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Investigation on Fertigation of Peach on Three Soils. III. Zones of Salt Accumulation

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Abstract

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The experiment was carried out in lysimeters on three soils: alluvial-meadow soil (Fluvisol) – sandy loam, cinnamon-forest soil (Luvisol) – clay loam, and smolnitsa (Vertisol) – clay. The fertilizers – urea $[CO(NH_2)_2]$ and phosphoric acid (H_3PO_4), were supplied through the irrigation system, the annual amounts being partitioned to monthly doses.

It was found that the applied by the irrigation water amounts of urea and phosphoric acid did not enhanced salt concentrations in the soil solution to unfavorable for the plants values.

The zones of salt accumulation coincided (by location, shape, and size) with the areas of increased nitrate content. Based on a strong correlation, it was derived a regression equation which allowed the concentrations of nitrate nitrogen in non-saline soils to be determined from the soil electrical conductivity, independently on the soil type and with a satisfying for practical purposes exactness.

Key words: drip-irrigation, fertigation, lysimeters, peach, soil electrical conductivity, nitrates

Introduction

The increased content of soluble salts in the root zone can suppress the growth of the plants and cause undesirable losses of crop production (Hoffman, 1986). The transport of salts in the soil is closely related to water flows and, therefore, the management of soil salinization is closely related to soil characteristics and to water management in the irrigation system. The problem is of especial importance under fertigation where the salt concentration in the irrigation water is being periodically enhanced because of the injection of fertilizers. Special problems and opportunities for control of the soil salinization have been introduced by the drip-irrigation where salts accumulate at the soil surface and at the periphery of the wetted soil volume (Bresler, 1977; Bucks and Nakayama, 1980; Bucks et al., 1982; Bouman and Nakayama, 1986).

The objective of this article is a study of the salt accumulation areas in the root zone of peach trees, determined by the fertigation, by the pattern of soil wetting, and by the specific properties of three soils, basic for the peach-production in Bulgaria. The irrigation water redistribution in the soil with a view to the application efficiency and the spatial distribution of root water uptake, as well as the migration and the localization of nitrogen and phosphorus were discussed in previous articles (Koumanov et al., 1998; Stoilov et al., 1999 a, b). The present results were obtained at the Plovdiv Institute of Fruit-Growing during the period 1994-1997.

Material and Methods

The investigation was carried out in a lysimetric unit on three soils: alluvial-meadow soil (Fluvisol) – sandy loam, cinnamon-forest soil (Luvisol) – clay loam, and smolnitsa (Vertisol) – clay; and with peach trees of Redhaven cultivar on GF-677 rootstock . The soil characteristics and the experimental set-up are described in detailes in previous articles (Koumanov et al., 1998; Stoilov et al., 1999).

The zones and the levels of salt accumulation were determined indirectly – by the electrical conductivity of soil samples taken 20 hours after the last water application. In 1995 and 1996, soil sampling was done by drilling radially from the dripper at 10 cm, 25 cm, 50 cm, 75 cm, and 100 cm, and by layers of 10 cm. In 1995 it was done weekly – four times after the maximal fertilization dose, and to 30 cm in depth. In 1996 soil sampling was done three weeks after the maximal fertilization doze, to depth of 80 cm. The average soil quantity provided by one sample was about 250 g. In 1997 soil samples were taken from a soil profile in 10 cm square grid, after digging a trench along the line tree-dripper. In this case each of the soil samples weighed approximately 1000 g.

The electrical conductivity of the soil samples was measured by a calomel electrode, after adding of distilled water (1:1) and thirty-minute stirring by a shuttle.

