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Nitrogen content and its uptake by maize as influenced by some meteorological elements and fertilization

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A b s t r a c t. The experiment was conducted during the period 1982–1987 at the field station Sredec, Stara Zagora region on leached Smolnitza soil. Two maize hybrids (300 and 700 FAO) grown under irrigation and five levels of Nitrogen (0, 302, 242, 182, 121 kg N ha^{-1}) and Phosphorus fertilization (0, 65, 52, 39, 26 kg P ha^{-1}) were observed.

Plant samples were taken for measuring the dry biomass and the content of total Nitrogen after an interval of 14 days from germination. On the basis of these indexes the uptake of Nitrogen was determined. During the vegetation period some meteorological parameters which have an influence on maize grown and the content and uptake of Nitrogen were measured daily (at 7, 14 and 21 h).

Regression equations describing the relations between temperature sum, precipitation sum, saturation deficit sum and the uptake of Nitrogen for each level of Nitrogen and Phosphorus fertilization were drawn up. A parallel between the requirements of the two hybrids with the meteorological elements during the vegetation period was carried out.

It was established that meteorological conditions have a different influence on the uptake of Nitrogen by maize. This depends more on the level of fertilization than on the hybrids.

K e y w o r d s: maize, N content, N uptake, temperature, saturation deficit

INTRODUCTION

Depending on the specific climatic conditions during plant growth there is an uptake of different quantities of mineral substances from the soil (Petr *et al*., 1988). It is of the utmost importance to agricultural practices to study the nutritional elements content in the soil and plants, because the biomass obtained from the plants and the uptake of the same elements by plant production are relevant for the nutritional needs of the plants. As a matter of fact, maize is a cultivated plant, able to absorb from the soil large quantities of Nitrogen (Stanchev, 1900). The Nitrogen content in maize depends not only on the peculiarities of the varieties of the cultivated hybrids, but also on the conditions of cultivation (Mengel *et al*., 1982). Increased drought has a detrimental influence over biomass and Nitrogen accumulations and uptake in middle and early maize hybrids, creating prerequisites for the accumulation of high quantity hydrolysable Nitrogen in the soil (Stancheva, 1995). Producing cereals has helped to establish the impact of some meteorological elements on the uptake of nutritional elements (Matuhno, 1979; Alexandrov and Donov, 2001).

The main purpose of the present research paper is to study the impact of meteorological parameters on the Nitrogen content and uptake of maize cultivated on leached vertisol and, by applying different fertilization standards, establish an inter-dependence between the indices analyzed.

MATERIALS AND METHODS

The experiment was carried out on a leached vertisol during the period 1982–1987 at a sample area located in the village of Sredec, in the district of Stara Zagora. Under long-term field trial conditions, the maize was grown as a monoculture, containing five options of Nitrogen and Phosphorus fertilization, identified below as B_1, B_2, B_3, B_4 and B_5. Two maize hybrids were cultivated, namely Px-20 (FAO Group 300) and H-708 (FAO Group 700) with no deficiency in the water regime; the watering time and the norm were determined in conformity with similar water balance experiences. Experiments were conducted on fertilization in order to specify its interaction with the climate and the soil as a component of the ecosystem itself. The controlled variant

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B_1 is without fertilization in order to determine the richness of the natural soil. The B_3 variant is best and accepted to be the norm, aiming to compensate, in full, the Nitrogen and Phosphorus uptake at a rate of 10.000 kg ha^{-1} of corn. This was fertilized with Nitrogen 242 and Phosphorus 52 kg ha^{-1}. The B_2 variant was fertilized with 125% of the adopted norm, namely with Nitrogen 302, Phosphorus 65 kg ha^{-1}, variant B_4 was fertilized with 75% of the adopted norm – namely with Nitrogen 182, Phosphorus 39 kg ha^{-1}, and the B_5 variant was fertilized with 50% of the adopted norm, namely with Nitrogen 121, Phosphorus 26 kg ha^{-1}. The Nitrogen fertilizers were placed as ammonium nitrate, the Phosphorus - as triple super phosphate. No Potassium fertilization was applied due to the high Potassium content in the soil.

