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Effects of Nitrogen and Potassium on Certain Agronomic and Chemical Characteristics of Samsun Tobacco in Greece*

by V. A. Mylonas, V. N. Athanasiadis and I. G. Sidiropoulos

Department of Agronomy, Tobacco Institute, Drama, Greece

INTRODUCTION

The amounts of major soil nutrients available markedly affect growth and development of the tobacco plant. Yield of Oriental tobacco is increased more pronouncedly with nitrogen than with any other nutrient. *Todorovski* (9) reported that the yield and profit of Otlja Oriental type tobacco increased when the rate of applied fertilizer (nitrogen – phosphorus – potassium (3–5–8)) increased from 0 to 1000 kg/ha. *Lulov* (4) suggested that for the Nevrokop tobacco growing area of Bulgaria, nitrogen must range from 30 to 60 kg/ha and phosphorus from 60 to 120 kg/ha. Increasing the rate of nitrogen above 60 kg/ha resulted in an increased yield but of lower quality. *Shoumarski* (7) reported that potassium at the rate of 66 kg/ha increased the yield of Oriental tobacco, whereas a higher rate of 132 kg K/ha had an adverse effect on yield.

Zulpiev (10) has shown that the yield of Samsun tobacco increased when the applied nitrogen increased from 45 to 90 and phosphorus from 40 to 80 kg/ha. However, a further increase of tested nutrients to 135 kg N/ha and 120 kg P/ha did not affect the yield, whereas quality was lowered. *Tariman* (8), using four rates of nitrogen (0, 30, 60 and 90 kg/ha) and potassium (0, 100, 200 and 300 kg/ha), obtained the highest yield and best quality of Samsun tobacco with 30 kg N/ha and 100 kg K/ha.

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The objectives of this study were to measure the effects of nitrogen and potassium at four rates on the yield and quality of Samsun tobacco grown under the soil and climatic conditions of Katerini, Greece.

MATERIALS AND METHODS

Nicotiana tabacum L. (cv. Samsun 53) was grown for three years (1973–1975) at Katerini, Greece, in different fields each year. The fields used were those commonly used in rotation (tobacco – wheat – tobacco) for tobacco production by growers. The soils were alluvial (Entisol). There was no effort to select fields with specific levels of nutrients. This resulted in the use of a wide range of soil fertility levels. Prior to fertilizer application, soil samples were taken from the plow layer and analyzed (Table 1). Phosphorus was determined by *Olsen*'s (6) procedure and potassium by *Dirks*' (2) procedure. Air temperature and rainfall for the period 1973–1975 are given in Table 2.

Table 1. Some characteristics of soils used.

Year	Textural class	pH	Organic matter (%)	P (ppm)	K (ppm)
1973	Sandy loam	7.5	1.9	11.8	77
1974	Silty loam	6.3	2.0	3.3	13
1975	Sandy loam	6.4	1.3	8.5	23

Table 2. Mean air temperature and rainfall in Katerini (average of three years (1973–1975)).

Month	Air temperature (°C)					Rainfall	
	absolute		mean		average/ day	height (mm)	days
	minimum	maximum	minimum	maximum			
January	−7.0	15.5	1.4	8.6	5.6	67.2	7
February	−6.0	18.5	1.1	10.1	6.6	73.1	8
March	−4.5	21.5	3.5	12.7	9.1	79.6	9
April	3.0	25.0	6.8	18.0	13.9	28.5	8
May	3.5	34.0	11.7	23.8	19.6	28.3	7
June	7.0	34.0	14.4	27.4	22.9	50.3	4
July	12.0	40.0	17.4	31.1	25.8	18.6	4
August	13.0	37.0	17.2	30.0	24.7	28.8	5
September	9.0	33.0	15.5	27.0	21.9	48.2	5
October	0.3	31.0	11.1	21.1	16.7	40.9	6
November	−5.5	19.0	4.8	13.8	10.7	129.3	8
December	−6.5	15.0	1.0	9.8	5.1	56.5	7

Nitrogen was applied at rates of 20, 40, 60 and 80 kg/ha and potassium at rates of 30, 60, 90 and 120 kg/ha. The rates were factorially combined and the resulting 16 treatments were replicated three times in a randomized complete block design. Phosphorus was applied at a uniform rate of 40 kg/ha. Seventy per cent of the nitrogen was in ammonium and 30% in nitrate form. The fertilizer nutrients were supplied from ammonium nitrate (33.5% N), ammonium sulfate (21% N), ordinary superphosphate (21% P_2O_5) and potassium sulfate (50% K_2O). Fertilizers were broadcast and incorporated into the soil to a depth of 15 cm about 3—5 days before transplanting. Plot sizes were 80, 48 and 40 m² in 1973, 1974 and 1975, respectively, with two guard rows between the plots. Plant spacing between the rows was 40 cm and 12.5 cm within the rows. All cultural practices were in accordance with those used by the growers for Samsun tobacco production. Leaves were harvested in five primings and were sun-cured.