Results and Discussion

Data for the distribution of the soil electrical conductivity throughout the investigated soil profiles are presented graphically

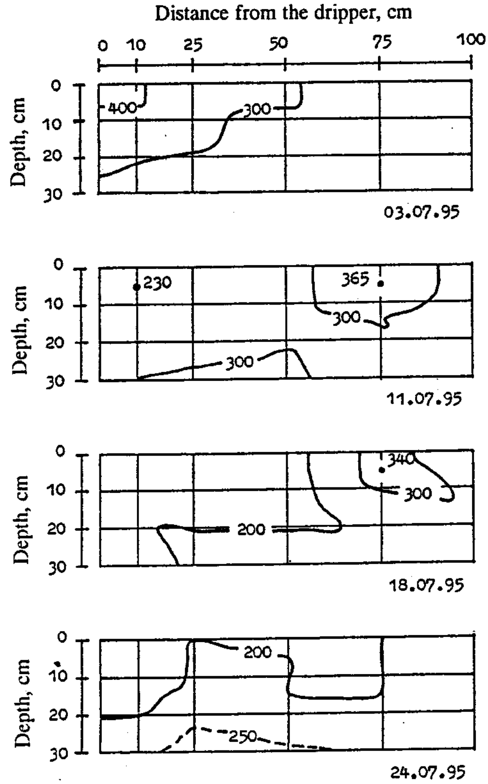

Fig. 1. Changes in the soil electrical conductivity (μS/cm) in the alluvial-meadow soil after applying of the maximal fertilization dose on 26.06.1995

on Figures 1 to 3 for 1995, on Figures 4 to 6 for 1996, and on Figures 7 to 9 for 1997. The estimated maximal values are respectively 610 μS/cm in the alluvial-meadow soil, 1350 μS/cm in the cinnamon-forest soil, and 2000 μS/cm in the smolnitsa. Although these values exceed many times the initial electrical conductivity of 200-300 μS/cm, in the prevailing volume of the root zone they are below the critical for the peach plants 1700 μS/cm (Maas and Hoffman, 1977). Apparently, the applied by the irrigation water amounts of urea and phosphoric acid have not induced unfavorable changes in the concentration of the soil solution.

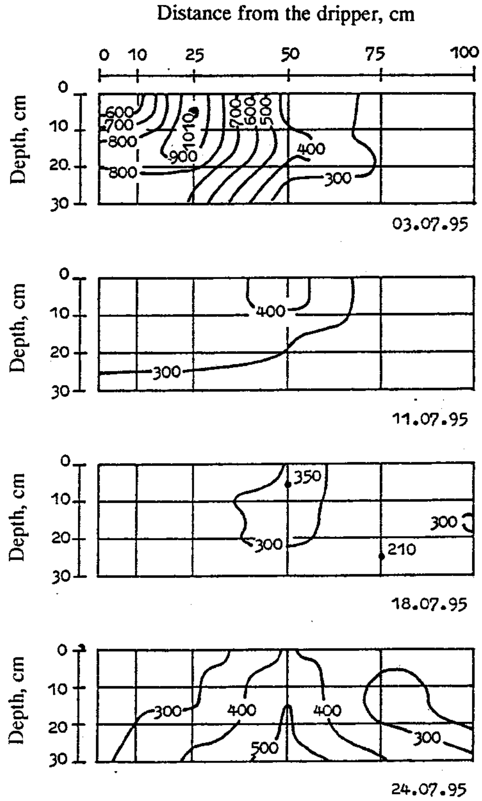

Fig. 2. Changes in the soil electrical conductivity (μS/cm) in the cinnamon-forest soil after applying of the maximal fertilization dose on 26.06.1995

