Effect of water supply on nutrient transport in grapevine varieties

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Summary: The effect of water supply on availability of macro nutrient elements (N, P, K) by the plants in the soil and their transport in the plants were examined. In a field experiment two grapevine varieties characterized by higher (White Riesling B 7) and lower (Kövidinka K 8) water requirement were compared on the basis of N, P, K concentrations of leaf blades, petioles and berries. A different water supply of the vineyard was achived by striped coverage of the soil with plastic foil to exclude rainfalls from the beginning of May to ripening. Humidity of the soil decreased as the vegetative phase advanced. Soil cover resulted in 25–30% decrease of the water content in the soil at flowering but this difference gradually disappeared till veraison (i.e. the start of intense growth of the berries). The water consumption in the White Riesling B 7 plantation was more intensive. Mobility and availability of N, P, K in the soil was restricted by water exclusion (i.e. plastic soil cover) at flowering. Nitrogen was slightly affected, whereas P and K were in a higher extent. Comparing the transport of nutrient elements in the two varieties, leaf blades of Kövidinka K 8 contained less N and more P and K than White Riesling B 7 at flowering and more N and P and less K at ripening. Water deficiency inhibited K accumulation in the berries of White Riesling B 7, while this effect did not appear in Kövidinka K 8.Water exclusion decreased the yield of White Riesling B 7 already at lower bud loading, the yield of Kövidinka K 8 was affected only at higher bud loading. The higher yields of the treatments in Kövidinka K 8 plantation support the superior performance of this variety under the hot and dry climate of the Hungarian Great Plain.

Introduction

In the last decade drought was one of the most important environmental factors limiting the productivity in Hungarian agriculture. The average amount of annual precipitation was 550 mm (1901–1975) in the region of the Hungarian Great Plain. The unfavourable distribution of the precipitation during the year, especially in the growing period contributed to the harmful effects of water deficiency exerted on plant development, mainly in that region, where the ground water level was deeper.

Water deficiency reduces not only the water transport of the plants but the nutrient element availability of the soil as well, as it was shown in a vineyard irrigation experiment (*Bálo* et al., 1998). This phenomenon has greater significance on light, sandy soils, considering their poor water-household properties. In the wine districts of the Great Plain these circumstances occur quite frequently.

Under restricted availability of nutrient elements in the soil, the efficiency of nutrient uptake becomes more important. The higher efficiency of the variety provides sufficient nutrient uptake even in the case of low avaible nutrient concentrations of the soil (*Erdei* et al., 1985; *Gerloff*, 1976, *Glass*, 1989; *Miklós* et al., 1997).

During the hot and dry summers of the last years the drought tolerance of grapevine varieties came into highlight. Under our climate an average yield of grapevine needs 600–650 mm annual precipitation (*Kozma*, 1993). The water requirement of grapevine is higher from bud burst to veraison (vegetative phase) than in the ripening phase (*Saayman & Labrechts*, 1995). The long drought periods frequently cause the formation of off-flavour aroma components (*Rapp & Versini*, 1996), diminishing the sensory values of the wines.

One of the possibilities to improve the conditions should be the irrigation of vineyards during period of drought, but the economical conditions cannot afford its general use in Hungary. The other possibility is the selection of varieties with genetically determined drought tolerance and optimalizing the parameters of agricultural technics such as fertilization and bud loading.

The aim of our work was to study the effect of soil water relations on the transport of nutrient elements. Two grapevine varieties were compared. White Riesling B 7 shows higher water requirement than Kövidinka K 8 in the cultivation practice.

Materials and methods

Experimental condition

Field experiment was established in 1997 and 1998 in an 8-year-old plantation of *Vitis vinifera* L. cv. Kövidinka K 8 and White Riesling B 7 varieties on sandy soils at Kecskemét-Katonatelep. The vineyards of the two varieties were settled side by side. High training system was formed with 3x1 m² spacing. Two bud loadings (L1: 18 and L2: 36 buds/stock, respectively) were applied. Water relations were influenced by covering the soil with plastic foil stripes from the beginning of May to harvest in three replicates, which were separated by uncovered stripes in the same length as the covered ones. The row length of the stripes was 20 stocks. Varieties were harvested according to their character, i.e. White Riesling B 7 was harvested at the end of September and Kövidinka K 8 in the mid of October.

Environmental parameters

The amount of rainfall, the average temperature were registered each day of the year by an automatic weather station.

