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Control of vegetative growth of grape vines (Vitis vinifera) with chloroethylphosphonic acid (Ethephon) and other growth inhibitors[1])

by

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Regulierung des vegetativen Wachstums von Reben (Vitis vinifera) durch Etephon und andere Hemmstoffe

Zusammenfassung. — Die hemmende Wirkung verschiedener Wachstumsregulatoren wurde an fünf Rebsorten geprüft: Alphonse Lavallée, Muskat Hamburg, Cardinal, Perlette und Queen of the Vineyards. Etephon hemmte bei einer Konzentration von 480 ppm deutlich das Spitzenwachstum der Triebe und verzögerte den Austrieb der lateralen Knospen um 8 bis 10 Wochen. Diese Behandlung erhöhte den Reifegrad der Traubenernte. Ein negativer Einfluß auf Knospendifferenzierung, Knospenaustrieb und Wachstum in der folgenden Wachstumsperiode wurde nicht gefunden. Etephon war erheblich wirksamer als die anderen verwendeten Substanzen: Alar, NC 9634, pp 413 und Morphaktin 7311. Alar verursachte eine Verkürzung der Triebe, ohne die Zahl der Nodi zu verändern. pp 413 hatte keine Wirkung, während Morphaktin und NC 9634 das Wachstum teilweise hemmten. Etephon wirkte weitaus nachhaltiger und gleichförmiger als wiederholtes Gipfeln in Handarbeit.

Introduction

The grapevine is conspicuous among other woody perennials in its yearly growth vigor. This particularity is expressed due to the standard severe pruning systems of grapevines.

The resulting shade, particularly in climatic conditions favoring long growth periods, interferes with color development, early fruit ripening, fruit size (4, 6, 7, 8), and sometimes also with flower differentiation for the following year (10, 13). The reduced differentiation will in turn increase the disbalance between vegetative and reproductive development of the vines, unless severe and unconventional pruning methods are undertaken. Even in rather balanced and fruitful vineyards, vegetative growth is often too strong in relation to its crop and needs for further development of its form. The shading effects become more severe the denser the planting of the vineyard, thus inducing growth decline in the following year. To overcome the negative responses to shading, it became a common practive to cut back the actively growing canes a few times in the course of the growth season. This, however, is not a satisfying commercial solution as the outburst of the lateral buds is stimulated by the topping to such an extent, that a constant continuation of this treatment is needed in order to arrest the growth and prevent the unfavorable shade (6, 13, 14).

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Table 1

The effect of some growth regulating substances on the development of young Alphonse Lavallée shoots. (Application April 30, 1973, measured May 24, 1973)

Der Einfluß einiger Wachstumsregulatoren auf die Entwicklung junger Triebe bei der Sorte Alphonse Lavallée. (Behandlung am 30. April 1973, Messung am 24. Mai 1973)

Substance applied ppm		Additional growth ± SE cm	Lateral bud development	Damage	
				Terminal bud abscission	Leaves
Control		68.9 ± 3.4	+	—	—
Alar	2000	49.8 ± 3.9	+	—	—
	4000	49.7 ± 3.2	+	—	—
NC 9634	1000	6.1 ± 1.0	+	—	+ (young)
	2000	4.0 ± 0.7	+	—	+ (young)
CEPA	480	4.3 ± 0.8	—	+	—
	960	3.9 ± 1.2	—	+	—

The reduction of leaf area by topping during the growing period did not effect fruit growth (3, 11, 12, 13). Treatments of the vines with growth regulators such as CCC, Alar, morphactins or Ethephon before, during, or after flowering resulted in growth inhibition. In some cases increased fruit set was found but usually fruit damage appeared (16, 17, 19).

However, no attempts for sectorial treatments sparing the fruit have been reported.

Methods

Well developed plants of the cultivars Alphonse Lavallée, Perlette, Cardinal and Muscat of Hamburg were chosen in irrigated 10 year old vineyards in the coastal plain of Israel.