After curing, tobacco from each plot was sorted, weighed and graded. The value per hectare was calculated using the average market price for the appropriate grades. A composite sample from the five primings for each plot (5% of whole cured leaf from the entire plot) was used for chemical determinations. The quantity of tobacco per sample was about 1100 g in 1973, 650 g in 1974 and 550 g in 1975. The samples were dried at 65 °C for 72 hours and ground in a Wiley mill to pass through a 1 mm (16 mesh) sieve. Total alkaloids were determined by the *Coresta** (1) procedure, total nitrogen by the *Kjeldahl* procedure, potassium by atomic emission and calcium and magnesium by atomic absorption in a Perkin-Elmer 403 spectrophotometer. Burning capacity was measured on the ground sample by the following procedure. A certain volume of ground tobacco (5 g) that passed through a 0.354 mm (42 mesh) sieve was equilibrated for 24 hours at 50 °C to a moisture content of 2.5%, and then placed in a channel 5 mm wide × 5 mm deep × 200 mm long made of glass rods. One end was ignited and the rate of burning (mm/min) of the tobacco was recorded. Data from each individual experiment were evaluated with an analysis of variance. The error mean squares for each characteristic studied were then compared using *Bartlett's* test for homogeneity of variances. As a result data were combined over the three years.

* Cooperation Centre for Scientific Research relative to Tobacco

RESULTS AND DISCUSSION

Since the interactions between nitrogen and potassium for determined characteristics were not significant, only the mean values of nitrogen rates over potassium and the mean values of potassium rates over nitrogen are presented.

The effect of nitrogen and potassium fertilization on yield, value/ha and burning capacity of Samsun tobacco are shown in Table 3. Leaf yield increased significantly as applied nitrogen increased from 20 to 40 kg/ha, whereas further increase of nitrogen to 60 kg/ha resulted in an insignificant increase in leaf yield. There was a tendency for value/ha of tobacco to increase as nitrogen increased from 20 to 40 kg/ha. A further increase of nitrogen to 60 and 80 kg/ha tended to decrease the value/ha of tobacco. Leaf yield and market value tended to increase as potassium fertilization increased from 30 to 60 kg/ha, beyond which no further increase occurred.

General observations in the field during the course of the experiments suggested that as nitrogen increased from 20 to 80 kg/ha the height of the plants and leaf area increased, whereas the color of leaves changed from yellow-green to dark green. The lowest rate of nitrogen (20 kg/ha) produced short plants with small, thin leaves showing symptoms of nitrogen deficiency. When cured, these leaves were pale in color and lacked the desired textural properties associated with high quality tobacco.

Table 3. Effect of nitrogen and potassium on yield, value and burning capacity of Samsun tobacco (average of three years).

Nutrient rate (kg/ha)	Yield (kg/ha)	Value ($/ha)	Burning capacity (mm/min)
Nitrogen (N)			
20	2507	7376	3.96
40	2721	7667	4.26
60	2794	7362	4.41
80	2806	6968	4.52
Least significant difference (p = 0.05)	145	n.s.*	0.41
Potassium (K)			
30	2657	7129	4.25
60	2730	7406	4.23
90	2719	7341	4.30
120	2722	7497	4.36
Least significant difference (p = 0.05)	n.s.	n.s.	n.s.

* not significant

Table 4. Effect of nitrogen and potassium on chemical composition of Samsun tobacco (average of three years).

Nutrient rate (kg/ha)	Total alkaloids (%)	Total N (%)	K (%)	Ca (%)	Mg (%)
Nitrogen (N)					
20	1.49	2.11	2.97	2.44	0.56
40	1.51	2.21	3.05	2.60	0.57
60	1.61	2.34	3.09	2.73	0.61
80	1.78	2.52	3.16	2.83	0.62
Least significant difference (p = 0.05)	0.08	0.11	0.13	0.17	0.05
Potassium (K)					
30	1.65	2.32	2.96	2.64	0.62
60	1.59	2.30	3.07	2.67	0.59
90	1.59	2.29	3.08	2.65	0.60
120	1.57	2.27	3.16	2.63	0.58
Least significant difference (p = 0.05)	n.s.*	n.s.	0.12	n.s.	0.03

* not significant

The rate of 40 kg N/ha produced good sized leaves, light orange in color with very good elasticity, thickness and body. This rate of nitrogen greatly improved the visual characteristics of cured leaves over the rate of 20 kg N/ha. From these observations it may be concluded that the rate of 20 kg N/ha supplied inadequate nitrogen for good plant growth. Calculating the price of tobacco produced with 20 kg N/ha and 40 kg N/ha, we observed that the price of tobacco of 20 kg N/ha is a little higher than the price of tobacco of 40 kg N/ha. This is explained by the traditional tendency to produce tobacco with small leaves. But the best quality is not always associated with very small leaves. The rate of 80 kg N/ha produced large leaves, dark orange in color and with decreased elasticity and body. These characteristics made the quality of the cured leaves less than desirable for manufactured products.

