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Effects of Para Rubber Solution on Grapevine Physiology, Yield and Quality

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ABSTRACT:

Weekly application of upto 5% aqueous solutions of Para rubber on 'White Malaga' grapevines, during the rainy season, starting 20 days after pruning and last for eight weeks, showed no adverse effect on growth and development of grapevines. At 5% level, fruit set and soluble solid content were significantly higher but the pulp of grapes in this treatment became softer than those in other treatments.

When the applications were done in the dry season on 'Cardinal' grapevines, no effect was found on leaf area and chlorophyll content. Transpiration was lower only during the first three days after the treatments. However, there were no differences in term'of grape qualities. Para rubber application alone could not deter the development of downy mildew *(Plasmopara viticola),* but it could prevent the formation of sporangiophore for at least one day.

INTRODUCTION

Commercial grape growing in Thailand had only been established in recent years, but has quickly dominated markets in Thailand and in its Neighboring countries, replacing imported grapes from foreign countries. However, grape growers are still facing many problems in its cultivation, particularly on disease control. One of the most important grape disease in Thailand is downy mildew, which is caused by *Plasmopara viticola*. Growers have been relied on chemical application to control the disease. This method is both expensive and uncertain on efficeincy in disease control.

Recently, Ziv and Hagiladi (1984) showed that powdery mildew on hydrangea and crapemyrtle could be effectively controlled by spraying sythetic polymers on the foliage. Para rubber is a natural polymer which can be easily and cheaply obtained in Thailand. Our preliminary experiment showed that no phytotoxicity was found when Para rubber solutions were applied on strawberry plant. Thus, it is the objective of this study to test whether or not Para rubber could be used to control downy mildew on grapevines without adverse effect on its growth and development.

MATERIALS AND METHODS

I. Application of Rainy Season

'White Malaga' grapevines (cylindroidal type) grown at Kamphaeng Saen Campus in Nakhon Pathom province were used in this experiment which consisted of 3 blocks with 3 replications of 3 shoots each.

Para rubber solutiong (0, 1, 2, 3, 4 and 5% V/V) were made from Para rubber concentrate (Patex Co., Bangkok) mixed with water and 0.25% 'Shellestrol' surfactant. Care was taken to control pH of the solution since acid condition could cause agglutination of Para rubber (Allen, 1972). The solutions were sprayed on the whole shoot; 20 days after pruning, at 7 days interval,

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starting in August and lasting for 8 weeks. Grapes were evaluated for soluble solids content (SSC) using a hand refractometer, titratable acidity using an automatic titrater and firmness using a firmness with Ø 5 mm plunger.

II Application in Dry Season

(a) Effect on leaf area, chlorophyll content fruit quality

Similar to I, 'Cardinal' grapevines commercially grown in Sampran, Nakhon Pathom were used. The application of 0, 1, 3 and 5% V/V Para rubber solutions was started in January, 15 days after pruning, at 7 days interval and lasted 7 weeks.

Leaf area analysis: The 4 th, 5th and 6th leaves of each shoot were tagged before the application. Leaf area was measured at the beginning and at the end of the experiment, using a leaf-area meter

Chlorophyll analysis: The 6th leaf as above was used for chlorophyll determination according to acetone extraction procedure (Witham *et al.*, 1971).

(b) Effect on transpiration

One year old 'Cardinal' grapevines grown in pots and forced to have only one shoot per plant, were used. When the new shoots were 30 days old the pot was covered with black plastic bag before spraying with different Para rubber solutions. They were then taken into a greenhouse without watering for 6 days. Transpiration rates were recorded everyday using the daily weight loss. completely Randomized block design was used containing 5 blocks of 2 plants in each block.

(c) Effect on disease control

Para rubber solutions of 0, 1, 3 and 5% V/V were sprayed weekly, with or without 'Dithane 45', fungicide 2,250 ppm, on potted 'Cardinal' grapevines, as in (b), starting when new shoots were 7 days old. They were then placed in a vineyard to allow natural infection of downy mildew. on the 4th and 6th weeks disease occurrence was checked by giving scores from 0 to 5; each score represented 20% of leaf area infected.

