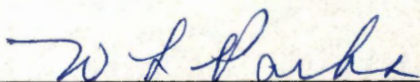
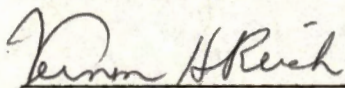


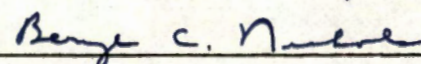
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I am submitting herewith a thesis written by Mohd. Azmi Ab.Rahman entitled "The Effects of Nitrogen Fertilization on the Yield and Quality of Two Burley Tobacco Varieties." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

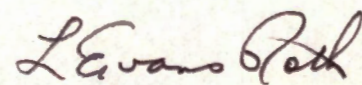

W. L. Parks, Major Professor

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Thesis

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THE EFFECTS OF NITROGEN FERTILIZATION ON THE YIELD AND
QUALITY OF TWO BURLEY TOBACCO VARIETIES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Mohd. Azmi Ab. Rahman

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ABSTRACT

An experiment was conducted in 1978 at the University of Tennessee Tobacco Experiment Station, Greeneville, Tennessee, to study the effects of nitrogen fertilization on the yield and quality of two burley tobacco (Nicotiana tabacum L.) varieties, namely Va 509 and Ky 17. The experimental design was a split plot with the rates of nitrogen fertilization being the main plots and the varieties the sub-plots.

No significant differences were found for yield, crop index and grade index between the two varieties or among the different nitrogen fertilization rates.

The tobacco varieties were not significantly influenced by the nitrogen rates although changing the levels of nitrogen fertilization significantly increased the concentrations of total nitrogen and nicotine and significantly decreased the amount of chloride in the cured leaf. Nitrogen rates had a tendency to decrease leaf potassium and increase leaf calcium but these differences were not significant.

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CHAPTER I

INTRODUCTION

A well-drained, highly productive soil is necessary for good yields of fine quality burley tobacco. Very few soils are fertile enough to produce such tobacco without using farm manure, commercial fertilizers or both. Where plant nutrients are not in proper supply and balance, both the yield as well as the quality are reduced.

In the fertilization of burley tobacco the producer should make sure that the soil is well supplied with available phosphorus and potassium; then supply the nitrogen required for good yield but within the productive capacity of the soil. Compared with the value of the crop, the costs of supplying P and K in fertilizers are small. Applications of these two plant nutrients larger than the crop needs cause no harm and most of the unused nutrients remains in the soil for succeeding crops. When making recommendations for the use of a particular nutrient, one always assumes that the other nutrients are present in adequate amounts. A deficiency of any one nutrient affects the use of all other nutrients by the plant. A very important factor in fertilizing burley tobacco is to provide the proper amount of nitrogen for the crop. Lack of nitrogen will normally lower both the yield and the quality. However, an over-supply of nitrogen delays maturity and also lowers its quality.

Experiments with sources and amount of nitrogen have been many and varied. They have shown that while there are several good sources of nitrogen for burley tobacco, the amount is more important than the form in which nitrogen is applied.

The objective of this research was to determine the effects of nitrogen fertilization on the yield and quality of two burley tobacco varieties.

CHAPTER II

REVIEW OF LITERATURE

Among the elements essential for the commercial production of tobacco, none has as pronounced an effect or requires the degree of attention in fertility practices as nitrogen. From the seedling stage through final harvest, the soil nitrogen regime affects the process of plant development more than other mineral elements. With respect to time of absorption, form in which absorbed, concentration in the leaf at various stages of growth, and in numerous other aspects, the role of nitrogen in the development and properties of the tobacco leaf is of major importance. The influence of variations in nitrogen supply on growth of the plant and properties of the cured leaf has been investigated more extensively than have the effects of any other essential element.

Yield and chemical composition of tobacco may be influenced by many factors, including variety, source and rate of fertilizer used. Nichols et al. (33) reported that N and K fertilization influenced concentrations of Ca, P and K in cured burley tobacco. Atkinson et al. (4) reported that concentrations of total N, total alkaloids and nitrate N in burley tobacco increased when N rates were increased. Work of Peterson et al. (40) revealed that N fertilizer directly affected Mg and Mn concentrations in cigar tobacco leaf; Ca and Mg were directly affected by P fertilization and inversely affected by K fertilization.