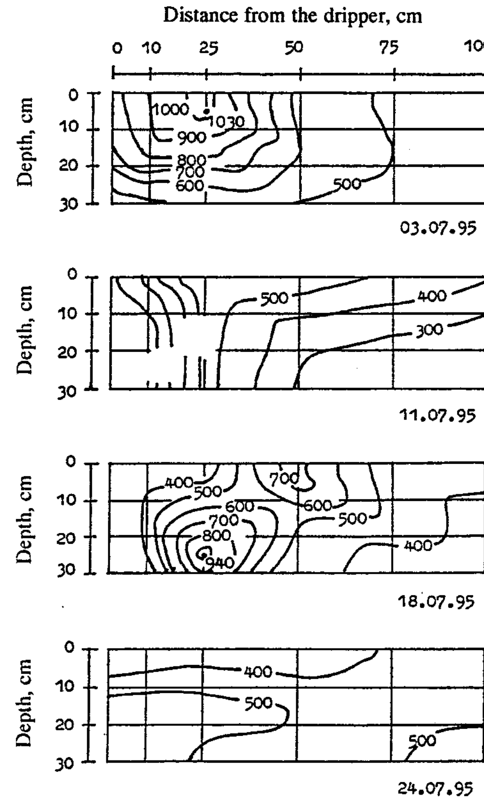

Fig. 3. Changes in the soil electrical conductivity (μS/cm) in the smolnitsa after applying of the maximal fertilization dose on 26.06.1995

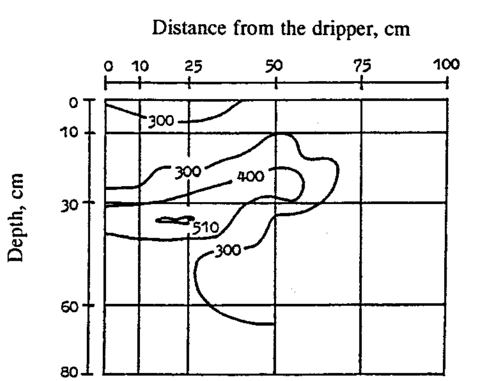

Fig. 4. Field of the soil electrical conductivity (μS/cm) in the alluvial-meadow soil two weeks after applying of the maximal fertilization dose; 10.07.1996; mg/kg

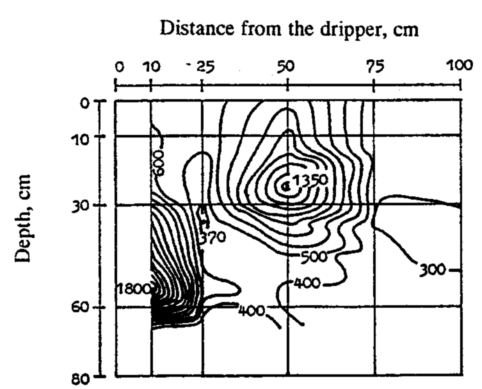

Fig. 5. Field of the soil electrical conductivity (μS/cm) in the cinnamon-forest soil two weeks after applying of the maximal fertilization dose; 10.07.1996; mg/kg

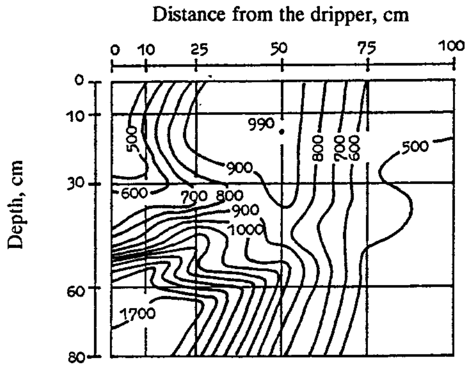

Fig. 6. Field of the soil electrical conductivity (μS/cm) in the smolnitsa two weeks after applying of the maximal fertilization dose; 10.07.1996; mg/kg

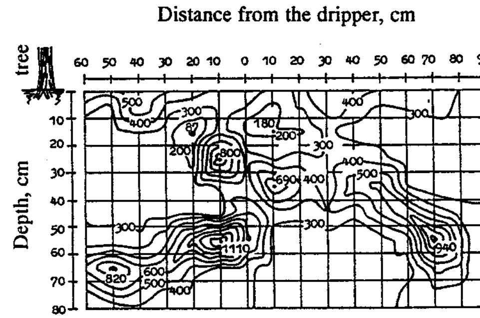

Fig. 8. Field of the soil electrical conductivity (μS/cm) in the cinnamon-forest soil three weeks after applying of the maximal fertilization dose; 15.07.1997; mg/kg

