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# MELIORACJE I INŻYNIERIA ŚRODOWISKA

20

Część II

POZNAŃ 1999

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# THE ROLE OF WATER FROM IRRIGATION IN PREPARING SOIL FOR REPLANTING AN ORCHARD

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ABSTRACT. The aim of the experiment was the evaluation of irrigation influence on the changes of the physico-chemical properties of the soil in a replanted orchard. The study was conducted in the years 1994-1998 in the experimental farm of the Agricultural University, in Przybroda. The studies were carried out on the effect of irrigation and fertilisation regimes on apple tree growth and on the physical and chemical properties of the soil during the first five years after replantation. Irrigation of the orchard after replantation is particularly important.

**Key words:** irrigation, replantation, water management, physical and chemical properties of soil

## Introduction

The issue of soil exhaustion is becoming more and more important both in scientific, technical and economic aspects. The role of water in investigations over the problem of orchard replanting factual usefulness due to soil environment changes presents a vital importance. Water present in soil, in the form of water solution, is one of the soil buiding stages. The function of the water present in soil and coming both from precipitation and intensive irrigation is matter and energy transportation taking place in agreement with soil water movement direction. The intensity of water movement direction changes in soil and the amount of flowing water against

Rocz. AR Pozn. CCCX, Melior. Inż. Środ. 20, cz. II: 223-231

PL ISSN 1230-7394

the background of soil profile moisture are decisive in water management - characteristic of soil. Soil water management course of the replanted orchard is a result of climatic, hydrogeological, soil and antropogenic conditions which should also include form of utilization and intensive irrigation (**Pacholak** 1992, **Pacholak** and **Przybyła** 1996, 1997, **Przybyła** 1994, **Rebandel** 1987, **Swell** and **White** 1979).

The aim of the work was to evaluate the influence of apple orchard irrigation on physical and chemical changes of soil.

## Materials and methods

The research was carried out in the period of 1994-1998 in an experimental apple orchard of Department of Pomology in Przybroda, about 25 km north of Poznań. The object of the investigations is situated on the area of the Szamotulska Plain. Both the evaluation classes as well as the soils of the plot are typical for the region of Wielkopolska agrticultural utility complexes and evaluation classes as well.

New trees were planted in spring of 1994 preserving the former system of both irrigation and fertilizing combinations after the 17 years old orchard, planted in 1976, had been grubbed up in autumn of 1993. Trees of Sampion cultivar were planted on P60 stock after a careful preparation applying the spacing of 3.5 m × 1.5 m i.e. 1900 pieces per one hectare of the area. The trees were trained in the form of Driling crowns i.e. applying specially built supporting constructions in the newly - planted orchard. The irrigation was carried out by help of a stationary sprinkling system with sprinklers having nozzles of 4 and 6 mm in diameter. The intensity of the sprinkled water was 7 mm/h in simple irrigation doses from 14 to 35 mm. The source of the irrigation water was the Pamiątkowskie Lake characterized by water purity of class 3. The water was pumped from the lake to a retarding reservoir placed on the area of fruit – growing experiments. The replanted trees, three years after they had been introduced, gave their first crop; the year 1996 was the first year of the orchard's yielding.

Three irrigation variants were compared in the period of 1994-1998 i.e. the years of training the orchard:

W0 – control/test variant, without irrigation,

W1 – medium intensity irrigation, applied to keep the soil moisture in the aimed depth layer (0-50 cm) at the level of 0.03 MPa,

W2 – high intensity irrigation, applied to keep soil moisture at the level of 0.01 MPa of water potential.

The obtained effects of functioning of the combination were evaluated in three aspects:

– analysis of the texture of the soil in focus,

– physical and chemical properties of the investigated soil profiles,
– evaluation of the influence of irrigation procedures both on the content of nutrients and soil pH.

## The course of meteorological conditions and applied irrigation types

Climatic conditions of the Przybroda plot have been characterized, for the period of 20 years, by changeable atmospheric precipitation sums as well as their varied distribution in the period of vegetation.

