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Nutrient reserves in grapevine canes as influenced by cropping levels

by

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Die Beeinflussung der Nährstoffreserven im Rebenholz durch den Traubenertrag

Zusammenfassung. — Der Einfluß unterschiedlicher Ertragsmengen auf die Reserven an Kohlenhydraten, Aminosäuren und mineralischen Nährstoffen in Holz und Knospen der Sorte Welschriesling wurde untersucht. Der Gehalt der ins Holz eingelagerten Nährstoffreserven hing von der Höhe des Traubenertrages ab. Eine zunehmende Anzahl von Knospen war mit einer Abnahme der Kohlenhydrat- und Mineralstoffkonzentration verbunden. Mineralstoffe, vor allem Stickstoff, Phosphor und Kalium, wurden in Reben mit schwachem oder fehlendem Ertrag in höherer Konzentration eingelagert als in Reben mit starker Traubenbelastung. Überstieg der Traubenertrag das Leistungsvermögen der Rebe, so wurden die Nährstoffreserven im Holz abgebaut. Die höchste Konzentration an Aminosäuren und Mineralstoffen lag im Holz traubenloser Reben vor. Aufgrund der gewonnenen Ergebnisse schien unter den vorliegenden Versuchsbedingungen für Welschriesling eine Anzahl von 72 Knospen, unter Einschluß von Verjüngungszapfen, optimal zu sein.

Introduction

Grapevines produce each year more fruit buds than can grow into fruiting shoots and bear the clusters to maturity in the following season. The problem in grapevine is, therefore, to secure the optimum number of clusters that are within the capacity of the vine to develop and bring to perfect maturity and at the same time allow them to store sufficient reserves in the cane by autumn so as to be utilized by emerging shoots in the following spring. During early spring grapevine draws heavily from the nutrient reserves of the canes and the other storage organs (3, 6). Even in vines adequately supplied with fertilizer nitrogen, stored nitrogen of the cane is used preferentially for new growth (4).

Carbohydrates stored in the canes is an indication of the health and vigour of the previous season's growth. Kliewer (8) stated that, in addition to scion, other factors such as rootstock, climate, mineral nutrition, trellising system, disease, and crop level also undoubtedly influence the concentration of amino acid reserves in grapevine. Since the initial growth of emerging shoots in the spring is at the expense of carbohydrates, proteins and other nutrient reserves in the canes, an evaluation of their content becomes important to assess the capacity of the vine for bearing economic crop.

Material and methods

The investigations were carried out on 8-year-old Italian Riesling vines grafted on *Vitis berlandieri* × *V. riparia* 5 C rootstocks growing in the vineyard of the

Table 1

Effect of bud load on the cropping behaviour, carbohydrate and total amino acids content of Italian Riesling

Einfluß der Knospenzahl auf die Ertragsbildung sowie den Kohlenhydrat- und Gesamtaminosäurengehalt bei Welschriesling

Treatment	Buds/vine planned	Actual number of buds retained	Number of buds sprouted	Average number of inflorescences/vine	Average bunch weight g	Average yield/vine kg	Carbohydrates[1]) mg/0.1 g dry matter		Total amino acids[2]) mg/g dry matter
							Canes	Buds	Canes
1	60	54.9	47.1	80.3	75.6	6.1	12.0	11.4	15.0
2	72	67.0	57.3	97.2	73.9	7.2	9.9	11.1	14.2
3	120	104.9	71.0	121.2	66.3	8.0	8.6	12.4	15.5
4	machine pruned	219.2	109.3	206.1	40.0	8.3	9.8	21.4	15.4
5	not pruned	338.9	208.6	259.1	28.2	7.3	9.5	18.6	15.1
6	60	55.0	48.0	—	—	—	9.5	24.8	24.6

[1]) Average of two observations.
[2]) Obtained by adding values of free and protein bound amino acids from table 2 for each treatment.

