Vitis 20, 8—14 (1981)

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Necrosis in grapevine buds (Vitis vinifera cv. Queen of Vineyard)

I. Relation to vegetative vigor[1])

by

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Knospennekrosen bei der Rebsorte Queen of Vineyard (Vitis vinifera)
I. Beziehung zur vegetativen Wüchsigkeit

Zusammenfassung. — Im binnenländischen Jordantal in Israel wurde eine Untersuchung über Auftreten, Entwicklung und Art von Knospennekrosen an den Trieben der Rebsorte Queen of Vineyard durchgeführt. Hierzu wurden ein wüchsiger Weinberg, in dem nekrotische Knospen gehäuft vorkamen, und ein Weinberg von mittlerer Wüchsigkeit mit wenigen nekrotischen Knospen ausgewählt.

In den Winterknospen von Queen of Vineyard trat eine Nekrose der Mittelknospe nur in der wüchsigen Rebanlage auf. Die Anzahl vertrockneter nekrotischer Knospen war besonders hoch an den Knoten 2—3 der Triebe; sie ging stetig zurück bis zum 7. Knoten; darüber wurden keine nekrotischen Knospen mehr beobachtet. Die Austrocknung der Mittelknospe erfolgte nur während einer kurzen Phase, 15—20 d nach der Blüte. Sie begann mit dem Auftreten einer nekrotischen Schicht an einem der basalen Knoten der Mittelknospe, wodurch die darüberliegenden Gewebe rasch degenerierten. Zwischen der potentiellen Fruchtbarkeit der Winterknospen und der Entwicklung einer nekrotischen Schicht wurde eine negative Korrelation gefunden. Die mögliche Beziehung zwischen Wüchsigkeit, Gibberellingehalt und Nekrosenhäufigkeit wird diskutiert.

Introduction

Winter buds on the grapevine canes are composite buds which have been defined as the basal buds of a lateral shoot. Each bud is comprised of a central bud, which gives rise to the normal spring growth, and two to three additional axillary buds. The axillary buds usually contain only a few flower primordia and remain dormant when the central bud develops in the spring. When the central bud or the developing shoot is damaged, one or two of the axillary buds will develop. No significant differences between the development of shoots from the central and the axillary buds have been reported, except with regard to the amount of fruit.

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[1]) Contribution from the Agricultural Research Organization, Volcani Center, Bet-Dagan, Israel, No. E-349, 1980 Series.

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Bud necrosis is a well known phenomenon in several tree species, e.g. *Ulmus americana* (11), *Syringa vulgaris* (6) and various *Prunus* stone fruits (4, 5). In almonds, a phenomenon described as "bud failure" (9) has been widely studied. In grapevines, necrotic buds have been observed while analyzing buds for yield prediction. Bud necrosis was described in detail by Bernstein (2), who also showed that the grapevines Dattier de Beirouth and Queen of Vineyard are among the most sensitive cultivars. In vineyards of Queen on Vineyard in Israel, it was observed that the degree of bud necrosis was considerably greater in lower buds than in the higher ones on the cane. The degree of bud necrosis was found to fluctuate over the years. The amount of bud necrosis occurring in any year was well correlated to the vigor of the vineyard (2). Significantly more necrotic buds were found on vigorous shoots than on weak ones. Similar correlations, though in an opposite direction, were found in *Ulmus americana* (11) and lilac (6).

The problem of bud necrosis is particularly severe in spur-pruned vineyards, as only the lower vigorous buds are used. Thus, the percentage of necrotic buds is high, resulting in the development of several unfruitful shoots from axillary buds. The situation becomes further aggravated with time, due to increased vigor in the nonfruitful vines. In sensitive cultivars the reduction in productivity due to bud necrosis has reached levels of up to 70 % (3).

Similar phenomena of necrosis in the central bud and the subsequent development of axillary ones were also found after gibberellic acid treatments in some cultivars. Exogenous gibberellic acid (GA_3) application was found to increase the vegetative vigor in grapevines (13) and may have caused changes in the balance of hormones, in particular of gibberellins, which might be related to the necrosis of vigorous basal grape buds.

The purpose of this study was to determine the extent of bud necrosis in the Queen of Vineyard grape cultivar and to describe its phenological and morphological aspects.

Materials and methods

Two vineyards of the cultivar Queen of Vineyard were chosen in the inland warm Bet-Shean Valley. The vines in both vineyards were grafted on the 41 B rootstock, trained in a factory roof system and spur-pruned. One (A) was 7 years old with high vigor, yielding 20—30 t of fruit/ha, and the other (B) was less vigorous, 11 years old, yielding 30—40 t of grapes/ha.