Analysing the precipitation distribution Figure 1 in the years 1979-1998, it can be stated that the periods of water deficit, as compared to the many years' mean, appeared irregularly. In the discussed period of 20 years, 7 years were dry, 6 moderately wet and 7 years were wet. Figure 1 presents precipitation sums (W0)

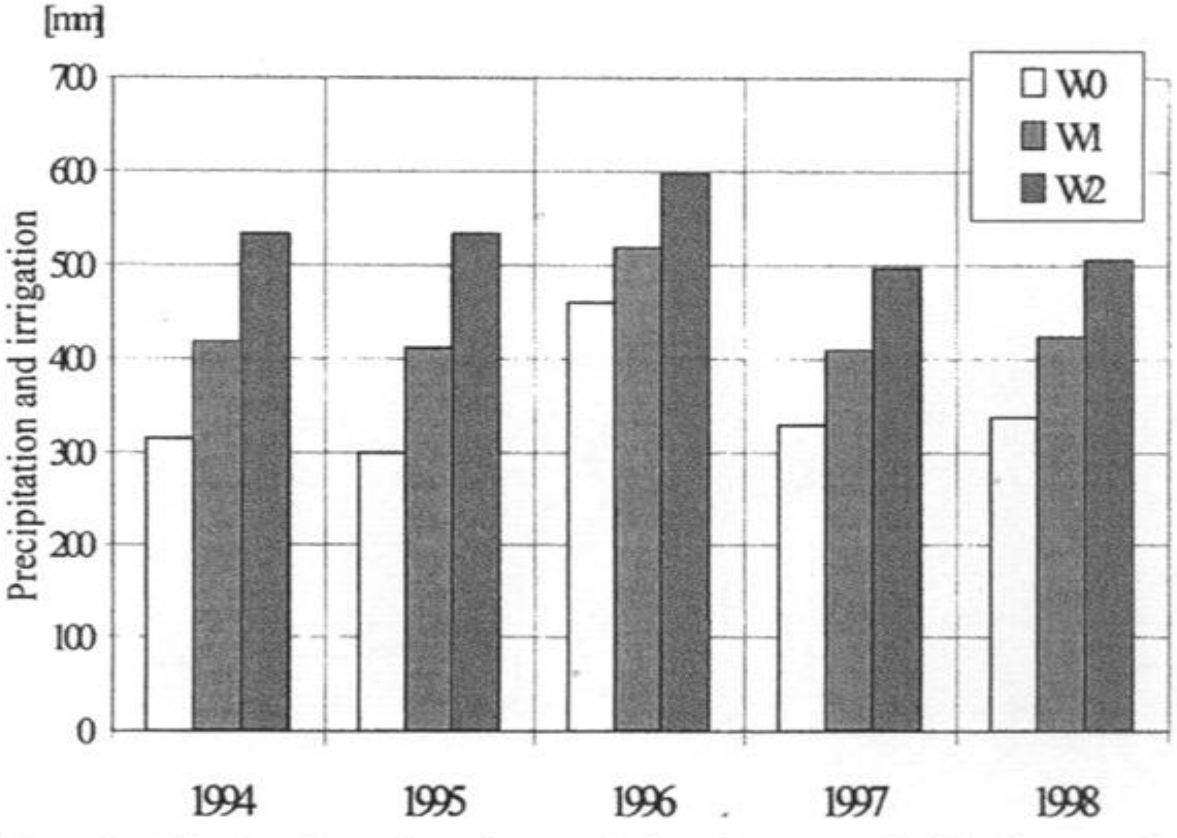


Fig. 1. Precipitation W0 and total sum of irrigated water applied in the successive vegetation periods in the years 1994-1998
Ryc. 1. Opady naturalne W0 oraz sumaryczne dawki wody w kombinacjach W1 i W2 w okresach wegetacji 1994-1998

