. A definite relationship exists between the content of phosphoric acid in the leaf and the yield of the crop; also between the content of phosphoric acid in the leaf and the percentage of phosphoric acid in the fertilizer, but the content of phosphoric acid is more nearly proportioned to the dry matter than to the total growth and water content. It was found that there was no relation between the content of potash in the leaf and in the fertilizer applied, and none between the variation, however great, of potash in the leaf and the variation in the yield. Also, there was no relationship between the amount of potash in the fertilizer applied and the yield of the crop. The amount of calcium and magnesia in the leaf was more nearly proportional to the dry matter then to the total growth and water content of Zea Mays. Also, the content of calcium and magnesium in the leaves of plants receiving superphosphate without potash was much higher than that of those plants which received potash with the superphosphate. Moreover, the calcium content of the leaves of plants receiving superphosphate differed but little from the calcium content of the leaves from the plants which received only lime.

Remy (15) in a discussion of fertilization in its relationship to the course of nutrient absorption of plants points out that environment as well as physiological characters have an influence on nutrient absorption during growth. Thus showing that it is not possible to speak of a strictly characteristic course of nutrient absorption for a given plant. It is characteristic of the relationship between anabolism and nutrient absorption that the absorption of soil nutrients at first markedly preceeds synthesis. As growth continues, an equilibrium is set up which, after reaching a high point, reverses the order of relationship. It was pointed out that it has never been observed when the stage of cessation of synthesis was reached before the cessation of nutrient absorption.

Remy (15) reported also that a greater supply of phosphoric acid and potash in the early stages of growth than is needed for the physiological requirement of the plant, is not deleterious, since these nutrients are not stimulating. These nutrients cannot cause an increase in the concentration of the soil solution sufficient to be injurious to the plant. However, in the case of nitrogen, the presence of an excessive supply in the soil during the early stages of growth can really be dangerous. If Nitrogen is not fully absorbed, it will be lost through leaching, and that quantity absorbed above immediate needs of the plant make the tender succulent plants susceptible to injury by frost and drought.

According to Burd (1) growth can be divided into three distinct periods. "The first period is one of intense vegetative activity; leaves are a vivid green, tissues are moist, and growth measured in both height and weight is considerable. The second period there is a structural differentiation taking place, leaves lose their green and moist appearance and leaves and stems fall off in total weight. The third period is characterized by a loss of weight and by dessication of all parts of the plant accompanied by a more or less complete loss of the green color of actively growing plant tissue".

Burd (1) in experiments conducted on alfalfa has shown that nitrogen, both in magnitude and in rate of absorption by the plant at all stages of growth, is more nearly proportional to total growth and water content of the plant than to that of the dry matter. The content of phosphoric acid is more nearly proportional to the yield of dry matter than to the total growth and water content of the plant, while the content of potash is similar to that of nitrogen in that both magnitude and rate of absorption by the plant at all stages of growth was more nearly proportional to the total growth, and water content, than to the yield of dry matter.

In experiments conducted by Wolfarth, Romer and Wimmer (19) it was found that barley, spring wheat, peas and mustard absorbed the maximum quantity of plant nutrients at the time of blossoming or at the beginning of fruit formation. As the crops approached maturity, part of the nutrients were returned to the soil, with the exception of phosphoric acid. If the supply of the nutrients was inadequate to meet the requirements of the plant, relatively larger amounts of these nutrients were returned to the soil than when the supply was sufficient for normal growth.

Gile and Carrero (10) report studies with rice in which it was found that after a certain stage of maturity was reached the content of plant nutrients decreased. The content of potash, phosphoric acid, nitrogen and sulfur in the ash of the above ground portion of the plant was found to decrease as the age of the plant increased.

In an experiment conducted by Burd (1) plants which were well protected, at all times to prevent a possible leaching out of the nutrients by rain, showed a loss in content of both nitrogen and potash as the plants approached maturity. The losses of these nutrients from the leaves of plants were explained on the basis that they were being returned either to the roots of the plants or to the soil.

Zitkowski and Coworkers (20) investigated the composition of sugar beets. Both leaves and roots were sampled at two week intervals throughout the growing season. Leaf composition showed an increase in chlorine, sulphates, and calcium with an accompanying decrease in iron and alumina oxides. Root composition showed similar results, with the exception of phosphoric acid, which showed a tendency to decrease in the leaves and increase in the roots. The calcium and magnesium content in roots increased appreciably while the content of potassium and sodium remained practically constant.

Davidson (8) conducted experiments to determine the composition of tobacco plants at different stages of growth. The results showed that plants from the plant bed had the highest, content of ash, phosphoric acid and potash. As the age of the plants increased, the content of potash and phosphoric acid gradually decreased while the content of lime and chlorine in the plants increased.

Davidson(9) conducted another experiment to determine the composition of four different varieties of tobacco. The four varieties studied were: Bradley broad leaf, Gold feeder, White Burley and Yellow Aronaco. All were found to agree very closely in chemical composition with the exception of White burley which contained about twice as much phosphoric acid as any other variety.

Davidson (7) found in his studies of the composition of two grades of flue-cured tobacco, that the ash of both were about the same, while the low grade tobacco contained about twice as much of each of nitrogen, phosphoric acid, potash, magnesium and sulfuric acid as the high grade.

In investigations in Agricultural Chemistry at the California Station (2) the evidence reported seems quite clear that with crops such as tomatoes and barley, it is possible under suitable conditions to obtain a highly consistent reflection of soil conditions in the composition of the crop.

Burd and Martin (4) in their studies in plant nutrition show that although the addition of nutrients to a fertile soil does not necessarily mean an increase in yield of the crop, it does have a marked influence on the absorption of one element and the diminishing effect on the absorption of others. For example, an application of phosphorus was found to reduce the absorption of potassium while nitrogen increases it.

Experiments conducted by Corelus (5) with potatoes show that this crop has its maximum nutrient requirements between the 10th and 14th weeks of growth. Sap analysis data shows that,"Under optimum conditions the nitrogen content would be 700-800 parts per million: the soluble phosphorus, a minimum of 150 parts at the beginning and 60 parts per million at the end of the growing season; the soluble magnesia, a minimum of 275 parts at the beginning and 800 parts per million at the end of the season; and the soluble potash being a minimum of 600 parts at the beginning and 1400 parts per million at the end of the season".

Hester (11) conducted a series of experiments with tomato plants, ~~from~~ on a well fertilized sandy loam soil, in which samples were collected at one-month intervals to determine the amount of plant nutrients absorbed during various periods of growth. It was found that with a production of 2 percent of the total dry weight during the first month, the plants absorbed 3 percent of the combined total nitrogen, phosphorus, calcium and magnesia and 2 percent of the total potassium. During the second month, the crop produced 26 percent of its total dry weight and absorbed approximately 30 percent of its combined total nutrients. During the final month of the growing period, there was an increase in absorption of nitrogen from 0.1 pounds per day in the first month, to 1.90 pounds, the second, and in the third and final month to 2.25 pounds. The total plant nutrient absorption per acre increased from 0.4 pounds per day in the first month to 4.3 pounds the second month and 9.5 pounds in the final month.

Hundertmark and Allison (12) conducted an experiment with potatoes in Florida to determine whether nitrogen in urea, a synthetic organic nitrogen carrier, could be substituted in a mixed fertilizer in place of the more expensive organic source of nitrogen. It was found that fifty percent of the N, in a mixed fertilizer for potatoes, may be derived from urea instead of natural organic fertilizer when the remminder is derived, 15 percent from sodium nitrate and 35 percent from ammonium sulphate, without appreciably affecting the yield.

PROCEDURE.

Yellow Mammoth was the variety of flue-cured tobacco used in this study. The tobacco was grown at Chatham on Granville Sandy Loam, and was fertilized with 900 pounds per acre of a 3-10-6 fertilizer. This fertilizer application supplied 27 pounds per acre of nitrogen, 90 pounds of phosphoric acid, 54 pounds of potash, 18 pounds each of magnesium and chlorine, as well as an estimated 90 pounds each of calcium and sulfur. Three different fertilizer formulas were used; but in each case, with the exception of the sources of nitrogen, they were made according to the official recommendations of the Tobacco Research Committee (18).

Nine treatments in duplicate were used with each plat being 1/40 acre in area. Plat No. 5 served as a check (standard fertilizer) and was furmulated as follows: 1/3 nitrogen derived from nitrate of soda, 1/3 from ammonium sulphate, and 1/3 from an equal combination of cottonseed meal, fish scrap (dried) and process tankage; all of phosphoric acid from 20 percent superphosphate; 1/3 potash from 60 percent muriate of potash (sufficient chlorine was supplied in muriate of potash and superphosphate to give the mixture the required 2 percent chlorine recommended), and 2/3 potash from 48 percent sulphate of potash and 2 percent magnesia was supplied from magnesium sulphate. The fertilizer for each of the other plats was formulated as follows: nitrogen as stated in the plat outline, Table 1; phosphoric acid and potash as stated above. Two percent magnesia from magnesium sulphate was included in the fertilizer mixture for each plat, except plats

<u>Table - 1:-</u> Plat Treatments.

Plat	Source	Nitrogen % Derived	
Plat 1	(Urea	1/3)	
	(Ammonium sulphate	1/3)	
	(Nitrate of Soda	1/3)	
Plat 2	(Urea	1/2)	
	(Ammonium Sulphate	1/2)	
Plat 3	(Urea	1/2)	All MgO from
	(Ammonium Sulphate	1/2)	Dolomite
Plat 4	(Urea	1/2)	
	(Ammonium Sulphate	1/2)	No MgO
Plat 5	(Check - Standard Fertilizer)		
	(Organic Nitrogen*	1/3)	
	(Ammonium Sulphate	1/3)	
	(Nitrate of Soda	1/3)	
Plat 6	(Organic Nitrogen*	1/3)	one-third (1/3) ofnitrogen -
	(Ammonium Sulphate	1/3)	the nitrate of soda ~~will be~~ was
	(Nitrate of Soda	1/3)	appléed as side dressing, 21 days after transplanting.
Plat 7	(Urea	1/2)	
	(Ammonium Sulphate	1/2)	one-half (1/2) of nitrogen at transplanting and one-half (1/2) 21 days later.
Plat 8	(Organic Nitrogen*	1/3)	one-third of nitrogen - the
	(Ammonium Sulphate	1/3)	nitrate and one-half (1/2)
	(Nitrate of Soda	1/3)	of the potash (3%) ~~will be~~ was applied 21 days after transplanting.
Plat 9	(Urea	1/2)	Fertilizer applied 2½" to
	(Ammonium Sulphate	1/2)	each side and 1" below the root crown of the plant.

* Nitrogen derived equally from a combination of cottonseed meal, fish scrap (dried) and process tankage.