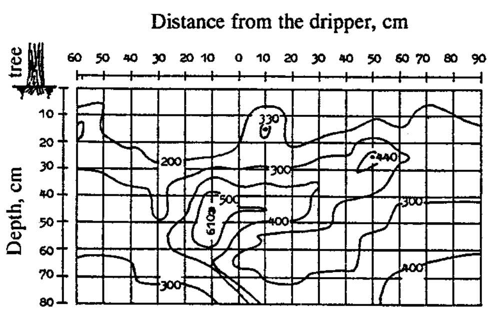

Fig. 7. Field of the soil electrical conductivity (μS/cm) in the alluvial-meadow soil two weeks after applying of the maximal fertilization dose; 04.08.1997; mg/kg

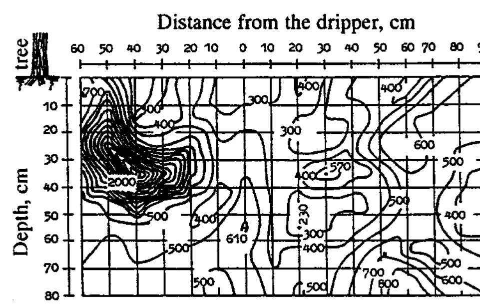

Fig. 9. Field of the soil electrical conductivity (μS/cm) in the smolnitsa three weeks after applying of the maximal fertilization dose; 14.07.1997; mg/kg

The spatial distribution of the water-soluble salts in the three soils gives reasons for the conclusion that these are mostly nitrates. The juxtaposition with the nitrate distribution (see Stoilov et al., 1999 a) reveals an impressive coincidence (by location, by shape, and by size) between the zones of salt accumulation and the areas with increased content of nitrate nitrogen. The established relationship between the soil electrical conductivity and the nitrate concentration was subjected to correlation and regression analyses based on the data for 90 soil samples from the alluvial-meadow soil, 212 from the cinnamon-forest soil, and 198 from the smolnitsa.

The obtained results are illustrated on Figures 10 to 12, presenting by soil types the correlation fields, the correlation ratios, the regression lines, and the derived regression equations. The correlation between the electrical conductivity and the nitrate concentration is strong in the three investigated soils (R=0.73, R=0.95, and R=0.90). The lowest correlation ratio is in the alluvial-meadow soil (R=0.73) where the values of soil electrical conductivity and the nitrate concentration vary in too narrow intervals.

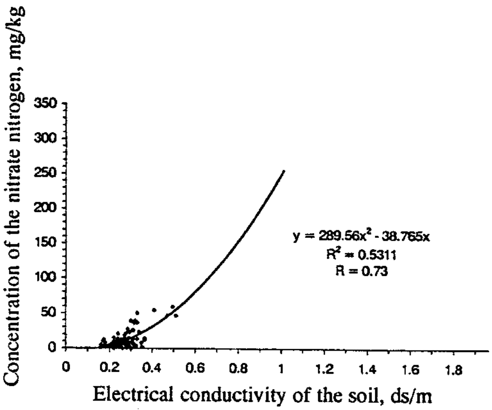

Fig. 10. Correlation between the soil electrical conductivity (dS/m) and the concentration of nitrate nitrogen (mg/kg) in the alluvial-meadow soil

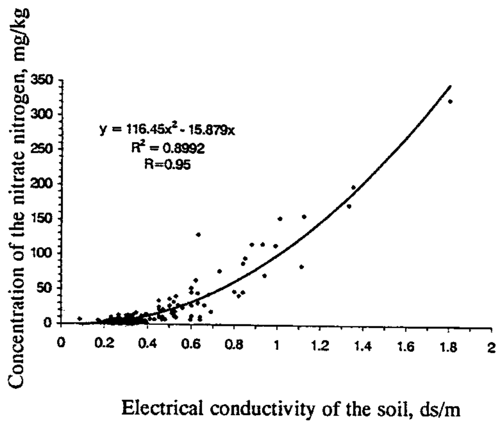

Fig. 11. Correlation between the soil electrical conductivity (dS/m) and the concentration of nitrate nitrogen (mg/kg) in the cinnamon-forest soil