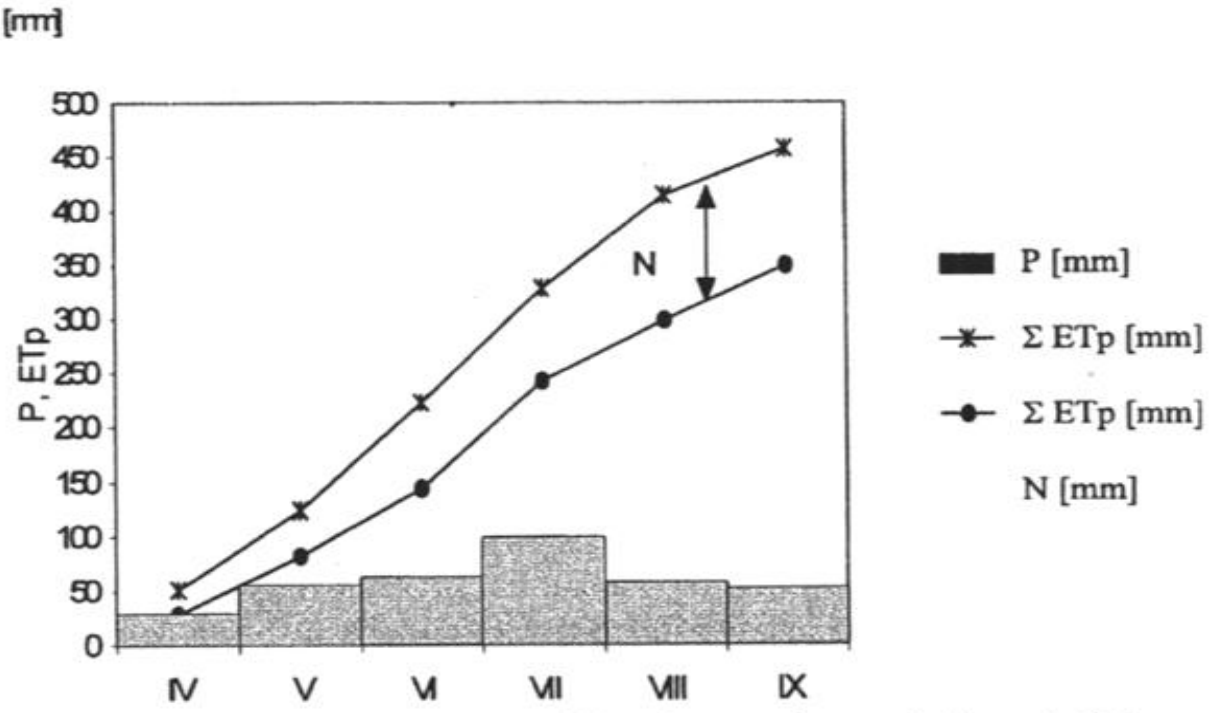


Fig. 2. Monthly sums of precipitation (P) and curves for cumulative potential evapotranspiration ($\sum$ETp) and precipitation ($\sum$P) and water deficiency (N), mean for years 1994-1998

Ryc. 2. Miesięczne sumy opadów (P) oraz krzywa sumowania ewapotranspiracji potencjalnej ($\sum$ETp) i opadów ($\sum$P) oraz suma niedoboru opadów (N) obliczone dla lat 1994-1998

and precipitation together with the applied irrigation doses (W1 and W2) in the vegetation period of the research successive years in the replanted orchard, which oscillated from 300 to 600 mm.

The differences between the values of precipitation calculated for the vegetation periods (IV-IX) and potential evapotranspiration (P – ETp = N), are characteristic for climatic water balance of the investigated soils. The obtained (P – Etp) differences indicate a clear occurrence of precipitation deficits and so imply the necessity of applying irrigation. Figure 2 presents five years' research period mean (1994-1998), comprising the period of the replanted orchard's growth.

## Results

The conducted investigations and analysis of six soil profiles within the combinations included in the experiments showed that the experimental soils should be qualified as podzolic soils proper built in the surface layer (0-50 cm) of light clay sand to heavy clay sand with clay occurring in the subsoil (Tab. 1 and 2).