The degree of differentiation and the percentage of necrotic buds were determined by a method similar to that used for productivity index determinations (1). A lateral cut was made through the bud at the height of the inflorescences primordia which was then dissected out with a needle under a stereoscopic microscope.

Shoots were collected at different periods of the growing season for analysis. Buds were designated necrotic only when no mites or mite activity were apparent. The phenological stage at each period was determined. Shoots were collected randomly and analyzed immediately.

For each determination, 10—15 shoot replicates were used. At least 100 buds were dissected to determine the productivity potential and the number of inflorescences per active bud. The results were analyzed statistically using the Multiple Range Test (MRT).

Results

The rate of shoot development at time of bloom in the experimental vineyards was assessed by determining the number of fully expanded leaves (Table 1). During the 11-d pre- to postbloom period, the rate of development was about 2 leaves/d. At full bloom, there were about 14 leaves at various stages of development above the fully expanded ones. At the period of full bloom, the buds in the axils of the fully expanded leaves showed various degrees of differentiation (Table 2). 25 d later, a further 12 fully expanded leaves were seen. At the end of bloom, the buds in the axils of the first 10 leaves showed various degrees of reproductive differentiation. During the following 3—4 weeks no further development of the inflorescence primordia could be seen.

The timing of the appearance of necrotic buds was studied over a 3-year period in vineyard A. The 3rd and 4th buds on Queen of Vineyard shoots were analyzed each year from full bloom to 120 d thereafter. Full bloom was observed on similar dates: April 15, 13 and 19 in 1974, 1975 und 1976, respectively. For the first 18—20 d after full bloom practically no necrotic buds were found. During the following 2 weeks a rapid increase in necrotic buds occurred in all 3 experimental years (Fig. 1). From observations made in 1974 and 1976 it could be deduced that only very few buds developed necrosis after this 2-week period.

Table 1

The rate of shoot development during the pre- to post-bloom period of Queen of Vineyard grapevine (vineyard B, 1975)

Verlauf des Triebwachstums bei der Sorte Queen of Vineyard in der Vor- bis Nachblühperiode (Weinberg B, 1975)

Date	Phenology	Fully expanded leaves
April 4	3—5 d before flowering	7—8
April 7	Beginning of flowering	9—10
April 14	Beginning of fruit set	12—14

Table 2

Leaf size and stage of development of buds along a shoot of Queen of Vineyard grapevine at the time of full bloom (vineyard B, 1975)

Blattgröße und Entwicklungszustand der Knospen längs eines Triebes der Sorte Queen of Vineyard zur Zeit der Vollblüte (Weinberg B, 1975)

Leaf position	Leaf development and size	Stage of axial bud
1—7	Fully expanded length 12.5 cm	Various degrees of reproductive differentiation
8—11	Fully expanded length 12.5 cm	4 differentiated leaves
12—13	Expanding, length 4.5—8 cm	3—4 differentiated leaves
14—15	Spread, length 1.5—2.5 cm	2—3 differentiated leaves
16—19	Fully formed folded in apex	Initiated leaves
20—24	3-lobe stage in apex	Embryonic hump
25—26	Embryonic hump	—

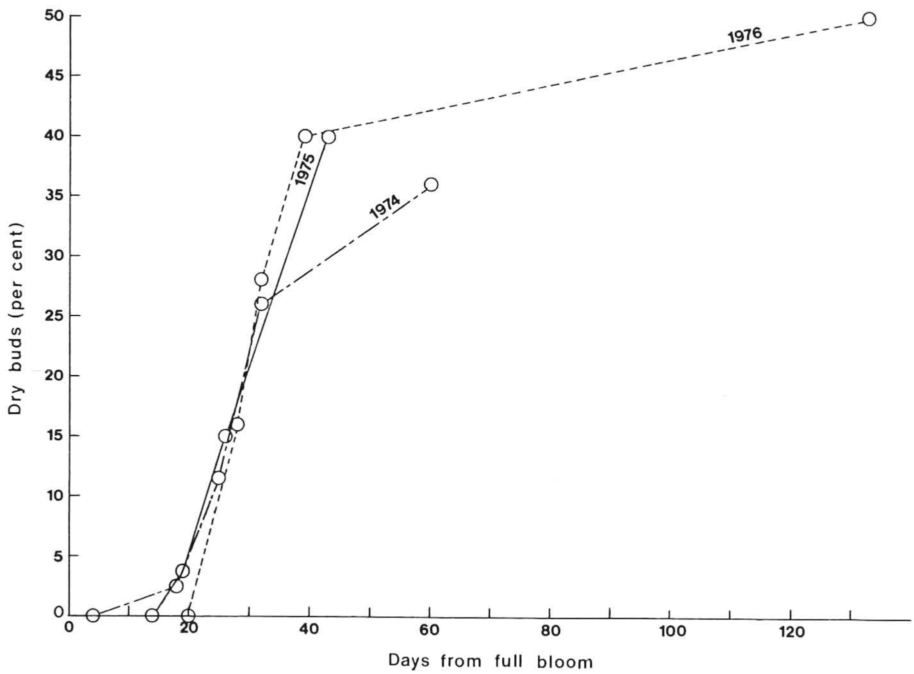

Fig 1: The pattern of bud necrosis development at nodes 3 and 4 on shoots of Queen of Vineyard grapevines during 1974—1976 (recorded in vineyard A; each point calculated from 100 buds).

