USE OF PACLOBUTRAZOL TO CONTROL VEGETATIVE GROWTH AND IMPROVE FRUITING EFFICIENCY OF GRAPEVINES (*Vitis vinifera* L.)

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Summary. Grapevines, characterized by intensive vegetative growth, were treated once or twice with paclobutrazol in concentrations of 1% and 0.1% at the time of bud bursting, two weeks before anthesis and at the time of anthesis. It was found that shoot growth was considerably inhibited and for the first time it was proved that the inhibition of growth differed, depending on the origin of shoots, and that the treatment at the time when the buds were bursting had a positive effect on grapevine productiveness. The effect of paclobutrazol was most obvious in shoots originating from dormant buds and to a lesser extent from trunks.
The yield of grapes increased as a result of twice repeated grapevine treatment at the time the buds were bursting and two weeks before anthesis. This treatment did not produce a negative effect on grapevine productivity in the following year. Appllication of paclobutrazol in two consecutive years increased the quantity of grapes as a result of only spraying the grapevines at the time of bud bursting and before bloom. Sugar and acids contants in the grapes from the various treatments did not differ significantly. A negative effect on yield was observed in case the treatment was made at the time of blooming.

***Key words*:** vine, vegetative growth, paclobutrazol, fruit composition, yield

Abbreviations: Paclobutrazol – (2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pentan-3-ol

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Introduction

Productivity of vines and quality of grapes depended considerably on the rate of plant growth and on the fruit-leaf ratio (Lavee, 1987). In most cases 12 leaves above the bunch enabled normal fruit development. Intensive vegetative growth decreased the number of fruit buds and of the berries per cluster. It disturbed light penetration and machine movement between the rows. Vegetative vigor of growth could be controlled via various approaches and different means. In this respect plant growth regulators have been well etablished as important cultural tools in grape production. Experiments in recent years have indicated the high potential of paclobutrazol. In pot experiments with rooted grapevine cuttings paclobutrazol considerably decreased the length of shoots and the area of leaves (Intrieri et al.,1986; Hunter and Proctor, 1990), suppressed trunk suckers (Reynolds and Wardle, 1990), increased the number of cortical cells and individual cell size appeared reduced in the roots and did not change leaf conductance (Wample et al., 1987). A greater than eight times reduction of apical internodes was observed in case of treatment with 10 mg per grapevine plant. The effect of paclobutrazol on root growth depended considerably on nitrogen nutrition (Calissi and Eaton, 1989). An excellent control on vegetative growth was ensured both by soil treatment (Wample et al., 1987; Hunter and Proctor, 1990; Reynolds and Wardle, 1990) and by stem or leaf application (Intrieri et al., 1986; Wample et al., 1987; Reynolds, 1988). The growth inhibition resulting from soil treatment was considerably less transient than that following spraying of the plants. There was no indication of phytotoxicity.

A single application of paclobutrazol to the soil in doses of 0.5 and 1g active substance per grapevine plant (Basiouny, 1994) or 0.55 to 2.2 kg a.s/ha (Williams et al., 1989) inhibited vegetative growth leading to reduced shoot extension, internode length and smaller leaf area as compared to the control. This inhibition was quite obvious toward the middle of the growing season. Paclobutrazol increased considerably the yield of cv. Magnolia grapes, reaching 24–27 %, enhanced total soluble substances and reduced total acidity (Basiouny, 1994). In cv. Thompson Seedless, however, no positive effect on yield was observed (Williams et al., 1989). Ahmedullah et al. (1986) demonstrated that stem application of paclobutrazol to grapevines of cv. Concord in concentrations of 5000 to 9000 ppm did not have an effect on yield and on the quality of grapes. However, a significant rise in cluster weight and in number of berries per cluster was found in case of leaf spraying cv. Roumi red grapevines (Shaltont et al., 1988). Evidently cultivar characteristics, climatic conditions, way of cultivation and time of treatment had an effect on plant reaction to paclobutrazol treatment.

The aim of the present investigation was to assess the effect of the plant growth regulator paclobutrazol, applied once or twice at different phases of plant development on the growth and productiveness of grapevines characterized by vigorous vegetative growth.

Material and Methods

The investigations were conducted during the period 1988–1990 in the town of Septemvri with 8-year-old grapevines from the intensively growing cv. Rkatsiteli (in a plantation near the village of Akandjievo). The distance between the plants was 2.4×1.2 m and the rows orientation were north–south. Sixty-seven buds were left per grapevine on fruit bearing shoots and trunk.