During the vegetation period of the maize, using Hydro Meteorological Service procedures (at 7.00 A.M., 2.00 P.M., and 9.00 P.M.) air temperature measurements, air humidity measurements and the precipitation sum were taken (Dabov, 1971). Every 14 days from the date of maize germination, plant samples were taken to determine the quantity of the absolutely dry biomass and the total N content (Peterburgski, 1986). Based on both indices, the element uptake analyzed was determined. During the vegetation period of the maize, the effective temperature sums and the saturation deficit sum were calculated.

The experimental data received was mathematically processed. As a result, regressive equations were worked out and the interdependence between the indices analyzed was presented as a graph. The importance of each regression was tested through dispersion analysis. The coefficients of determination and the standard error and importance levels were used as precision and accuracy criteria.

RESULTS AND DISCUSSION

Fertilization with Nitrogen and Phosphorus increases – to some definite degree – accumulated biomass and the accumulation and the uptake of those elements by maize hybrids. Figures 1 and 2 are graphs of the average Nitrogen content (1982–1987) during different periods, starting with germination and finishing with the ripening of both hybrids. The Nitrogen content decreases from germination until the formation of the reproductive organs; after that the said content remains equal for both hybrids. The aforesaid change is much more expressed in the variants with fertilizers than in those without them. In both variants – the first one including fertilization, which was adopted as a norm, and the other one including 125% fertilization – both hybrids have almost equal values, just a little higher than those in the other two variants concerning 75 and 50% of fertilization from the established norm. Having only average values it is quite difficult to describe the differences in each year, but we can see that in drier and hotter years, Nitrogen accumulation is smaller.

Meteorological parameters which have the strongest impact on the Nitrogen uptake of maize have also been established. These are the effective temperature sums and the saturation deficit sum. Both sums are calculated with an accumulation for each period when plant samples were taken.

The saturation deficit sum is a complex factor, which could serve as an evaluation of the saturation conditions. In Fig. 3, the linear regression equations for the dynamic in Nitrogen uptake for maize hybrid Px-20 have been presented depending on the accumulated temperature sums. In Fig. 4, the respective linear regression equations for the

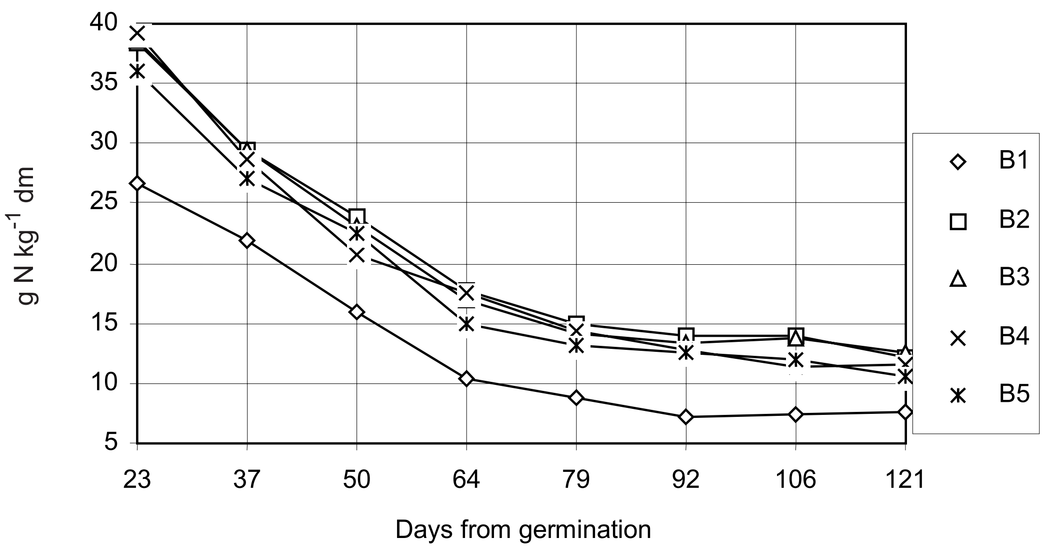

Fig. 1. Content of Nitrogen in maize, FAO.3, 1982–1987, Sredec.