Soil and plant analysis

For tracing the humidity of the soil, water content in 0–20, 20–40, 40–60, 60–80 cm soil depth was measured every second week in four repetitions of each treatment from the begining of May till veraison and after harvest, at the end of October. The samples were dried at 105 °C for four hours. The average water content of 0-80 cm soil layer was calculated for interpretation.

To characterize the availability of nutrient element in the soil, samples were taken from the 0–30 and 30–60 cm depth at flowering time. The samples were dried at 60 °C, ground and sieved. An electro-ultrafiltration (EUF) method (Németh, 1979) was applied for the extraction of nutrients from the soil. The amount of nutrient elements in EUF 20 °C extract is considered as fractions available for the which can be taken up during the growing season. The values of the main macro nutrients (N, P, K) will be shown. The concentration of PO_4^{3-}, NO_3^- ions and N-total were measured photometrically. N-total means the sum of nitrate and mineralizable organic nitrogen fractions (organic nitrogen fraction of low molecular weight). Potassium concentration was determined by atomic absorption spectrophotometry (AAS).

Leaf samples were gathered at flowering and at ripening. The leaf blades and petiols were separated immediately. After the standard preparation procedure (washing, drying, grinding and sieving) samples were ashed at 550 °C, digested in 6n HCl and after filtration diluted with distilled water for the determination of concentration in P (photometrically) and K (AAS). Kjeldahl method was applied for the measurement of N concentration. Berries of the ripe bunches were analysed similarly to the leaves.

Since the beginning of the experiment was a little bit later than flowering in 1997, only the average values of 1998 are interpreted. The results of the two bud loadings were taken into account together at the calculation.

Results

The total amount of rainfall (605 mm) in the experimental vineyard in 1998 was distributed relatively equally during the seasons. From January to the end of April 136 mm rain fell. With the plastic cover of soil surface from bud burst to harvest (from the begining of May to the end of September) 363 mm rainfall was excluded. The humidity of the soil decreased consequently as the vegetative phase advanced parallel with the growing of green plant parts *(Figure 1.)*.

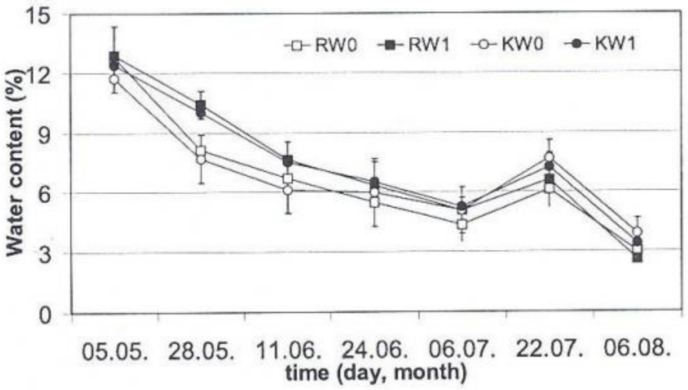

Figure 1 Change of the average water concentration of the soil in the 0-80 cm depth in the soil of covered (W0) and uncovered (W1) plots of White Riesling (R) and Kövidinka K 8 (K) varieties

The water content of covered (W0) and uncovered (W1) soil stripes was nearly the same (12.3% and 12.7%) at the begining of the experiment. The water supply of each treatment decreased continuously till August to 3-4%. In the plantation of White Riesling B 7 (R) water content of the soil was utilized in a higher extent than in Kövidinka K 8 (K). These differences gradually disappeared to August, when beside rainfall exclusion, the soil cover inhibited the evaporation, retaining the water in the soil. At the end of October the moisture of the plots reached 8–9.5%. The average difference between W0 and W1 treatments was less than 10%.

The soil of the experimental vineyard was well-supplied with nitrogen, potassium and phosphorus according to the soil data measured at flowering *(Figure 2.)*. Nutrient supply was more abundant in the upper 0–30 cm than in 30–60 soil layer in both plantation. Total nitrogen and nitrate levels were similar in the 0–30 cm and 30–60 cm soil layers of each treatment, except the nitrogen concentration of the uncovered plots in White Riesling B 7 (RW1) plantation, where the lower total nitrogen and higher nitrate values could be related to an intensive nitrogen mineralization. Nitrate mobility was hardly affected althought nitrate ion is considered as the most mobil anion in the soil. The greatest effect of soil cover manifested in the change of the available phosphorus concentration (EUF-P 20 °C). In consequence of water exclusion (W0) phosphate was retained in the soil resulting in higher P levels. The humidity (W1) enhanced P mobility and the availability causing P depletion of the soil