About 4—6 weeks after full bloom, when shoot length reached 120—140 cm spray treatments of various growth regulating substances were given to the upper growing part of the shoots. The sprays were applied in most cases with a 10 l "Lehavot" knapsack sprayer, operated by compressed CO_2 at constant pressure. Triton X-100 was used as a wetting agent in all treatments. The regulators tested were Alar (Union Carbide), morphactin 7311 (Celamerck), NC 9634 (Fisons), pp 413

Table 2

The effect of morphactin 7311 on the growth and development of young Alphonse Lavallée shoots. (Application May 20, 1974, measured June 13, 1974)

Der Einfluß von Morphaktin 7311 auf Wachstum und Entwicklung junger Triebe bei der Sorte Alphonse Lavallée. (Behandlung am 20. Mai 1974, Messung am 13. Juni 1974)

Morphactin 7311 ppm	Additional growth ± SE cm	Lateral bud development	Damage	
			Terminal bud abscission	Young leaves
0	64.0 ± 2.5	+	—	—
6.25	61.5 ± 4.1	+	—	—
25	53.2 ± 3.5	±	—	—
50	5.2 ± 0.8	—	+	—
100	2.8 ± 0.7	—	+	+

(ICI), and Ethephon — CEPA (Amchem). The concentrations used will be indicated with the results for each experiment.

Results were determined as amount of growth after treatment. Prelabeled treated canes were measured at various intervals up to two months from regulator application. Growth determination consisted in most cases of 20 measurements for each replicate in each experiment. In part of the experiments the effect of the treatments on fruit coloration was estimated using a 0—5 grading scale, in others the absorption of juice from crushed grapes was determined at 530 nm, the wavelength suitable for anthocyanin determination, and expressed as OD × 1000. Total soluble solids (TSS) were measured by a hand refractometer and acidity by juice titration. The effect on differentiation was determined by recording the number of inflorescences in the following year. Each treatment was given in four replicates of 3 to 12 vines according to the various experiments.

The effect of various growth retardants on the extention growth of Alphonse Lavallée untopped shoots. From left to right: NC 9634 2000 ppm, CEPA 960 ppm, Alar 4000 ppm and control.

Der Einfluß verschiedener Hemmstoffe auf das Längenwachstum von nicht gegipfelten Trieben, Sorte Alphonse Lavallée. Von links nach rechts: NC 9634 2000 ppm, CEPA 960 ppm, Alar 4000 ppm und Kontrolle.

Results

A group of growth inhibiting substances was applied to growing shoots of Alphonse Lavallée vines in May 1973 and the amount of growth measured after 24 days (Table 1). Alar at both concentrations used had only a limited effect on the shoot growth. NC 9634 and CEPA on the other hand practically inhibited shoot growth entirely. NC 9634, however, caused some damage to young leaves and strong closure of tendrils while CEPA inhibited also the opening of lateral buds during the recorded period (Fig.). A repetition of this experiment in 1974 showed similar results.

pp 413 (ICI) had no inhibiting effect on the vine shoot growth. The effect of morphactin 7311 on growth inhibition was tested at various concentrations with vines of the same variety. Concentrations of 50 and 100 ppm caused a nearly complete growth inhibition of the shoots (Table 2). This inhibition was accompanied

with an abscission of the terminal bud similar to the results with CEPA. At high, strongly inhibiting concentrations lateral bud break was also halted which was not the case with the lower ones. It should be noted, however, that the high concentration of morphactin 7311 caused some damage of yellowing and deformation to the young leaves. A nastic deformation was also noted at the end of the season after the resumption of growth. This nastic change expressed itself by half a turn of the shoots.