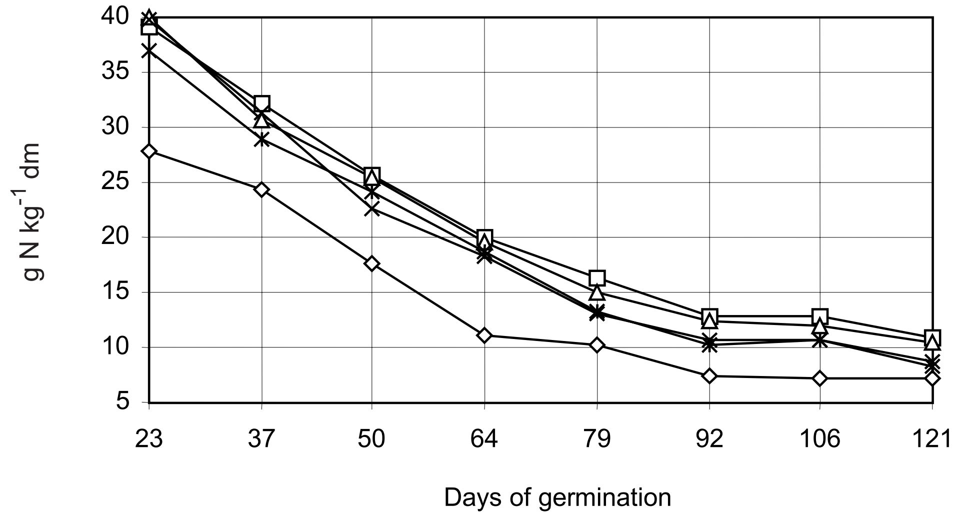

Fig. 2. Content of Nitrogen in maize, FAO.7, 1982–1987, Sredec. Legend as in Fig. 1.

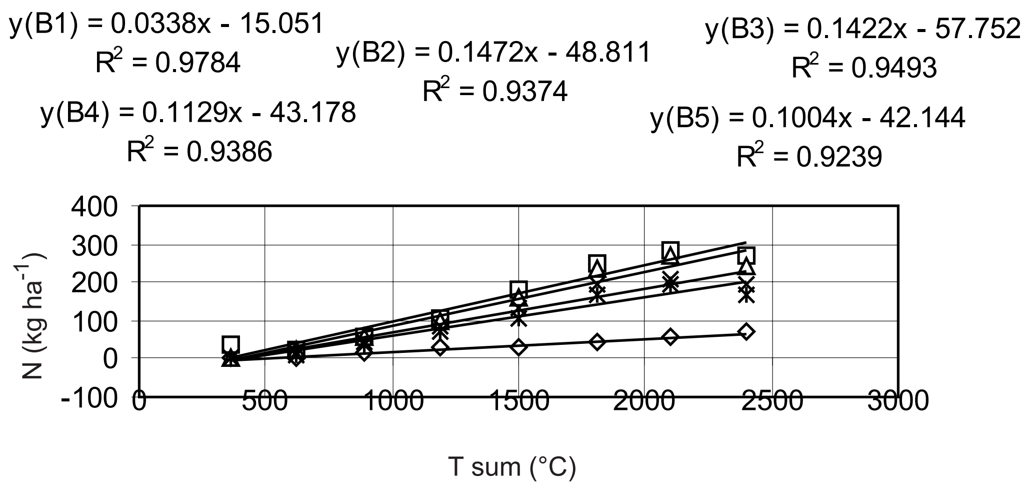

Fig. 3. Influence of temperature sum on the uptake of Nitrogen from maize, 1982–1987, FAO.3, Sredec. Legend as in Fig. 1.

dynamic of the Nitrogen uptake concerning the later maize hybrid H-708 have been presented. In Figs 5 and 6, linear regression equations for the dynamic of the Nitrogen uptake concerning the middle early and later maize hybrids influenced by the saturation deficit sum have been presented. The linear regression equations presented are averages for the period of research and describe very well the links between the indices analyzed.

Analyzing the impact of the air temperature shown by the temperature sum on the different variants, we found that the correlation is highest in those variants without fertilization (B_1) and in both hybrids (R^2=0.98).