Zeitliches Auftreten der Knospennekrosen an den Knoten 3 und 4 von Trieben der Sorte Queen of Vineyard in den Jahren 1974—1976 (nach Erhebungen in Weinberg A; je Punkt wurden 100 Knospen ausgewertet).

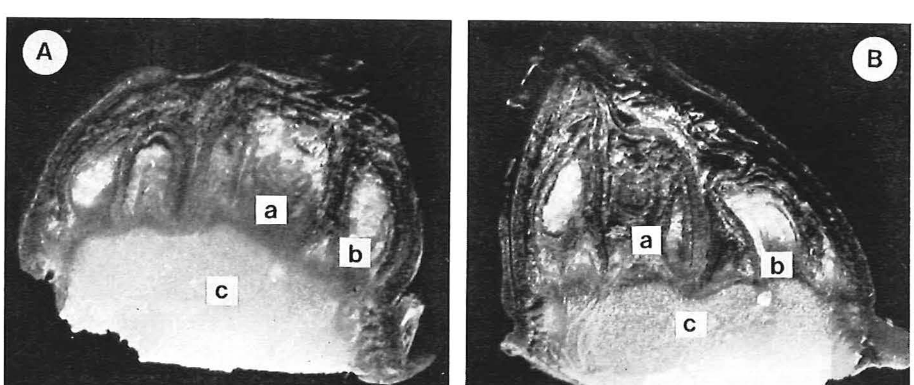

Fig 2: Longitudinal section through a mature Queen of Vineyard winter bud. A: Normal. B: Central bud dry. — a = Central bud, b = axillary bud, c = bud base.

Längsschnitt durch eine reife Winterknospe von Queen of Vineyard. A: Normal. B: Mittelknospe vertrocknet. — a = Mittelknospe, b = Axillarknospe, c = Knospenbasis.

The morphological appearance of grape buds in which the central bud had deteriorated differed from that of normal buds. The axillary buds expanded and filled the space created by the drying and shrinking of the central bud. The development of necrosis was followed by means of dissections carried out at intervals during the period of rapid increase in the number of necrotic buds. In spite of this marked increase, early stages of necrosis were found only in very few buds. This might be due to the rapidity of the drying process from its initiation to the death of the central bud. Necrosis started at the 3rd or 4th node of the central bud (Fig. 2). All the bud tissues above that node degenerated, while only slight necrosis was found below that level. The basal tissues of the central bud usually remained green and undamaged (Fig. 2).

The distribution of necrotic buds along the shoot was determined in the vigorous vineyard (A). Thick shoots (diameter > 10 mm) were separated from thinner shoots (diameter < 10 mm) and analyzed. In the thicker shoots the percentage of necrotic buds was highest at nodes 2, 3 and 4. A marked reduction of necrosis was noted at nodes 4—7. Above the 7th, the number of necrotic buds was very low. The thin shoots showed a similar pattern, but the percentage of necrotic buds up to the 7th node was considerably lower than in the thicker shoots (Fig. 3). No difference could be found in the potential productivity of the buds (number of inflorescence primordia per bud) on thin and thick shoots from the same vine.

In both cases the productivity potential generally showed an increase in the buds up to the 7th node together with a decrease in potentially necrotic buds. Thereafter, the productivity potential remained at a constant high level and bud necrosis