Institute of Viticulture and Enology, Pécs, Hungary. They were spaced 1.3 × 3 m and trained on 1 m high cordon. The experiment consisted of 6 treatments with 10 vines in each treatment, replicated 8 times. Treatments 1, 2, 3 consisted of vines pruned to 60, 72 and 120 buds. The vines under treatment 1 were pruned to 6 10-bud canes. In treatment 2, in addition to 6 10-bud canes, 6 2-bud renewal spurs were retained. 12 10-bud canes were retained in vines under treatment 3. In treatment 6, the vines were also pruned to 60 buds (6 10-bud canes), but all the inflorescences were removed 2 weeks before flowering. The average number of inflorescences removed per vine was 81. The vines under treatment 4 were pruned by machine leaving 5 to 10 buds on each cane. (The canes growing sidewards were cut in a vertical plane.) In treatment 5 the vines were left unpruned. About 150 canes and 8—10 g of dormant buds were collected from vines of all replications under each treatment after harvest on 6th December, 1971, for the estimation of carbohydrates and amino acids. The canes collected from each of the 10 vines of each treatment and 8 replicates were combined together. Only actual buds consisting of inflorescence and leaf primordia, bud scales etc. were collected. On an average 1—2 canes of about 50—100 cm length per vine were removed. Sections, 2—4 cm in length, from the 3rd node of each cane collected were removed for chemical analysis.

The canes and buds were dried at 52 °C. The canes were shredded into fine shavings in a pencil grater and pulverized in a coffee grinder. Thus a homogeneous powder of composite sample for each treatment was obtained. The dried powder was stored in glass stoppered bottles until used. Carbohydrates were estimated in canes and buds according to the method of Pánczel and Eifert (13) with a slight modification. Sugars and starch were estimated together as total carbohydrates; the powdered plant material was homogenized with distilled water instead of ethanol as mentioned in the above cited reference. The extracts for determining free and bound amino acids were prepared according to Jako (5). Free amino acids were extracted with 80 per cent ethanol. The extracts were centrifuged and the clear extracts were subjected to amino acid analysis in an automatic amino acid analyser. The residual tissues after the extraction of free amino acids were hydrolyzed with 6 n HCl and the hydrolysates were processed for assay of bound amino acids according to Moore and Stein (11).

Total nitrogen content of canes and buds was estimated by the micro Kjeldahl method (1). Phosphorus was estimated using ammonium molybdovanadate reagent (2). Potassium, calcium, magnesium, copper, manganese, iron and zinc were estimated in the extracts with a Perkin Elmer atomic absorption spectrophotometer. Boron content was estimated colorimetrically using 1,1-diantrimid reagent (10, pp. 378—382).

Results and discussion

Carbohydrate content

Though differences in the carbohydrate reserves in the canes in various pruning treatments were relatively small, a decrease in carbohydrate accumulation with the increase in bud load was discernible (Table 1). Treatment 1 vines with the minimum number of shoots and yield of 6.07 kg stored the maximum amount of carbohydrates and treatment 3 vines, with 8.03 kg crop, stored the minimum level of carbohydrate in the canes. While treatments 1 and 6 are similar as far as bud load is concerned, the vines with full crop (treatment 1) showed greater accumulation of

Table 2

Effect of bud load on the level of amino acids in canes of Italian Riesling (μg/g dry matter)
Einfluß der Knospenzahl auf die Aminosäurenkonzentration im Holz von Welschriesling (μg/g Trockensubstanz)

