Vitis **20**, 311—319 (1981)

Department of Horticulture, Punjab Agricultural University, Ludhiana, India

Seasonal changes in carbohydrate and mineral composition of overvigorous and devitalized Anab-e-Shahi grapevines in relation to unfruitfulness[1])

by

K. S. Bains, A. S. Bindra and J. S. Bal

Die jahreszeitlichen Veränderungen der Kohlenhydrat- und Mineralstoffzusammensetzung bei luxurierenden und kümmernden Anab-e-Shahi-Reben in Beziehung zu ihrer Unfruchtbarkeit

Zusammenfassung. — Der Gesamtkohlenhydratgehalt in grünen Trieben, Tragruten und altem Holz war bei fruchttragenden Anab-e-Shahi-Reben größer als bei luxurierenden oder kümmernden Reben. Die höchste Konzentration der Gesamtkohlenhydrate wurde bei allen drei Rebtypen von Dezember bis Februar beobachtet; in den Trieben der traubentragenden Reben wurden im Mai die niedrigsten Werte festgestellt. Die Gesamtzuckerkonzentration nahm in der Reihenfolge fruchttragende, luxurierende, kümmernde Reben ab. Bei nicht-traubentragenden (luxurierenden und kümmernden) Reben war der Zuckergehalt im Februar am größten; traubentragende Reben erreichten ihr Zuckermaximum schon im Januar. Nichtreduzierende Zucker fehlten bei allen Reben von März bis September praktisch vollständig und waren erst von Oktober an nachzuweisen.

Luxurierende Reben zeigten einen höheren Stickstoffgehalt als traubentragende und kümmernde Reben. Die letzteren wiesen das ganze Jahr über sehr niedrige Stickstoffkonzentrationen auf. Bodenanalysen ergaben, daß auch ihre Parzelle sehr schwach mit Stickstoff versorgt war. Bei fruchttragenden und luxurierenden Reben enthielten die grünen Triebe prozentual mehr Stickstoff als das alte Holz. Zwischen dem Phosphorgehalt normaler und luxurierender Reben bestand kein signifikanter Unterschied. Bei den luxurierenden Reben war der Kaliumgehalt etwas höher als bei den traubentragenden und kümmernden Reben.

Luxurierende Reben besaßen wenig Kohlenhydrate und sehr viel Stickstoff, traubentragende Reben wiesen mittlere Kohlenhydrat- und Stickstoffkonzentrationen auf, während die kümmernden Reben einen niedrigen Kohlenhydrat- und einen sehr geringen Stickstoffgehalt zeigten.

Introduction

The Anab-e-Shahi grape is quite popular in Punjab as it possesses attractive bunches and berries, high yield, good transportability and fruit resistance to rain damage. Unfruitfulness in this cultivar is one of the serious problems faced by the grape growers in Punjab (Bindra *et al.* 1974). Grapevines may go barren due to their excessive vegetative growth as a result of heavy manuring or because they get devitalized from excessive bearing (Olmo 1970). Overvigorous vines go barren due to insufficient differentiation of flower buds and their subsequent death (Bindra and

[1]) Part of a Thesis submitted by the senior author for the M. Sc. degree.

Chohan 1976), while in devitalized vines there are an insufficient number of canes. There is evidence that both these conditions are associated with a disturbance in the internal balance of nutrient elements and elaborated metabolites (Winkler 1965; Khanduja and Balasubrahmanyam 1972; Shikhamany and Satyanarayana 1973).

Therefore, studies to investigate the seasonal changes in the levels of metabolites, nutrient elements, carbohydrate/nitrogen ratio in the shoots of bearing, overvigorous and devitalized grapevines were made to understand better the nature of unfruitfulness.

Materials and methods

The experiments were conducted on 10-year-old vines of Anab-e-Shahi at three different locations of Ludhiana district, viz. Punjab Agricultural University, Ludhiana (overvigorous vines), vineyard of Shri M. S. Sidhwan (devitalized vines) and the vineyard of Shri Sardara Singh at Salem Tabri (bearing vines). These vines (except those of P. A. U.) were planted at a distance of 3 m × 6 m and were trained to the Bower system. Vines of P. A. U. vineyard were closely spaced, i. e. 3 m × 3 m, hence they were very vigorous with low yield (Table 1). Vineyard of Shri M. S. Sidhwan was devitalized as indicated by pruning weight and yield. The vines at Salem Tabri were getting regular cultural practices and they were in good bearing condition.