Tobacco burning capacity increased significantly as nitrogen increased from 20 to 80 kg/ha. The increased application of nitrogen increased leaf area and resulted in a thinner cured leaf. Since a thin leaf usually has better burning qualities than a thick, close-textured one, the increased nitrogen fertilization favourably affects the combustibility of tobacco, although high concentrations of nitrogen in the leaf tend to reduce combustibility (5) due to the difficulty of combustion of proteins and related nitrogen compounds. Potassium fertilization tended to increase burning capacity.

Table 4 shows the influence of nitrogen and potassium on certain chemical characteristics of cured Samsun tobacco. Generally, the percentage of total alkaloids and total nitrogen in the whole cured leaf increased significantly when the rate of nitrogen increased from 20 to 80 kg/ha. The differences of total alkaloids and total nitrogen among the rates of applied nitrogen were relatively small. When nitrogen increased from 20 to 60 kg/ha, total alkaloids increased by 8% and total nitrogen by 15%. Nitrogen is considered to be a dominant factor which influences the level of strength in tobacco smoke.

There was a tendency for the percentage of leaf potassium to increase as nitrogen fertilization increased from 20 to 80 kg/ha. This indicates that the increased availability of soil nitrogen affects the uptake of other nutrients such as potassium, calcium and magnesium. The percentage of leaf calcium increased significantly as the rate of nitrogen increased from 20 to 60 kg/ha, whereas a further increase of nitrogen to 80 kg/ha resulted in an insignificant increase in calcium concentration. Leaf magnesium concentration tended to increase as applied nitrogen increased. The higher calcium and magnesium concentration in cured leaves with increasing nitrogen rate may be related to preferential uptake of NO_3^- compared to NH_4^- nitrogen uptake from soil and probably to a higher concentration of organic acids. The NO_3^- concentration in cured leaves increased with an increasing nitrogen rate (3).

There was a tendency for the percentage of total alkaloids and total nitrogen in the leaf (Table 4) to decrease as applied potassium increased. This decrease was very small but indicated that potassium fertilization may balance some detrimental effects of nitrogen fertilization on tobacco quality.

Generally, the concentration of leaf potassium tended to increase as the rate of potassium increased from 30 to 120 kg K/ha. The soil potassium varied from field to field. The field used in 1973 had the highest value of available potassium (Table 1), while the field used in 1974 had the lowest value of available potassium. Evaluating the data of potassium concentration in the cured leaf for each crop year, we concluded that the effect of increased

potassium fertilization was more pronounced in 1974 than in 1975 and in 1973. This indicates that this effect of potassium fertilization was higher when the available soil potassium was lower. The rates of potassium used had no effect on calcium concentration (Table 4). Magnesium concentration tended to decrease as applied potassium increased.

SUMMARY

Field experiments were conducted in 1973–1975 at Katerini, Greece, to determine the effects of nitrogen and potassium fertilization rates on the yield, value and chemical composition of Samsun tobacco (*Nicotiana tabacum* L. (cv. Samsun 53)) leaves. Nitrogen was applied at rates of 20, 40, 60 and 80 kg/ha and potassium at rates of 30, 60, 90 and 120 kg/ha.

Leaf yield increased significantly as applied nitrogen increased from 20 to 40 kg/ha, whereas further increase of nitrogen to 60 or to 80 kg/ha resulted in an insignificant increase in leaf yield. There was a tendency for value/ha of tobacco to increase as nitrogen rate increased from 20 to 40 kg/ha. A further increase of nitrogen to 60 and 80 kg/ha tended to decrease the value of tobacco. Generally, burning capacity and percentage of total alkaloids, total nitrogen, calcium and magnesium increased significantly as applied nitrogen increased. Percentage leaf potassium tended to increase as rate of nitrogen increased.

Leaf yield and value/ha tended to increase as applied potassium increased from 30 to 60 kg/ha, beyond which no further increase occurred. Burning capacity and concentration of leaf potassium tended to increase, whereas the percentage of total alkaloids and magnesium tended to decrease as the rate of potassium increased. Concentrations of nitrogen and calcium were not affected by potassium rates.