3 and 4. For plat 3 magnesia was derived from dolomitic limestone,

while plat 4 received no magnesia. All phosphoric acid and potash supplied in the organics was included in making up the actual total of these elements contained in the mixture. It will be noted in the plat outline (Table 1) that 1/3 of the nitrogen, the nitrate, supplied in the fertilizer for the crop grown on plat 6 was applied as a side dressing. Plat 8 received 1/3 of its nitrogen, the nitrate, and 1/2 of its potash as a side dressing. Fertilizers were, in all cases, made neutral with calcic limestone. Fertilizers for all plats, except 9, were applied by the local method of application; while on plat 9, the fertilizer was applied by machine and placed 2½ inches to each side and 1 inch below the root crown of the plant.

A sample of transplants, one hundred and sixty five plants, were taken from the plant bed the day that plants were set in the field. These transplants were of average size and uniformity. The first field samples were taken 21 days following transplanting and samples were taken thereafter at two week intervals until the plants reached maturity. These samples consisted of ten plants of uniform size. Due to the size of the plants, only five plants were taken at the second, third and fourth sampling periods.

Weather conditions, following transplanting were ideal for the first eight weeks of the growing season. During the ninth week (July 16-23), a rainy spell occurred; and for five consecutive days the precipitation was approximately one-half inch each day. Following the rainy period, tobacco ripened very rapidly. The first harvest began on July 26: and on August 8 (the date of sampling for the fifth growth period), approximately 60 percent of the crop on each plat had been harvested. Consequently, samples for the fifth period were not taken.

Also, at the same time as field samples were obtained, sap extractions were made on a five gram sample of plant tissue. The plant tissue used for sap extraction was taken from the lower part of the midribs of the leaves. Sap extractions were made according to the rapid chemical method employed by Corelus (6). The extractions were analyzed for total soluble nitrogen, total soluble phosphorus, potash, magnesia and calcium.

After the field samples had been completely air dried, they were analyzed by chemical methods in order to determine the total amounts of nitrogen, phosphoric acid, potash, magnesia and calcium contained in the plants at the various stages of growth. Plants taken at the end of 21 and 35 days of growth under field conditions were relatively small, therefore, the leaves and stalks were combined and analyzed while the leaves and stalks were analyzed separately for the 49th and 63rd day growth samples.

The total nitrogen was determined according to the official methods of the A. O. A. C. (14). The total calcium, magnesia and phosphoric acid determinations were modified from the official A. O. A. C. method in the following manner: The plant material was burned to a gray ash, taken up in dilute HCl (1 ≠ 4) and made up to exactly 250 cc. Determinations were made on 100 cc aliquots according to official A. O. A. C. methods. The potash determination used was a modification of the Schueler and Thomas method (17) and was run as follows: treat one gram of dried plant material with 10 cc of 10% H_2SO_4, burn over an open flame to dry and expel SO_3 fumes; burn residue in an oven to a gray ash, take up ash in 25 cc of a dilute HCl solution and neutralize with NaOH, acidify solution with 4 drops of 99% acetic acid, add 10 cc alcohol, cool, add 5 cc of 30% cobalti nitrite solution, allow to stand over night at 5° C. and filter, wash precipitate five times with .01 N. HNO_3, place in original beaker, add 20 cc of .5 N NaOH and 75-100 cc of hot water, boil 3 minutes, transfer hot solution to an excess of permanganate in 25-50 cc of water and 5 cc H_2SO_4, boil, add excess of oxalic acid, back titrate with permanganate solution, (13).

RESULTS.

At the time of sampling there were no outstanding differences in the various plats either in size or quality of plants. The treatments employed on Plats 1, 2, 3 and 5 show no significant differences in yield or value per acre due to different sources of nitrogen applied to flue-cured tobacco. Applying one-third of the nitrogen (the nitrate) and one-half of the potash as a side dressing 21 days after transplanting gave an increase in yield of 193 pounds and \$25.47 per acre in value as compared to applying all of the fertilizer at planting time (plats 5 and 8). Machine placement of the fertilizer (plat 9) gave an increase in yield of 163 pounds and \$29.92 per acre in value as compared to mixing the fertilizer with the soil (plats 2 and 9).

Table - 2:- Effect of Various Fertilizer Treatments on the Yield and Value per Acre of Flue-Cured Tobacco for 1939.

	Source of Nitrogen	Pounds per Acre	Value per Acre
1	Urea 1/3, Ammonium Sulfate 1/3, Sodium Nitrate 1/3	1096	\$ 191.34
2	Urea 1/2, Ammonium Sulfate 1/2	1117	186.35
3	Urea 1/2, Ammonium Sulfate 1/2, from ($MgCO_3$)	1085	191.98
4	Urea 1/2, Ammonium Sulfate 1/2, from (No Mg)	1102	210.51
5	Standard Fertilizer* (T. E. C.) - check -	1092	191.30
6	Standard Fertilizer (Sodium Nitrate ½ side dressed)	1074	195.72
7	Urea 1/2, Ammonium Sulfate 1/2 (½ N-Side dressed	1170	206.56
8	Standard Fertilizer (Sodium Nitrate and ½ K_2O side dressed)	1285	216.77
9	Urea 1/2, Ammonium Sulfate 1/2 (in bands)	1280	214.27

* Refer to Plat 5: Table 1.

The data presented in Table 2 shows that on June 13, three weeks after transplanting, plants receiving treatments 6 and 9 (plats 6 and 9) produced the most rapid growth, while those receiving treatment No. 2 (plat 2) made the least growth of any of the treatments used. On June 27, the end of the second growth period, the largest increase in weight was produced with treatment 4 (plat 4). The greatest rate of growth occurred during the sixth and seventh weeks, following transplanting at which time treatment 9 (plat 9) gave the greatest rate of growth. During the eighth and ninth weeks, treatment 3 (plat 3) gave the greatest total increase in growth. An average of the yields for each period of growth in which all treatments are combined shows that for the first three weeks following transplanting the plants increased in weight only 32.5 pounds per acre. During the fourth

Table - 3:- The Rate of Growth of Flue-cured Tobacco by Periods Expressed in Pounds per Acre.

Treatments No.(1)	June 13	June 27	July 11	July 25	Total
1	23.0	225.2	730.5	651.8	1630.5
2	18.9	221.4	826.5	693.9	1760.7
3	33.6	317.9	685.6	748.6	1785.7
4	31.6	343.1	846.8	5.0.6	1732.1
5	37.3	262.4	755.5	383.9	1439.1
6	45.2	299.9	774.4	435.0	1554.5
7	32.5	299.8	955.9	423.3	1711.5
8	28.5	308.7	862.3	671.9	1871.4
9	41.7	304.7	1054.4	336.9	1737.7
Average	32.5	287.0	855.2	517.3	1692.0

(1) Detailed treatments are given on page 12

and fifth weeks the increase in growth was 287 pounds per acre. However, in the sixth and seventh weeks an additional increase of 832.4 pounds per acre was obtained. Also during the eighth and ningh weeks considerable growth was produced as evidenced by a gain of 539.5 pounds per acre.

Table - 4:- Percent of Total Growth Produced in Each Period.

Treatment No. (1)	June 13	June 27	July 11	July 25
1	1.41	13.81	44.80	39.97
2	1.07	12.57	46.94	39.41
3	1.88	17.80	38.39	41.92
4	1.82	19.80	48.88	29.47
5	2.59	18.23	52.49	26.67
6	2.90	19.29	49.81	27.98
7	1.89	17.51	55.85	24.73
8	1.52	16.49	46.07	35.90
9	1.39	17.53	60.67	19.38

(1) Detailed treatments are given on page 12

The data in table 4 shows that for the first two periods of growth there were no marked differences in favor of any treatment. In the third period, July 11, treatment No. 9 (plat 9) produced the greatest growth and treatment No. 3 (plat 3) the least. However, in the fourth period, July 25, it will be noted that treatment No. 3 (plat 3) gave the greatest growth and treatment No. 9 (plat 9) gave the least.

It is of interest to note, when all treatments are combined, that during the first five weeks following transplanting approximately 19 percent of the total yield per acre was produced. However, about 81 percent of the total yield was produced during the last 28 days of the 63 day growing period.

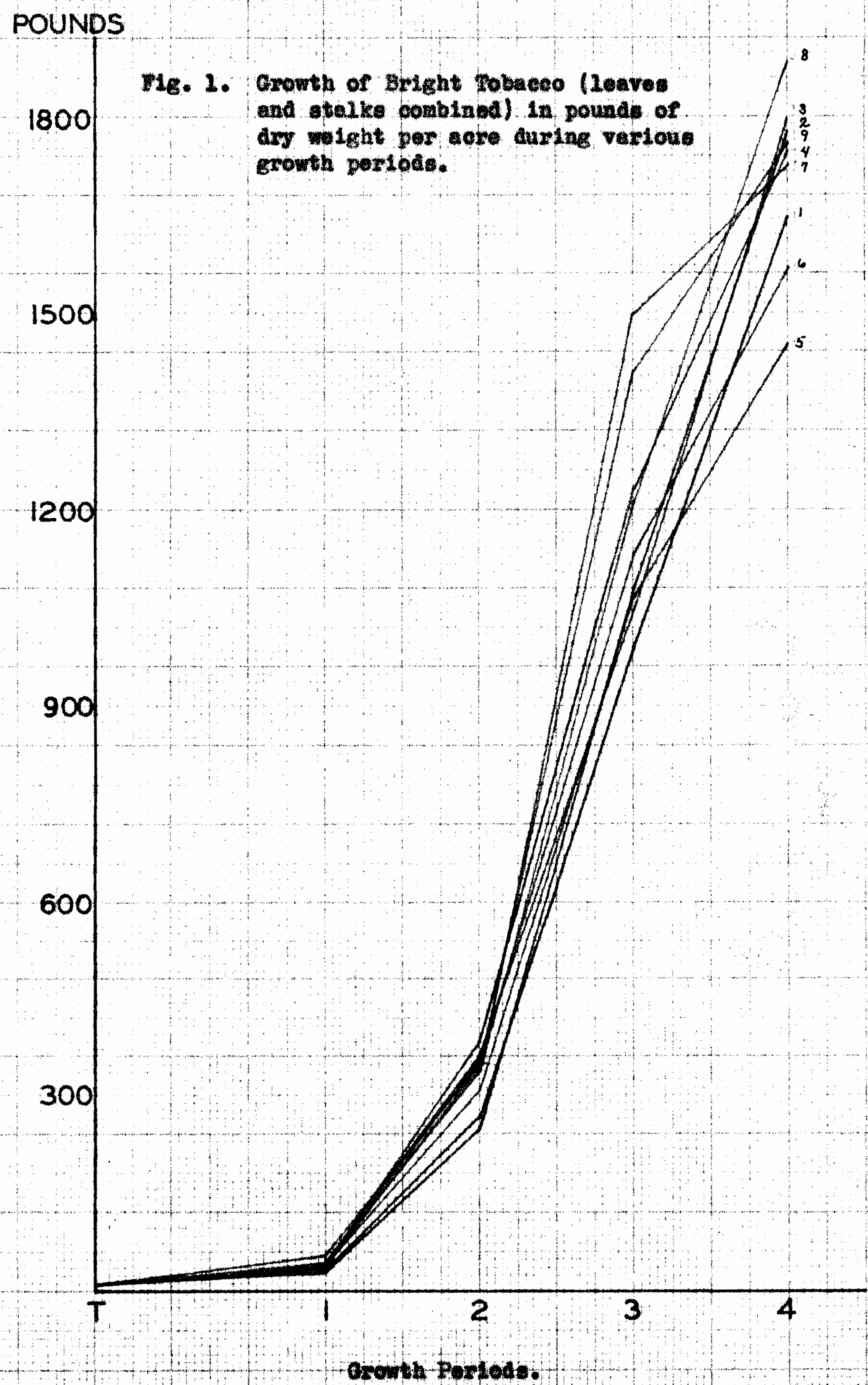


Fig. 1. Growth of Bright Tobacco (leaves and stalks combined) in pounds of dry weight per acre during various growth periods.