**Table 1**

**Texture of investigated soils**
**Skład granulometryczny badanych gleb**

| Number of profile Numer profilu | Depths Warstwa (cm) | Texture symbol Symbol składu granulometrycznego | Sceleton particles Części szkieletowe (%) | | Soil size fraction Frakcje części ziemistych (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | > 2 | 2-1 | 1-0.5 | 0.5-0.25 | 0.25-0.1 | 0.1-0.05 | 0.05-0.02 | 0.02-0.006 | 0.006-0.002 | < 0.002 |
| | | | | | mm | | | | | | | |
| 1 | 0-50 | pgl | 2.1 | 1.0 | 8.2 | 17.5 | 36.3 | 13 | 9 | 6 | 5 | 5 |
| | 50-95 | gl | 1.0 | 1.1 | 7.5 | 15.3 | 30.2 | 11 | 6 | 7 | 4 | 19 |
| | 95-100 | gl | 2.7 | 1.3 | 7.3 | 14.7 | 31.0 | 13 | 8 | 7 | 3 | 16 |
| 2 | 0-50 | pgl | 1.6 | 1.5 | 8.0 | 17.7 | 34.3 | 16 | 10 | 8 | 3 | 3 |
| | 50-95 | gl | 1.5 | 1.3 | 6.7 | 14.2 | 30.0 | 11 | 7 | 8 | 3 | 20 |
| | 95-100 | gl | 1.7 | 1.2 | 7.5 | 16.0 | 31.5 | 13 | 7 | 8 | 4 | 13 |
| 3 | 0-30 | pgm | 0.9 | 1.0 | 9.2 | 17.0 | 34.8 | 16 | 8 | 6 | 5 | 4 |
| | 30-50 | gl | 0.9 | 1.2 | 6.7 | 14.0 | 30.3 | 10 | 7 | 7 | 3 | 22 |
| | 50-80 | gl | 1.9 | 1.9 | 8.2 | 14.8 | 33.0 | 11 | 8 | 8 | 4 | 15 |
| | 80-120 | gl | 1.9 | 1.3 | 8.7 | 15.5 | 31.8 | 12 | 9 | 7 | 5 | 13 |
| 4 | 0-60 | pgl | 3.6 | 1.5 | 8.7 | 17.3 | 37.0 | 14 | 9 | 6 | 5 | 3 |
| | 60-110 | gl | 1.1 | 0.9 | 7.5 | 16.5 | 31.0 | 11 | 7 | 6 | 4 | 17 |
| | 110-150 | gl | 1.6 | 1.4 | 7.3 | 15.0 | 30.7 | 12 | 8 | 7 | 5 | 15 |
| 5 | 0-45 | gl | 1.1 | 0.9 | 7.7 | 17.3 | 35 | 15 | 10 | 6 | 5 | 4 |
| | 45-90 | gl | 1.0 | 1.2 | 6.5 | 13.0 | 28.5 | 12 | 9 | 7 | 6 | 20 |
| | 90-145 | gl | 2.0 | 1.5 | 7.5 | 14.5 | 29.0 | 13 | 7 | 10 | 6 | 13 |
| 6 | 0-35 | pgl | 1.0 | 0.9 | 7.3 | 16.7 | 35.0 | 15 | 10 | 6 | 5 | 4 |
| | 35-70 | gl | 0.7 | 1.0 | 6.5 | 13.8 | 28.7 | 12 | 6 | 7 | 3 | 23 |
| | 70-100 | gl | 1.8 | 1.0 | 7.3 | 14.2 | 30.5 | 11 | 7 | 7 | 4 | 19 |
| | 100-150 | gl | 2.9 | 1.2 | 7.5 | 14.7 | 28.8 | 12 | 7 | 11 | 5 | 14 |

Ground water table oscillated from 120 cm in spring to 190 cm in autumn in the period of investigations (1994-1998). Defining soil texture (Tab. 1) and physical and chemical properties (Tab. 2) made it possible to evaluate the content of assimilable nutrients depending on the applied irrigation combinations. It was found that the varied soil irrigation used for some years characteristically influenced:

- physical and chemical properties of soil in the replanted orchard,
- content of nutrients,
- soil pH.

Table 2

**Some physical and chemical properties of investigated soil profiles**
**Niektóre właściwości fizyczne badanych profili glebowych**