The soil analysis of these three vineyards is given in Table 1. Annual rainfall during 1975 was 800 mm and 742 mm during the year 1976. The minimum and maximum temperature of this area varied from 3.2 °C to 39.3 °C during the year 1975 and from 4.8 °C to 38.6 °C during the year 1976.

15 vines each of bearing, devitalized and overvigorous vines were tagged for study. Samples were taken at various intervals, from November 1975 to November 1976. Each sample was replicated three times. Shoot samples (4th to 6th nodes) were oven-dried at 60 °C and ground to pass through a 40-mesh-sieve.

Reducing sugars, non-reducing sugars and starch were analyzed according to the method of A. O. A. C. (1972).

Total nitrogen was estimated by Micro-Kjeldahl method as given in A. O. A. C. (1972).

Phosphorus was determined by the vanadomolybdate colour reaction as outlined by Jackson (1967).

Potassium was estimated by flame photometer as described in A. O. A. C. (1972).

The data were analyzed statistically according to split-plot design taking types and portions as main treatments and months as subtreatments. Treatment effects and interactions were analyzed.

Results and discussion

Total carbohydrates

Total carbohydrates in canes and shoots were significantly higher in bearing vines than in overvigorous or devitalized ones (Fig. 1). The differences between overvigorous and devitalized vines were more marked than for bearing and overvigorous ones. This seems logical as the overvigorous vines utilize most of the carbohydrates for their vegetative growth (Galet 1973) and devitalized vines are too weak to synthesize their food materials.

Table 1

Morphological observations showing differences between overvigorous (non-fruitful), bearing (normal growth) and devitalized (non-bearing) Anab-e-Shahi grapevines and soil conditions of vineyard sites

Morphologische Charakterisierung der luxurierenden (nicht fruchtbaren), traubentragenden (normalwüchsigen) und kümmernden (nicht-tragenden) Anab-e-Shahi-Reben nebst den Bodenverhältnissen ihrer Standorte

Type of vine	Trunk ϕ (cm)	% canes/vine as related to cane ϕ	Cane ϕ (cm)	Bark in canes (% fr.wt.)	Wood in canes (% fr.wt.)	Pruning wt./vine (kg)	Yield/ vine (kg)	Soil conditions				
								Texture	Org. cont. (%)	N	P (kg/acre)	K
Overvigorous	13	32	1.2—1.4	9	91	9.00	2	Loamy sand	0.63	139.2	87.2	140.5
		68	1.4—1.8									
Bearing	10	25	1.0—1.2	17	83	3.30	40	Sandy loam	0.93	148.1	88.1	134.8
		75	1.2—1.3									
Devitalized	8	55	0.4—0.6	36	64	1.85	0	Loamy sand	0.45	113.5	89.1	74.6
		45	0.6—0.7									

Table 2

Periodic changes in the carbohydrate/nitrogen ratio of shoots, canes and old wood, respectively, of Anab-e-Shahi grapevines

Die periodischen Veränderungen des Kohlenhydrat : Stickstoff-Verhältnisses der Triebe und Tragruten bzw. des alten Holzes von Anab-e-Shahi Reben

Type of vine	15th of											
	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Bearing:												
Shoots	—	—	—	—	11.82	10.15	13.80	19.33	21.19	22.78	25.49	32.10
Canes/old wood	29.88	23,94	28.37	20.20	13.41	11.17	14.97	16.74	17.65	18.33	28.57	34.48
Overvigorous:												
Shoots	—	—	—	—	5.49	5.19	6.25	7.53	8.77	14.86	13.13	17.69
Canes/old wood	16.33	9.62	12.63	8.36	5.71	4.95	5.85	5.78	6.66	7.86	9.08	13.00
Devitalized:												
Shoots	—	—	—	—	11.70	14.40	14.70	15.89	17.33	21.10	22.50	24.81
Canes/old wood	32.86	23.13	30.90	20.41	15.74	10.71	11.94	12.17	13.33	11.78	14.10	18.57

C. D. at 5 % — for types: 2.20, for months: 3.70, for portions: 1.45, for months × types: 7.20, for months × portions: 5.12.

