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# Effect of Different Nitrogen and Potassium Fertilizer Levels on Quality and Quantity Yield of Flue-Cured Tobacco (Coker 347)

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**Abstract:** In order to determine the effect of different nitrogen and potassium rates on flue-cured tobacco (Coker 347), an experiment performed in the tobacco research institute at Rasht, north of Iran, in 2010. Four Nitrogen levels (100, 150, 200 and 250 kg/ha) and three Potassium levels (250, 300 and 350 kg/ha) were investigated as factorial experiments in randomized complete block design with four replication. In this study, the effect of Nitrogen and Potassium levels on height, total leaf, leaf length, leaf width, green leaf yield, cured leaf yield, start of flowering, End of flowering, average income and chemical component such as nicotine percentage and sugar percentage was evaluated. Effect of nitrogen levels on total leaf, leaf length, leaf width, green leaf yield, cured leaf yield, end of flowering and income were significant at 1% probability level, also on height, start of flowering and nicotine percentage were significant at 5% probability level. Results show that addition of nitrogen levels up to 250 kg/ha increased height, total leaf, leaf length, leaf width, green leaf yield, cured leaf yield, start of flowering, end of flowering and nicotine percentage. Also, the highest income was related to 150 kg/ha nitrogen fertilizer. There were significant differences among potassium fertilizer levels on income and sugar percentage. Addition of potassium fertilizer levels, up to 350 kg/ha increased income and sugar percentage. There were no significant differences on interaction affect of nitrogen and potassium.

**Key words:** Flue-cured tobacco · Potassium · Nitrogen · Nicotine Percentage · Sugar Percentage

## INTRODUCTION

The western type of tobacco, including flue-cured tobacco because of special characteristics many expect to have water and nutrient. Strengthening of land under tobacco cultivation by fertilizers necessary and inevitable. Among the nutrient requirements of plants nitrogen and potassium, essential elements of plant growth and directly interact and affect the growth and development [1]. The main purpose of fertilization in tobacco plants not only the quantity but quality should be considered. So that all operations in tobacco farming and fertilizer supply at the same time should enhance the quality and quantity [2]. Nitrogen in tobacco cultivation from seedling stage to harvest considered as a key element that can affect the quality and quantity more than any other nutrients [3]. Nitrogen absorption in the third week after transplanting tobacco was slow and then from third to eighth weeks immediately increases. Approximately 80 percent of nitrogen is absorbed by plants in this time. High levels of nitrogen after this period due to increased concentrations of nicotine can reduce product quality [4]. In the presence of high amounts of nitrogen although a slight increase in product wet weight was observed but delay in maturity and changing color of leaves from yellow to brown was considered. Nitrogen has the greatest impact on taste and too much of it can cause nasty taste. In terms of reduction of nitrogen short stems, narrow and poor tissues, pale and vertical leaves and reduced in leaf yield was observed. Reduced synthesis of chlorophyll from nitrogen deficiency is the main cause of producing of pale leaves. Nicotine concentration in leaves is a key indicator to evaluate the quality of tobacco [4]. Mahdavi *et al*. [5], concluded that increasing nitrogen levels from 17 kg to 52 kg per hectare, increasing the length and width of leaves, green leaf yield and cured leaf yield, nicotine and