(d) Effect on sporulation of *Plasmopara viticola*

'Cardinal' grapevines infected with *P. viticola* were tagged in the field, as in (a), between 5 to 6 p.m. The basal part of the leaf was cleaned with cotton, soaked with distilled water, in order to get rid of any sporangiophore and sporangium. The leaf was then sprayed with Para rubber solutions with or without 'Dithane M 45', as in (c). Completely randomized design was used with 5 replications, one leaf each. On the following morning (4 to 5 a.m.) and at the same time for the next 2 days leaf samples were collected and submerged in 2:1 alcohol and glacial acetic acid solution (Visarathanonth, 1973) for 5 to 6 hours, until chlorophyll was removed. The infected area was then cut into 0.5 by 1.0 cm pieces, put on a slide, cleaned with alcohol and stained with aniline blue, 0.8% in lactophenol. Sporangiophore was counted in 5 randomed microscopic field per leaf.

RESULTS AND DISCUSSION

I. Effect of Rainy Season Application of Para rubber solutions on Yield and Quality of 'White Malaga' grapevines

At all concentrations (levels) of Par rubber solutions sprayed, there was no visible phytotoxicity observed. Downy mildew symptom was found equally in all treatments. However, at harvesting time, it can be seen in Table 1 that yield and quality of grapes were significantly better in 5% treatment. Percentage of fruit set in 5% treatment was at 80%, about twice as much as those in other treatments. Furthermore, soluble solid content of grapes was significantly higher at 5% level despite the highest percent fruit set. The result suggested that grapevines under 5% solution treatment were healthier thanin other treatments. Disease infection that might cause fruit drop and reduction in photosynthetic capability, could be

Table 1. Effect of Para rubber solutions on fruit set, soluble solid content, titratable acidity and firmness of 'White Malaga' grapes.

Treatments	Fruit set[1/] (%)	SSC[1/] (%)	TA[1/] (%)	Firmness[1/] (kg)
Water	28.24 c	11.26 b	0.642 a	1.542 a
1% Para Rubber solution	44.66 b	12.20 b	0.580 a	1.808 a
2% Para rubber solution	38.44 bc	13.40 b	0.478 a	0.600 a
3% Para rubber solution	29.43 c	13.06 b	0.503 a	0.800 a
4% Para rubber solution	48.00 b	11.90 b	0.446 a	0.408 b
5% Para rubber solution	80.92 a	15.76 a	0.693 a	0.480 b

[1/] Value in each colum followed by the same letter do not differ significantly at 5% level according Duncan's multiple range test.

less in this treatment; eventhough, it was not obviously observed. One draw back found with this treatment was the low fruit firmness reading. It was possible that early fruit maturation occurred under this condition grapevines were healthier.

II. Effect of Dry Season Application on Physiology of 'Cardinal' Grapevines, Its Fruit Qualities and Disease Occurrence

Since Para rubber is a natural polymer, using it for coating plant parts should limit the exchange of gases and moisture between the inside and outside of plant tissues. If transpiration is limitted, heat could accumulate and result in an increase in tissue temperature, and a higher metabolic rate will follow. Consequently, less photosynthetic product may be left for further plant or fruit growth. Similarly the polymer could limit oxygen and carbon dioxide exchanges. Both gases are important components of the respiratory and photosynthetic processes, which are the backbone of all plant growth and development.

The effects of Para rubber solutions on transpiration, chlorophyll content and leaf area of 'Cardinal' grapevines are shown in Tables 2 and 3 respectively. Chlorophyll content and leaf area were not significantly different in any treatment. However, lower transpiration rate occurred with Para rubber treatment

Table 2. Effect of Para rubber solutions on leaf area and chlorophyll content of 'Cardinal' grapevines.