Perlette vines responded to the application of CEPA, Alar and morphactin in a way similar to Alphonse (Table 3). Both CEPA and the morphactin caused a nearly complete growth inhibition while Alar had only a moderate effect. The morphactin,

Table 3

The effect of various regulating compounds on the growth and development of young Perlette grape shoots. (Application May 8, 1974)

Der Einfluß verschiedener Wachstumsregulatoren auf Wachstum und Entwicklung junger Triebe bei der Sorte Perlette. (Behandlung am 8. Mai 1974)

Substance applied ppm		Growth during 22 days ± SE cm	Internode length cm	Foliage	Terminal bud abscission	TSS %	Titr. acid %
Control		84.0 ± 5.7	7.9	normal	—	11.0	0.70
Cepa	480	5.1 ± 0.7	—	normal	+	12.7	0.55
	960	2.4 ± 0.7	—	normal	+	11.9	0.61
Alar	1500	49.0 ± 5.4	3.9	normal	—	11.8	0.67
	3000	33.0 ± 4.0	3.0	normal	—	11.9	0.63
Morph-actin	50	10.0 ± 1.9		yellowing and deformation	±	11.2	0.76

however, showed also with this variety a rather severe damage of yellowing and deformation of the young leaves. The partial growth inhibition of Alar was expressed by a reduction of internode length while their number was not affected. The CEPA caused the abortion of the growing point and did not allow the lateral buds to develop during a period of about 8 weeks. Except for the lower concentration of CEPA which caused a somewhat earlier fruit maturation no other significant differences in TSS or titratable acid content were found.

Due to the consistent effect of the CEPA on growth inhibition its effect on vegetative growth and fruit maturation of Cardinal, an early colored variety, was studied. Three concentrations of CEPA were sprayed on the upper part of shoots on well developed Cardinal vines in the middle of May. Shoot growth inhibition was determined one week before harvest. Fruit maturation was followed over a period of 20 days from application (Table 4). As shown previously CEPA inhibited most strongly the elongation growth and prevented lateral bud break. Even at a concentration of 240 ppm growth was practically halted. It was obvious that in this variety the treatments had a clear effect on enhancing fruit ripening. All three concentrations used enhanced TSS accumulation, acid reduction, coloration and increased significantly the amount of fruit harvested at the first picking date. The two higher concentrations of 480 and 960 ppm were more efficient than the lower one. The effect was clearly notable over the whole maturation period. No significant effect on berry size could be noted. When CEPA applied to the upper part of the shoots at time of bloom or fruit set dripped down to the bunch, fruit development was damaged.

Table 4

The effect of CEPA on the vegetative growth and fruit maturation of Cardinal grapes. (Application May 12, 1975 on the upper parts of 120—140 cm long shoots at Bne Atarot)

Der Einfluß von CEPA auf vegetatives Wachstum und Beerenreife bei der Sorte Cardinal. (Behandlung des oberen Teils der 120—140 cm langen Triebe am 12. Mai 1975 in Bne Atarot)

	16/6/1975			22/6/1975					6/7/1975	
CEPA ppm	Additional growth (± SE) cm	TSS %	Grade of fruit color 0—5	TSS %	Titr. acid %	Fruit harvested %	Juice color OD × 10^3 at 530 nm[1])	Berry Fr. Wt. g	TSS %	Cumulative fruit harvested %
0	42.8 ± 5.3	8.7	1.6	10.3	0.94	23	26.3	5.4	12.3	76.5
240	5.1 ± 1.9	2.2	9.5	11.4	0.78	27	56.5	5.6	13.0	87.7
480	0	2.7	9.7	12.0	0.70	38	95.8	5.6	13.2	88.2
960	0	2.8	9.7	12.0	0.69	46	77.5	5.5	14.0	90.0
MSE	—	±0.1	±0.2	±0.2	±0.02	±5		±0.1	±0.3	±2.3

[1]) Whole fruit macerate.