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total nitrogen but the overall effect on the ash, sugar and potassium did not. Rachman and colleagues [6], reported that application of nitrogen increases leaf dimensions (length and width of leaf) that is causing the yield rise. Castelli and colleagues [7], concluded that increasing the amount of nitrogen increases the number of leaves, plant height, stem diameter and wet leaf weight. Kena [8], concluded that increasing the amount of nitrogen has increased the amount of nicotine. Marchetti *et al*. [9] reported that the amount of nitrogen fertilizer increased yield but also delayed harvest of the leaves. Shamel Rostami *et al*. [3] reported that nitrogen is a key element in fertilization of flue-cured tobacco from seedling stage to harvest and more than any element affect growth and development. Potassium known as an essential element for plant nutrition. Potassium concentration in tobacco leaves ranges from 2 to 8 percent, which sometimes reaches 10 percent. Virginia tobacco absorbed potassium in the first three weeks after transplantation (3 percent), four weeks later (69 percent) and in the last two weeks (28 percent) will be absorbed [10]. The effect of potassium on plant growth and crop production can be divided into five categories, including observational making plants resistant to diseases, producing hard and strong stems and reduced lodging, increased performance and transfer of starch, sugar and fat and make the plants resistant to frost [11]. The most critical time for giving potassium in the early stages of plant growth. Plants deficient in potassium have less resistance against external factors but sufficient potassium, causing resistance to temporary drought, regulation of enzyme activity, increasing the intensity of photosynthesis speed up the transfer of materials made during the process of photosynthesis and also, it plays a positive role on transfer of nitrogen and protein synthesis. Consuming of potassium fertilizer in producing of Virginia tobacco increases the elasticity and flexibility and change color of leaves to orange. Tobacco leaves that do not have enough potassium, after curing are brittle and straw like while leaves that can supply enough potassium are bright yellow. Today tobacco quality is the most important characteristics for tobacco companies and cigarette manufacturing and consuming of potassium fertilizer has important role for increasing of tobacco quality [12]. Results of the effects of potassium by Liu and colleagues [13] showed that potassium application in early stages of growth had a significant effect on yield and had less effect on the potassium content of leaves but potassium application in later stages of growth had a great impact on potassium content of leaves and little impact on yield also potassium application in middle stages of growth had a great effect on both potassium content of leaves and yield. This investigation was conducted to determine effect of different Nitrogen and Potassium fertilizer levels on quality and quantity yield of flue-cured tobacco in Rasht tobacco institute.

## MATERIALS AND METHODS

*Nicotiana tabacum L. cv. Coker* (347) was grown on well drained sandy loam soil at Rasht tobacco institute (northern Iran), in 2010. Experiment location 15 degrees 35 minutes east longitude and 36 degrees 39 minutes North latitude and height above sea level is zero. Before the project soil samples taken of various plots. Soil analysis results show that (Table 1), the soil texture was Sandy Loam and PH was 5.7. Nitrogen was applied as ammonium nitrate at four rates of 100, 150, 200 and 250 kg N/ha. Potassium sulfate was applied at three rates of 250, 300 and 350 kg K/ha. A randomized complete block experimental design, replicated 4 times, was used with nitrogen and potassium rates arranged in 4×3 factorial. Each plot consisted of 6 rows. The plant distance was 1 meter between rows and 0.5 meter within rows. The tobacco plants were transplanted on 15 may 2010.Each plot was assigned to two-third of ammonium nitrate and all the potassium sulfate fertilizer. The remaining one-third of the ammonium nitrate fertilizer was side-dressed 6 weeks after transplanting. Based on soil analysis, no P fertilizer was applied. Chemical treatments to control weeds were also applied. Topping was performed at the end of July at the flowering stage. Frequent irrigations were performed from transplanting to the end (middle of September). Leaves were hand harvested as they ripped from the end of July to the end of October and six sequential harvests were performed in total in each plot, following the traditional practice of the region. During the growing season factors such as plant height, leaf number, stem diameter, length and width of leaves, start of flowering and end of flowering were measured and recorded. Tobacco leaves harvested among center row of each plot and cured. Matching and sorting operations carried out and then product evaluation and purchase after that green leaf yield, cured leaf yield, average price of a kg of tobacco, nicotine and sugar percent of the leaf were calculated. The statistical software MSTATC was used for analysis variance. Comparisons among the means were conducted using Duncan's multiple range tests.