The highest percentage of carbohydrates in canes was observed from December to February in all vines. From February to April, there was an abrupt fall in their level irrespective of the type of vine. Under Punjab conditions the vines become dormant from December to February. The peak values during this period are in all probability due to the fact that vines make little growth after the middle of October and storage exceeds consumption. Growth is initiated at the end of February or beginning of March and it continues rampantly till the end of April. Due to this active growth the carbohydrate level is depleted. These results are in harmony with the findings of Khajuria (1969).

During the period from April to June the carbohydrate content in old wood of bearing vines did not change and decreased to a minimum in September. This was probably due to the fact that from April to June the growth decreases as a result of high temperature and competition from developing berries, then gets reinitiated after the onset of monsoon rains, resulting in lowering carbohydrate level. A sharp increase occurred after September i.e. when the vegetative growth slows down. Accumulation of high carbohydrate reserves for good fruiting just prior to and during the period of flower-bud formation and decreased carbohydrate levels during the period of active growth is a normal physiological phenomenon (Gardner *et al.* 1952; Winkler *et al.* 1974). Percentage value of carbohydrates was higher in shoots than in old wood of all types of vines, because the carbohydrates present in old wood are utilized by the shoots during their early growth and they are not replenished later to the same extent. Also the shoots are in direct contact with leaves synthesizing food material. Secondly, there is a lower percentage of wood in shoot samples accounting for higher carbohydrate values.

Starch

The starch content, which is a major component of total carbohydrates, showed trends similar to that of total carbohydrates (Fig. 2).

Total sugars

Sugar values behaved somewhat similar to those of total carbohydrates (Fig. 3). After 15th August, shoots from overvigorous vines had significantly lower total sugars than bearing vines, presumably because of consumption of sugars by the rapidly growing shoots.

In fruitful vines the sugar content in shoots did not vary between 15th April and 15th November. During early summer the developing berries and after harvest the developing shoots consumed sugars. In September and October, when the growth slowed down, the sugars did not change, probably because of their conversion into starch. It also appears that the conversion of starch to sugars to meet the requirements of shoot formation started between 15th December and 15th January. Thereafter, in canes and old wood total sugars decreased slightly but gradually up to the last sampling date, i.e. 15th November, as a result of decreased bark percentage in the old wood.

In shoots of bearing vines the minimum values of total sugars were observed in June, while in overvigorous and devitalized vine shoots in August. In canes of bearing vines the maximum value for total sugars was recorded in January, while in overvigorous and devitalized vines in February.