Regression coefficient *a* is 0.03, and *b* is 15–18. This has already been confirmed by the previous research (Alexandrova and Donov, 2001) on the middle early hybrid, cultivated on alluvial soil under the same agrotechnical conditions, namely: R^2=0.92. We can also see some distinction in coefficient regression *a*=0.002 and *b*=0.63 due to the divergence in the meteorological parameters and the soil type. Since this concerns meadow alluvial soil, the impact of the temperature factor is much heavier than that concerning the leached vertisol.

In the variants including fertilization, the impact of the temperature factor on the Nitrogen uptake is equally very

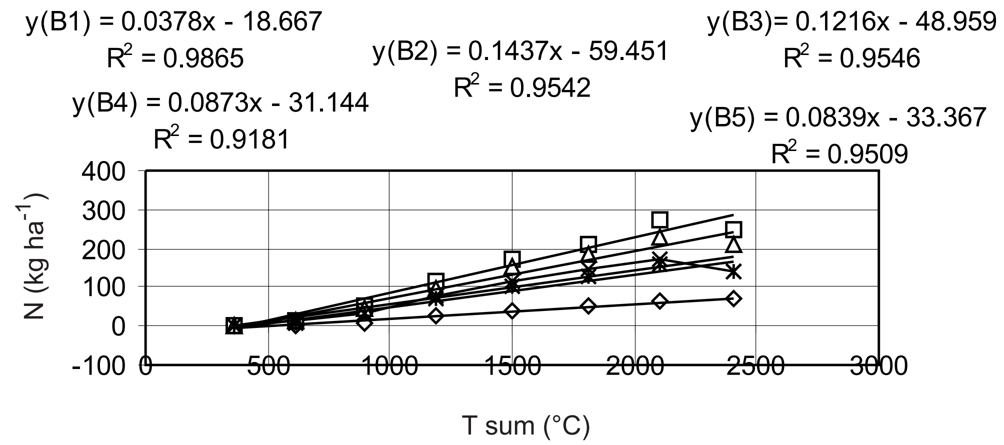

Fig. 4. Influence of temperature sum on the uptake of Nitrogen from maize, 1982–1987, FAO.7, Sredec. Legend as in Fig. 1.

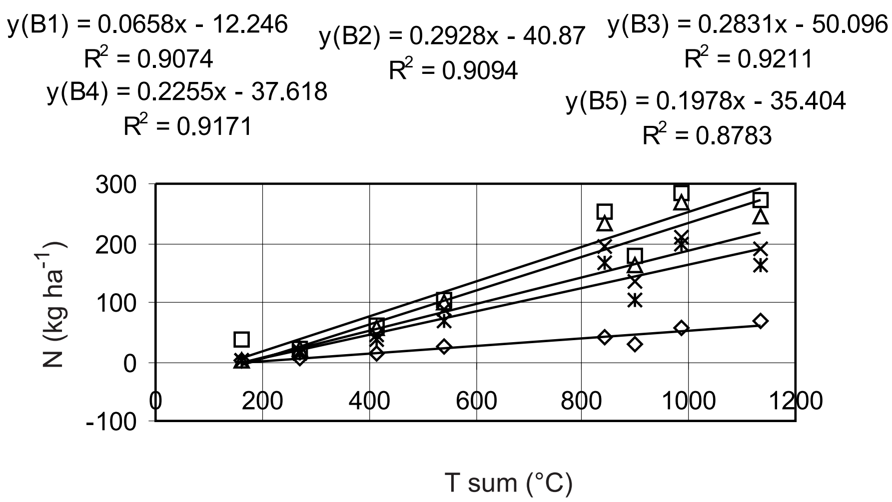

Fig. 5. Influence of saturation deficit sum on the uptake of Nitrogen from maize, 1982–1987, FAO.3, Sredec. Legend as in Fig. 1.

strong but in those cases we have the fertilization factor as well. That factor has a stronger impact concerning the middle early hybrid in Variant B_2 and B_3 (R^2=0.93, coefficient a =0.14, the straight line slope is at 49–58). In Variants B_4 and B_5 the determination coefficient is also high; the regression coefficient a is 0.10–0.11. The regression straight line's slope is smaller and remains constant at 42–43. In the late hybrid H-708 could be observed a divergence in the regression coefficients a in Variants B_4 and B_5. They are lower (0.08), the straight line's slope is smaller as well at 31–33, despite high determination coefficients (0.91–0.95). We could arrive at the conclusion that air temperature has a strong impact on the Nitrogen uptake for maize cultivated on leached vertisol, irrespective of the fertilization standard applied.