Studies on field grown tobacco crops have shown that the uptake of N and K was higher in active vegetative growth phase, whereas the

uptake of P approximately corresponded with the dry-matter production (7,19,41). Similar experiments conducted later showed that the supply of phosphorus and potassium beyond the flowering stage decreased the dry-matter production and the uptake of nitrogen and potassium, but they caused an increase in the uptake of phosphorus. The percent of nitrogen, phosphorus and potassium, however, increased sharply in the lamina as well as in other plant parts during the quiescent phase (18).

Experiments with rates, kinds and methods of application of N fertilization have been many. Their effects on the yield and quality have been studied in detail. Generally, concentrations of alkaloids and nitrogen increased and sugars decreased as the nitrogen rate was increased with solid fertilizers (54). Increasing the N fertilization of the tobacco plant within reasonable limits has resulted in increased yields (5,6,22,30,37,38,44) although there is little effect upon the grade index of the dark tobacco (37). However, Atkinson et al. (5) working with burley tobacco reported that yields were not increased when more than 200 pounds of nitrogen per acre were applied. In the same study, price was generally lower when more than 110 pounds of nitrogen per acre were applied. This is generally true when high rates of nitrogen fertilizer are used (15,34,53).

Although increasing the rates of nitrogen fertilization has been shown to increase yields, several workers found that such practice delayed the maturity period of the tobacco plant (2,27). Andersen et al. (2) found that the delay caused the reduction in the levels of individual phenolic constituents while Mahadik (27) concluded that nitrogen applied at rates up to 40 pounds per acre caused a slight delay in maturity.

Despite this delay, leaf size (length and breadth) and plant growth were increased by nitrogen applications (3,10,27).

The accumulation of nicotine which is synthesized in tobacco roots is regulated more by the nitrogen supply than by any other plant nutrient, since nitrogen is a part of the nicotine molecule. Generally, as the supply of available nitrogen increases from deficiency to excess, the nicotine of the leaf increases (10,12,13,30,44,47,51). The rate of plant growth and topping also influence the accumulation of nicotine. Kroontje et al. (24) found that the greater portion of nicotine was accumulated after topping, i.e., 70 to 100 days. Woltz (55) reported that topping and suckering flue-cured tobacco plants increased both sugar and nicotine content in the leaves above that of nontopped plants.

Similar results of nicotine were obtained by Gaines (16) and for total alkaloids by Chaplin (11). Since its site of synthesis is in the roots, nicotine production ceases very shortly after roots are deprived of external nitrogen while the nicotine from older leaves is translocated to younger tissues only in negligible quantities (39). An increase in nicotine concentration usually results in a decrease of sugar concentration, affecting the sugar-nicotine ratio of the leaf, which is frequently used as a basis for evaluation relating to strength or smoothness. The former is positively related to the total concentration of nitrogen in the leaf (54). Nevertheless, an experiment carried out by Atkinson and Sims (6) revealed that adding more than 160 pounds per acre of nitrogen did not increase the yield, nor did it increase the total nitrogen and nicotine contents in cured leaves.

Though it is known by now that increasing the nitrogen rates normally results in increased total nitrogen and nicotine of the tobacco leaf, it also causes a slight decrease in potassium concentration while the calcium content tends to increase (10,32,52). In other words, the percentage of calcium in tobacco leaf tends to vary directly with nitrogen and indirectly with potassium.

A high potassium content in cured leaves has frequently been used as one criterion of quality, and relatively few, if any, soils on which tobacco is grown are capable of producing the quality or the yield desired without fertilizer potassium. The high plant requirements for potassium exist not only after transplanting but also in seedling stage. It was found by Hutcheson and Woltz (21) that potassium in combination with either sulfate or nitrate appeared to be the most beneficial of elements on root development. A deficiency has been shown to reduce the weight and the length of the roots more than other elements (45). However, application of potassium alone has not shown any favorable effect for any yield character (23), although an increase from 100 to 200 pounds per acre of nitrogen rate increased total plant contents of K, Ca, Mg and Mn (46).