Paclobutrazol (250 g/l^{-1} a.i.) was applied by both stem and leaf treatment in concentrations of 1% and 0.1% using a backpack sprayer and spraying until drip occurred. No wetting agents were used. The following treatments were included in the present study: 1. control; 2. treatment with 1% paclobutrazol at the beginning of bud bursting; 3. treatment with 0.1% paclobutrazol solution two weeks before the expected time of anthesis; 4. treatment with 0.1% paclobutrazol solution at the time of anthesis; 5. twice repated treatment – at the beginning of bud bursting and two weeks before the expected time of anthesis with the respective concentrations of paclobutrazol; 6. two treatments – at the beginning of bud bursting and at the time of anthesis. The experiment was carried out after the randomized complete block design in 4 replications, each including 15 grapevines.

In 1989, one-half of the grapevines from each treatment, previously treated in 1988 left untreated and to the other half were applied the same concentrations of the paclobutrazol as in 1988 season. Grapevines serving as controls were sprayed with water in both years of the experiment. In 1989 a new series of grapevines were included for treatment after the same scheme.

The percentage of fruit bearing shoots and of those not bearing fruits was recorded. Shoot length was measured at intervals of 10 days. The number and weight of the clusters were determined at the time when the grapes were ripe. Sugar content was analyzed using an Abbe refractometer and titratable acidity was determined. Freezing of the buds during the winter and their development in the following season was recorded.

Results

Grapevine treatment with paclobutrazol had a considerable influence on shoot growth. The effect was quite different, depending on the origin of shoots and the period of treatment. Most pronounced inhibition was observed in shoots from dormant buds (Fig.1).This fact is of particular importance because a considerable number of shoots in cv. Rkatsitely grow out of dormant buds. Treatment of the grapevines at the time the buds burst inhibited growth, therefore at the end of the vegetation period the reduction was respectively 18%, 27% and 39% for shoots growing out from trunks, from fruit bearing shoots and from dormant buds. The effect of paclobutrazol was better expressed following two sprayings of the plants at the time of bud bursting