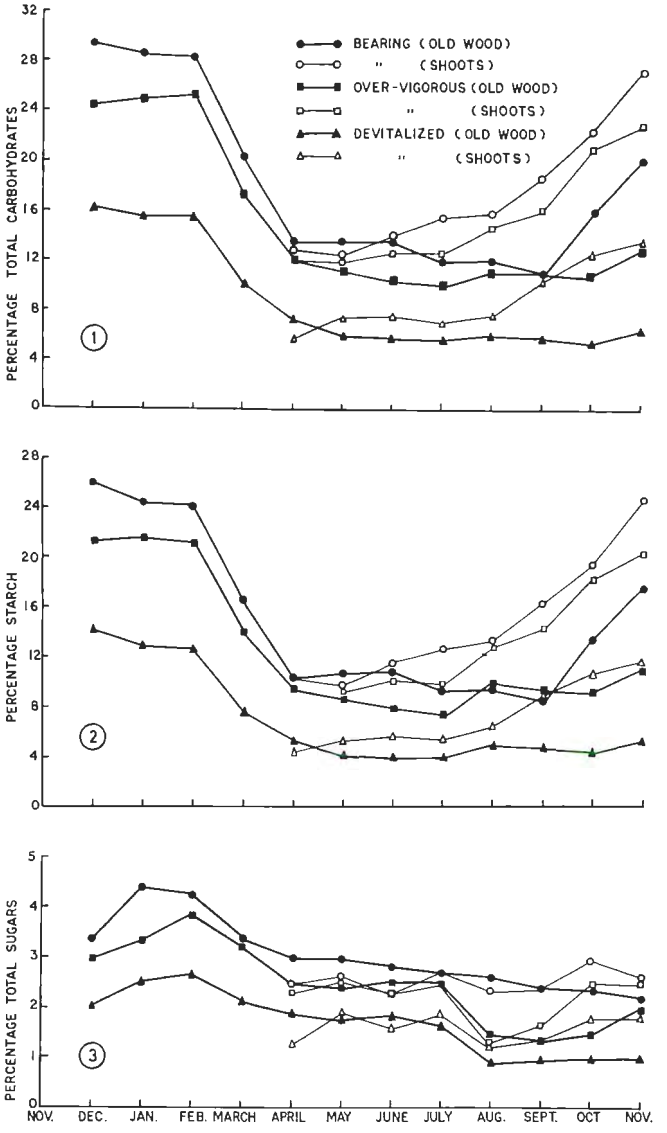

Fig. 1: Periodic changes in the total carbohydrate content. — Fig. 2: Periodic changes in the starch content. — Fig. 3: Periodic changes in the total sugar content.

Abb. 1: Die periodischen Veränderungen des Gesamtkohlenhydratgehaltes. — Abb. 2: Die periodischen Veränderungen des Stärkegehaltes. — Abb. 3: Die periodischen Veränderungen des Gesamtzuckergehaltes.

Reducing and non-reducing sugars

The non-reducing sugars were not found in detectable quantities from March to September in either type of vine (Fig. 5). The peak occurred in February in over-vigorous and devitalized vines, while in bearing vines it reached a maximum in December. The absence of non-reducing sugars in shoots until the month of October

seems interesting. In all probability, the enzyme system for production of sucrose seems to be temperature-sensitive and may be operative only when the temperatures are lower than the threshold maxima for the reactions, which may be possible only in the cooler months of the year from October onwards. These findings have been supported by Kliewer (1967), Pogosyan and Sklyarova (1965) and Khajuria (1969).

In the absence of non-reducing sugars the trend of reducing sugars from March to September was the same as for total sugars (Fig. 4). There was a significant difference in levels of reducing sugars in all three types of vines. Bearing vines had higher concentrations than overvigorous and devitalized ones. Devitalized vines had lowest values throughout the year. This is possible due to the fact that in overvigorous vines consumption exceeded synthesis and devitalized vines were too weak to manufacture food materials, while bearing vines are closer to the ideal and have normal vegetative growth (Winkler *et al.* 1974).

Nutrient elements

Nitrogen values from old wood and shoots were higher in overvigorous vines, followed by bearing and devitalized vines, respectively (Fig. 6). The level in devitalized vines was quite low throughout the year. This was probably due to the fact that shoots and canes of overvigorous vines were spaced at 3 m × 3 m and were subjected to a severe pruning. Devitalized vines were very weak, hence they could not take up the nitrogen from the soil. Also the nitrogen status of devitalized vineyards was very low as observed in soil analysis. Winkler *et al.* (1974) reported that an optimum level of nitrogen is necessary for fruitful conditions and any deviation from this level may result in insufficient floral induction and hence unfruitfulness.

In bearing and overvigorous vines the percentage was higher in shoots than in old wood. This seems plausible as the young cells contain relatively more protoplasmic material as compared to cell wall material and the former is rich in nitrogenous compounds (Meyer *et al.* 1965). Secondly, there is a lower amount of bark in old wood samples and the high percentage of wood accounts for lower nitrogen status in old wood samples.

There was no significant difference in phosphorus levels of bearing and overvigorous vines (Fig. 7), although the bearing vines had slightly higher levels of phosphorus than devitalized vines. This is again due to the inability to absorb nutrient elements by the weak vines. Potassium level of overvigorous vines was slightly higher than that of bearing and devitalized vines (Fig. 8). Devitalized vines had lower values of potassium than bearing ones.

Carbohydrate/nitrogen ratio

The composite mean values for carbohydrate/nitrogen (CH/N) ratio in old wood as well as shoots were higher in bearing than in overvigorous and devitalized vines (Table 2). Overvigorous vines had the lowest levels of CH/N ratio throughout the year. This is quite possible due to the fact that nitrogen status of overvigorous vines is very much high while it is quite low in devitalized vines and these higher and lower values of nitrogen are responsible for lower and higher CH/N ratio of overvigorous and devitalized vines, respectively. These results are in harmony with the opinion of Winkler (1965).