Treatm.	Lys	His	Arg	Asp	Thr	Ser	Glu	Pro	Gly	Ala	Val	Ileu	Leu	Tyr	Phe
Free amino acids															
1	3.2	3.2	80.1	228.1	—	—	30.9	21.1	5.6	31.6	44.4	18.8	27.2	9.7	51.3
2	2.9	1.1	53.9	90.7	—	—	17.5	24.9	4.0	38.3	15.4	7.3	7.3	—	22.3
3	3.8	2.7	77.6	189.6	—	—	22.2	29.6	4.8	37.1	40.5	14.6	21.6	7.2	63.1
4	2.7	2.4	34.6	226.4	—	—	15.9	7.6	4.6	30.1	32.1	14.9	21.7	9.4	60.7
5	2.0	1.8	61.7	252.7	—	—	25.0	15.1	5.0	20.7	33.4	16.0	25.7	3.0	48.8
6	4.4	3.4	125.6	229.8	—	—	14.9	16.7	6.0	30.9	22.3	7.8	12.7	4.2	47.4
Bound amino acids															
1	939.8	461.7	2069.3	1492.6	841.0	1015.7	1725.6	819.5	966.4	917.8	643.2	449.3	1115.7	211.7	735.0
2	884.5	395.7	1276.1	1520.6	777.6	918.5	1843.7	858.9	1000.4	1002.8	833.3	549.1	1231.7	188.5	663.1
3	1022.8	428.7	2207.3	1475.3	812.2	936.4	1807.5	890.4	995.4	958.1	689.3	507.5	1171.6	301.6	749.9
4	967.5	428.7	1690.0	1574.6	816.0	954.2	1920.8	929.8	995.4	1023.6	737.3	538.7	1190.3	365.4	825.2
5	939.8	362.7	1241.6	1455.8	804.5	981.7	1944.9	937.7	1081.1	1068.3	770.0	522.1	1252.4	365.4	853.2
6	1271.5	593.6	6035.6	2328.5	1150.1	1782.0	2617.2	1197.8	1266.3	1494.5	887.0	607.4	1430.4	281.3	1164.2

carbohydrates in the canes than the vines in treatment 6 (without crop). The explanation for this difference is not known.

The carbohydrate content of buds showed almost an opposite trend to that of canes. The maximum percentage of carbohydrates in the buds was found in treatment 6 (without crop) followed by treatment 4 (Table 1). The level of carbohydrates was less in treatments 1 and 2 compared to treatments 4, 5 and 6. The results obtained in the present investigations are in general agreement with those of WEAVER *et al.* (14), WEAVER and McCUNE (15). While the investigations carried out by the authors cited above did not include as many different crop levels as in the investigations presented here, the tendency in all cases was for vines with a heavy crop to store comparatively smaller amounts of carbohydrates in canes than vines with no crop or vines with light crop that was within the capacity of the vines. This is because vines expend carbohydrates on the ripening of fruit.

Amino acid concentration of canes

The concentration of amino acids varied greatly among the treatments. Among the various amino acids analysed, arginine, aspartic acid, glutamic acid, leucine were found in higher concentration in the bound amino acids group and arginine and aspartic acid in the free amino-acids group (Table 2). Aspartic acid was the principal amino acid among the free amino acids and arginine was the most pre-

Table 3

Effect of bud load on the contents of macro and micro nutrient elements of canes and buds[1])

Einfluß der Knospenzahl auf den Gehalt an Makro- und Mikronährstoffen in Holz und Knospen

Treatment	Total N	P	K	Ca	Mg	Zn	B	Fe	Mn	Cu
	mg/0.1 g dry matter					µg/g dry matter				
Canes										
1	0.87	0.10	0.58	0.70	0.18	15.0	9.4	104.3	42.0	10.0
2	0.73	0.08	0.55	0.82	0.15	14.0	5.2	106.1	43.0	7.0
3	0.87	0.07	0.45	0.70	0.11	12.0	4.6	86.5	37.0	8.5
4	0.74	0.07	0.47	0.73	0.15	12.0	4.6	74.0	34.0	8.5
5	0.75	0.08	0.48	0.69	0.13	12.0	4.6	39.0	34.0	8.5
6	0.90	0.11	0.70	0.74	0.15	19.0	4.6	213.0	27.0	6.9
Buds										
1	1.07	0.15	0.47	1.06	0.21	33.0	9.4	182.0	56.0	21.0
2	1.23	0.14	0.48	1.18	0.28	35.0	12.3	251.0	40.0	27.0
3	1.05	0.14	0.47	1.08	0.28	36.0	12.7	252.0	33.0	26.0
4	1.03	0.13	0.57	1.28	0.20	27.0	9.5	163.0	64.0	13.0
5	0.92	0.15	0.43	1.30	0.20	24.0	9.8	135.0	49.0	13.0
6	1.01	0.17	0.62	1.11	0.28	29.0	13.3	125.0	37.0	16.0