Phosphorus is vital in plant metabolism processes such as photosynthesis, phosphorylation and processes linked to the Krebs cycle. Responses of tobacco to fertilizer phosphorus are reflected more clearly in the early growing stage than in either the final yield or the quality of the cured leaf. One of the prominent effects of P on the growth of tobacco is the shorter period required for the plant to reach maturity (53). In addition to delayed maturity, low P also leads to decreased

nitrogen and magnesium content of the leaf (29). It is also believed that phosphate improves the color of flue-cured tobacco. Phosphorus is positively related to sugar content (49,54). Total nitrogen has twice the negative influence as that of the positive influence by phosphate on sugar content (28). Application of P_2O_5 alone does not result in any favorable effect on yield. However, if applied with farm manure, there is a significant increase in the yields of tobacco (23). Work of Gopalachari et al. (17) revealed that yield of tobacco was highly dependent upon the availability of P in the soil. The uptake of fertilizer P applied and the percentage recovery of P by tobacco plant increased in soils having low available P. Yield of cured leaf increased significantly when applied with 110 pounds P_2O_5 but at higher rates, yields would be reduced (17). In another experiment, Rhoads (43) concluded that calcium and magnesium contents in leaf tissue were decreased by phosphate in comparison to high nitrate and chloride solutions.

Calcium is essential to cell wall structure and constitutes one of the principal ash contents in tobacco, next only to potassium. Generally present in the plant as insoluble salts, calcium is not very mobile. Increasing cell number was reported from plants which received excess calcium supply (20). Increased calcium may increase the sugar content of tobacco leaf (50). Miller and Corder (31) found that calcium deficiency in some varieties of burley tobacco did not seem to affect appreciably the yield or quality. They concluded that calcium deficiency, which is normally shown in the small leaves near the bud and in the sucker growth, was a problem of calcium availability within the plant and not a deficiency of calcium in the soil since it is very immobile.

Calcium not only serves as an essential nutrient to tobacco plants, but it also contributes to the maintenance of the desired soil pH for tobacco growth. Lack of calcium may result in the leaf malfunctions; adverse effect on terminal bud growth and thickening of the leaf. This may produce tobacco of extremely poor quality. Lamarre (25) found that the best yield and ripest tobacco were obtained after liming to achieve a pH of 5.5 to 6.0 where tobacco was more fully developed. There are reports, however, indicating an inverse relationship between the content of calcium and the quality of Canadian grown flue-cured tobacco (14).

Small amounts of chloride in the fertilizer may improve yield and certain quality factors such as color, moisture content, elasticity, burning and keeping quality of tobacco. Larger amounts of chloride, however, decrease the fire-holding capacity of the tobacco leaf (36). Some increase in average price also has been obtained from small amounts of chloride in the fertilizer. Usually about 20 pounds per acre gives the maximum increase and higher rates may give no effect or a reduction (32). Woltz et al. (54) reported that the nicotine content was not significantly affected by chloride. Also increasing the nitrogen fertilizer tends to decrease the percentage of chloride in the cured leaf (34), while its level normally increases from base to top of the plant (33).

Environment should also be considered in order to produce tobacco of good quality. It is one of the factors involved in relation to fertilizer responses especially when in the presence of good initial soil condition over lands that follow traditional agricultural methods (1,42).

CHAPTER III

METHODS AND MATERIALS

An experiment was conducted during the growing season of 1978 on a Minvale silt loam soil at the Tobacco Experiment Station in Greeneville, Tennessee. Prior to fertilization, the soil was 6.7 and P and K contents were 50 and 90 pounds per acre respectively.

A split-plot randomized design with four replications was used; main plots were nitrogen rates at four different levels and sub-plots were tobacco (Nicotiana tabacum L.) varieties. Each sub-plot consisted of 4 rows 42 inches apart and 40 feet long with plants spaced 16 inches apart with the 2 center rows being harvested for yield and chemical analysis. Rates of nitrogen used were 75, 150, 225 and 300 lbs/A. The two burley tobacco varieties were Va 509 and Ky 17.

All plots received a base fertilization in the form of NPK commercial fertilizer at 1500 lbs/A in the ratio of 5-10-5, respectively. The fertilizer was broadcast after plowing and disked into the soil. All tobacco plants were transplanted on June 15, 1978, and four weeks later the treatments receiving more than 75 pounds of nitrogen per acre were side-dressed with sufficient ammonium nitrate to bring the total amount of nitrogen to 150, 225 and 300 pounds per acre for the respective treatments.

The tobacco was topped on August 25, 1978, and the tobacco plants were sprayed a few days later with MH-30 for sucker control at the rate of 170 mg/plant. The plants were harvested on September 9, 1978, and

placed in the barn for curing. The tobacco was cultivated, harvested and cured according to conventional methods.