Studying the impact of the saturation deficit sum with the maize biomass, we find a divergence between both hybrids. By the middle early hybrid, the meteorological factor impact is strong and the fertilization norm does not have a considerable influence on it. The determination coefficient is between 0.87 in the variant with fertilization with 50% of the norm to 0.90 in the variant without fertilization. The said coefficient is the highest as it concerns Variant B_3. The lowest coefficient is the coefficient of regression a as it

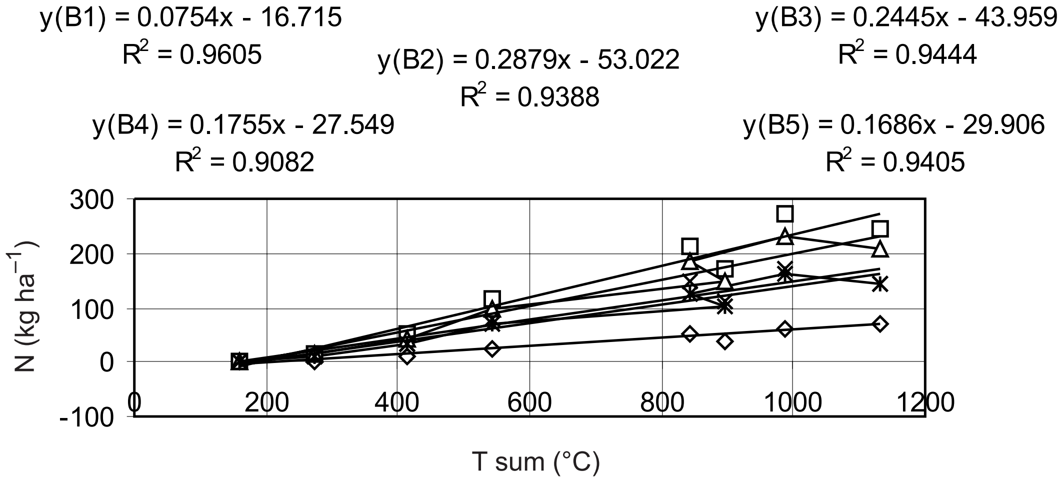

Fig. 6. Influence of saturation deficit sum on the uptake of Nitrogen from maize, 1982–1987, FAO.7, Sredec. Legend as in Fig. 1.

concerns the variant without fertilization at 0.06, and as it concerns the variants with fertilization, the coefficient is between 19 and 29. As it concerns the later hybrid, the impact of the saturation factor is the strongest as it concerns the variants without fertilization (R^2=0.96, a=0.07). As it concerns the variants with fertilization, it could be seen as a divergence of the fertilization levels – R^2 is from 0.90 to 0.94, and a is from 17 to 29.

The divergence in the determination of the saturation factor impact on the Nitrogen uptake between both hybrids remains in the straight line's slope – as it concerns the 125% norm variant fertilization, the straight line's slope is bigger as it concerns the later hybrid, and as it concerns the other variants with fertilization, the straight line's slope increases as it concerns the middle early hybrid, and we arrived at the conclusion that as it concerns variants B_3, B_4, and B_5 the saturation deficit sum is stronger as it concerns the later hybrid.

CONCLUSIONS

The regression equations obtained concerning the temperature and the saturation factors on the Nitrogen uptake by the maize hybrids, determine quite precisely, the Nitrogen uptake concerning the maize under concrete climatic conditions for a particular area. The data obtained can serve to optimize the needs of the maize as it concerns fertilization.

As it concerns the variant without fertilization (B_1) a strong interdependence has been established between the air temperature sum and the Nitrogen uptake in both hybrids (R^2=0.98).

The connection existing between the saturation deficit sum and the Nitrogen uptake (R^2=0.90–0.96) has also been proved but it has not been made widely available to date

For the variants with fertilization, a stronger dependence was established in variants B_2 and B_3.

For the hybrids the connection, namely the Nitrogen uptake: meteorological factors – is stronger than that concerning middle early hybrids as it concerns later hybrids.

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