Table - 5:- Average Daily Gain for Each Sampling Period in Pounds per Acre.

Plat No.	June 13	June 27	July 11	July 25
P-1	1.09	16.08	52.18	46.55
P-2	.90	15.81	59.03	49.56
P-3	1.60	22.70	48.97	53.47
P-4	1.50	24.50	60.48	36.47
P-5	1.77	18.74	53.96	27.42
P-6	2.15	21.42	55.31	31.07
P-7	1.54	21.40	68.27	30.21
P-8	1.35	22.05	61.56	47.99
P-9	1.98	21.76	57.31	24.06

It will be noted in table 5 that the average daily gain per acre for each growth period (average of nine duplicate plats) was for the 21 days following transplanting, 1.54 pounds per day. From the 22nd to 35th day, the daily gain was 20.5 pounds per acre per day; from the 36th to 49th day it was 57.45 pounds per day while for the 50th to the 63rd day it was 38.53 pounds per day.

SAP ANALYSIS.

The data presented in tables 6, 7, 8 and 9 show a wide variation in soluble nitrogen ~~wide variation~~ in plant sap extracts between plats at each sampling period, but this variation is not consistent between duplicate treatments and thus is not considered significant. The concentration of soluble nitrogen for the five sampling periods shows a high concentration at transplanting and a slightly lower concentration during the 21 day growth period. This drop in concentration of nitrogen was probably due to the plants establishing themselves after transplanting. In the 35th day growth period the concentration of soluble nitrogen was very high, after which it decreased rapidly as the plants approached maturity. This drop in concentration occurs over the periods at which the plant is making its greatest percentage of its growth, and may be accounted for by a greater utilization of the nitrogen during these two periods.

The concentration of soluble phosphorus in the plant was similar in trend to that of soluble nitrogen but not in magnitude. The concentration of phosphorus was low in the transplants and dropped slightly during the 21 day growth period. During the 35th and 49th day growth periods the concentration of soluble phosphorus was very high but decreased very rapidly during the last period of growth as the plants approached maturity. This drop in concentration, as in the case of soluble nitrogen, occurred when the plants were making the most rapid growth.

The concentration of potash and calcium was low in the early stages of plant growth and very high during the latter periods. Potash and calcium absorption differ from that of the soluble nitrogen and phosphorus in that the rate of absorption of these elements increased very rapidly as the plant approached

Table - 6:- Total Yield, rate of growth per acre, and p.p.m. of plant nutrients contained in green tobacco at transplanting and 21 days after transplanting (June 13).

Plats	Total Yield per Acre - lbs.	Rate of Growth Pounds per acre.	p.p.m. of Plant Nutrients in Tobacco				
			NO_3	P_2O_5	K_2O	MgO	CaO
Transplants	11.2	--------	425	138	7,500	1,950	475
1	34.6	23.4	337	60	4,500	1,000	300
2	25.2	14.0	400	135	7,000	1,500	450
3	28.9	17.1	350	120	7,500	2,000	600
4	24.4	13.2	500	175	5,500	1,500	400
5	34.4	23.2	300	130	7,500	1,500	450
6	39.7	28.5	315	150	7,000	2,000	300
7	39.3	28.1	315	125	8,000	2,000	300
8	39.8	28.6	450	125	5,500	2,000	250
9	55.1	43.9	375	65	5,000	2,000	400
1a	33.9	22.7	500	175	9,500	1,500	225
2a	35.0	23.8	400	82	7,500	2,000	525
3a	61.3	50.1	300	135	10,000	1,500	750
4a	61.3	50.1	500	82	5,000	1,750	500
5a	62.7	51.5	415	135	8,000	1,500	150
6a	73.1	61.9	150	178	7,500	2,000	275
7a	48.2	37.0	340	87	8,000	1,750	425
8a	39.7	28.5	275	90	4,500	2,000	500
9a	50.7	39.5	490	65	9,500	2,000	400

Average of the Above Individual Plat Treatments.

Transplants	11.2	----	425	138	7,500	1,950	475
1	34.2	23.0	419	118	7,000	1,250	263
2	30.1	18.9	400	109	7,250	1,750	488
3	45.1	33.6	325	128	8,250	1,750	675
4	42.8	31.6	500	129	5,250	1,625	450
5	48.5	37.3	358	133	7,750	1,500	300
6	56.4	45.2	233	163	7,250	2,000	288
7	43.7	32.5	328	106	8,000	1,875	363
8	39.7	28.5	363	108	5,000	2,000	375
9	52.9	41.7	433	65	7,250	2,000	400
Average	43.7	32.4	362	117	7,000	1,750	400

Table - 7:- Total Yield, rate of growth per acre, and p.p.m. plant nutrients contained in green tobacco 35 days after transplanting (June 27).

Plats	Total Yield per Acre - lbs.	Rate of Growth Pounds per Acre	p.p.m. of Plant Nutrients in Tobacco				
			NO_3	P_2O_5	K_2O	MgO	CaO
1	267.2	232.6	790	175	5,500	1,750	575
2	228.7	193.6	900	180	4,500	1,900	675
3	319.4	290.5	550	270	9,500	1,750	825
4	245.6	221.2	340	175	7,500	1,750	825
5	210.5	176.1	925	270	7,500	1,750	700
6	239.6	199.9	630	285	5,000	1,100	750
7	318.2	278.9	800	350	4,500	1,250	700
8	285.6	245.8	790	350.	7,000	1,500	750
9	323.1	268.0	900	300	8,000	1,500	825
1a	251.7	217.8	900	180	4,500	1,750	500
2a	284.3	249.3	830	220	4,500	1,900	675
3a	406.6	345.3	525	420	5,500	2,000	1,100
4a	526.6	465.0	620	430	5,000	1,250	825
5a	411.4	348.7	280	620	7,500	2,000	825
6a	473.1	400.0	300	620	8,000	1,750	950
7a	369.0	320.8	650	500	7,500	1,900	825
8a	411.4	371.7	600	430	2,500	1,750	750
9a	392.1	341.4	830	285	5,000	2,000	750

Average of the Above Individual Plat Treatments.

1	259.4	225.2	845	178	5,000	1,750	538
2	251.5	221.4	865	200	4,500	1,900	675
3	363.0	317.4	538	345	7,500	1,875	963
4	386.1	343.1	480	303	6,250	1,500	825
5	310.9	262.4	603	450	7,500	1,375	763
6	356.3	299.9	465	453	6,500	1,425	850
7	343.6	299.8	725	423	6,000	1,575	763
8	348.5	308.7	695	390	4,250	1,625	750
9	357.6	304.7	865	293	5,500	1,750	788
Average	330.7	287.0	675	337	6,000	1,697	768

Table - 8:- Total yield and rate of growth per acre, and p.p.m. of plant nutrients contained in green tobacco 49 days after transplanting (July 11)

Plats	Total Yield per Acre - Lbs.	Rate of Growth Pounds per Acre.	p. p. m. of Plant Nutrients in Tobacco. NO_3	P_2O_5	K_2O	MgO	CaO
1	968.7	701.5	375	240	16,000	1,100	1,250
2	1,013.4	784.7	125	175	10,000	1,000	1,500
3	1,105.7	786.3	150	180	5,000	1,100	1,500
4	1,140.3	894.7	380	180	10,000	1,100	1,000
5	1,001.9	791.4	100	250	10,000	1,000	500
6	1,163.4	923.8	360	175	10,000	1,000	1,000
7	1,276.3	958.1	160	105	12,500	1,100	1,500
8	1,176.8	891.2	150	130	10,000	1,000	1,750
9	1,377.7	1,054.6	175	85	16,000	1,000	1,000
1a	1,010.3	758.6	200	215	18,000	1,100	1,750
2a	1,152.6	868.3	275	275	16,000	1,000	1,750
3a	991.5	584.9	135	350	11,000	1,000	1,500
4a	1,325.2	798.5	100	165	11,000	1,000	2,000
5a	1,131.1	719.7	75	385	18,000	1,000	1,500
6a	1,098.2	625.1	80	350	16,000	1,100	500
7a	1,322.8	953.8	75	300	12,500	1,000	1,500
8a	1,244.8	833.4	80	375	5,000	1,000	1,500
9a	1,446.4	1,054.3	85	200	5,000	1,000	1,500

Average of the Above Individual Plat Treatments.

1	989.5	730.1	288	228	17,000	1,000	1,500
2	1,083.0	826.5	200	225	13,000	1,000	1,625
3	1,048.6	685.6	143	265	8,000	1,050	1,500
4	1,232.6	846.6	240	175	10,500	1,050	1,500
5	1,066.5	755.5	88	318	14,000	1,000	1,000
6	1,130.8	774.4	220	263	13,000	1,050	750
7	1,299.6	955.9	118	203	12,500	1,050	1,500
8	1,210.8	862.3	115	253	7,500	1,000	1,625
9	1,412.5	1,054.4	130	143	10,500	1,000	1,250
Average	1,185.9	832.4	171	230	11,777	1,022	1,361

Table - 9:- Total yield and rate of growth per acre, and p.p.m. plant nutrients contained in green tobacco 63 days after transplanting (July 25).