Collection of Field Data

After curing, the tobacco from each plot was separated into five grades and these were graded by the Federal Tobacco Grading Service. Samples of the cured tobacco for chemical analyses consisted of 10 randomly selected plants from each plot. Stems were removed from the cured leaves and only the laminae were used for chemical analysis. They were dried at 70 C for 48 hours, ground in a Wiley mill, labeled and stored in air-tight plastic bags. All but nicotine analysis were done in the Plant and Soil Science laboratory. The latter was determined by an R. J. Reynolds Tobacco Company chemist in Winston-Salem, North Carolina.

Laboratory Analyses

Nitrogen was determined using the phenolhypochlorite color reaction as described by Thomas et al. (48) and outlined in Appendix A. Potassium and calcium were determined by the procedures described by Blanchard et al. (8) as outlined in Appendix B. Chloride content was determined by the procedures outlined by O'Brien (35). Details of these procedures are given in Appendix C.

Statistical Analyses

An analysis of variance for all results was calculated following the procedures described by Little and Hills (26).

CHAPTER IV

RESULTS AND DISCUSSION

The data summarized in Table 1 illustrates the influence of nitrogen fertilizer on the yield, crop index and grade index of the tobacco. Detailed results of these data are given in Appendices D through F respectively.

Yield

Tobacco yield responded positively to the rates of N fertilizer used. As the rates were increased from 75 to 300 lbs/A, both varieties showed some increases in yields although these increases were not significant at the 5 percent probability level. Ky 17 yielded 98 pounds per acre more than Va 509 but the difference was not significant.

Crop Index

The values shown for the crop index represent the average monetary returns per acre a farmer may expect from the tobacco. These values are very important in management decisions relative to tobacco production.

The data show that increasing nitrogen generally increased the crop index of the tobacco. Neither the nitrogen rates nor the varieties showed any significant influence on the crop index.

Grade Index

The rates of nitrogen had little effect on the grade index of the tobacco although both yield and crop index increased with N rates. No significant difference between the varieties was observed.

Table 1. Influence of Different Nitrogen Rates on the Yield, Crop Index and Grade Index of Two Burley Tobacco Varieties

Variety	N Rates (lbs/A)	Yield (lbs/A)	Crop Index (\$/A)	Grade Index (\$/100 lbs)
Va 509	75	2,884	3,328	129.02
	150	2,830	3,254	128.51
	225	3,153	3,639	129.01
	300	3,273	3,766	128.81
Ky 17	75	2,613	3,004	128.44
	150	3,303	3,795	128.43
	225	3,313	3,796	128.09
	300	3,304	3,783	127.91
Means for Nitrogen Rates Across Varieties [*]				
	75	2,748a	3,166a	129.00a
	150	3,066a	3,525a	128.00a
	225	3,233a	3,717a	129.00a
	300	3,288a	3,774a	128.00a
Means for Varieties Across Nitrogen Rates [*]				
Va 509		3,035a	3,497a	129.00a
Ky 17		3,133a	3,594a	128.00a

^{*} Means within a column and section followed by a common letter are not significantly different at 0.05 level of probability.

A summary of the results for the average chemical composition of burley tobacco is given in Table 2. More detailed results are found in Appendices G through K.

Percent Nitrogen

There was an increase in percent nitrogen in cured leaf for each level of nitrogen used. Increasing the rate from 75 to 150 lbs/A did not increase the concentration of nitrogen significantly but there was a significant difference between rates of 75 and 225 lbs/A in their percent N content. No significant difference was observed between rates of 225 and 300 lbs/A although the latter was significantly higher from that of 75 and 150 lbs/A. The percent nitrogen in the cured leaf was not significantly influenced by either variety.

Percent Nicotine

Since nitrogen is part of the nicotine molecule, an increase in percent nitrogen should increase the nicotine content of the leaf. Increasing the N rates from 75 to 300 lbs/A for both varieties resulted in increased percent nicotine. No significant difference was observed in the nicotine content of the tobacco that received 75, 150 and 225 lbs/A of nitrogen. Further increase in the rate to 300 lbs/A, however, significantly increased the nicotine content of the cured leaf. The two varieties showed no significant difference in their nicotine content, but Va 509 had a slightly higher content than Ky 17. Previous works by some researchers showed results similar to these findings (10, 12, 13, 30, 44, 47, 51), confirming that the nicotine content of the tobacco leaf is directly related to the amount of nitrogen fertilization.

