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THE INTENSITY OF UPTAKE AND UTILIZATION OF NITROGEN AND CHEMICAL CHARACTERISTICS OF ORIENTAL TOBACCO DEPENDING ON THE RATE OF NITROGEN FERTILIZER

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ABSTRACT

The uptake and utilization of nitrogen during the growing season and changes in chemical composition of dry tobacco depending on the rate of nitrogen fertilizer were investigated in stationary field trial with tobacco as a long-term monoculture. The investigation included four rates of N fertilization: 0, 25, 50 and 100 kg N/ha. The increasing rates of nitrogen fertilizer increased the uptake and utilization of nitrogen during the growing season and its concentration in the leaves from the lower, middle and upper stalk position. In oriental tobacco, nitrogen uptake for creation of 1 g dry above-ground biomass over a 24-hour period is the highest in the period from transplanting to the stage of rapid growth. In the check and in the variant treated with 25 kg N/ha, daily nitrogen requirements were the highest from the stage of rapid growth to maturation of leaves from the lower stalk position. With fertilization rates of 50 kg and 100 kg N/ha, the nitrogen requirements were the highest from the stage of maturation of leaves from the lower stalk position to butonization.

In soil and climate conditions in which the trial was set up, the rate of 50 kg N/ha can be considered as optimal for obtaining tobacco with chemical composition that will meet the requirements of cigarette industry.

Key words: Oriental tobacco, nitrogen fertilizer, uptake of nitrogen, utilization of nitrogen

ИНТЕНЗИТЕТОТ НА УСВОЈУВАЊЕ И ИСКОРИСТУВАЊЕ НА АЗОТОТ И ХЕМИСКИТЕ КАРАКТЕРИСТИКИ НА ОРИЕНТАЛСКИОТ ТУТУН ВО ЗАВИСНОСТ ОД ДОЗИТЕ НА АЗОТНИТЕ ЃУБРИЊА

Во ова истражување е проучувана спецификата на усвојувањето и искористувањето на азотот во текот на вегетацијата и промените во хемискиот состав на тутунот во зависност од дозите на азотно ѓубриво, во услови на стациониран, долгогодишен опит на тутунот во монокултура и континуирано ѓубрење со одредени дози на ѓубриња.

За таа цел се поставени черири варијанти, ѓубрени само со азотно ѓубре, со дози од: 0, 25, 50 и 100 kg N/ha.

Испитувањата покажаа дека со зголемување на дозите на азотно ѓубре се зголемува интензитетот на усвојувањео и искористување на азотот во текот на вегетацијата, и неговата концентрација во листовите од долниот, средниот и горниот појас.

Интензитетот на усвојување на азотот, изразен во mg, за создавање на 1 g сува надземна биомаса во едно денонoќие е најголемо во периодот од расадување до фазата на буен пораст на ориенталскиот тутун. Кај контролата и варијантата ѓубрена со 25 kg N/ha, најголемата дневна потреба за азот за создавање на надземната маса се јавува од периодот на буен пораст до созревањето на листовите од долниот бербен појас. При внесување на 50 и 100 kg N/ha,

пикот за потребите од азот е во периодот од созревањето на листовите од долниот бербен појас до фазата на бутонизација.

При почвено – климатските услови во кои се извршени испитувањата, може да се констатира дека варијантата ѓубрена со 50 kg N/h е оптимална за добивање на тутун чиј хемиски состав одговара за потребите на цигарната индустрија.

Клучни зборови: ориенталски тутун, ѓубрење со азот, усвојување на азот, искористувње на азот

INTRODUCTION

Nitrogen is essential for tobacco growth, development, yield and quality. The existing information about the needs of oriental tobacco for nitrogen is mainly based on the data for chemical composition of plants (Yancheva, 2002, 2009; Sekin et al., 2002). Other important parameters describing the nitrogen nutrition of plants are the intensity of uptake and utilization of nitrogen. The former characterizes the amount of N needed to build 1 g of dry matter per day and the latter - the absolute quantity of the element required to construct the mass of plants per unit area per day (Mitreva and Iliev, 1984). The intensity of nitrogen uptake depends on the phase of plant growth and the rate of nitrogen fertilization (Apostolova, 1983; Nankova and Stoyanova, 1995). The daily export of nitrogen in plant biomass per unit area varies with the development phase and the level and type of fertilization (Mitreva and Iliev, 1984; Panayotova, 1999; Sifola and Postiglione, 2003).