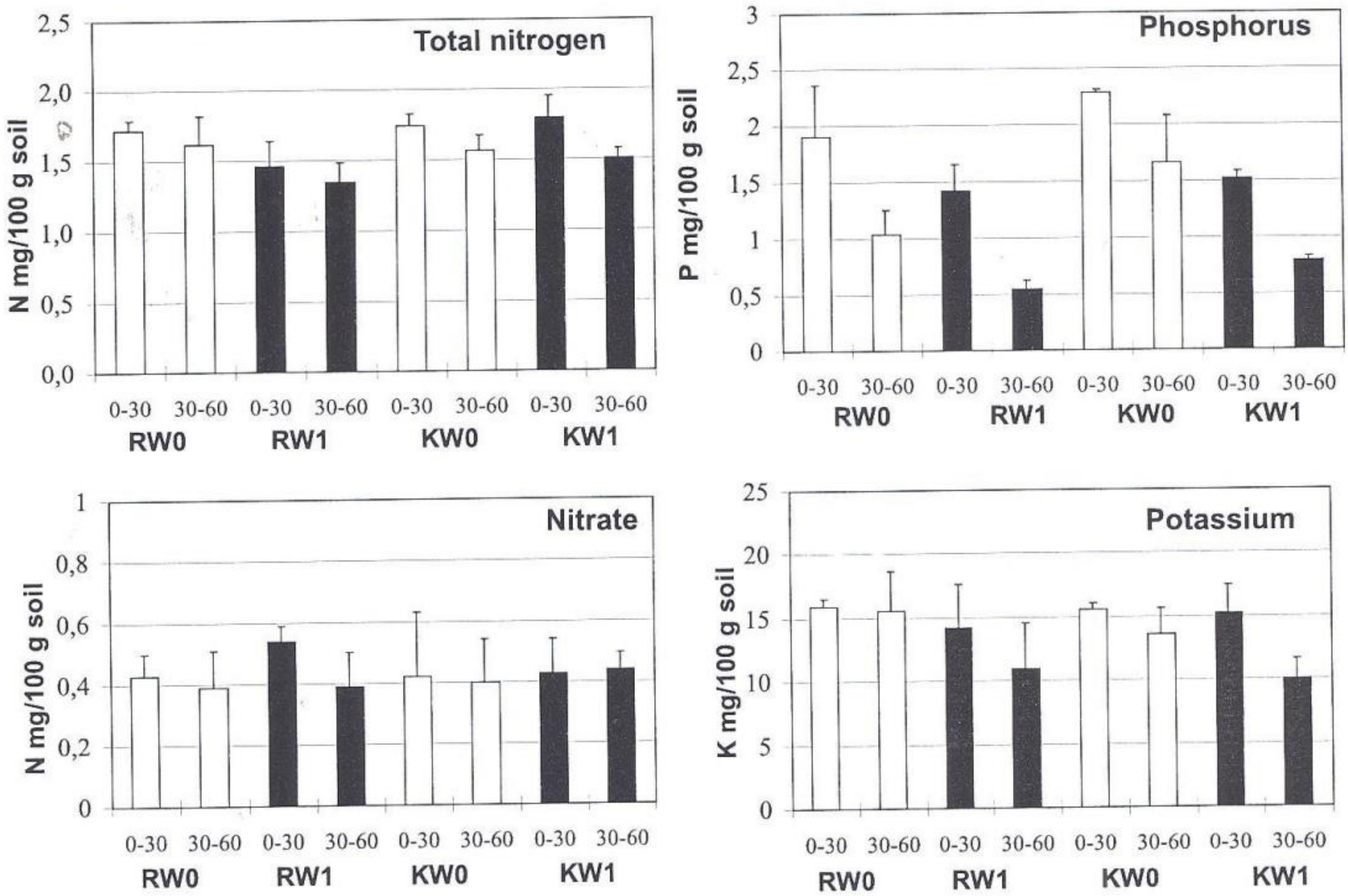

Figure 2 Effect of water supply on the available total nitrogen, nitrate, phosphate and potassium concentration in the soil of covered (W0) and uncovered (W1) plots of White Riesling (R) and Kövidinka K 8 (K) varieties at flowering

in the examined 0–60 cm soil layer. The change in potassium concentration showed the same trend, the mobility of this cation was also inhibited by soil cover, especially in the 30–60 cm depth. The effect of water deficiency was more expressed in the soil of White Riesling B 7 (R) plantation than in Kövidinka K8 variety (K).

