Energetic aspects of the productive potential of grapevine in Malé Karpaty vineyard region

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ABSTRACT: The grapevine productive potential estimated according to PAR input and efficiency of its conversion into phytomass yield are analysed in the paper. The analysis was based on results of experiments realised in the framework of research projects VTP 27-19 and GP 1/8172/01 in 1999–2001 in Malé Karpaty vineyard region, Hlohovec district. It was concluded that the actual phytomass production and also grape production were on average on the level of 53% of potential yields given by the radiation input. The productive potential according to PAR input can be 1.9 times higher in Malé Karpaty vineyard region.

Keywords: photosynthetically active radiation; productive potential; grapevine; Malé Karpaty vineyard region

Solar radiation influences the productive potential of plants by its physiological as well as physical effects. Physiological effects of solar radiation evoke biochemical processes of photosynthesis and plant development. Physical effects of solar radiation accelerate or decelerate these processes. The radiation of the wavelength 380–760 nm has the highest physiological effect and therefore this range of radiation is indicated as photosynthetically active radiation (PAR). PAR is a direct source of energy for photosynthetic assimilation and consequently for phytomass production. The input of solar radiation into ecosystems and its utilisation by plants is one of the basic agroclimatic parameters of productive potential in the environment.

Phytomass yield determined by genetic parameters of plant and PAR input (when other meteorological factors, water balance and nutrients are in optimum and effects of pests and diseases are absent) is considered as the productive potential of crop (Ničiporovič 1971). Estimation of this potential on the level of climatic zones, ecosystems or regions is still in the focus of interest of scientists, economists as well as policy makers.

Except for PAR input the basic criterion of the productive potential of crops on a regional scale is maximum possible efficiency of transformation of PAR into organic matter and yield by crops. Ničiporovič (1971) stated that the theoretical maximum of this efficiency can reach K = 9%. Ničiporovič (1971) reported for field crops K = 3–5%. On the basis of statistical analysis K = 30% was estimated for grapevine (Špánik et al. 2004).

The productive potential of grapevine estimated according to PAR input and efficiency of its conversion into phytomass yield are analysed in this paper. The theory of yield formation of field crops from the aspect of energy input in moderate climate zones was solved in the past by Ničiporovič (1971), Alberda (1971), Špánik and Tomlain (1983). Some aspects of possible growing areas as well as yield formation of grapevine in agroclimatic conditions of Slovakia were evaluated by Špánik et al. (2004).

METHODS

Data used for the evaluation of grapevine productive potential were measured in 1999–2001 in the framework of research projects VTP 27-19 and GP 1/8172/01. Research area was situated in Hlohovec district (147 m above sea level) – Malé Karpaty vineyard region. The Lenz Moser high training system was used for grapevine cultivation and each bush took up an area of 3 m^2. According to agroclimatic regionalisation of the Slovak Republic (Kurpelová et al. 1975) the research area belongs to predominantly warm region from the aspect of temperature conditions where daily mean air temperature sums Σt = 2,800–3,000°C, very dry subregion from the aspect of water balance when during the summer

season (from June to August) the difference between potential evapotranspiration and precipitation totals $E_0 - P \geq 150$ mm, and district of predominantly moderate winter where the mean of absolute temperature minimum during winters is in the range –18.0 to –20.0°C.

Meteorological data for the years 1999–2001 were extracted from database of Slovak Hydrometeorological Institute in Bratislava.

Photosynthetically active radiation (PAR) was calculated according to Savin-Angström method (Špánik, Tomlain 1983). Potential yield of grapevine (U_{pf}) was calculated according to the equation:

$$U_{pf} = \frac{PAR_{VOV} K_{\max}}{Q_e \times 100} \quad (kg/m^2) \qquad (1)$$

where: PAR_{VOV} – the photosynthetically active radiation input during the vegetation period of grapevine,

$K_{\max}$ – the maximum conversion coefficient of photosynthetically active radiation (3%),

Q_e – the energy equivalent needed for the production of 1 kg of phytomass (4.652 kWh).