Plats	Total Yield per Acre - lbs.	Rate of Growth Pounds per Acre.	p.p.m. of Plant Nutrients in Tobacco.				
			NO_3	P_2O_5	K_2O	MgO	CaO
1	1,654.5	685.6	120	50	14,000	1,100	1,500
2	1,613.2	599.8	90	48	15,000	1,250	1,000
3	1,649.5	543.8	50	40	18,000	1,250	1,500
4	1,755.2	614.9	75	40	18,000	1,100	1,500
5	1,536.3	534.4	85	40	18,000	1,100	1,500
6	1,295.1	152.5	50	40	18,000	1,250	1,000
7	1,825.9	549.6	55	35	15,000	1,250	1,500
8	1,816.7	639.9	50	46	12,500	1,250	2,000
9	1,889.3	511.6	40	30	14,000	1,000	1,000
1a	1,628.4	618.1	50	48	15,000	1,100	1,500
2a	1,940.6	788.0	40	40	15,000	1,250	1,500
3a	1,945.0	953.5	50	60	14,000	1, 100	1,500
4a	1,731.5	406.3	55	63	12,500	1,000	1,500
5a	1,364.6	233.5	50	50	14,000	1,250	1,500
6a	1,835.8	737.6	55	48	14,000	1,250	1,500
7a	1,619.9	297.1	55	40	12,500	1,250	2,000
8a	1,948.8	704.0	50	50	15,000	1,350	1,500
9a	1,608.6	162.2	55	64	12,500	1,100	2,000

Average of the Above Individual Plat Treatments.

1	1,641.3	651.8	85	49	14,500	1,100	1,500
2	1,776.9	693.9	65	44	15,000	1,250	1,250
3	1,797.2	748.6	50	50	16,000	1,175	1,500
4	1,743.3	510.6	65	52	15,250	1,050	1,500
5	1,450.4	383.9	68	45	16,000	1,175	1,500
6	1,565.8	435.0	53	44	16,000	1,250	1,250
7	1,722.9	423.3	55	38	13,750	1,250	1,750
8	1,882.7	671.9	50	48	13,750	1,300	1,750
9	1,748.9	536.9	50	47	13,250	1,050	1,500
Average	1,703.2	539.5	60	46	14,833	1,177	1,500

maturity. The calcium and potash show the same trend in concentration throughout the growing period but the magnitude of concentration of the potash is much greater than the calcium.

The concentration of magnesia was highest during the early stages of growth and gradually decreased as the plants approached maturity. This may indicate that magnesia absorption is more or less constant throughout the growing period, for as growth increases the concentration of magnesia correspondingly decreases.

CHEMICAL ANALYSIS.

The data presented in tables 10, 11, 12, 13 and 14 shows that during the early stages of growth, first five weeks after transplanting, flue-cured tobacco was higher in content of total nitrogen than during the later stages of growth. Also as the plants approached maturity the content of nitrogen in both the leaves and stalks decreased rapidly.

Transplants contained a higher percentage of phosphoric acid than at any stage of growth. After the plants were transplanted the content of phosphoric acid in flue-cured tobacco increased up to the 35th day growth period. However, during the latter stages of growth and as the plants approached maturity there was a slight decrease in content of phosphoric acid.

Transplants had a much higher content of potash than did the plants at the end of the first period of growth. There was a marked increase in content of potash at the end of the fifth week following transplanting as compared to that of the plants harvested three weeks after transplanting. During the third and fourth periods of growth the content of potash in the plants decreased rapidly. The stalks contained a higher percentage of potash than did the leaves, and as the plants approached maturity there was a decided decrease in the condent of potash in both the stalks and leaves.

The transplants had a higher content of calcium than did the plants 21 days after transplanting. The calcium content of the plants showed a decided increase during the second period of growth as compared to that of plants at the end of the first growth period. At the end of the third growth period the plants had a very high content of calcium in both the leaves and the stalks, but as the plants approached maturity the content of calcium in both the leaves and stalks decreased very markedly.

The transplants had a low content of magnesia. There was a slight decrease in content of magnesia in the plants 21 days after transplanting as compared to that of the transplants. The content of magnesia in the plants increased appreciably during the second and third periods of growth while there was a decided decrease in content of magnesia in the plants during the last

Table - 10:- Chemical Composition of Flue-cured Tobacco, (oven dry basis) at transplanting.

Plat No.	Yield Pounds per Acre.	P E R C E N T: N	P E R C E N T: P_2O_5	P E R C E N T: K_2O	P E R C E N T: CaO	P E R C E N T: MgO
Transplants	11.2	4.71	1.21	6.29	3.07	.87

Table 11:- Chemical Composition of Flue-cured Tobacco, (oven dry basis) 21 days after transplanting.

Plat No.	P E R C E N T: N	P E R C E N T: P_2O_5	P E R C E N T: K_2O	P E R C E N T: CaO	P E R C E N T: MgO
1	4.74	.91	4.16	2.45	.61
2	4.73	.93	3.82	2.36	.88
3	4.44	.86	3.71	3.04	.62
4	4.77	.92	4.24	2.72	.73
5	4.24	.89	4.18	2.58	.60
6	4.34	.84	4.56	2.71	.73
7	4.31	.90	4.54	2.50	.77
8	5.20	.92	3.79	2.81	.61
9	5.16	.73	3.98	2.23	.81
1a	4.68	.82	4.27	2.64	.47
2a	4.42	.76	4.20	2.59	.57
3a	4.67	.89	4.48	2.57	.47
4a	4.85	.89	4.83	3.39	.47
5a	4.27	.89	4.21	2.73	.98
6a	4.16	.91	4.91	2.66	.95
7a	4.83	.96	4.63	2.76	.72
8a	4.32	.85	5.94	2.78	.92
9a	4.41	.79	3.98	2.99	.61

Average of Duplicate Treatments Shown Above.

1	4.71	.86	4.21	2.54	.54
2	4.57	.84	4.01	2.47	.72
3	4.55	.87	4.09	2.80	.54
4	4.81	.90	4.53	3.05	.60
5	4.25	.89	4.19	2.65	.79
6	4.25	.87	4.73	2.68	.84
7	4.57	.93	4.58	2.63	.74
8	4.76	.88	4.86	2.79	.76
9	4.78	.76	3.98	2.61	.71
Average	4.58	.87	4.35	2.69	.69

Table - 12:- Chemical Composition of Flue-cured Tobacco (oven dry basis) 35 days after transplanting.

Plat No.	PERCENT				
	N	P_2O_5	K_2O	CaO	MgO
1	4.99	1.01	5.91	2.99	1.02
2	5.04	1.06	6.77	3.04	1.08
3	4.89	1.04	5.60	3.43	.89
4	4.97	.95	5.90	3;77	1.00
5	4.91	1.01	6.72	3.13	1.07
6	4.77	.93	6.90	3.29	1.01
7	4.68	.91	6.29	3.10	1.14
8	5.07	.94	5.04	3.36	1.23
9	4.95	.90	5.34	2.80	1.43
1a	5.45	1.11	5.85	3.38	1.03
2a	4.74	.98	6.38	3.01	.95
3a	4.86	1.05	4.54	3.24	.86
4a	4.38	.89	5.29	3.16	.81
5a	4.36	1.03	5.38	2.80	.90
6a	3.91	.93	5.78	2.82	1.03
7a	4.54	.96	6.43	3.50	1.03
8a	4.37	.99	6.52	3.41	1.04
9a	4.63	.95	7.01	3.91	1.26

Average of Duplicate Treatments Shown Above.

1	5.22	1.06	5.88	3.17	1.02
2	4.89	1.02	6.57	3.02	1.01
3	4.87	1.04	5.07	3.33	.87
4	4.67	.92	5.59	3.46	.90
5	4.63	1.02	6.05	2.96	.98
6	4.34	.93	6.34	3.05	1.02
7	4.61	.93	6.36	3.30	1.08
8	4.72	.96	5.78	3.38	1.13
9	4.79	.92	6.07	3.35	1.34
Average	4.75	.98	5.97	3.23	1.04

Table - 13:- Chemical Composition of the Leaves and Stalks of Flue-cured Tobacco (oven dry basis (49 days after transplanting. (1)

Plat No.	P E R C E N T									
	N		P_2O_5		K_2O		CaO		MgO	
	L	S	L	S	L	S	L	S	L	S
1	3.80	3.79	.77	.90	4.59	5.82	4.72	1.04	1.08	.51
2	3.74	3.29	.82	.89	4.88	5.83	4.30	1.05	.96	.55
3	3.47	3.34	.80	.86	4.33	5.18	5.02	1.09	.95	.46
4	3.85	3.68	.76	.92	4.59	7.28	5.32	1.19	.94	.53
5	3.43	3.06	.81	.82	3.70	6.35	4.43	.82	1.09	.33
6	3.35	3.66	.76	.91	3.76	6.00	4.84	.87	1.23	.44
7	3.63	3.64	.71	.89	4.82	5.73	5.25	1.10	1.16	.51
8	3.63	3.65	.77	.84	3.47	7.15	4.83	1.14	1.21	.52
9	3.36	3.21	.65	.76	4.06	6.53	3.93	.85	1.63	.54
1a	4.22	3.92	.84	.92	4.35	6.38	4.97	1.30	1.26	.41
2a	4.07	3.30	.85	.85	3.88	6.11	5.01	1.22	1.16	.46
3a	3.75	2.52	.83	.73	4.32	5.78	4.41	1.14	.84	.35
4a	3.19	2.79	.64	.75	4.89	5.33	5.50	1.29	.75	.35
5a	3.05	2.34	.80	.84	4.84	4.91	4.44	1.05	.96	.39
6a	3.09	2.78	.81	.82	4.64	5.44	4.19	.98	1.12	.41
7a	3.07	2.56	.79	.82	3.84	5.39	5.31	1.09	.95	.43
8a	3.18	2.57	.79	.80	4.81	5.77	5.05	1.11	1.09	.38
9a	3.79	2.11	.77	.90	3.95	6.05	5.49	1.16	1.27	.32

Average of Duplicate Treatments Shown Above.