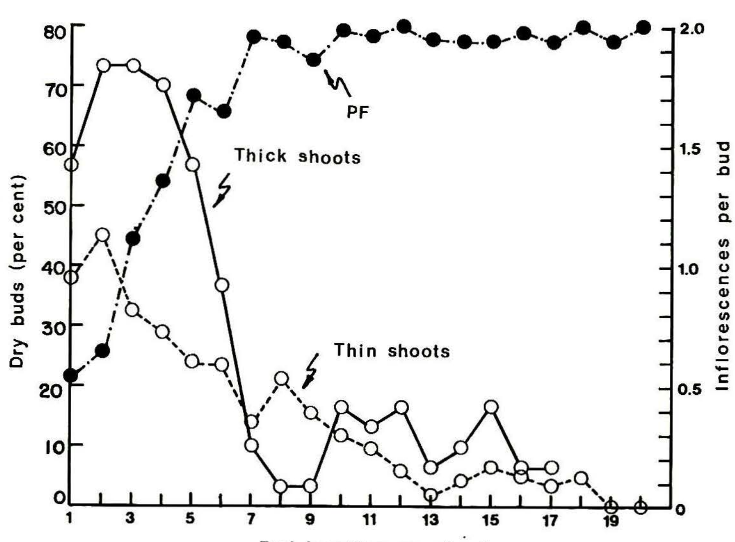

Fig 3: Distribution of necrotic buds along thin (< 10 mm diameter) and thick (> 10 mm diameter) shoots of Queen of Vineyard and number of inflorescence primordia per bud (PF) in the vigorous vineyard (A) during 1976.

Verteilung nekrotischer Knospen längs dünner (Durchmesser < 10 mm) und dicker Triebe (Durchmesser > 10 mm) von Queen of Vineyard sowie Anzahl der Infloreszenzprimordien je Knospe (PF) in dem wüchsigen Weinberg (A) im Jahre 1976.

was very low. Over the 3-year period, the average incidence of necrosis in the lower 10 buds of the shoots was about 40 % in the vigorous vineyard (A), and about 10 % in the moderately growing vineyard (B).

Discussion

Anatomical and morphological observations of Queen of Vineyard grapevine buds indicated that the deterioration of the central bud started with the appearance of a necrotic layer at its 3rd or 4th node and developed upwards. This resembles the necrotic pattern in small terminal shoots described in *Ulmus americana* (11). In *Ulmus* one of the nodes below the apex develops a necrotic layer distal to which the buds gradually dry up. In both the grapevine buds and the *Ulmus* shoots a necrotic pattern develops without inducing a defined abscission layer. Bud necrosis occurs early in the growing season and is mainly limited to the lower buds. It could therefore be concluded that necrosis occurred in those buds which developed during the most vigorous period of shoot growth.

The final number of dry buds was usually reached 3 weeks after full bloom. Previous studies have shown that the application of exogenous GA_3 to Queen of Vineyard shoots (12, 14) is followed 3 weeks later by an increase in necrotic buds. As natural bud drying has been shown to correlate with vigor it could be speculated that the pattern of necrotic bud development might be similar to that observed after a treatment with GA_3. This would explain why induction of necrosis in buds takes place during the flowering period. It is difficult as yet, however, to speculate a direct relationship between flowering and bud drying. Hale and Weaver (8) claimed already in 1962 that the flowers do not constitute a sink for metabolites as is the growing vegetative meristem. Bud necrosis could thus not be explained in terms of diversion in metabolite flow from the buds to the inflorescences. It should be noted that following high yields in Queen of Vineyard, when each shoot is carrying 1—2 inflorescences, the number of necrotic buds is usually low (3).

A high negative correlation was found between the amount of necrotic buds and the degree of inflorescence differentiation in the buds. Buds with a high differentiation potential have a very low tendency to develop necrosis. This was demonstrated in buds above the 7th node, all of which have a high productivity potential and a very low necrotic rate. It seems that the endogenous conditions which lead to low inflorescence differentiation also initiate processes leading to necrosis of the central buds of Queen of Vineyard. Lower buds on the shoot have a higher vigor potential and a lower reproductive differentiation rate, and these tend to develop more necrotic buds. It is suggested that the balance of endogenous growth regulators, and particularly high gibberellin levels, might be responsible for the smaller degree of inflorescence differentiation in the lower buds of grapevines (10) and at the same time be involved in the initiation of necrosis in these buds (14). A similar relationship between gibberellin and the number of differentiating flower buds has been described in citrus (7).

Summary

A study on the occurrence, development and nature of necrotic buds on shoots of the Queen of Vineyard grape cultivar was carried out in the continental Jordan

Valley in Israel. A vigorous vineyard having an abundance of necrotic buds and a moderately growing one with few necrotic buds were chosen.

Necrosis of the central bud in the Queen of Vineyard winter buds occurred only in the vigorous vineyard. The number of necrotic dry buds was particularly high at nodes 2—3 on the shoot and decreased progressively up to the 7th node above which necrotic buds were not observed. Drying of the central bud occurred over a short period, 15—20 d after bloom. It started with the appearance of a necrotic layer at one of the basal nodes of the central bud which caused a rapid degeneration of the tissues above this layer. A negative correlation was found between the fruiting potential of winter buds and the development of a necrotic layer. The possible relation between vigor, gibberellins and bud necrosis is discussed.

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Eingegangen am 21. 1. 1981

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