Conversion coefficient of photosynthetically active radiation (K) was estimated according to the equation:

$$K = \frac{U_{af} \times Q_e}{PAR_{VOV}} \times 100 \quad (kg/m^2) \qquad (2)$$

Grapevine variety Weiss Riesling was used as a model variety for calculations in this study. The vegetation period of grapevine (VOV) was limited by the onset and end of daily mean air temperature $t \geq 10.0$°C. This period was divided into 17 decades. According to ideal growth curves next parameters were estimated:

- potential yield of phytomass – dry matter (U_{pf}) in kg/m^2,
- potential yield of grapes – dry matter (U_{ph}) in kg/m^2,
- actual phytomass yield – dry matter (U_{af}) in kg/m^2,
- actual yield of grapes – dry matter (U_{ah}) in kg/m^2,
- conversion coefficient of PAR into potential dry matter of phytomass (K_{pf}) in %,
- conversion coefficient of PAR into potential dry matter of grapes (K_{ph}) in %,
- conversion coefficient of PAR into actual dry matter of phytomass (K_{af}) in %,
- conversion coefficient of PAR into actual dry matter of grapes (K_{ah}) in %.

According to statistical analysis further conversion coefficients for dry and fresh matter of phytomass and grapes were proposed:

k_1 = 0.339: from fresh phytomass to dry phytomass,

Table 1. Potential and actual production of grapevine phytomass and utilisation of solar radiation by the crop in Hlohovec district, 1999–2001

Decade	Date	U (kg/m^2)				K (%)			
		pf	ph	af	ah	pf	ph	af	ah
1	29. IV.	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
2	10. V.	0.04	0.02	0.02	0.01	0.6	0.3	0.3	0.2
3	20. V.	0.11	0.06	0.06	0.03	1.1	0.6	0.6	0.3
4	31. V.	0.22	0.13	0.12	0.07	1.6	0.9	0.9	0.5
5	10. VI.	0.38	0.22	0.20	0.12	2.4	1.4	1.3	0.7
6	20. VI.	0.59	0.34	0.31	0.20	3.5	2.0	1.9	1.3
7	30. VI.	0.88	0.50	0.47	0.29	4.1	2.4	2.2	1.3
8	10. VII.	1.26	0.72	0.67	0.40	6.1	3.5	3.2	1.8
9	20. VII.	1.71	0.99	0.91	0.54	8.4	4.8	4.4	2.6
10	31. VII.	2.09	1.21	1.11	0.65	6.5	3.7	3.5	1.9
11	10. VIII.	2.40	1.38	1.28	0.73	5.3	3.0	2.8	1.4
12	20. VIII.	2.64	1.52	1.40	0.80	4.2	2.4	2.3	1.2
13	31. VIII.	2.83	1.63	1.51	0.86	3.1	1.8	1.6	1.0
14	10. IX.	2.90	1.67	1.54	0.89	1.9	1.1	1.0	0.8
15	20. IX.	2.95	1.70	1.57	0.90	1.3	0.8	0.7	0.4
16	30. IX.	2.97	1.71	1.58	0.91	0.7	0.4	0.4	0.2
17	7. X.	2.97	1.71	1.58	0.91	0.0	0.0	0.0	0.0

pf – potential yield of phytomass, ph – potential yield of grapes, af – actual yield of phytomass, ah – actual yield of grapes

k_2 = 0.576: from dry phytomass to dry matter of grapes,

k_3 = 0.588: from dry phytomass to fresh matter of grapevine.

RESULTS AND DISCUSSION

Potential and actual yield

Mean input of PAR during the vegetation period of grapevine (PAR_{VOV}) in 1999–2001 was the basis for estimation of potential and actual yields of grapevine. It was found that PAR_{VOV} = 411 kWh/m^2. Cumulative increases of dry phytomass as well as yields of fresh grapes were estimated according to equation 1 (Table 1). As resulted from tables and figures, the potential yield of phytomass amounted to 2.97 kg/m^2 during the evaluated years. Yield of fresh grapes was 1.71 kg/m^2, which is 58% of dry phytomass.

Actual yield of total phytomass was significantly lower than the potential phytomass when the mean value found during the evaluated period was 1.58 kg/m^2. Actual yield of fresh grape was 0.91 kg/m^2.

A difference between potential and actual yields indicates the level of vineyard practice. According to the results of this study the agroclimatic productive potential defined by input and potential conversion of PAR is utilised by present practice on the level of 53%. In agroclimatic conditions of the Slovak Republic the basic reason causing this fact is shortage of water during the vegetation period of grapevine. This fact is also important from the aspect of possible climate change impacts.