66

1	4.01	3.85	.80	.91	4.47	6.10	4.84	1.17	1.17	.46
2	3.90	3.29	.83	.87	4.38	5.97	4.65	1.13	1.06	.50
3	3.61	2.93	.81	.79	4.32	5.48	4.71	1.11	.89	.40
4	3.52	3.23	.72	.86	4.74	6.30	5.41	1.24	.84	.44
5	3.24	2.70	.80	.83	4.27	5.63	4.43	.93	1.02	.36
6	3.32	3.22	.78	.85	4.20	5.78	4.51	.92	1.17	.42
7	3.35	3.10	.75	.85	4.33	5.56	5.28	1.09	1.05	.47
8	3.41	3.11	.78	.82	4.14	6.46	4.94	1.12	1.10	.45
9	3.57	3.16	.71	.83	4.00	6.29	4.71	1.00	1.45	.43
Average	3.55	3.18	.77	.85	4.32	5.95	4.83	1.08	1.09	.44

(1) (L = Leaves
(S = Stalks

Table - 14:- Chemical Composition of the Leaves and Stalks of Flue-cured Tobacco (oven dry basis) 63 days after transplanting. (1)

Plat No.	P E R C E N T									
	N		P_2O_5		K_2O		CaO		MgO	
	L	S	L	S	L	S	L	S	L	S
1	3.30	1.66	.67	.61	3.51	4.45	4.18	1.16	.87	.41
2	3.08	1.80	.78	.65	3.74	4.21	4.48	1.32	.84	.52
3	3.15	1.51	.68	.70	3.36	4.07	4.27	1.41	.84	.58
4	2.83	1.47	.69	.59	3.79	3.80	4.52	1.26	.52	.49
5	2.87	1.38	.68	.60	3.46	3.41	4.27	1.05	.95	.33
6	2.19	1.15	.63	.66	2.95	4.59	3.62	1.14	.79	.46
7	3.33	1.77	.68	.60	2.93	4.05	4.34	1.24	.95	.43
8	2.64	1.66	.59	.65	3.60	4.06	3.80	1.21	.94	.43
9	2.94	1.43	.65	.51	3.11	3.74	4.11	1.07	1.10	.56
1a	3.68	1.21	.87	.53	3.60	3.70	4.55	1.33	.65	.39
2a	2.51	1.22	.74	.59	3.39	3.20	5.28	1.18	.71	.40
3a	2.32	1.57	.63	.78	3.26	3.56	3.72	1.35	.65	.39
4a	2.60	1.45	.64	.61	3.29	3.70	4.51	1.37	.68	.29
5a	2.25	1.48	.71	.67	3.92	4.05	3.41	1.00	.65	.43
6a	2.26	1.21	.66	.61	3.64	4.24	3.67	.92	.63	.49
7a	2.54	1.22	.66	.58	3.56	3.59	3.89	.96	.75	.56
8a	2.55	1.48	.63	.61	3.49	4.33	3.70	1.26	.78	.32
9a	2.76	1.50	.69	.64	3.67	4.11	4.32	1.23	.76	.43

Average of Duplicate Treatments Shown Above.

6

1	3.49	1.44	.77	.57	3.55	4.07	4.36	1.24	.76	.40
2	2.79	1.51	.76	.62	3.56	3.70	4.88	1.25	.77	.46
3	2.73	1.54	.65	.74	3.31	3.81	3.99	1.38	.74	.48
4	2.72	1.46	.66	.60	3.54	3.75	4.41	1.31	.60	.39
5	2.56	1.43	.69	.63	3.69	3.73	3.84	1.02	.80	.38
6	2.22	1.18	.64	.63	3.29	4.39	3.64	1.03	.71	.47
7	2.93	1.49	.67	.59	3.24	3.82	4.11	1.10	.85	.49
8	2.59	1.57	.61	.63	3.54	4.19	3.75	1.23	.86	.37
9	2.85	1.46	.67	.57	3.39	3.92	4.21	1.15	.93	.49
Average	2.76	1.45	.68	.62	3.46	3.93	4.13	1.19	.78	.48

(1) (L = Leaves
(S = Stalks.

stage of growth or as they approached maturity. The leaves had a decidedly higher content of magnesia than did the stalks.

The data presented in table 15 shows that tobacco utilized on the average a total of 34.97 pounds per acre of nitrogen during its nine weeks of growth. However, it used less than one and one-half pounds or 3.7 percent of the total nitrogen utilized during the first three weeks after transplanting. During the fourth and fifth weeks, the plants utilized approximately 14 pounds per acre of nitrogen or 34.2 percent of the total. The maximum utilization of nitrogen occurred during the sixth and seventh weeks of growth -- during this period the plants utilized approximately 25 pounds per acre of nitrogen or 62.1 percent of the total. It appears that no nitrogen was utilized after the 49th day. In fact, the data shows a slight loss of nitrogen, 0.78 pounds, during ~~this~~ the eighth and ninth weeks of growth.

Comparing the plats receiving nitrogen derived from different sources (plats 1, 2 and 5) the data shows that tobacco produced on plat 1 utilized 41.73 pounds per acre of nitrogen, ~~and~~ that on plat 2 utilized 35.91 pounds, while that on plat 5 utilized only 28.7 pounds per acre of nitrogen during the 63 day growing period. Plat 2 produced a larger total yield, leaves and stalks combined, (table 9) than either plats 1 or 5. During the first two periods of growth the crop on plat 5 utilized decidedly more nitrogen than did that on plats 1 and 2. During the third period of growth,

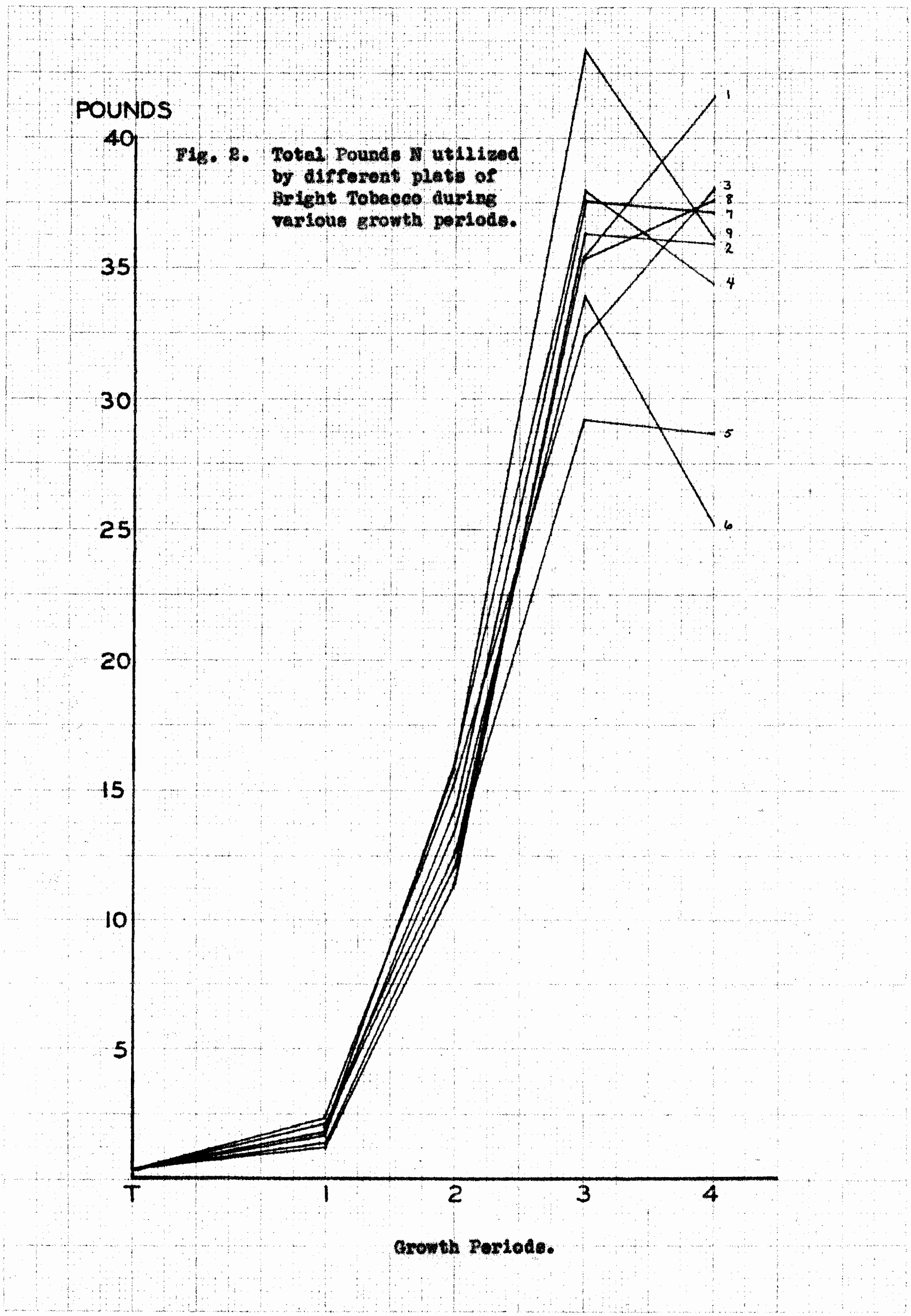


Fig. 2. Total Pounds N utilized by different plats of Bright Tobacco during various growth periods.

plats 1 and 5 utilized about the same amount of nitrogen per acre which was decidedly less than that utilized by the crop on plat 2 during this period. During the last period of growth the tobacco on plat 1 utilized 15.3 percent of the total nitrogen absorbed during the 63 day growing period while the crop on plats 2 and 5 show a slight loss in the amount of nitrogen utilized. This indicates quite clearly that the sources of nitrogen have a definite influence on the quantity of nitrogen absorbed by the crop.

Comparing plats 2, 7 and 9, in which all of the nitrogen was derived equally from each urea and ammonium sulphate, the tobacco contained approximately the same amounts of nitrogen at the 63 day sampling period. However, during the 49th day period plat 9 had utilized more than plat 2. In each instance it appears that no nitrogen was utilized after the 49th day. In fact, plats 2 and 7 show a loss of -1.3 percent of nitrogen while plat 9 shows a loss of -16.9 percent of nitrogen utilized.

The yield per acre, leaves and stalks combined, was highest for plat 2 and lowest for plat 7. The yield and value per acre of saleable leaf (table 2) was highest for plat 9 and lowest for plat 2. This indicates quite clearly that the method of fertilizer application has a direct influence on the yield and quality of saleable leaf.

Comparing plats 5, 6 and 8, in which the nitrogen was derived from sources specified by the Tobacco Research Committee for a standard flue-cured tobacco fertilizer, it was found that plat 8 utilized decidedly more nitrogen than either plats 5 or 6. Between the 49th and 63rd days plat 8 utilized 5.9 percent of the total nitrogen while plat 6 showed a loss of -26.3 percent in nitrogen utilized and plat 5 showed a slight loss of -1.3 percent of total nitrogen utilized. The value and yield per acre (table 2) of saleable leaf produced on plat 8 is much higher than that of either plats 5 or 6, which are almost the same. These points are shown graphically in figure 1.

The rate of utilization of phosphoric acid was different from that of nitrogen in that in every instance considerable quantities were utilized during the last stages of growth. On the average, tobacco utilized about 10.5 pounds per acre of phosphoric acid during the 63 day growing period, of which 55 percent of the total was utilized during the sixth and seventh weeks. Tobacco utilized a very small quantity of phosphoric acid during the first three weeks after transplanting. However, it utilized 25.8 percent of the total during the fourth and fifth weeks of growth. In the last 14 days of the 63 day growing period the rate of utilization of phosphoric acid decreased, only 17.2 percent of the total was utilized in this period as the plants approached maturity.