Table 1: Soil analysis results of the experimental sites

| Depth (cm) | 0-30 | Texture | Sandy loam |
|---|---|---|---|
| O.C (%) | 1.78 | pH | 5.760 |
| Clay (%) | 18.00 | EC (ds/m) | 0.315 |
| Sand (%) | 69.00 | N (%) | 0.160 |
| Silt (%) | 13.00 | K (mg/kg) | 207.910 |
| Cl (%) | 16.00 | P (mg/kg) | 205.610 |

## RESULTS AND DISCUSSION

**Plant Height:** Analysis of variance (Table 2) showed that plant height only affected by nitrogen (5% probability level) and potassium different rates had no significant effect on this trait. Comparisons among the nitrogen means (Table 3) by Duncan's multiple range tests showed that minimum plant height (123.2 cm) obtained by using of lowest levels of nitrogen fertilizer (100 kg/ha) while highest plant height (137.8 cm) was obtained by using the highest level of nitrogen fertilizer (250 kg/ha). The reasons for increase in height with increasing amounts of nitrogen fertilizer can be attributed affect of nitrogen on vegetative growth, cell division in plant organs, especially stems and provides suitable conditions for stem elongation. Castelli *et al.* [7], obtained almost the similar results. They reported that with increase in use of nitrogen plant height increase.

**Number of Leaves:** Results showed that nitrogen rates had significant affect on number of leaves at 1 % probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that Maximum number of leaves (33) was related to the highest level of nitrogen fertilizer (250 kg per hectare) and minimum number of leaves (23) was related to the lowest level of nitrogen fertilizer (100 kg per hectare). It seems that there are correlations between plant height and number of leaves, so that with increasing stem height due to consuming more nitrogen fertilizer causes increasing number of leaves. Zamora [14], also reported similar results.

**Length and Width of Leaves:** Results showed that (Table 2) nitrogen amount had significant affect on these traits at 1% probability level. Comparisons among the nitrogen means (Table 3) showed that maximum leaf length (54.34 cm) was related to the highest level of nitrogen fertilizer (250 kg per hectare) and minimum length of leaf (45.68 cm) was related to the lowest level of nitrogen (100 kg per hectare).also, maximum leaf width (26.10 cm) was related to the highest level of nitrogen fertilizer (250 kg per hectare) and minimum length of leaf (23.44 cm) was related to the lowest level of nitrogen (100 kg per hectare). With increasing amounts of nitrogen fertilizer, length and width of leaves increased. It can be said nitrogen stimulates the biosynthesis and export of cytokinin hormone from roots to leaves that causes increasing cell division and increasing length and width of the leaves. Rachman [6] and Mahdavi [5] reported same results

**Start of Flowering:** Results showed that nitrogen rates had significant effect on start of flowering at 5% probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that the most (48 days) and the least start of flowering (42 days) were obtained in 250 kg N/ha and 100 kg N/ha, respectively. Because of nitrogen role to stimulate vegetative organs and delay leaf senescence. Marchetti *et al.* [9] were reported the same results.

**End of Flowering:** Results showed that nitrogen rates had significant effect on start of flowering at 1% probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that highest end of flowering (88days) was related to the highest level of nitrogen fertilizer (250 kg per hectare) and with decrease of nitrogen fertilizer levels to 100 kg per hectare, it was reduced 17 percent. Marchetti *et al.* [9] were reported the same results.

**Fresh Leaf Weight:** Results showed that nitrogen rates had significant effect on fresh leaf weight at 1% probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that the most (19650kg) and the least (4230kg) fresh leaf weight were produced in 250 and 100 kg nitrogen fertilizer per hectare, respectively. With increasing amounts of nitrogen fertilizer increased fresh leaf weight. This increase can be due to the positive effect of nitrogen on the dry matter changes and increasing the plant's leaf area. Castelli *et al*. [7], Marchetti *et al*. [9] and Rachman *et al*. [6] reported same results

**Dry Leaf Weight:** Results showed that nitrogen rates had significant effect on dry leaf weight at 1% probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that the most (2196kg) and least (1467kg) dry leaf weight were produced in 250 and 100 kg nitrogen fertilizer per hectare, respectively. Positive effect of application of nitrogen fertilizer on dry leaf weight were reported by Liu [13] and Shamel Rostami [11].