Treatments	Percentage of leaf area increased[1/]			Chlorophyll[1/] content (mg/g)
	4th leaf	5th leaf	6th leaf	
Water	404.60 a	301.82 a	195.96 a	2.186 a
1% Para rubber solution	410.22 a	303.82 a	202.02 a	2.180 a
3% Para rubber solution	409.80 a	302.64 a	199.46 a	2.192 a
5% Para rubber solution	405.92 az	306.06 a	206.44 a	2.196 a

[1/] Values in each column followed by the same letter do not differ significantly at 5% level according to Duncan's multiple range test.

Table 3. Transpiration rate of 'Cardinal' grapevines applied with Para rubber solutions.

Treatments	Transpiration rate ($mg/cm^2/day$)[1/]					
	1st day	2nd day	3rd day	4th day	5th day	6th day
Water	40.70 a	42.56 a	37.10 a	45.38 a	41.42 a	42.36 a
1% Para rubber solution	37.90 a	35.32 b	33.74 a	42.12 a	43.48 a	41.94 a
3% Para rubber solution	40.50 a	36.48 b	34.78 a	40.86 a	38.46 a	39.68 a
5% Para rubber solution	37.00 a	33.52 b	31.86 a	42.92 a	40.12 a	43.42 a

1/ Values in each column followed by the same letter do not differ significantly at 5% level according to Duncan's multiple range test.

Table 4. Fruit qualities of 'Cardinal' grapevines after the application of Para rubber solutions.

Treatments	Fruit[1/] weight (g)	Fruit[1/] diameter (cm)	Fruit length (cm)	Soluble[1/] solids (%)	Taste[1/] score
Water	3.56 a	1.66 a	1.80 a	14.2 a	2.2 a
1% Para rubber solution	3.30 a	1.72 a	1.84 a	14.6 a	2.2 a
3% Para rubber solution	3.66 a	1.68 a	1.82 a	14.3 a	2.0 a
5% Para rubber solution	3.54 a	1.70 a	1.78 a	14.4 a	2.4 a

1/ Values in each column followed by the same letter do not differ significantly at 5% level according to Duncan's multiple range test.

during the first 3 days after application. It was significantly lower by as much as 20% compared with the control on the second day. Transpiration rates of grapevines on subsequent days were about 40 $mg/cm^2/day$ in all treatments indicating that the effect of Para rubber film on grape leaves, as a barrier for moisture movement, had deminished. It was probably due to the degradation of the polymer under high solar intensity and other hostile atmospheric conditions.

With the above results, therefore, there should not be a dramatic effect on yield and quality of grapes, assuming that pathogenic microorganism was not affected by the application. Table 4 showed qualities of grapes produced under these treatments. Fruit weight, fruit size, soluble solids content and taste score among fruits in each treatment were not significantly different.

Thus, the above experiment indicated that the application of Para rubber solutions had no ill-effect on the physiology of grapevines. However, it is necessary to show that it is effective in controlling grapevines diseases. An experiment on the use of Para rubber solutions was conducted in comparison with the use of a fungicide 'Dithane M 45' which was commonly used by grape-growers to control downy mildew. Disease occurrence was reported in two ways, i.e. percentage of grapevine popu-

Table 5. Percentage of disease occurrence and level of disease virulence on 'Cardinal' grapevines 4 and 6 weeks after the application of Para rubber and Dithane M 45 solutions.