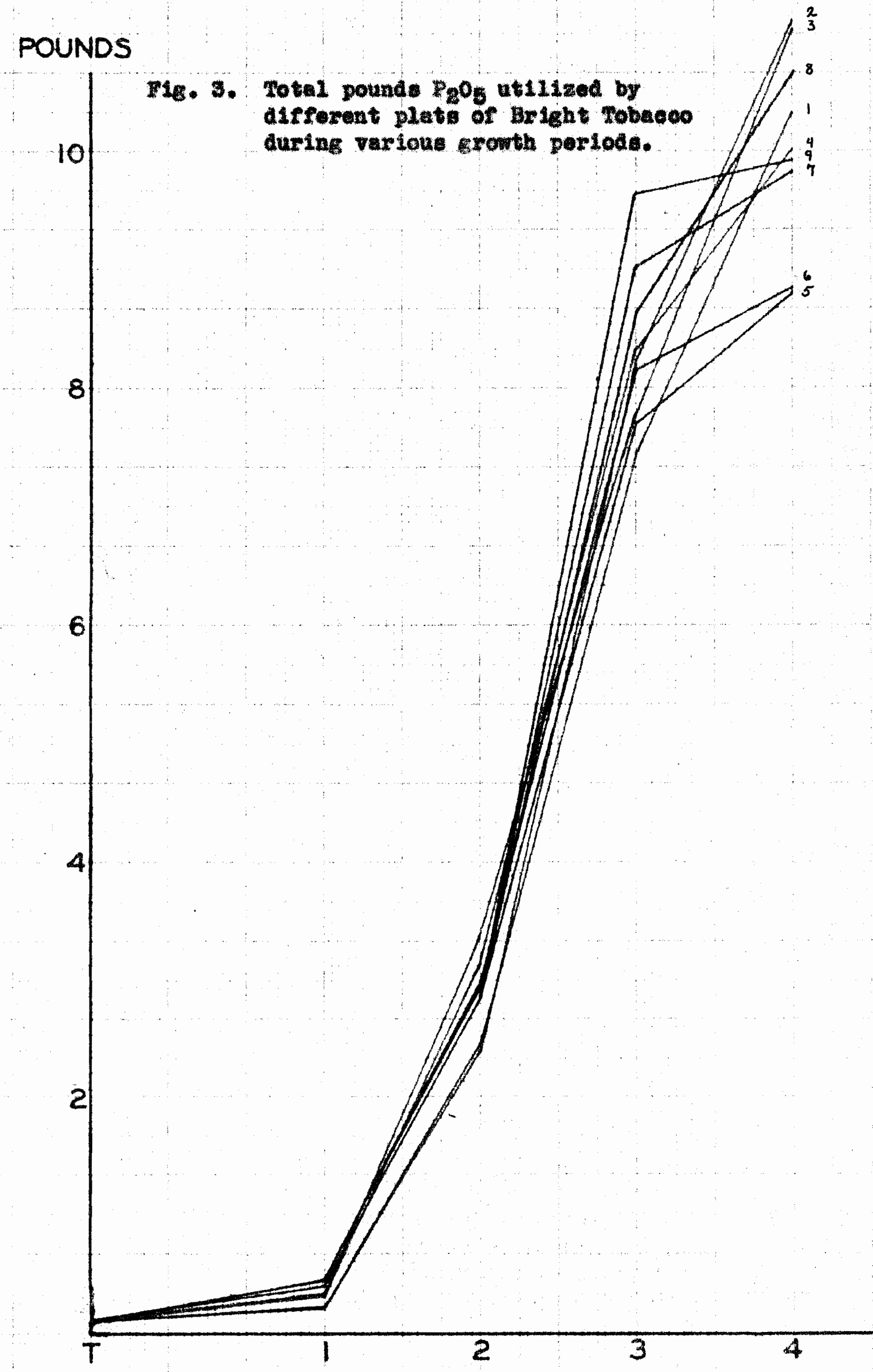


Fig. 3. Total pounds P_2O_5 utilized by different plats of Bright Tobacco during various growth periods.

Growth Periods.

Figure 3 shows a decided leveling out of the phosphoric acid utilization by the crop grown on plats 5, 6, 7 and 9 during the last period of growth. This leveling out correlates with the amount of growth made on these plats during this period as is shown in figure 1. Plats 5, 6, 7 and 9 made the greatest amount of growth during the 6th and 7th weeks and a much lower percent of their growth during the 8th and 9th weeks. The tobacco grown on plats 1, 2, 3 and 8,however, made about the same percentage of growth during the 8th and 9th weeks as they did during the 6th and 7th weeks. This is reflected in figure 3 which shows a continued utilization of phosphoric acid during the 8th and 9th weeks of growth.

From this data (table 15) there is an indication that the percentage utilization of phosphoric acid is directly correlated with the percentage increase in growth. Also plats 2, 3 and 8 produced the highest total yield (leaves and stalks combined) and utilized the greatest amount of phosphoric acid, while plats 4, 7 and 9 showed the next highest yield and utilized slightly less phosphoric acid than plats 2, 3 and 8. With the exception of plat 1, which shows a greater utilization of phosphoric acid than plats 4, 7 and 9, there is a direct correlation between the amount of phosphoric acid utilized and the amount of total growth (leaves and stalks combined) for each period of growth.

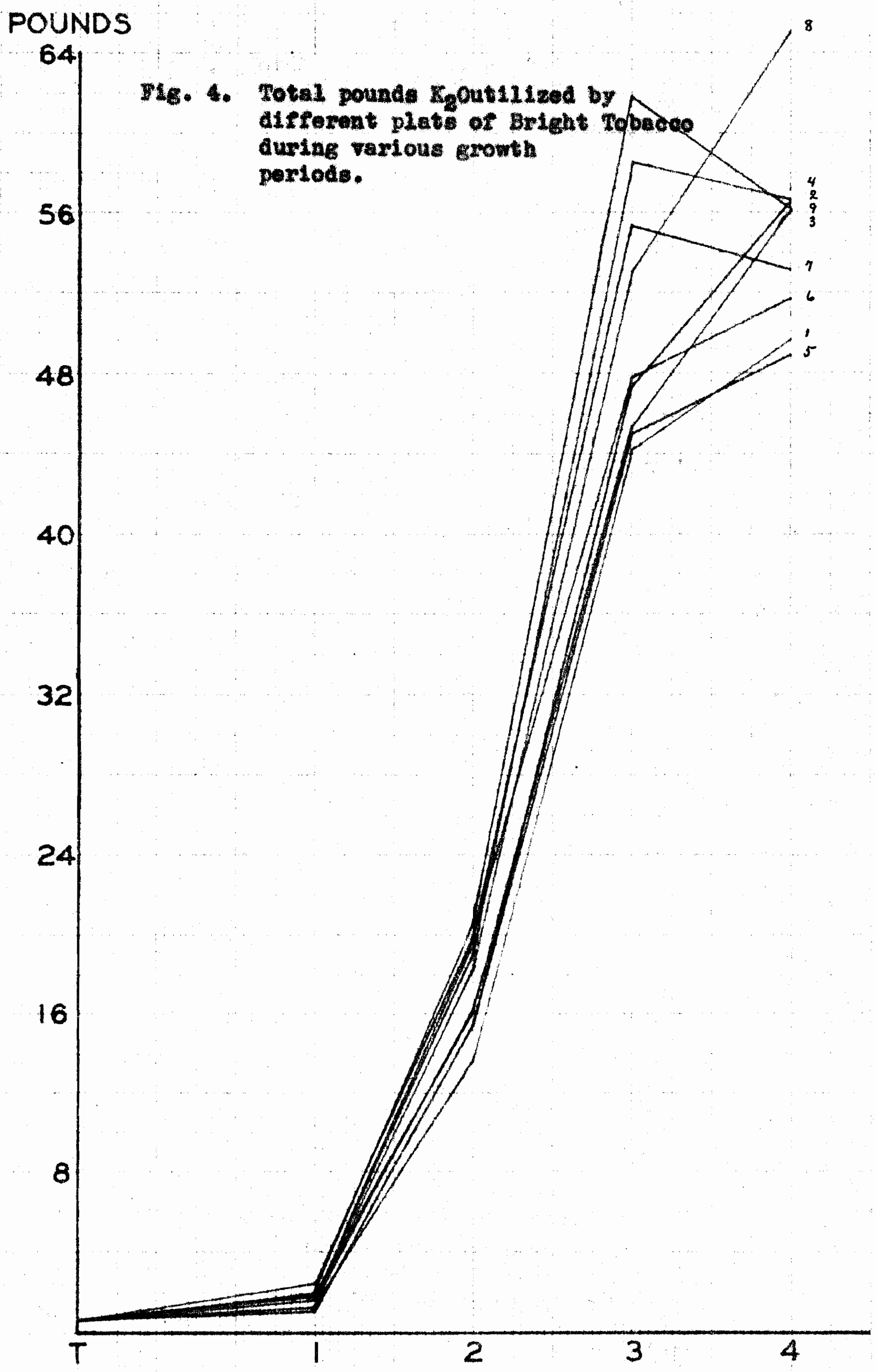
The rate of utilization of potash is similar to that of nitrogen, but in a little greater quantity. An average of all the plats show that about 59 percent of the potash absorbed was utilized during the sixth and seventh weeks of the nine week growing period. During the first three weeks very little potash was utilized, while on the 4th and 5th weeks about 27 percent of the total was utilized. During the last 14 days of the 63 day growing period there was very little utilization, in fact in some cases there was a loss in potash.

Tobacco grown on plats 1, 2, 3 and 8 show a rather heavy utilization of potash during the 8th and 9th weeks of growth, while that on plats 5 and 6 show a very small utilization of this plant nutrient during the last stages of growth. No potash was utilized after the 49th day by tobacco grown on plats 4, 7, and 9, in fact plats 4 and 7 show a loss in utilization of potash of about -4.0 percent while plat 9 shows a decided loss, -9.5 percent. The utilization of potash by tobacco is shown graphically in figure 4.

The amount of potash utilized by the plants apparently had no effect on the value per acre or on the yield of saleable leaf. But the treatments which have the highest total yield, plats 2, 3, 4, 8 and 9, also utilized the largest amounts of potash.

The tobacco absorbed about 10.5 pounds of magnesia during its nine weeks of growth, of which, about 60 percent was utilized

Fig. 4. Total pounds K_2O utilized by different plats of Bright Tobacco during various growth periods.



Growth Periods.

during the 6th and 7th weeks. During the first three weeks the crop used less than one-fourth of a pound of magnesia per acre, while in the next two weeks it used a little more than 3 pounds per acre. Although the tobacco made substantial growth during the 8th and 9th weeks, there was very little absorption of magnesia, and in some cases a loss of magnesia after the 49th day.