Table 2: Analysis of variance for studied traits

| Source of variance | df | Plant height (cm) | Leaf number | Stem diameter (cm) | Leaf length (cm) | Leaf width (cm) | Start of flowering (day) |
|---|---|---|---|---|---|---|---|
| | | MS | | | | | |
| Nitrogen | 3 | 452.354* | 198.61** | 44.311** | 159.76** | 15.163** | 88.5* |
| Potassium | 2 | 1.188 | 12.896 | 4.054 | 2.465 | 2.364 | 3.146 |
| N×K | 6 | 3.771 | 4.257 | 0.702 | 1.599 | 0.070 | 3.313 |
| Error | 33 | 109.566 | 6.318 | 4.035 | 16.99 | 3.730 | 25.84 |
| CV% | | 7.21 | 8.92 | 9.71 | 8.23 | 7.82 | 11.34 |

| Source of variance | df | End of flowering (day) | Fresh leaf weight (kg/ha) | Dry leaf weight (kg/ha) | Average income (Rials) | Nicotine percentage | Sugar percentage |
|---|---|---|---|---|---|---|---|
| | | MS | | | | | |
| Nitrogen | 3 | 540.139** | 63069774.31** | 1175351.91** | 166985208.3** | 0.540* | 0.797 |
| Potassium | 2 | 5.688 | 10147968.75 | 62369.27 | 75685208.3** | 0.108 | 4.225* |
| N×K | 6 | 5.076 | 2232274.31 | 7445.66 | 2976041.7 | 0.010 | 0.129 |
| Error | 33 | 49.417 | 4218145.52 | 27335.50 | 11571672.9 | 0.099 | 1.269 |
| CV% | | 8.94 | 12.21 | 9.27 | 10.49 | 10.64 | 8.55 |

** and * respectively significant in 1% and 5% area

Table 3: Comparison of mean effect of nitrogen fertilizer on measured traits

| Treatment | Plant height (cm) | Leaf number | Stem diameter (cm) | Leaf length (cm) | Leaf width (cm) | Start of flowering (day) | End of flowering (day) | Fresh leaf weight (kg/ha) | Dry leaf weight (kg/ha) | Average income (Rials) | Nicotine (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $N_1$ | 123.2b | 23.50d | 18.20c | 45.68c | 23.44b | 41.75b | 73.08b | 14230c | 1467d | 9820000d | 2.570b |
| $N_2$ | 129 ab | 26.58c | 20.42b | 49.08bc | 24.26b | 44ab | 75b | 15990b | 1639c | 36950000a | 2.693ab |
| $N_3$ | 132.9a | 29.58b | 21.38ab | 51.29ab | 24.93ab | 45.33ab | 78.25b | 17410b | 1833b | 34050000b | 2.778ab |
| $N_4$ | 137.8a | 33a | 22.77a | 54.34a | 26.10a | 48.25a | 88.17a | 19650a | 2196a | 29580000c | 2.835a |

Within each column, means followed by the same letter don't differ significantly at $p<0.05$

**Nicotine Percentage:** Results showed that nitrogen rates had significant effect on nicotine percentage at 5% probability level (Table 2). Comparisons among the nitrogen means (Table 3) showed that maximum nicotine percentage (2.835%) was related to the highest level of nitrogen fertilizer (250 kg per hectare) and minimum nicotine percentage (2.570%) was related to lowest level of nitrogen fertilizer (100 kg per hectare). Because nicotine is an alkaloid with the formula: (C10H14N2) which the nitrogen element in the structure has been used and produced in roots and after that transferred to leaves if environmental conditions such as water and nutrient are provided, with increasing amounts of nitrogen, nicotine synthesis also increased. Mahdavi *et al*. [5] and Tsotsolins [15] got almost similar results.

**Sugar Percentage:** Results showed that potassium rates had significant effect on sugar percentage at 5% probability level (Table 2). Comparisons among the nitrogen means (Fig. 1) showed that maximum sugar percentage (13.72%) was related to the highest level of potassium fertilizer (350 kg per hectare) and minimum nicotine percentage (12.70%) was related to lowest level of nitrogen fertilizer (250 kg per hectare). If environmental conditions are provided in the presence of potassium, stomata will be opened and more carbon dioxide is converted to glucose. Liu [13], Markand [16] and Shamel Rostami [17], reported that sugar percentage would be increased with increase in potassium levels.