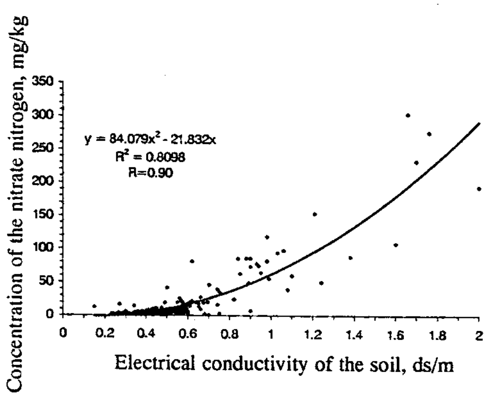

Fig. 12. Correlation between the soil electrical conductivity (dS/m) and the concentration of nitrate nitrogen (mg/kg) in the smolnitsa

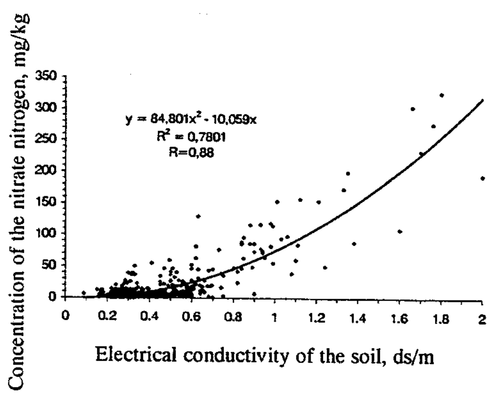

Fig. 13. Correlation between the soil electrical conductivity (dS/m) and the concentration of nitrate nitrogen (mg/kg), based on data for the three soil types

By soils, the derived regression equations are:

Alluvial-meadow soil:	$Y = 289.56\,X^2 - 38.765\,X;$	(1)
Cinnamon-forest soil:	$Y = 116.45\,X^2 - 15.879\,X;$	(2)
Smolnitsa:	$Y = 84.079\,X^2 - 21.832\,X;$	(3)

where X is the soil electrical conductivity in dS/m, and Y is the concentration of nitrate nitrogen in mg/kg.

The obvious similarity of the obtained regression relationships suggests that the correlation between the soil electrical conductivity and the nitrate concentration can be expressed by one universal equation, independently on the soil type. Thus, the correlation and the regression analyses were based on all 500 soil samples, taken from the three lysimeters in the period 1995-1997. The obtained results are presented on Figure 13. The derived regression equation is again of second degree and has the following form:

$$Y = 84.801\,X^2 - 10.059\,X, \qquad (4)$$

where again X is the soil electrical conductivity in dS/m, and Y is the concentration of nitrate nitrogen in mg/kg.

The reliability of the obtained relationship is proven by the correlation ratio, R=0.88, which shows a strong correlation between the investigated characteristics. Thus, by equation (4), the concentration of nitrate nitrogen in non-saline soils might be estimated directly from the soil electrical conductivity, without the labour and material consuming laboratory analysis and with a satisfying for practical purposes exactness.

Conclusions

The applied by the irrigation water urea and phosphoric acid have not induced unfavorable for the peach plants changes in the salt concentration of the soil solution.

The zones of salt accumulation coincide by location, shape, and size with the areas with increased content of nitrate nitrogen

Based on the established strong correlation and respectively on the derived regression equation, the concentration of nitrate nitrogen in non-saline soils might be estimated through the soil electrical conductivity, independently on the soil type and with satisfying for the practical purposes exactness.

Acknowledgements

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