The CH/N ratio in all the three types of vines was higher in winter than in summer months. Probably this is due to the fact that vines make little growth after middle of October.

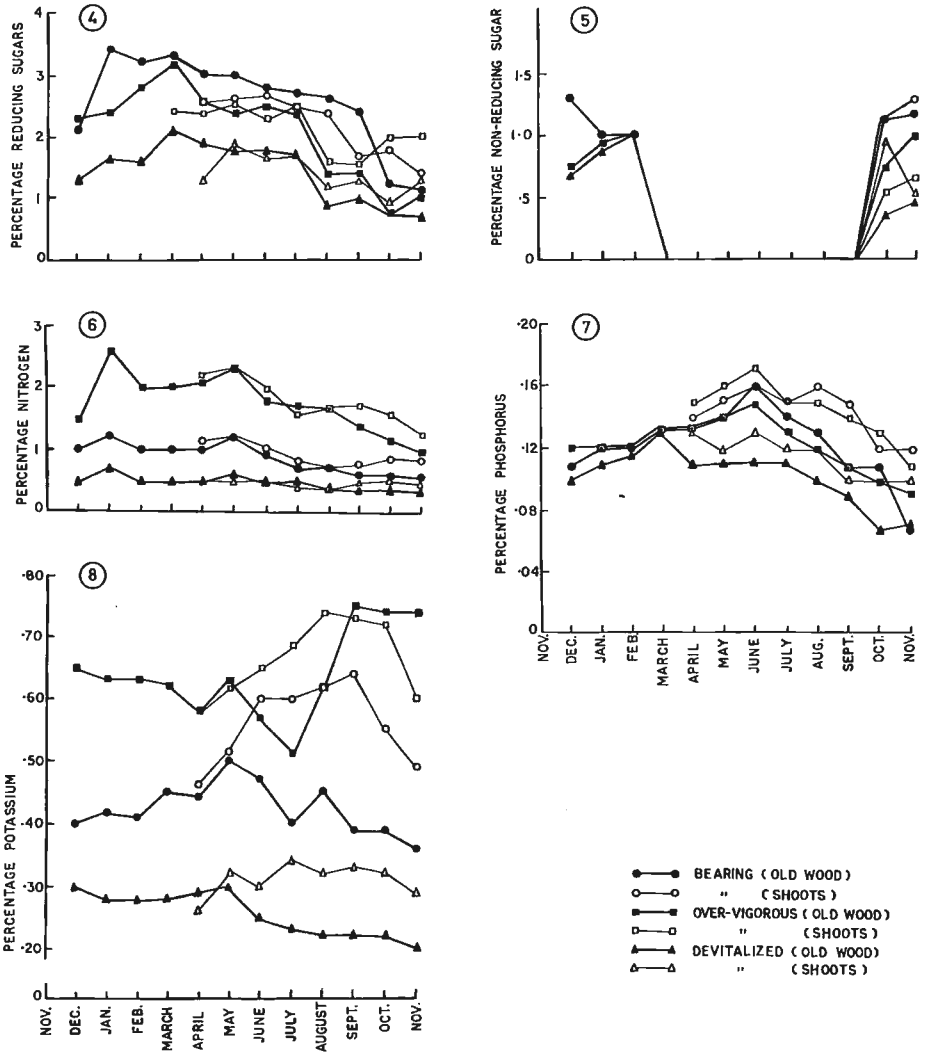

Fig. 4: Periodic changes in the reducing sugar content. — Fig. 5: Periodic changes in the non-reducing sugar content. — Fig. 6: Periodic changes in the nitrogen content. — Fig. 7: Periodic changes in the phosphorus content. — Fig. 8: Periodic changes in the potassium content.

Abb. 4: Die periodischen Veränderungen des Gehaltes an reduzierenden Zuckern. — Abb. 5: Die periodischen Veränderungen des Gehaltes an nichtreduzierenden Zuckern. — Abb. 6: Die periodischen Veränderungen des Stickstoffgehaltes. — Abb. 7: Die periodischen Veränderungen des Phosphorgehaltes. — Abb. 8: Die periodischen Veränderungen des Kaliumgehaltes.