At flowering, N, P, K concentrations of leaf blades showed an optimal nutrient supply of the wineyards *(Figure 3A.)*. The insufficient water conditions limited the availability of the nutrient elements in ripening phase, contributing to the significant decrease of nutrient element concentration in the leaf blades from flowering to ripening *(Figure 3A.)*. Varietal differences could be observed in the nutrient element transport. Kövidinka K 8 accumulated less N and more P and K in the leaf blades at flowering, and more N, P and significantly less K at ripening than White Riesling B 7. Similar tendencies appeared in the data of petioles *(Figure 3B)*, where the differences were more obvious. The plastic coverage of the soil affected the N, P, K transport. On covered stripes higher nitrate concentration was found in both plant parts at ripening as a consequence of the lower water content and inhibited the NO_3^- leaching in the soil. Phosphorus concentration of leaf blades and petioles reflected the better accesibility and transport condition of P in uncovered plots of White Riesling B 7 during the growing season, but P transport of Kövidinka K 8 was hardly affected. Soil covering resulted the highest differences in K concentration of leaf blades and petioles at both varieties. Potassium level in the leaf blades of the later ripening Kövidinka K 8 variety was under the optimum at ripening probably as a consequence of extremely high yield. Nutrient transport of White Riesling B 7 variety was influenced by the water supply in a higher extent, reflected by the difference between the results of covered (RW0) and uncovered (RW1) plots of petioles and leaf blades.

The tendencies of nitrogen and phosphorus concentration of the leaf blades at ripening were manifested in the N and P content of the berries as well *(Figure 4.)*. Soil cover scarcely influenced N and P but reduced K concentration of the berries of White Riesling GM 239 while berries of Kövidinka K 8 contained more N and P in this treatment. In spite of low K levels in the leaf of Kövidinka K 8 at ripening, this variety accumulated 32% more K in its berries than White Riesling B 7 in the covered plots while K levels were about the same at higher water supply. Since K concentration of berries influences quality parameters of the must and wine,