[1]) Average of two observations.

dominant among the bound amino acids (8.5 to 25 %). The data indicate that the crop level affected the concentration of arginine, both free and bound, in grapevine canes. Arginine was found maximal in concentration in the canes in almost all treatments indicating that arginine is the main form of nitrogen storage in grapevines. This is in agreement with the observations of KLIEWER (6, 7) and NASSAR and KLIEWER (12). KLIEWER and COOK (9) reported that free amino acids especially in the canes were rapidly utilized for new shoot growth following bud break. Utilization was first from canes, then from trunk and lastly from roots. They further opined that arginine from canes was utilized liberally by growing young shoots immediately after bloom. Threonine and serine were absent from the free amino acid fraction and cystine and methionine were found in traces in both the groups in all treatments.

The canes in treatment 6 (no crop) showed maximum concentration of free and bound amino acids except tyrosine (bound amino-acids group) implying that the absence of crop in this treatment enabled the vines to store these amino acids in large concentrations in their canes (Tables 1 and 2).

Reserve mineral nutrient elements

The trend in the mineral nutrient reserves concentration of canes and buds under different treatments is quite distinct, especially pertaining to major nutrient elements (Table 3). Nitrogen, phosphorus, potassium, zinc and iron were maximum in the canes and phosphorus, potassium and boron in the buds of treatment 6, indicating that the absence of crop enables the vines to accumulate these nutrient elements in greater quantities in the canes and buds. By contrast, in the canes and buds of Italian Riesling vines under treatment 5, bearing the maximum number of inflorescences, the concentration of these elements was much lower. Thus, the canes under treatment 5 showed minimum levels of calcium and iron and the buds showed minimum of nitrogen, potassium and zinc. These conspicuous differences in the inorganic elements reserves amongst treatments lead us to the conclusion that the greater the quantity of developing crop the greater the utilization of these elements by the vines and therefore little is left to be stored in the storage organs as reserves for next season.

The progressive decrease in the concentration of potassium in the canes with gradual increase of crop in the vines shows the significant role of this element in the physiology of developing crop. There is conspicuous difference between canes and buds with respect to all elements, except potassium, which is generally lower in buds and this merits further investigations.

It may be concluded that differences in carbohydrates concentrations in canes related to bud load were smaller compared to differences in total amino acids in canes. Vines with crop removed showed the highest concentrations of total amino acids and mineral elements and with minimum bud load higher accumulation of carbohydrates in canes. This suggests that evaluation of nutrient reserves in canes could be used as an important consideration in limitation of crop level in grapevine. On the basis of the results obtained, a bud load of 72 buds per vine with provision for renewal spurs appeared to be optimum load for Italian Riesling vines under the conditions of the experiment.

Summary

The effect of differential cropping level on the carbohydrates, amino acids and mineral nutrient elements reserves in the canes and buds of Italian Riesling vines

was investigated. The amount of nutrient reserves stored in the canes depended upon the level of crop borne by the vines. The increase in bud load was associated with a decrease in concentrations of carbohydrates and mineral elements in canes. Mineral elements, especially nitrogen, phosphorus and potassium were stored in larger concentrations in vines with little or no crop compared to heavily cropped vines. With heavy crop beyond the capacity of the vine, the nutrient reserves were depleted in canes. The concentration of amino acids and inorganic elements was maximum in the canes of vines with no crop. On the basis of the results obtained, a load of 72 buds with provision for renewal spurs appeared to be optimum for Italian Riesling vines under the conditions of the experiment.

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