Summary

Total carbohydrates in shoots, canes and old wood were higher in fruitful vines than in overvigorous or devitalized ones. The highest percentage of total carbohydrates was observed from December to February in all three types of vines. The minimum values for total carbohydrates in shoots of bearing vines were recorded in May. Total sugars were highest in bearing vines, followed by overvigorous and devitalized ones, respectively. Non-bearing (overvigorous and devitalized) vines had maximum sugar content in February, while bearing vines reached the maximum in January. Non-reducing sugars were practically absent in all vines from March to September. The first evidence of their presence was obtained in October.

Nitrogen concentration was higher in overvigorous vines, followed by bearing and devitalized ones, respectively. Its level in devitalized vines was very low throughout the year. Also the nitrogen status of devitalized vineyard was very low, as observed in soil analysis. In bearing and overvigorous vines the percentage nitrogen was higher in shoots than in old wood. There was no significant difference in the phosphorus levels of bearing and overvigorous vines. Potassium level of overvigorous vines was slightly higher than that of bearing and devitalized vines.

Overvigorous vines had low carbohydrates and very high nitrogen, bearing vines had moderate carbohydrates and moderate nitrogen, while the devitalized vines had low carbohydrates and very low nitrogen level.

Literature cited

A.O.A.C., 1972: Official methods of analysis. Washington, D. C.

Bindra, A. S., Chadha, K. L. and Raj, Y., 1974: Barrenness in Anab-e-Shahi grapes. Indian Hort. 19, 3—5.

— — and Chohan, J. S., 1976: Flower-bud killing in Anab-e-Shahi grapes, effect of different cultural practices. Indian J. Hort. 33, 34—27.

Galet, P., 1973: Précis de viticulture. Imprimerie Paul Déhan, Montpellier.

Gardner, V. R., Bradford, F. C. and Hooker, K. C., 1952: The fundamentals of fruit production, 3rd Ed., 224—244 and 669—685. McGraw Hill Book Co., Inc., New York.

Jackson, M. L., 1967: Soil chemical analysis. Asia Publishing House, Bombay, New Delhi.

Khajuria, H. N., 1969: Studies on fruit bud differentiation and carbohydrate nitrogen status in the grapes (*Vitis vinifera* variety Gulabi). M. Sc. Thesis, Punjab Agricult. Univ., Hissar.

Khanduja, S. D. and Balasubrahmanyam, V. R., 1972: Fruitfulness of grapevine buds. Econ. Bot. 26, 280—294.

Kliewer, W. M., 1967: Annual cyclic changes in concentration of sugar and organic acids in Thompson Seedless grapes. Proc. Amer. Soc. Hort. Sci. 91, 205—212.

Meyer, B. S., Anderson, D. B. and Bohning, R. H., 1965: Introduction to plant physiology. D. van Nostrand Co. Inc., Princeton, New Jersey, New York.

Olmo, H. P., 1970: Report to Government of India on grape culture, 45—46. F. A. O., United Nations, Rome.

Pogosyan, K. S. and Sklyarova, I. A., 1967: Temperature requirements for the second stage of hardening of the grapevine and changes in the carbohydrate composition at below freezing temperatures (Russ.). Agrobiologiya 14, 109—116. [Abstr.: Hort. Abstr. 35, 7402].

SHIKHAMANY, S. D. and SATYANARAYANA, G., 1973: A study on the association of leaf nutrient content with poor yields in Anab-e-Shahi grapes (*Vitis vinifera* L.). Indian J. Hort. 30, 376—380.

WINKLER, A. J., 1965: General Viticulture, 94—150 and 234—284. University of California Press, Berkeley.

— — , COOK, J. A., KLIEWER, W. M. and LIDER, L. A., 1974: General Viticulture, 90—138 and 410—439. University of California Press, Berkeley.

Eingegangen am 8. 9. 1981

K. S. BAINS
Dist. Ext. Spt. (Hort.)
Department of Horticulture
Punjab Agricultural University
Ludhiana (Punjab)
India