Utilisation of solar radiation by crops

Changes of PAR conversion coefficient during the vegetation period of grapevine in 1999–2001 in Hlohovec vineyard district are presented in Table 1 and Figs. 1 and 2. The highest values of conversion coefficients were found in the 8th–10th decades (K_{af} = 3.2–3.5). The mean value of dry matter phyto-

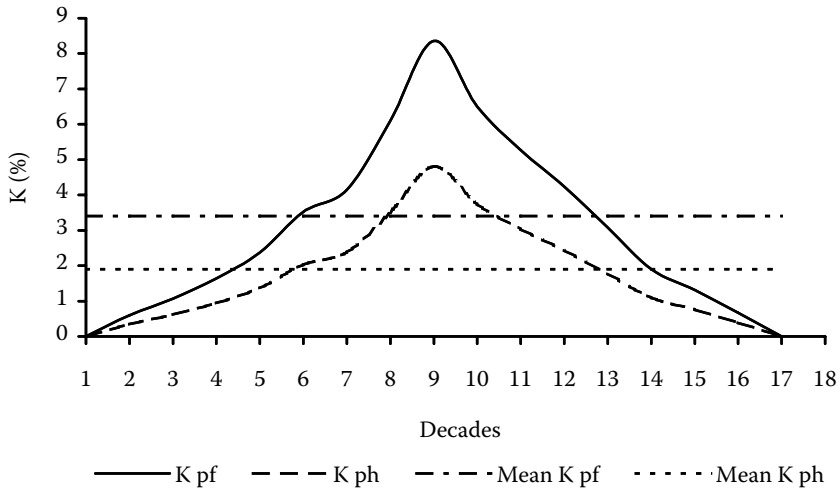

Fig. 1. Coefficient of PAR utilisation (K in %) in grapevine crop for actual yield (Ua) in Hlohovec region, 1999–2001

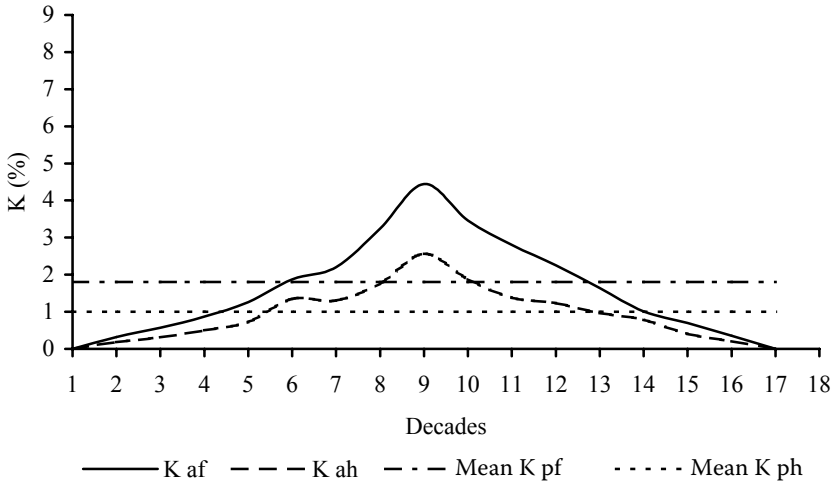

Fig. 2. Coefficient of PAR utilisation (K in %) in grapevine crop for potential yield (Up) in Hlohovec region, 1999–2001

mass conversion coefficient K_{af} was 1.8% and grape yield conversion coefficient was K_{ah} = 1%.

If the mean values of PAR conversion coefficients for actual (K_{af} = 1.8%, Fig. 2) and potential phytomass yield (K_{pf} = 3.4%, Fig. 1) are compared, the difference $K_{pf} - K_{af}$ = 1.6% is found. Mean input of PAR found during the evaluated years – 411 kWh/m^2 was utilised at 53% only. It means that only 218 kWh/m^2 was utilised in the productive process.

It resulted from the fact mentioned above that the productive potential according to energetic input can be 1.9 times higher than present yields. This potential is reachable by taking some adaptive measures in the field of irrigation, nutrition, pest and disease control and selection of proper varieties for different vineyard regions.

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Energetické aspekty produkčného potenciálu viniča hroznorodého v Malokarpatskej vinohradníckej oblasti

ABSTRAKT: V práci je analyzovaný produkčný potenciál viniča hroznorodého podľa príkonu radiačnej energie do biologickej sústavy. Analýza vychádza z experimentov realizovaných v rámci VTP 27-19 a GP 1/8172/01 v rokoch 1999–2001 v Malokarpatskej vinohradníckej oblasti, v regióne Hlohovec. Analýza ukázala, že súčasná aktuálna produkcia fytomasy, ale aj úrody hospodárskej sa podľa energetickej zložky prostredia nachádza na úrovni priemerne 53 %. Produkčný potenciál je podľa energetickej zabezpečenosti Malokarpatskej vinohradníckej oblasti 1,9-krát vyšší.

Kľúčové slová: fotosynteticky aktívne žiarenie; produkčný potenciál; vinič hroznorodý; Malokarpatská vinohradnícka oblasť

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