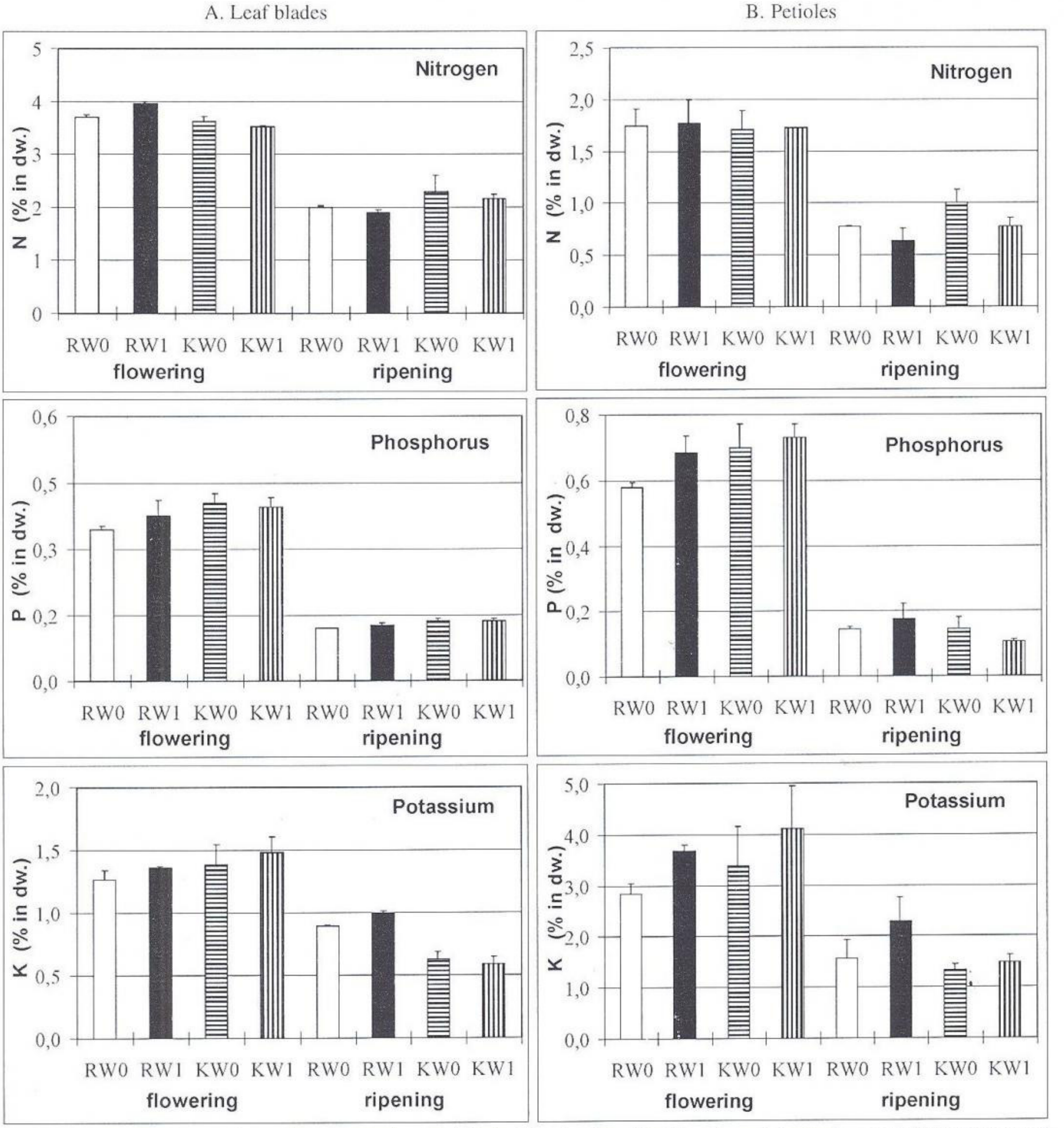

Figure 3 Nitrogen, phosphorus and potassium concentration of leaf blades (A) and petioles (B) at flowering and ripening in covered (W0) and uncovered (W1) plots of White Riesling (R) and Kövidinka (K) varieties

this varietal difference under dry condition is important regarding the wine quality.

The yields in the Kövidinka K 8 plantation were higher at both loadings (L1: 18 buds/stock, L2: 36 buds/stock) as showen in *Table 1*. The restricted water condition (W0) did not affect the yield of Kövidinka K 8 at L1 loading but 21% yield increase was gained at L2 loading on uncovered plots. The insufficient water supply significantly reduced the yield of White Riesling B 7 already at lower bud loading, causing

Table 1 Effect of bud loading and water supply on yield of Kövidinka K 8 and White Riesling varieties

Bud loading	Treatment	Yield Kövidinka K 8	(t/ha) White Riesling
L1	W0	22.6	11.6
	W1	22.1	16.4
L2	W0	21.7	14.5
	W1	26.3	21.7

30% (L1) and 34% (L2) yield reduction. The yield difference between the two varieties was 94% (L1) and 50% (L2) in covered plots, 35% (L1) and 21% (L2) in uncovered plots.

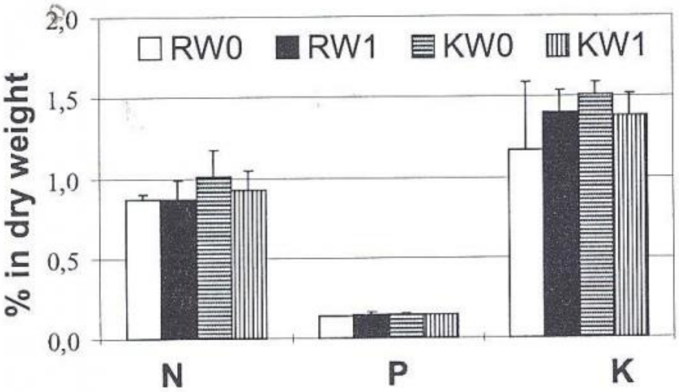

Figure 4 Nitrogen, phosphorus and potassium concentration of the berries in covered (W0) and uncovered (W1) plots of White Riesling (R) and Kövidinka (K) varieties

Discussion

According to the rainfall data, different water supply (240 mm in covered and 605 mm in uncovered strips) could be generated by covering the soil with plastic foil. Since water saturation of the soil needed 23 cm^3 water/100 g soil (18.7% water content), the 12.5% soil moisture in springtime corresponds to 67% of saturation value which can be considered as sufficient water supply (70–80% available soil water, Kozma, 1993), it decreased to 16–21% until August. Water deficiency developed in covered plots in the first period of the vegetative phase. The restricted water condition was probably mitigated by the horizontal diffusion of water in the soil. The genetically determined longer roots of Kövidinka K 8 variety could reach the ground water level.

At flowering, available P and K concentrations of the soil were influenced in the highest extent by the water supply, in good agreement with the results of Bálo et al. (1998). White Riesling B 7 variety needed more water and was more susceptible for the condition of decreasing water supply. The better nutrient uptake efficiency of Kövidinka K 8 manifested in the intensive accumulation of N, P, K in the berries and high yield of covered plots. The crop security of Kövidinka 8 was acceptable even under drought condition.

Acknowledgement

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