The aim of the study was to determine the specificity of the intensity of uptake and utilization of nitrogen during the plant growth and changes in chemical composition of cured tobacco depending on the rate of nitrogen fertilization.

MATERIAL AND METHODS

A field experiment with long-term fertilization was conducted with the oriental tobacco variety Plovdiv 7 in 2006. The rendzina soil of the site was heavy sandy loam. For the purpose of the study, four nitrogen rates were tested: 0; 25; 50 and 100 kg ha^{-1}. Nitrogen was applied as urea before transplanting. The fertilizer was uniformly broadcast over the soil surface of each plot before being incorporated into the soil. Tobacco seedlings were transplanted at a 0.5 x 0.12 m distance (166 000 plants/ha). All cultural practices were in accordance with those used by the growers for oriental tobacco production.

For the determination of N in the above-ground biomass, twenty plants were sampled in seedling stage and ten plants per variant - during the following phenological stages: rosette (35 days after transplanting - DAT), ripeness of basal leaves (56 DAT), ripeness of middle leaves (77 DAT) and ripeness of upper leaves (98 DAT). Plants were separated into leaves, stalks and inflorescences. Individual parts were washed to remove all traces of soil. The samples were dried to a constant weight in an oven at 65 ^{o}C and dry weight was recorded. Total nitrogen was determined using the Kjeldahl method. The intensities of nitrogen uptake and utilization were calculated after determining the dry weight of plant parts at the different phenological stages, the nitrogen content and the number of days between periods of observation (Mitreva and Iliev, 1984).

The random samples of sun-cured leaves were analyzed for nicotine (ISO 15152), proteins (BDS 9142-88), reducing sugars (ISO 15154) and ashes (ISO 2817).

RESULTS AND DISCUSSIONS

The intensity of N uptake by tobacco above-ground biomass for formation of 1 g dry matter per 24 hours changes depending on the period of the growing season and the rate of nitrogen fertilization (Fig. 1). It varies from 8.9 to 33.3 mg N/1 g dry matter per day. The highest consumption of nitrogen for formation of 1 g dry matter is during the period from seedling establishment to the beginning of active vegetative growth (1-35 DAT). The uptake of nitrogen during this period gets ahead of accumulation of biomass, which leads to its enrichment with nitrogen. In the later stages of the growing season, the intensity of N uptake decreases. Such a reduction in the amount of nitrogen to build a unit of dry matter during the vegetation was established by Mitreva and Iliev (1984) and Tomov and Manolov (2004). In unfertilized plots, the intensity of N uptake gradually decreases during the growing season. The intensity of nitrogen uptake is influenced by the amount of N applied. Consumption of nitrogen increases from seedling establishment to bud formation (from 1 to 77 DAT) as the rate of applied nitrogen increases. During the bud formation until flowering (78-98 DAT) the intensity of nitrogen uptake does not depend on nitrogen treatments.