A comparison of plats 2, 3 and 4 which received magnesia derived from magnesium sulphate and magnesium carbonate, and no magnesia respectively, an effect was noted both in content and amount utilized, ~~by~~ figure 5 and 6. The trend in magnesia utilized (pounds per acre) by plats 2 and 4 was similar but the magnitude of absorption was much greater on plat 2 which received magnesia derived from magnesium sulphate than on plat 4 which received no magnesia. The trend in utilization of magnesia (pounds per acre) by plat 3 was gradual, and resulted in a greater utilization as the plants approached maturity, while the utilization in plats 2 and 4 ~~which~~ showed a decided drop after the seventh week of growth.

The content of magnesia in the plant material grown on plats 2, 3 and 4 increased during the 4th and 5th weeks after transplanting. After this period the content of magnesia decreased as the plants approached maturity. Presented graphically plats 2 and 4 show a parallelism in content of magnesia throughout the growing period, but plat 2 had the greatest content of

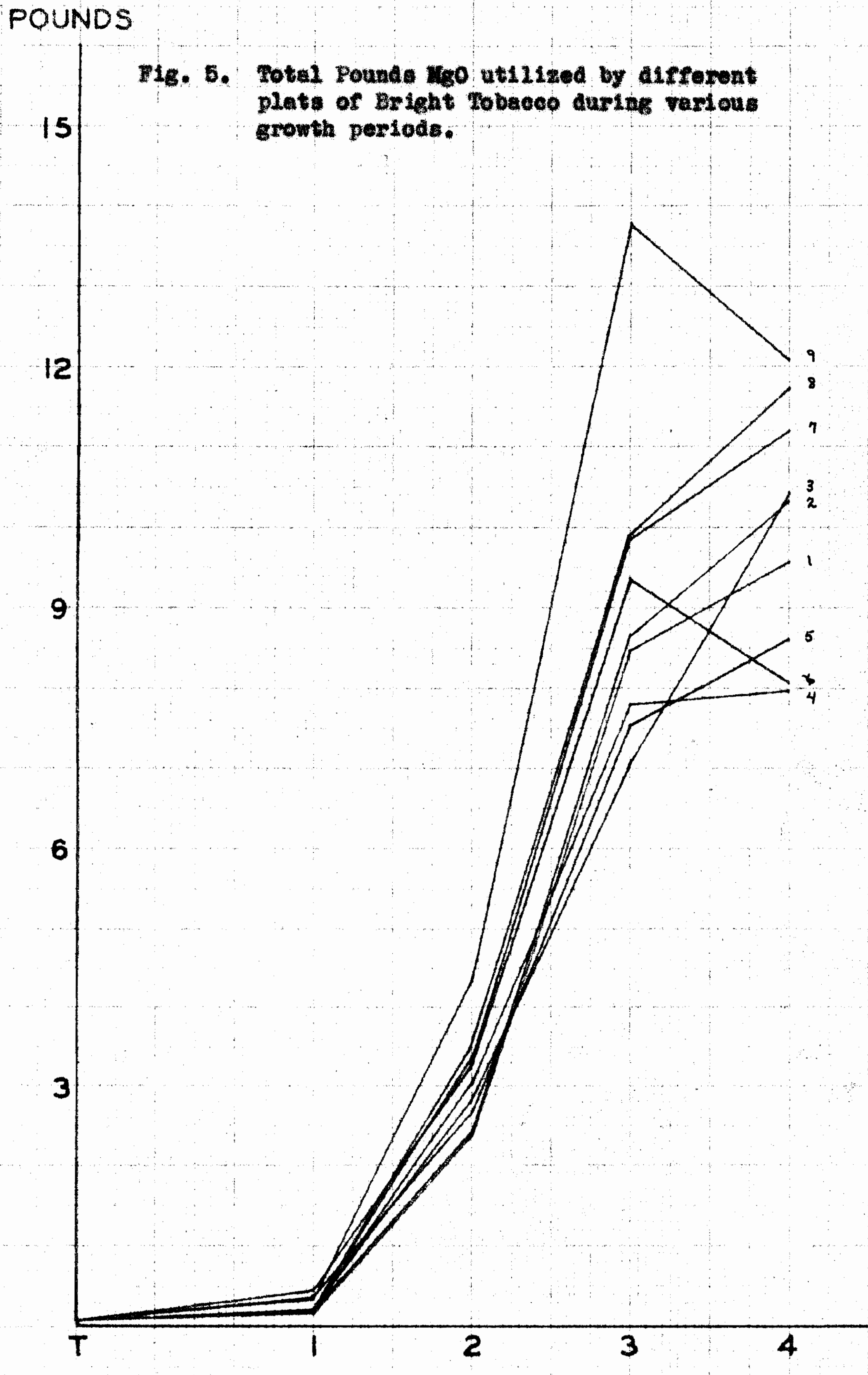


Fig. 5. Total Pounds MgO utilized by different plats of Bright Tobacco during various growth periods.

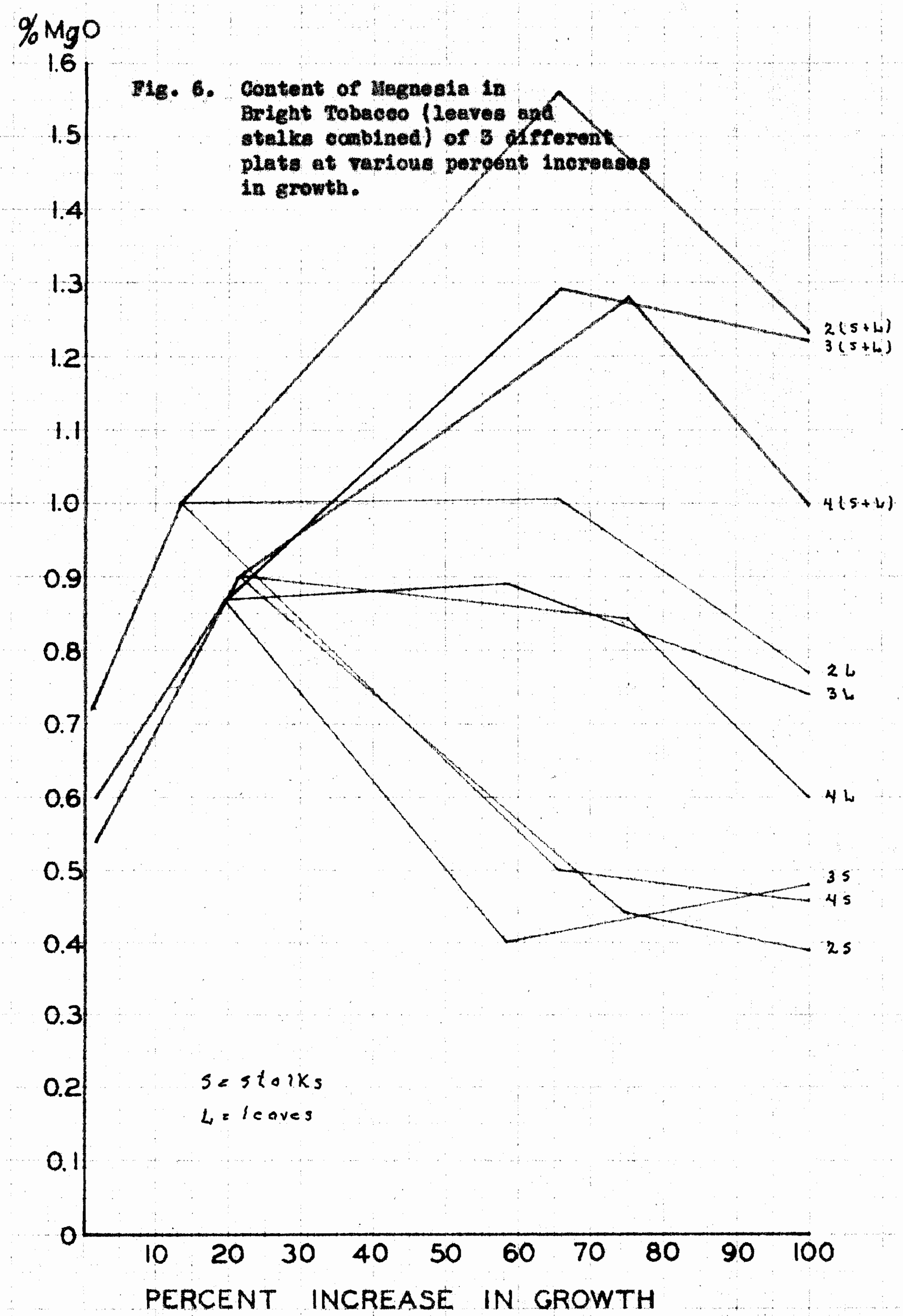


Fig. 6. Content of Magnesia in Bright Tobacco (leaves and stalks combined) of 3 different plats at various percent increases in growth.

magnesia. Plat 3 which received magnesia derived from magnesium carbonate showed a leveling out in concentration as maturity was approached while plats 2 and 4 showed a decided decrease.

The above results indicate that magnesium sulphate supplies magnesia in a readily available form which can be utilized by plants. This availability is shown by a higher content in the plant material and also by a higher percent utilization of magnesia in the first 49 days of growth as compared with the content and percent utilized by plats 3 and 4 (no magnesia and magnesia from magnesium carbonate). Magnesia derived from magnesium carbonate is more slowly available than magnesia in magnesium sulphate as is shown by a greater content in the plant material and amount utilization by tobacco in the latter stages of growth.

About four times as much calcium as magnesia was utilized by the tobacco crop. A total of approximately 48 pounds of calcium was utilized of which about 60 percent of the total was used during the sixth and seventh weeks of growth. Less than one pound per acre was utilized during the first three weeks after transplanting, while in the 4th and 5th as well as the 8th and 9th weeks the crop used about 9 pounds of calcium in each period.

Although calcium has a magnitude of absorption about five times greater than phosphoric acid it is very similar in trend.