| Number of profile Numer profilu | Depths Warstwa (cm) | Texture symbol Symbol składu granulometrycznego | Organic mater Substancja organiczna (%) | Density particle Gęstość fazy stałej ($g \cdot cm^{-3}$) | Water hygroskopicity Woda higroskopowa (%) | Maximal hydroscopity water volume Maksymalna higroskopowa pojemność wodna (%) | pH in $H_2O$ w $H_2O$ | pH in KCl w KCl | $CaCO_3$ (%) | $Fe_2O_3$ (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0-50 | pgl | 0.93 | 2.62 | 0.55 | 0.94 | 5.3 | 4.7 | 0 | 0.46 |
| | 50-95 | gl | 1.47 | 2.65 | 2.65 | 4.16 | 7.1 | 6.2 | n.m. ślad | 1.73 |
| | 95-100 | gl | 1.14 | 2.65 | 2.20 | 3.67 | 7.3 | 6.3 | n.m. ślad | 1.40 |
| 2 | 0-50 | pgl | 0.58 | 2.63 | 0.32 | 0.73 | 4.6 | 4.3 | 0 | 0.48 |
| | 50-95 | gl | 1.44 | 2.65 | 2.83 | 4.57 | 6.1 | 5.1 | 0 | 1.71 |
| | 95-100 | gl | 0.9 | 2.65 | 1.82 | 2.90 | 7.0 | 6.2 | n.m. ślad | 1.27 |
| 3 | 0-30 | pgm | 1.39 | 2.6 | 0.67 | 1.55 | 4.4 | 3.9 | 0 | 0.43 |
| | 30-50 | gl | 1.64 | 2.66 | 3.14 | 5.05 | 5.2 | 4.4 | 0 | 1.81 |
| | 50-80 | gl | 1.28 | 2.68 | 2.19 | 3.57 | 7.0 | 6.1 | 0 | 1.57 |
| | 80-120 | gl | 0.87 | 2.62 | 1.29 | 2.30 | 8.1 | 7.6 | 6.6 | 0.98 |
| 4 | 0-60 | pgl | 0.46 | 2.64 | 0.40 | 0.63 | 5.1 | 4.9 | 0 | 0.43 |
| | 60-110 | gl | 0.92 | 2.67 | 2.51 | 3.60 | 5.4 | 4.6 | 0 | 1.61 |
| | 110-150 | gl | 0.58 | 2.65 | 2.22 | 3.39 | 7.9 | 7.1 | 1.5 | 1.3 |
| 5 | 0-45 | gl | 1.15 | 2.57 | 0.70 | 1.15 | 4.9 | 4.4 | 0 | 0.38 |
| | 45-90 | gl | 1.18 | 2.63 | 3.03 | 4.71 | 6.4 | 5.8 | 0 | 1.82 |
| | 90-145 | gl | 0.73 | 2.61 | 1.44 | 2.59 | 8.2 | 7.6 | 10.2 | 1.10 |
| 6 | 0-35 | pgl | 1.08 | 2.6 | 0.66 | 1.19 | 5.5 | 5.0 | n.m. ślad | 0.40 |
| | 35-70 | gl | 1.28 | 2.68 | 3.08 | 4.79 | 5.9 | 5.0 | n.m. ślad | 1.98 |
| | 70-100 | gl | 0.99 | 2.67 | 2.81 | 4.40 | 6.9 | 6.4 | n.m. ślad | 1.86 |
| | 100-150 | gl | 0.38 | 2.67 | 1.45 | 2.60 | 8.1 | 7.6 | 10.4 | 1.09 |

The carried out analysis of the results showed the applied irrigation, independently of the level of fertilizing of the orchard in the years 1976-1993, had no significant influence on the changes of phosphorus content. However it brought about a rise in potassium content, independently of the degree of soil moisture. The preserved level of water moisture caused a significant increase in magnesium content. A higher soil moisture brought about an increased amount of magnesium. An intensive irrigation of the soils of the orchard showed a rise in pH reaction (Fig. 3).