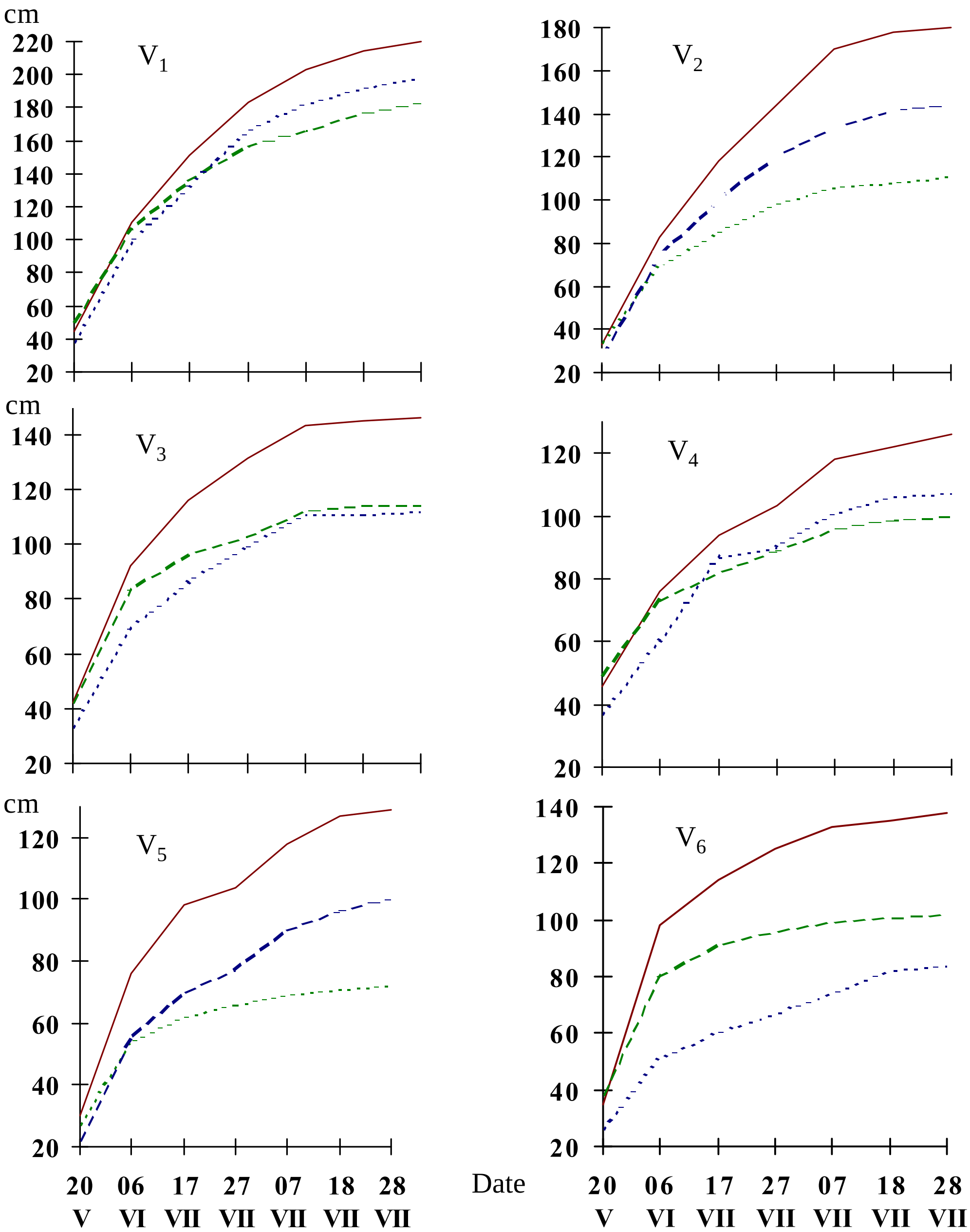

Fig. 1. Influence of paclobutrazol application on shoot length of "Rkatsiteli" vines. —— shoots from trunks; ----- shoots from buds of fruit bearing stems; ···· shoots from dormant buds. V_1 – control; V_2 – treatment with 1% paclobutrazol – bud bursting; V_3 – treatment with 0,1% paclobutrazol – two weeks before anthesis; V_4 – treatment with 0,1% paclobutrazol – anthesis; V_5 – two treatments: bud bursting + two weeks before anthesis; V_6 – two treatments: bud bursting + anthesis.

and two weeks before anthesis. After the growth processes ceased the differences were from the order of 41–61% as compared to the control. The effect on the growth of lateral shoots was better expressed.

Paclobutrazol did not inhibit the development of buds left after pruning (Table 1). The number of shoots developed was even slightly higher following single treatments. A certain trend toward increase in number of fruit bearing shoots was observed in some treatments. This led to an increase in number of inflorescences and to a respective improvement of the bearing coefficient.

Table 1. Effect of paclobutrazol on the elements of yield in grapevine, cv. Rkatsiteli

Treatments	No of remaining buds	No of develop. shoots	Developed shoots %	No of fruit-bearing shoots	Fruit-bearing shoots %	No of inflores-cences per vine
1. Control	67	43	64.0	28	67.7	38
2. Treatment with 1% PB – bud bursting	67	46	69.4	30	66.5	42
3. Treatment with 0.1% PB – two weeks before anthesis	67	45	67.8	31	68.9	40
4. Treatment with 0.1 % PB – anthesis	67	46	69.0	30	62.8	38
5. Two treatments with PB – bud bursting + two weeks before anthesis	67	40	60.4	32	76.7	46
6. Two treatments with PB – bud bursting + anthesis	67	39	57.4	28	65.5	33
LSD (5%)		2.3		1.4		3.6

Changes were also evident in grapevine productiveness depending on the time of paclobutrazol treatment (Table 2). Spraying the plants at the time of bud bursting with a 1% solution of paclobutrazol increased the quantity of grapes by 18%. It had a positive influence also following the treatment two weeks before anthesis. Highest increase in yield was attained by the repeated treatment – at the time of bud bursting and two weeks before anthesis. The increase in yield was a result of higher number of clusters and of greater mean weight. The sugar content of treated grapes, as compared to the control, was not reduced. Total acidity showed a trend toward decreasing. A negative effect on yield was observed in case the treatment was made during the time of anthesis.