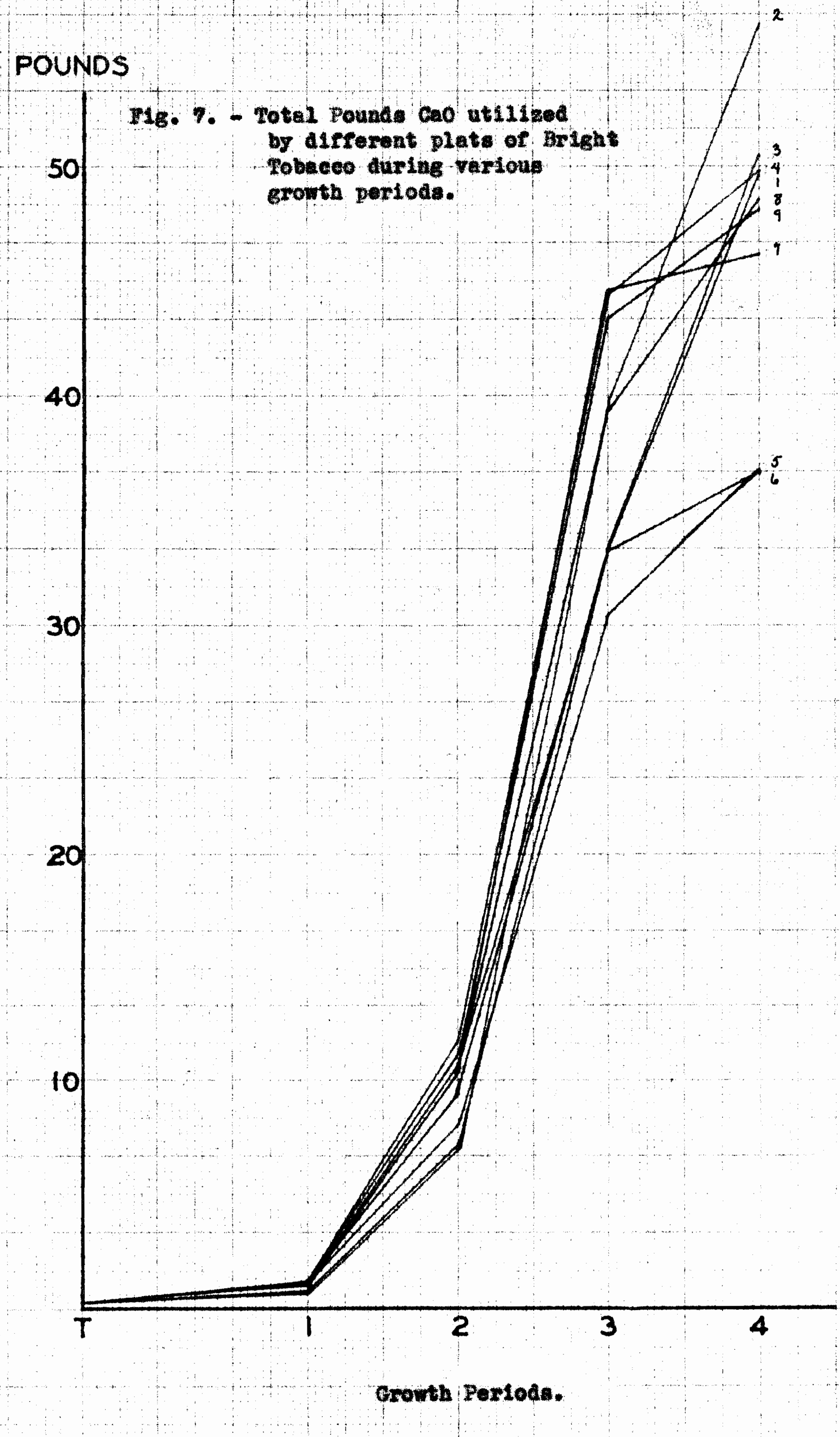


Fig. 7. - Total Pounds CaO utilized by different plats of Bright Tobacco during various growth periods.

Table 15:- Amount and Percent Utilization of Nutrients by one Acre of Bright Tobacco at Different Growth Periods. (Air Dry Basis.)

Plat - 1.	Lbs. N.	% Utilized	Lbs. P_2O_5	% Utilized	Lbs. K_2O	% Utilized	Lbs. CaO	% Utilized	Lbs. MgO	% Utilized
Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.47	2.4	.27	1.5	1.31	1.4	.78	1.0	.17	.8
2nd. (22-35)	12.04	25.6	2.46	21.4	13.61	25.1	7.25	13.1	2.36	23.1
3rd. (36-49)	35.44	56.7	7.46	48.9	44.81	62.4	33.03	52.3	8.48	64.6
4th. (50-63)	41.73	15.3	10.35	28.2	49.67	11.1	49.57	33.6	9.57	11.5
Plat - 2.										
Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.25	2.2	.23	1.0	1.12	.9	.69	.7	.19	1.0
2nd. (22-35)	11.52	28.6	2.40	19.7	15.48	25.7	7.18	11.6	2.38	21.4
3rd. (36-49)	36.38	69.2	8.22	53.0	47.26	57.0	39.82	58.4	8.65	61.3
4th. (50-63)	35.91	-1.3	11.11	26.3	56.41	16.4	56.21	29.3	10.32	16.3
Plat 3.										
Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.94	3.9	.37	2.3	1.77	2.0	1.14	1.7	.21	1.2
2nd. (22-35)	15.81	36.9	3.38	27.6	16.16	26.0	10.68	19.0	2.81	25.1
3rd. (36-49)	32.43	44.2	7.77	40.2	45.30	52.6	33.31	45.2	7.07	41.2
4th. (50-63)	38.07	15.0	11.03	29.9	56.01	19.4	50.40	34.1	10.43	32.5

Table 15:- (Continued)

Plat - 4.	Lbs. N.	% Utilized	Lbs. P_2O_5	% Utilized	Lbs. K_2O	% Utilized	Lbs. CaO	% Utilized	Lbs. MgO	% Utilized
Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.90	3.8	.35	2.3	1.84	2.1	1.26	2.0	.21	1.5
2nd. (22-35)	16.05	37.7	3.17	28.5	19.14	29.9	11.80	21.3	3.02	35.7
3rd. (36-49)	37.98	58.5	8.31	52.0	58.54	68.0	44.33	65.8	7.80	60.7
4th. (50-63)	34.32	-9.8	10.01	17.2	56.53	-3.5	49.72	10.9	7.96	2.1

Plat - 5.

Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.94	5.1	.40	3.2	1.89	2.6	1.20	2.4	.37	3.3
2nd. (22-35)	12.75	37.7	2.86	28.3	16.29	29.9	8.08	18.9	2.67	27.0
3rd. (36-49)	29.17	57.2	7.71	55.9	45.09	59.8	30.45	61.4	7.55	57.0
4th. (50-63)	28.70	-1.6	8.80	12.6	48.81	7.7	36.73	17.3	8.61	12.7

Plat - 6.

Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	2.18	5.1	.46	3.9	2.48	3.6	1.37	2.9	.45	3.9
2nd. (22-35)	13.50	33.8	2.98	28.9	19.84	34.0	9.51	28.3	3.27	20.4
3rd. (36-49)	33.95	61.1	8.19	59.7	47.93	54.9	33.26	65.2	9.37	65.7
4th. (50-63)	25.15	-26.3	8.64	7.5	51.75	7.5	36.75	9.6	8.06	-14.1

Table 15:- (Concluded)

Plat - 7.	Lbs. N.	% Utilized	Lbs. P_2O_5	% Utilized	Lbs. K_2O	% Utilized	Lbs. CaO	% Utilized	Lbs. MgO	% Utilized
Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.84	3.7	.37	2.6	1.83	2.2	1.05	1.6	.29	1.8
2nd. (22-35)	14.43	33.9	2.93	26.3	19.95	33.1	10.36	20.3	3.39	27.9
3rd. (36-49)	37.62	62.4	9.06	63.1	55.39	64.7	44.62	74.8	9.84	58.1
4th. (50-63)	37.13	-1.3	9.84	8.0	53.18	-4.0	46.11	3.3	11.20	12.2

Plat - 8.

Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	1.73	3.4	.32	1.9	1.76	1.7	1.01	1.5	.27	1.5
2nd. (22-35)	14.44	34.2	3.01	25.5	18.56	26.1	10.66	19.9	3.50	27.8
3rd. (36-49)	35.40	56.5	8.64	53.5	53.06	53.5	39.41	59.4	9.90	55.0
4th. (50-63)	37.59	5.9	10.65	19.1	65.09	18.7	48.69	19.2	11.72	15.7

Plat - 9.

Transplant	.48	----	.12	----	.64	----	.31	----	.09	----
1st. (0-21)	2.36	4.4	.37	2.5	1.96	2.2	1.29	2.1	.35	1.9
2nd. (22-35)	15.50	30.6	3.03	27.3	20.46	30.2	11.26	20.9	4.37	29.3
3rd. (36-49)	43.39	65.0	9.64	67.3	61.86	67.6	43.34	67.2	13.79	68.8
4th. (50-63)	36.19	-16.8	9.92	2.9	56.02	-9.5	48.06	9.8	12.09	-12.4

Figure 7 shows a decided leveling out in trend of plats 4, 6, 7 and 9 over the 8th and 9th weeks, while plats 1, 2, 3, 4 and 8 show a continued utilization of this nutrient during this period.

This absorption trend of calcium by flue-cured tobacco, as in the case of phosphoric acid indicates that the percentage utilization of calcium is directly correlated with the percent increase in plant growth.

SUMMARY.

1. Flue-cured botacco 21 days after transplanting had made only 2 percent of its total growth per acre. It made 17 percent during the 4th and 5th weeks of growth; 49.4 percent during the 6th and 7th weeks; and 31.8 percent of the total growth was produced during the 8th and 9th weeks of the growing season.

2. The concentration of soluble nitrogen in the plant sap was very high during the second growth period. During the third and fourth periods of growth the content of nitrogen decreased very rapidly.

3. The concentration of soluble phosphorus in the plant sap was very high during the second and third periods of growth and very low in the fourth period of growth.

4. The concentration of potash in the plant sap was high in the first two stages and exceedingly high during the last two stages of growth. Also, the concentration of potash showed a gradual increase in concentration with each successive stage of growth until the plants reached maturity.

5. The concentration of calcium in the plant sap showed a decided increase with each successive stage of growth.

6. The concentration of magnesia in the plant sap was very high in the first stage of growth and decreased gradually with each successive stage of growth as the plant approached maturity.

7. Different sources of nitrogen had a decided effect on the utilization of nitrogen by the plant. Also, side dressing of part of the nitrogen decreased the total amount of nitrogen utilized by the plant. The greatest utilization of nitrogen occurred during the 6th and 7th weeks of the growing season. After the 49th day of growth no nitrogen was absorbed by the plants.

8. The percentage utilization of phosphoric acid appears to be correlated with the percentage increase in growth. Also, the amount of phosphoric acid utilized is correlated with the amount of total growth. The greatest utilization of phosphoric acid occurred during the 6th and 7th weeks of growth.

9. Side dressing one-half of the potash 21 days after transplanting increased the efficiency of the plants in utilizing potash. The greatest utilization of potash occurred during the 6th and 7th weeks of growth. Also, very little potash was utilized during the 8th and 9th weeks of growth.

10. The source of magnesia effects the quantity and rate of utilization of magnesia by the plants. Magnesia derived from magnesium sulphate was found to be more readily utilized by tobacco than magnesium derived from magnesium carbonate. The greatest utilization of magnesia occurred during the 6th and 7th weeks of growth.

11. The percentage utilization of calcium is directly worrelated with the percent increase in growth. The greatest utilization of magnesia occurs during the 6th and 7th weeks of growth.

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