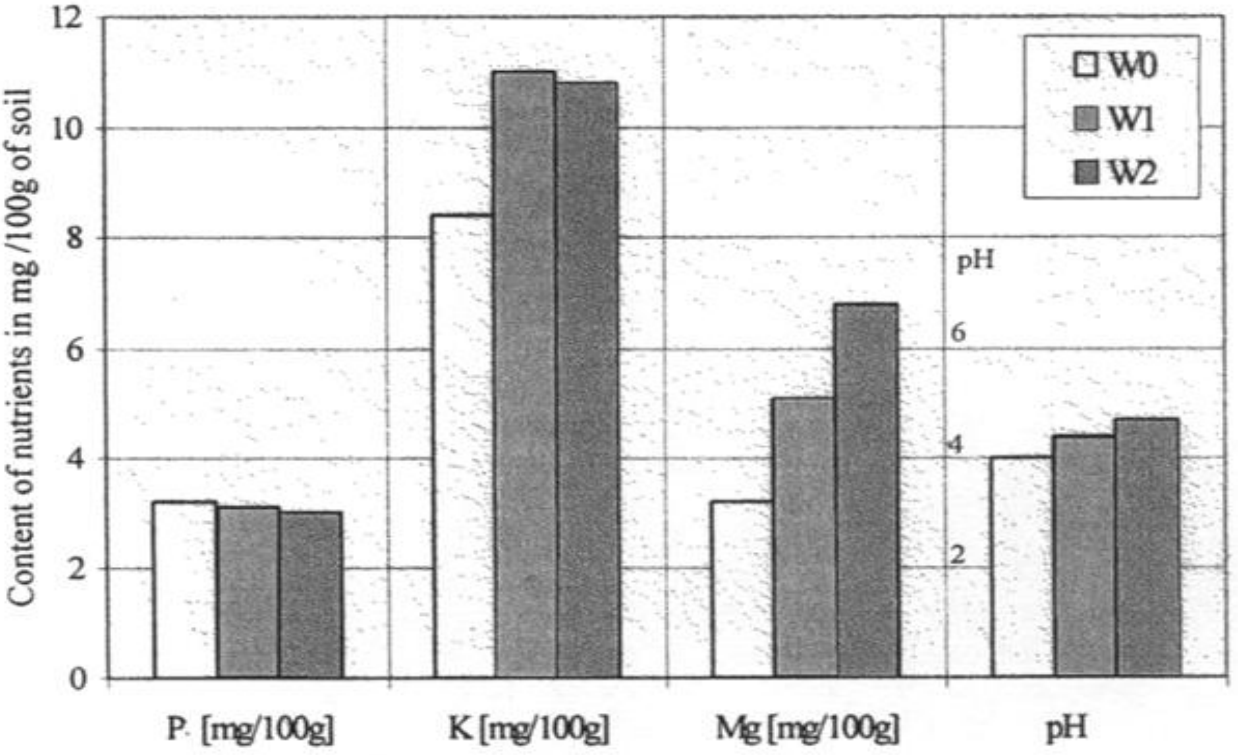


Fig. 3. Irrigation and content of available nutrients in the soil (mg/100 g of soil) and pH
Ryc. 3. Wpływ nawodnień na zasobność gleb w mg/100 g gleby oraz pH

The effects of the influence of irrigation of the replanted orchard on the content of nutrients in soil in its aimed depth layer as well as soil pH reaction are presented in Figure 3.

## Conclusions

The carried out many years' careful investigations on the evaluation of the role of irrigation water on physical and chemical soil properties in the replanted apple orchard let the authors draw the following conclusions:

1. A clear need for the orchard irrigation existed during all the years of the investigations.

2. Intensive irrigation of the orchard had no significant influence on physical properties of the soil.

3. Irrigation influenced changes of the content of assimilable nutrients in soil. The changes were tightly connected with the analysed element. The most significant influence was found while analysing the content of magnesium when parallel to higher irrigation intensity, its concentration increased too.

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## ROLA WODY Z NAWADNIANIA W PRZYGOTOWANIU GLEBY DO REPLANTACJI SADU JABŁONIOWEGO

### Streszczenie

Przedstawione w pracy badania nad oceną wpływu wody z nawodnienia na właściwości fizyczne i chemiczne gleb w replantowanym sadzie jabłoniowym pozwoliły na wyciągnięcie następujących wniosków:

1. We wszystkich latach objętych badaniami istniała wyraźna potrzeba nawadniania sadu.

2. W warunkach intensywnego nawadniania sadu nie miało ono istotnego wpływu na właściwości fizyczne gleby.

3. Nawadnianie wpływało na zmiany zawartości przyswajalnych składników w glebie. Były one ściśle związane z analizowanym pierwiastkiem. Najistotniejszy wpływ stwierdzono przy analizie zawartości magnezu, gdzie wraz z intensywnością nawadniania wzrastało jego stężenie.