Table 2. Influence of Different Nitrogen Rates on the Average Chemical Composition of Two Burley Tobacco Varieties

Variety	N Rate (lbs/A)	% N	% Nicotine	% K	% Cl	% Ca
Va 509	75	2.54	3.82	3.28	0.66	3.55
	150	2.92	4.06	2.81	0.53	3.58
	225	2.99	4.05	2.44	0.48	3.05
	300	3.70	4.97	2.52	0.49	3.60
Ky 17	75	2.81	3.84	2.98	0.56	3.01
	150	3.00	3.91	3.00	0.53	3.53
	225	3.39	4.08	2.81	0.50	3.26
	300	3.52	4.40	2.77	0.46	3.20
Means for Nitrogen Rates Across Varieties *						
	75	2.68a	3.83a	3.13a	0.61a	3.28a
	150	2.97ab	3.99a	2.90a	0.53b	3.56a
	225	3.20bc	4.06a	2.62a	0.49b	3.15a
	300	3.61c	4.68b	2.64a	0.48b	3.40a
Means for Varieties Across Nitrogen Rates *						
Va 509		3.04a	4.22a	2.76a	0.54a	3.44a
Ky 17		3.18a	4.06a	2.89a	0.51a	3.25a

* Means within a column and section followed by a common letter are not significantly different at 0.05 level of probability.

Percent Potassium

While both nitrogen and nicotine were found to have been directly affected by N rates, potassium tended to have an inverse relationship when rates of nitrogen were increased. Although there was no significant difference in potassium content with respect to nitrogen rates and varieties, increasing nitrogen rates generally decreased the leaf potassium concentration. Thus, where higher nitrogen rates are used, consideration should be given to increasing potassium fertilization also.

Percent Chloride

Percent chloride in cured leaf is normally reduced as more nitrogen is added. This result is similar to that of Nichols et al. (34). Increasing the rates from 75 to 150 lbs/A of nitrogen fertilizer showed a significant decrease in leaf chloride content. No significant change in chloride content was obtained for higher nitrogen rates. A comparison of the two varieties did not show any significant differences in the chloride content of the cured leaf.

Percent Calcium

Although the calcium content tends to vary directly with the amount of nitrogen fertilization, the increase in this case is not as consistent as that of nitrogen and nicotine. This could be due to the fact that Ca is affected more by K fertilization rather than by nitrogen (10,32,40,52). An increase in the amount of K normally will result in a decrease in the amount of Ca in the leaf and the opposite generally occurs on a well limed soil.

CHAPTER V

SUMMARY

The main objective of this experiment was to study the effects of nitrogen fertilization on the yield and quality of two burley tobacco varieties. It was found that as far as yield, crop index and grade index were concerned, no significant difference between Va 509 and Ky 17 was observed and these values were not significantly affected by the various rates of nitrogen fertilization.

The chemical composition of the cured leaf of the two varieties indicated that total nitrogen, nicotine and calcium increased as rates of nitrogen fertilization were increased. However, calcium content was somewhat inconsistent. This investigation also revealed that potassium and chloride content varied indirectly to nitrogen rates. It was also found that calcium and potassium did not differ significantly, an indication that the various nitrogen rates had no effects on the content of both Ca and K. The different levels of nitrogen fertilization, however, had significant effects on the content of total nitrogen, nicotine and chloride in the cured leaf. Nitrogen rates increased the total nitrogen and nicotine content in the cured leaf. Chloride content, however, was significantly higher at the lowest rate of 75 lbs/A. Further increase of nitrogen application had no significant effect on its content.

No significant effect on all the chemical composition (content) of the cured leaf was found between Va 509 and Ky 17. This is an indication that these two varieties of tobacco have similar characteristics;

however, the different levels of nitrogen fertilization had significant effects on percent nitrogen, percent nicotine and percent chloride in the cured leaf.

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CRANE & CREST



APPENDICES

APPENDIX A

NITROGEN DIGESTION PROCEDURE

1. Weigh .2 gm of finely ground leaf tissue and transfer to 125 ml Erlenmeyer flasks.
2. Add 10 ml concentrated H_2SO_4 and let pre-digest overnight. Place on cool hot plate.
3. Heat at 205 C until volume is reduced by 50 percent.
4. Set off hot plate and let cool.
5. When cool enough to hold in palm of hand, add 15 ml of 35 percent. H_2O_2 to each flask.
6. Place on hot plate and heat at high temperature (205 C) until about 45 minutes after clearing is completed.
7. If sample does not clear within 30 minutes to 1 hour, set off, cool, and repeat steps 5 and 6.
8. Transfer to 250 ml volumetric flasks and take to volume with distilled water.
9. Shake thoroughly, let set for time to stabilize and run on Autoanalyzer.