**Income:** Results showed that nitrogen rates had significant effect on income at 1% probability level (Table 2). Comparisons among the nitrogen means (Fig. 2) showed that highest income (36950000rials) was obtained by using 150 kg nitrogen fertilizer per hectare while lowest income (9820000rials) obtained by using of lowest levels of nitrogen fertilizer (100 kg/ha). with increasing of nitrogen fertilizer to 150 kg/ha income increased after that up to 250 kg/ha decreased. It seems that with increasing amount of nitrogen, fresh leaves weight and dry leaves weight increased but leaves quality decreased and purchase price of tobacco leaves decreased that effected total income. Ryding [18], reported the same results. On the other hand, results showed that potassium rate had significant effect on income at 1% probability level (Table 2). Comparisons among the potassium means (Table 3) showed that highest income (34790000rials) was obtained by using 350 kg potassium fertilizer per hectare while lowest income (9820000rials) obtained by using of lowest levels of

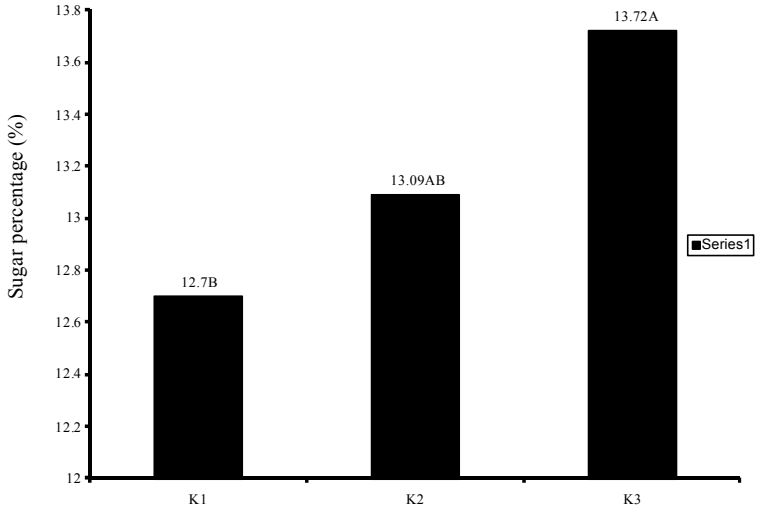


Fig. 1: Effect of potassium levels on Sugar percentage

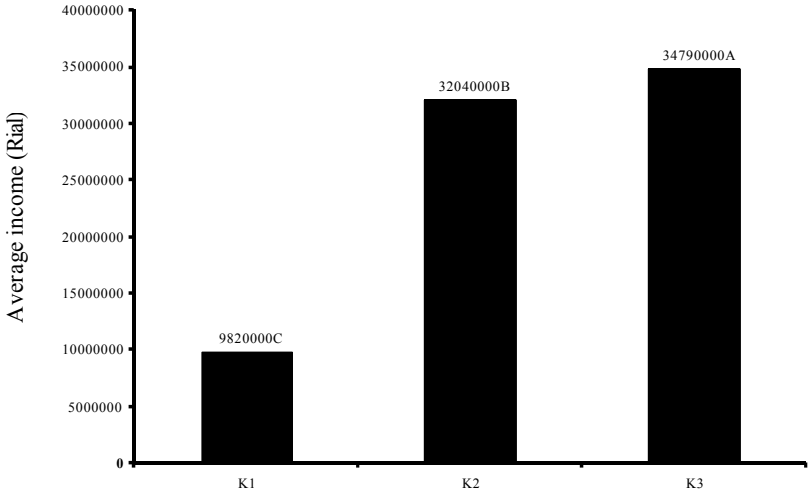


Fig. 2: Effect of potassium levels on average income

potassium fertilizer (100 kg\ha). In tobacco cultivation, potassium is a luxury element that has great effects on leaf quality and with increasing of potassium fertilizer purchase price of tobacco leaves increase. Shamel Rostami [11, 17] reported the same results.

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