Treatments	Percentage of disease occurrence[1/]		Level of disease virulence (score)[1/]	
Water	73.90 a	92.40 a	2.22 a	2.33 a
1% Para rubber solution	73.00 a	94.60 a	1.66 ab	2.00 a
3% Para rubber solution	76.70 a	93.70 a	2.00 ab	2.22 a
5% Para rubber solution	78.20 a	91.90 a	1.77 ab	2.00 a
Dithane M 45	72.20 a	91.40 a	1.44 bc	1.77 a
1% Para rubber solution + Dithane M 45	76.30 a	87.50 a	1.44 bc	1.66 a
3% Para rubber solution + Dithane M 45	72.50 a	91.50 a	1.33 c	1.77 a
5% Para rubber solution + Dithane M 45	73.70 a	90.00 a	1.44 bc	1.88 a

[1/] Values in each column followed by the same letter do not differ significantly at 5% level according-Duncan's multiple range test.

lation that showed the disease symptom and level of disease virulence. Table 5 showed that Para rubber alone could not effectively control the disease. After 4 and 6 weeks, about 75 and 93 percent of grapevines showed downy mildew symptom respectively. The level of diseas-virulence was about 2.0, or 21 to 40 percent of leaf area were infected. On the contrary, 'Dithane M 45' was effective in controlling the disease, particularly when look at the level of disease virulence for 4 weeks of the applications. The effectiveness diminished somewhat after 6 weeks. The use of rubber solution with 'Dithane M 45' showed no synergistic effect.

The use of synthetic polymer in controlling diseases is based on forming a coating film and a physical barrier to prevent the germination of germ tube of pathogenic fungi (Ziv and Frederiksen, 1983). However, the transpiration study, water loss was reduced only during the first few days, suggesting that the weekly application was not enough to maintain that physical barrier. The polymer film probably degraded later on. More frequent application of Para rubber solution should be tried.

Another advantage of using polymer film to control disease is that once plants have been infected the coated film can form a barrier against the spread of the fungi. It was reported that mycelium of *Plasmopara viticola* (downy mildew) usually grows in the intercellular space and concentrates near the stomates. The fungi formed haustoria which would penetrate into the cell to absorb food. When the environment is suitable, high humidity and low temperature, sporangiophore could be formed within a day (Lafon and Bulit, 1981). An experiment on effect of Para rubber solution spray on sporulation of *Plasmopara viticola* was conducted. Table 6 showed that Para rubber application could effectively inhibit the formation of sporangiophore during the first day. The effectiveness was reduced by approximately 50% on the second day and completely diminished on the third day. However 'Dithane M 45' spray with or without Para rubber solution completely inhibit the sporulation of the fungi until the end of the 3 day experiment.

The above information suggested that the effectiveness of Para rubber solution applied

Table 6. Number of sporangiophore of *Plasmopara viticola* on 'Cardinal' grapevenes; 1, 2 and 3 days after the application of Para rubber and Dithane M 45 solutions.

Treatments	Number of sporangiophore per[1]/ 2.54 cm^2 of infected leaf area		
	1 day	2 days	3 days
Water	21.94 a	22.09 a	25.34 a
1% Para rubber solution	0 b	11.55 b	25.40 a
3% Para rubber solution	0 b	14.20 b	23.68 a
5% Para rubber solution	0 b	8.17 b	22.50 a
Dithane M 45	0 b	0 c	0 b
1% Para rubber solution + Dithane M 45	0 b	0 c	0 b
3% Para rubber solution + Dithane M 45	0 b	0 c	0 b
5% Para rubber solution + Dithane M 45	0 b	0 c	0 b

1/ Values in each column followed by the same letter do not differ significantly at 5% level according to Duncan's multiple range test.

might be improved if the applications were made more often and/or the concentration increased more than 5% It should be considered however, that adverse effects of the application must be minimal.

CONCLUSIONS

Para rubber solution applied weekly at 5% level on 'White Malaga' grapevines during the rainy season could increase fruit set and raised the soluble solid content of the fruit significantly. However, when it was used on 'Cardinal' grapevines during the dry season, the same benefit was not found at upto 5% level. It was shown that the application of Para rubber solutions had no effect on chlorophyll content, leaf area or transpiration rate of grapevines. The effectiveness in controlling disease by Para rubber solutions was not found. However the application prevented the formation of sporangiophore of *Plasmopara viticola* effectively for at least one day. It was suggested that higher concentration and more frequent application interval might improve the benefit of this natural polymer in controlling grapevine diseases.

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