APPENDIX B

WET ASH DIGESTION PROCEDURE FOR POTASSIUM AND CALCIUM

1. Weigh .5 gm of finely ground leaf tissue and place in digestion tube in aluminum digestion block.
2. Add 2-3 glass beads, funnels. Add 4 ml concentrated HNO_3 and let pre-digest 8 hours.
3. Heat at 150 C for 1 hour and let cool.
4. Add 2 ml concentrated HClO_4 .
5. Heat at 235 C for 2 hours.
6. Set off plate and let cool until cold.
7. Add 1 ml concentrated HCl .
8. Heat to 150 C for 15 minutes and let cool.
9. Transfer to 100 ml volumetric flasks and take to volume in distilled water.
10. Shake thoroughly and let set 6-8 hours before analysis with Autoanalyzer.

APPENDIX C

DETERMINATION OF WATER-SOLUBLE CHLORIDE OF LEAF TISSUE

1. Weigh a .10 gm sample and place in a 250 ml Erlenmeyer flask.
2. Add a small portion of activated charcoal and 25 ml de-ionized water.
3. Place on shaker for 10 minutes and then remove.
4. Filter the supernatant through Whatman's No. 42 filter paper.
5. If filtrate is clear, analyze on the Autoanalyzer.*

*The flow diagram for this analysis in the Autoanalyzer is presented in Figure 1.

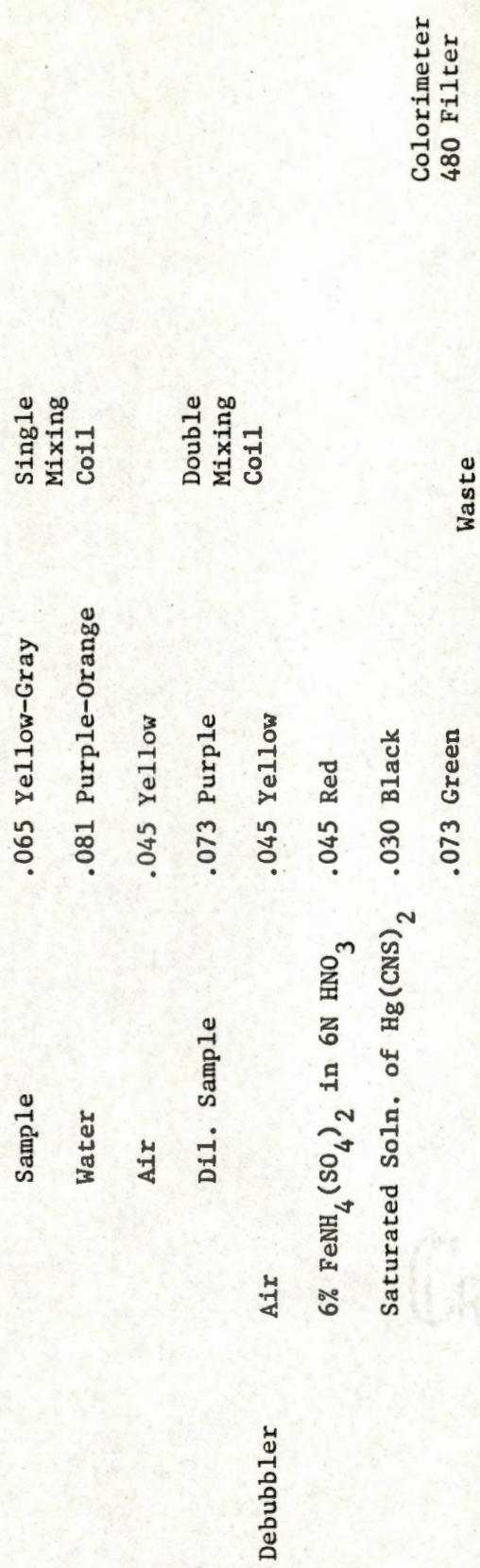


Figure.1. Manifold for Chloride Determinations.