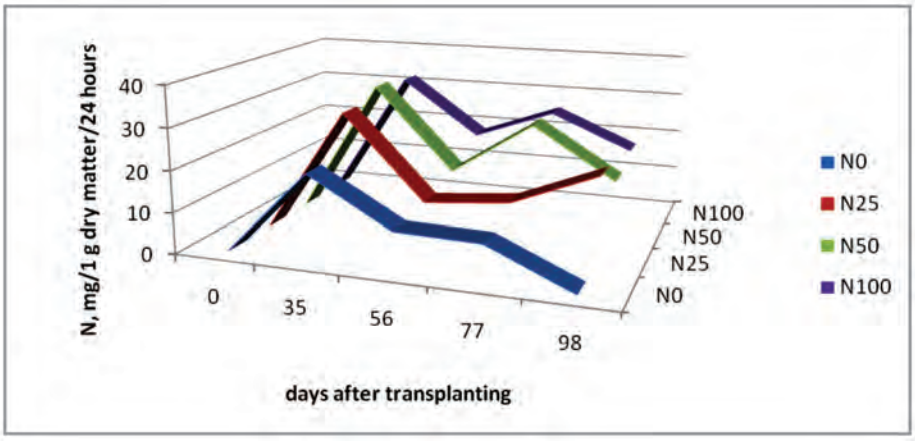

Fig. 1. Intensity of nitrogen uptake by tobacco above-ground biomass

Sifola and Postiglione (2003) reported that the daily uptake of nitrogen for the whole plant formation depends on soil processes, fertilization practices and physiology (uptake, translocation, assimilation and partitioning). During the period of rapid dry matter accumulation (DMA) and nutrient uptake in flue-cured tobacco (between 41 and 75 DAT) the soil must have sufficient amount of available nutrients to satisfy the needs of the plant (Moustakas and Nizanis, 2005). The intensity of nitrogen utilization ranges from 144.5 to 1602 g N/ha/day depending on the observation period and fertilization rate (Fig. 2). In the period between seedling establishment and beginning of active growth (1-35 DAT), the absolute daily amount of nitrogen absorbed by plants per unit area is relatively low (144.5-348.5 g/ha/day). The high total N content of plants and high intensity of nitrogen uptake during this period are indicative of relatively high demand of the plant for this element in the initial phase of development. The utilization of nitrogen during vegetation follows sigmoidal curve. The maximum daily utilization for unfertilized control and plots fertilized with low nitrogen rate – 25 kg N/ha coincides with the period of maximum accumulation of dry matter (36-56 DAT). When plants are fertilized with 100 kg N/ha, the maximum daily consumption of nitrogen is observed between 57 and 77 DAT and once more coincides with the maximum daily DMA. The maximum utilization of N does not coincide with the peak period in the accumulation of dry matter when plants are fertilized with 50 kg N/ha. The intensity of nitrogen utilization

strongly depends on the amount of N applied. The effect of increasing N rates on daily consumption of nitrogen in formation of the above-ground biomass is positive in the period beween beginning of active growth and bud formation (36-77 DAT) but insignificant at later interval. The increasing of nitrogen fertilization rates is associated with a linear increase in absolute amount of nitrogen needed for formation of the above-ground biomass from 36 to 77 DAT.

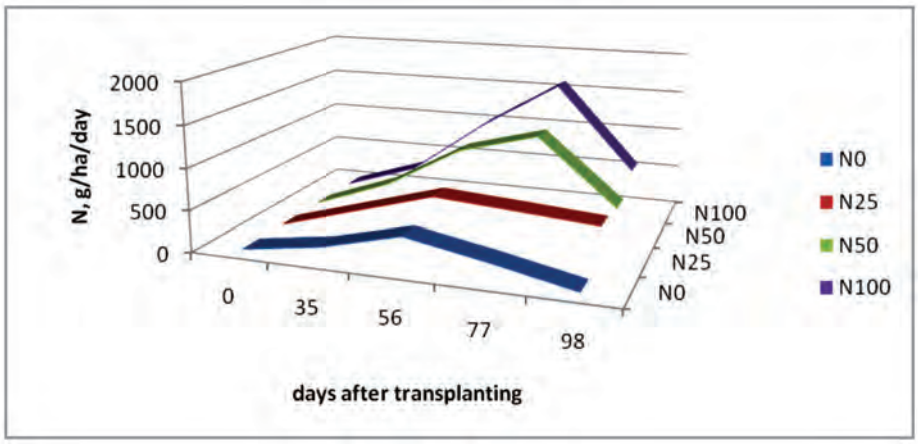

Fig. 2. Intensity of utilization of nitrogen

The specificity of the consumption of nitrogen from the soil influences the leaf nitrogen concentration during the growing season and chemical characteristics of cured tobacco. The concentration of nitrogen in the mature leaves ranged from 1.3 to 3.8% (Fig. 3). The nitrogen content in the leaves depends on the priming and the rate of N fertilizer. It rises from the lower to the upper priming and differences between them are increased in response to the increasing levels of applied N. The rates of nitrogen fertilizer have a strong effect on N in the mature leaves. The nitrogen content in the leaves increases in response to the increasing rates of nitrogen fertilizer.