Treatment of grapevines with paclobutrazol in the previous year had an effect on the yields in the following year. Single treatment of the plants with 1% solution

Table 2. Influence of paclobutrazol application on yield and fruit composition of grapevine, cv. Rkatsiteli

Treatments	No of bunches per vine	Bunches av. wt. g	Yield per vine kg	Yield per vine %	Brix %	Acidity g/l
A) Treatment of vines in the current year						
1. Control	31	148	4.610	100	20.0	9.05
2. Treatment with 1% PB – bud bursting	36	151	5.440	118	20.5	8.85
3. Treatment with 0.1% PB – two weeks before anthesis	33	153	5.050	109	21.6	6.98
4. Treatment with 0.1 % PB – anthesis	26	134	3.550	77	21.2	7.95
5. Two treatments with PB – bud bursting + two weeks before anthesis	37	152	5.580	121	20.0	8.59
6. Two treatments with PB – bud bursting + anthesis	27	165	4.410	96	22.0	6.98
LSD (5%)	3	13	0.310		0.5	0.9
B) Treatment of vines in the previous year						
1. Control	33	143	4.725	100	20.8	10.72
2. Treatment with 1% PB – bud bursting	35	153	5.360	113	19.8	9.85
3. Treatment with 0.1% PB – two weeks before anthesis	31	159	4.830	102	21.0	7.74
4. Treatment with 0.1 % PB – anthesis	27	147	3.970	84	21.8	8.40
5. Two treatments with PB – bud bursting + two weeks before anthesis	38	137	5.216	110	20.6	10.20
6. Two treatments with PB – bud bursting + anthesis	29	150	4.354	92	21.1	7.90
LSD (5%)	2	10	0.250		0.6	0.6
C) Treatment of vines in two consecutive years						
1. Control	33	145	4.785	100	18.8	10.00
2. Treatment with 1% PB – bud bursting	37	162	6.005	125	21.3	8.25
3. Treatment with 0.1% PB – two weeks before anthesis	35	165	5.770	121	21.2	8.55
4. Treatment with 0.1 % PB – anthesis	24	159	3.825	80	20.2	9.38
5. Two treatments with PB – bud bursting + two weeks before anthesis	30	147	4.420	92	19.0	6.98
6. Two treatments with PB – bud bursting + anthesis	24	135	3.230	68	22.6	8.40
LSD (5%)	3	12	0.380		0.4	0.8

at the beginning of bud bursting contributed to a 13% increase in the yield of grapes. Twice repeated spraying of the grapevines during bud bursting and two weeks before anthesis had also a positive effect on the yield in the next year. Sugar and acid content were not considerably different in the individual treatments.

Use of paclobutrazol in two consecutive years led to increased yield only in case of a single treatment at the earlier phases of plant development. The mean weight of clusters was higher. A certain increase in sugar content of the grapes was noted. Data concerning the qualitative indices of grapes were within the normal range required for production of high quality white wines.

Discussion

Paclobutrazol inhibited growth considerably and contributed to the increase of fruit-formation not only of grapes but also of many other tree species. However, proofs about the ways in which this plant growth regulator changed the biochemical plant characteristics are scarce. Its role as anti-gibberellin is considered sufficient for the induction of higher yield and for improvement of the quality (Hedden and Graebe, 1985; Reynolds and Wardle, 1990; Basiouny, 1994). A translocation was proven of radioactive paclobutrazol in grapevine sprouts which was exclusively apical (Intrieri et al., 1987). Active compound reaching the subapical meristems inhibited gibberellin production by inhibiting the oxydation of kaurene into kaurenoic acid, which is a cytochrome P 450 catalyzed reaction occuring in microsomes (Hedden and Graebe, 1985). This in turn reduced the rate of cell division without causing any cytoxicity. The high vegetative vigor in grapevines, as shown, is associated with high endogenous levels of gibberellins (Lilov et al., 1983; Lavee, 1987). The reduction in vegetative growth by altering relative sink strengths within the plant had an indirect consequence of allowing a greater partition of the assimilates to reproductive growth, to flower bud formation, fruit formation and fruit growth. Our results show the high effectiveness of paclobutrazol after treatment of the grapevines at the time of bud bursting.

It might also be possible that paclobutrazol caused changes in the photosynthetic activity of chloroplasts. The reduced leaf area was corrected by the thicker leaves and the increase of their photosynthetic capacity (Calissi and Eaton, 1989; Wample et al., 1987). Paclobutrazol appears to be a promising means of controling the balance between vegetative and generative development.

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