Generally, for production of a good yield and quality of Samsun tobacco in soils similar to that of Katerini, Greece, the rate of applied nitrogen should be higher than 20 kg/ha but lower than 60 kg/ha, while the rate of applied potassium should be above 30 kg/ha and up to 90 kg/ha.

ZUSAMMENFASSUNG

Zur Untersuchung des Einflusses der Düngung mit unterschiedlichen Stickstoff- und Kaliumgaben auf den Ertrag, den Marktwert und die chemische Zusammensetzung von Samsun-Tabak (*Nicotiana tabacum* L. (Sorte Samsun 53)) wurden in den Jahren 1973 bis 1975 in Katerini/Griechenland Feldversuche durchgeführt. Stickstoff wurde in den Mengen 20, 40, 60 und 80 kg/ha und Kalium in den Mengen 30, 60, 90 und 120 kg/ha gegeben.

Bei einer Erhöhung der Stickstoffmenge von 20 kg/ha auf 40 kg/ha stieg der Blattertrag signifikant an, während er bei weiterer Steigerung auf 60 kg/ha oder 80 kg/ha nur unerheblich zunahm. Der Marktwert je Hektar Tabak stieg mit der Erhöhung der Stickstoffgabe von 20 kg/ha auf 40 kg/ha an und nahm bei weiterer Steigerung auf 60 kg/ha und 80 kg/ha ab. Mit zunehmender Stickstoffmenge erhöhte sich im allgemeinen die Brennbarkeit und der Gehalt an Gesamtalkaloiden, Gesamtstickstoff, Calcium und Magnesium signifikant; auch wurde die Tendenz eines Anstiegs des Kaliumgehaltes des Blattgutes bei zunehmender Stickstoffgabe beobachtet.

Wurde die Kaliumgabe von 30 kg/ha auf 60 kg/ha angehoben, so erhöhten sich Blattertrag und Marktwert je Hektar; eine weitere Anhebung der Kaliumgabe erbrachte jedoch keine weitere Zunahme. Mit steigender Kaliumgabe zeigten Brennbarkeit und Kaliumgehalt des Blattgutes eine zunehmende, der Gehalt an Gesamtalkaloiden und Magnesium hingegen eine abnehmende Tendenz. Der Gehalt an Stickstoff und Calcium wurde durch die Kaliummenge nicht beeinflußt.

Allgemein ist festzustellen, daß beim Samsun-Tabak zur Erzielung eines guten Ertrages und guter Qualität bei Bodenverhältnissen ähnlich denen von Katerini/Griechenland die Stickstoffgabe über 20 kg/ha liegen, aber 60 kg/ha nicht übersteigen und die Kaliumgabe zwischen 30 kg/ha und 90 kg/ha liegen sollte.

RÉSUMÉ

Des expériences agricoles ont été effectuées de 1973 à 1975 à Katerini, en Grèce, afin de déterminer l'influence de diverses doses d'azote et de potassium sur le rendement, la valeur et la composition chimique des feuilles de tabac Samsun (*Nicotiana tabacum* L. (variété Samsun 53)). L'azote a été appliqué en doses de 20, 40, 60 et 80 kg/ha et le potassium en doses de 30, 60, 90 et 120 kg/ha.

L'accroissement du rendement a été considérable avec l'augmentation de l'apport d'azote de 20 à 40 kg/ha, alors qu'une augmentation à 60 ou 80 kg n'a provoqué qu'une faible augmentation du rendement. La valeur à l'hectare du tabac a augmenté avec l'augmentation de l'apport d'azote de 20 à 40 kg/ha, mais elle a diminué avec les doses plus élevées de 60 et 80 kg/ha. En général, la combustibilité et la teneur en alcaloïdes totaux, de l'azote total, du calcium et du magnésium de la feuille a augmenté de façon significative avec l'augmentation de l'apport d'azote, alors que le potassium manifestait une tendance à l'augmentation.

L'accroissement de l'apport en potassium de 30 à 60 kg/ha a fait augmenter le rendement et la valeur à l'hectare des feuilles. Un apport plus élevé en potassium n'a plus entraîné d'amélioration. Avec l'accroissement des doses de potassium, la combustibilité ainsi que la teneur en potassium des feuilles ont eu tendance à augmenter alors que la teneur en alcaloïdes totaux et en magnésium accusaient une tendance contraire. La teneur en azote et en calcium n'a pas été influencée par le taux de potassium.

En général, pour obtenir un bon rendement ainsi qu'une bonne qualité de tabac «Samsun» dans des sols similaires à ceux de Katerini, la dose d'azote à appliquer doit être supérieure à 20 kg/ha mais inférieure à 60 kg/ha alors que la dose de potassium devait être comprise entre 30 et 90 kg/ha.

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Authors' address:

Department of Agronomy,
Tobacco Institute,
Drama, Greece.