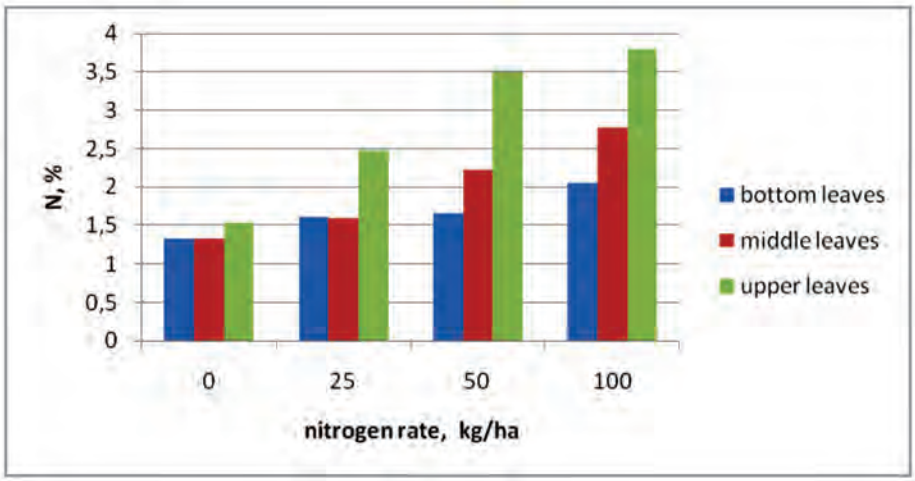

Fig. 3. Concentration of nitrogen in tobacco mature leaves from bottom, middle and upper stalk position during the growing season

Most of the chemical constituents of tobacco, although genetically controlled, have been found to change with the growth stage and a number of cultural practices (Lolas et al., 1979). Chemical characteristics of cured tobacco change depending on nitrogen fertilizer rate (Table 1). The percentage of nicotine and proteins in cured leaves increases when the rate of nitrogen increases from 0 to 100 kg/ha. There is a negative relationship between increasing N levels and sugars content. Ash content increases with increasing nitrogen rate up to 50 kg/ha, while further raise of nitrogen level has an insignificant effect.

These values of chemical characteristics of cured tobacco correspond to the specific content of total nitrogen in the leaves during the growing season. The relationships among leaf total N and the content of nicotine, proteins, reducing sugars and ash are explained by the following regression equations:

$$У_{nicotine} = 0.45+0.48x;\ R=0.958;\ R^2=0.918$$
$$У_{proteins} = 1.73+1.32x;\ R=0.995;\ R^2=0.989$$
$$У_{reducing\ sugars} = 24.72-3.54x;\ R=0.989;\ R^2=0.979$$
$$У_{ash} = 8.06+1.01x;\ R=0.939;\ R^2=0.882$$

Table 1. Chemical characteristics of the variety Plovdiv 7 (% of dry weight)

Nitrogen rate (kg/ha)	Nicotine	Proteins	Reducing sugars	Ash
0	1.05	3.49	20.0	9.40
25	1.50	4.35	17.9	9.92
50	1.59	4.93	15.6	10.88
100	1.83	5.50	14.9	10.73

Smoke delivery and smoke composition depend on the characteristics of the leaf tobacco. The nitrogenous constituents are considered the most important in determining flavor and smoking quality of tobacco. According to Ghiuselev (1983), nicotine content from 1.0 to 1.6% is related to fullness of flavor but higher content leads to strong and pungent smoke. When sugar content increases over 16%, and this is accompanied by low content of nitrogen substances, the resulting taste is of insufficient completeness. The daily consumption of plants receiving 50 kg N/dka ranges from 339 to 1148.8 g N/ha/day, due to which the concentration of nitrogen in mature leaves from the bottom, middle and upper stalk position during the growing season varies from 1.7 to 3.5%. Given the above limits, we can point out that in terms of experience, the chemical composition of tobacco fertilized with 50 kg N/ha would have the beneficial effect on the smoking properties.

CONCLUSIONS

1. The increasing N rates intensify the uptake and utilization of nitrogen as well as its concentration in the mature leaves from the bottom, middle and upper stalk position during the growing season.

2. The intensity of the N uptake for formation of 1 g dry matter per 24 hours is highest during the period from seedling establishment to the beginning of active growth of oriental tobacco. The maximum daily consumption of N for the formation of the above-ground biomass per unit area for unfertilized plants and for plants fertilized with low nitrogen rate (25 kg N/ha) is during the period beween the beginning of active growth and ripeness of basal leaves. Nitrogen utilization rate of plants, fertilized with 50 and 100 kg N/ha is high between ripeness of basal leaves and bud formation.

3. Under the experimental climatic and soil conditions, a nitrogen fertilizer rate of 50 kg ha^{-1} should be considered as optimal to produce tobacco with desirable chemical composition for cigarette manufacturing.

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