APPENDIX D

Table 3. Yield and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
lbs/A						
75	Va 509	2,830	3,021	3,215	2,468	2,884
	Ky 17	2,733	2,797	2,220	2,703	2,613
150	Va 509	2,836	2,647	2,858	2,980	2,830
	Ky 17	3,657	3,316	3,052	3,185	3,303
225	Va 509	3,523	2,910	2,925	3,254	3,153
	Ky 17	3,332	3,349	2,998	3,573	3,313
300	Va 509	3,545	3,943	2,963	2,640	3,273
	Ky 17	3,065	3,984	3,303	2,864	3,304
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	1,415,399	471,800	2.89	
Replications		3	587,862	195,954	1.20	
Error (a)		9	1,471,012	163,446		
Varieties		1	77,323	77,323	1.06	
N rates x varieties		3	567,941	189,314	2.60	
Error (b)		12	874,860	72,905		

APPENDIX E

Table 4. Crop Index and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
lbs/A						
75	Va 509	3,270	3,534	3,668	2,840	3,328
	Ky 17	3,128	3,192	2,525	3,170	3,004
150	Va 509	3,252	3,031	3,265	3,469	3,254
	Ky 17	4,228	3,810	3,475	3,668	3,795
225	Va 509	4,033	3,416	3,349	3,756	3,639
	Ky 17	3,806	3,861	3,430	4,088	3,796
300	Va 509	4,067	4,515	3,387	3,096	3,766
	Ky 17	3,492	4,604	3,758	3,276	3,783
Source of Variation		df	SS		MS	F
Nitrogen rates		3	1,811,764		603,921	2.90
Replications		3	832,699		277,566	1.33
Error (a)		9	1,874,394		208,266	
Varieties		1	76,343		76,343	0.77
N rates x varieties		3	769,593		256,531	2.59
Error (b)		12	1,189,325		99,110	

APPENDIX F

Table 5. Grade Index and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
lbs/A						
75	Va 509	129.14	130.77	127.54	128.63	129.02
	Ky 17	127.95	127.58	127.12	131.11	128.44
150	Va 509	128.17	128.00	127.70	130.17	128.51
	Ky 17	129.23	128.45	127.27	128.76	128.43
225	Va 509	128.01	131.04	127.99	129.01	129.01
	Ky 17	127.69	128.89	127.88	127.90	128.09
300	Va 509	128.27	128.01	127.83	131.13	128.81
	Ky 17	127.35	129.19	127.23	127.88	127.91
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	0.5813	0.1938	0.26	
Replications		3	14.8531	4.9510	6.60*	
Error (a)		9	6.7559	0.7507		
Varieties		1	3.0814	3.0814	2.27	
N rates x varieties		3	0.9180	0.3060	0.23	
Error (b)		12	16.2748	1.3562		

* Indicates significance at .05 level of probability.

APPENDIX G

Table 6. Percent Nitrogen and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
Percent						
75	Va 509	2.13	2.75	2.69	2.60	2.54
	Ky 17	2.40	3.06	3.13	2.63	2.81
150	Va 509	3.06	2.75	3.38	2.50	2.92
	Ky 17	3.00	2.88	3.19	2.94	3.00
225	Va 509	3.19	2.50	3.40	2.88	2.99
	Ky 17	3.38	3.06	3.69	3.44	3.39
300	Va 509	3.98	3.86	3.65	3.31	3.70
	Ky 17	3.60	3.65	3.75	3.06	3.52
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	3.7310	1.2437	9.16*	
Replications		3	0.8083	0.2694	1.98	
Error (a)		9	1.2219	0.1358		
Varieties		1	0.1554	0.1554	6.85*	
N rates x varieties		3	0.3837	0.1279	5.63*	
Error (b)		12	0.2720	0.0227		

* Indicates significance at .05 level of probability.

APPENDIX H

Table 7. Percent Nicotine and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
Percent						
75	Va 509	3.92	4.32	3.33	3.72	3.82
	Ky 17	3.99	4.03	4.17	3.16	3.84
150	Va 509	4.24	4.25	4.39	3.35	4.06
	Ky 17	4.22	4.42	3.60	3.40	3.91
225	Va 509	4.12	3.55	4.44	4.08	4.05
	Ky 17	4.04	3.99	4.32	3.96	4.08
300	Va 509	5.24	5.07	5.38	4.18	4.97
	Ky 17	4.94	3.99	4.47	4.18	4.40
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	3.3558	1.1186	7.12*	
Replications		3	1.6608	0.5536	3.53	
Error (a)		9	1.4131	0.1570		
Varieties		1	0.2278	0.2278	2.04	
N rates x varieties		3	0.4734	0.1578	1.42	
Error (b)		12	1.3375	0.1115		

* Indicates significance at .05 level of probability.