Table 5

The effect of CEPA on shoot elongation of vigorous Cardinal and Muscat of Hamburg vines in a commercial factory roof trained vineyard. (Applied May 15, 1975, results expressed as additional growth in cm)

Der Einfluß von CEPA auf das Triebwachstum starkwüchsiger Reben der Sorten Cardinal und Muskat Hamburg („Fabrikdach-Erziehung"). (Behandlung am 15. Mai 1975, Ergebnisse ausgedrückt als Zuwachs in cm)

CEPA ppm	Cardinal			Muscat of Hamburg		
	June 6	June 18	July 19	June 6	June 18	July 19
0	66.6	134.0	298.0	78.5	144.0	171.0
480	18.1	37.3	71.5	13.0	39.2	64.0
720	10.3	28.0	41.9	9.5	38.0	61.0

In a large scale experiment Ethephon was applied to very vigorous, drip irrigated factory roof trained Cardinal and Muscat of Hamburg vineyards. Shoot growth inhibition was very strong, however, it was not complete (Table 5). In the non treated or hand topped controls the canopy covered very densely the overhead trellises, causing completely shaded tunnels which resulted in a considerable leaf drop and, with Muscat of Hamburg, in fruit softening. Furthermore, in the untreated controls due to the excess shade dry main branches were found in the year following the experiments. In the treated plots light penetrated the canopy easily and no leaf drop occurred. At the higher concentration of 720 mg/l even 2 months after the treatment only about 60% of the overhead trellises were covered. Fruit development and berry size were normal and maturation was uniform.

Discussion

The extension growth in intensive viticulture is usually considerably strong and demands topping. This, however, is a continuous operation due to growth stimulation of the lateral buds (6, 14). The application of growth retardants, such as CCC and Alar has been tried (7, 16), but results were usually unsatisfactory. Extension growth was not retarded enough and lateral buds were only partially inhibited. Furthermore, in some cases fruit growth was also inhibited (19). The effect of CEPA on maturation of fruit, in general, including grapes is well known (5, 18). In this study an inhibiting effect of CEPA when applied to the upper part of topped or untopped shoots, on the extension growth and lateral bud opening of four grape varieties has been shown. Shoot growth inhibition by CEPA resulted also in a slight enhancement of fruit ripening or ageing. This effect is suggested to be indirect considering the low rate of translocation of CEPA applied to the upper part of the shoots. The enhanced maturation seems therefore to be a result of the early secession of vegetative extension growth (2). This might be explained by a change in the sink for metabolites as a result of decline of the growing point and inhibition of lateral bud development. The growth inhibiting effect on the vine shoots, however, seems to be a direct one causing a decline of active growing tissue and inhibition of bud opening. Ethylene itself has already previously been shown to inhibit vegetative growth (2). The duration of ethylene release might be critical in the extension growth inhibition of vine shoots. This is suggested due to the lack of response of grape shoots to another ethylene releasing chemical, Alsol (Ciba Geigy)

(unpublished data) which releases ethylene at a considerable higher rate (1). As CEPA has been shown to be rather stable when applied to various plant organs (9) a specific effect of the CEPA could not be excluded. Furthermore translocation of ^{14}C Ethephon towards the growing point in vine shoots has been shown (15). This translocation was suggested to be directed towards the sink. Since the growing point in the treated shoots declined it might be possible that the fruit would act as the only sink, thus a translocation of sugars, other metabolites and even the CEPA to the fruit might have occurred. However, sprays at this high concentration directed also the flowers or very young fruit, spoiled the bunch and delayed maturation (17). The rapid response of shoots to the chemical enables control of growth at will at any stage of active shoot development.

Summary

In order to arrest vegetative growth of grape shoots, various growth regulating substances were applicated on five grapevine cultivars: Alphonse Lavallée, Muscat of Hamburg, Cardinal, Perlette, and Queen of the Vineyards. Ethephon at a concentration of 480 ppm efficiently inhibited the terminal growth of the canes and prevented the opening of lateral buds on the shoots for about 8 to 10 weeks. This treatment somewhat enhanced maturation of the current yield. No negative effect on bud differentiation, bud opening and growth in the following season was found. The use of Ethephon was much more effective than the other regulators tested such as Alar, NC 9634, pp 413, and morphactin 7311. Alar caused a shortening of the canes, not effecting the number of nodes. pp 413 had no activity in our system while both the morphactin and NC 9634 did inhibit growth partially. The Ethephon treatment was far more efficient and uniform than repeated manual topping.

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