APPENDIX I

Table 8. Percent Potassium and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
Percent						
75	Va 509	2.78	3.40	2.44	4.50	3.28
	Ky 17	2.40	3.00	2.30	4.20	2.98
150	Va 509	2.60	3.36	2.10	3.16	2.81
	Ky 17	2.98	3.00	2.00	4.00	3.00
225	Va 509	2.24	2.70	1.90	2.90	2.44
	Ky 17	1.90	4.10	2.24	2.98	2.81
300	Va 509	2.00	2.50	1.80	3.78	2.52
	Ky 17	1.40	3.80	2.30	3.56	2.77
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	1.3795	0.4598	1.79	
Replications		3	12.6971	4.2324	16.45*	
Error (a)		9	2.3156	0.2573		
Varieties		1	0.1250	0.1250	0.65	
N rates x varieties		3	0.5271	0.1757	0.91	
Error (b)		12	2.3227	0.1936		

* Indicates significance at .05 level of probability.

APPENDIX J

Table 9. Percent Chloride and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
		Percent				
75	Va 509	0.76	0.70	0.56	0.60	0.66
	Ky 17	0.60	0.61	0.54	0.49	0.56
150	Va 509	0.62	0.58	0.44	0.48	0.53
	Ky 17	0.62	0.61	0.46	0.43	0.53
225	Va 509	0.45	0.57	0.40	0.48	0.48
	Ky 17	0.45	0.49	0.47	0.59	0.50
300	Va 509	0.55	0.55	0.39	0.45	0.49
	Ky 17	0.40	0.56	0.40	0.48	0.46
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	0.0879	0.0293	6.10*	
Replications		3	0.0769	0.0256	5.33*	
Error (a)		9	0.0435	0.0048		
Varieties		1	0.0045	0.0045	1.96	
N rates x varieties		3	0.0161	0.0054	2.35	
Error (b)		12	0.0279	0.0023		

* Indicates significance at .05 level of probability.

APPENDIX K

Table 10. Percent Calcium and Analysis of Variance for Two Burley Tobacco Varieties When Fertilized with Different Rates of Nitrogen

Treatment (N lbs/A)	Variety	Replication				Average
		1	2	3	4	
Percent						
75	Va 509	2.80	3.60	4.20	3.60	3.55
	Ky 17	2.54	2.80	3.50	3.20	3.01
150	Va 509	3.00	3.80	3.90	3.62	3.58
	Ky 17	3.20	3.56	3.46	3.90	3.53
225	Va 509	3.30	2.36	2.70	3.82	3.05
	Ky 17	3.20	3.14	3.20	3.50	3.26
300	Va 509	3.40	3.56	3.90	3.52	3.60
	Ky 17	2.40	3.40	3.58	3.40	3.20
Analysis of Variance						
Source of Variation		df	SS	MS	F	
Nitrogen rates		3	0.7030	0.2343	1.15	
Replications		3	1.8600	0.6200	3.05	
Error (a)		9	1.8274	0.2030		
Varieties		1	0.3003	0.3003	3.92	
N rates x varieties		3	0.7004	0.2335	3.05	
Error (b)		12	0.9195	0.0766		

VITA

The author was born in Penang, Malaysia on November 3, 1952. His parents are Ab. Rahman Said and Cik Amah Ismail. He attended the local primary school before attending the Sekolah Datuk Abdul Razak, Perak, for his secondary education. Upon passing his Malaysian Certificate of Education Examination in 1970, the author was admitted to the Malaysian Agricultural University for a three year diploma program. Upon completion of his study, he served the Federal Land Development Authority of Malaysia as an assistant manager in an oil palm plantation for a year.

In June 1975, the author enrolled at Louisiana State University, Baton Rouge, for a Bachelor of Science degree in agriculture, which was awarded in June 1977. In the fall of 1977, he began study towards a Master of Science degree in plant and soil science at The University of Tennessee, Knoxville. This degree was awarded in December 1979.