Influence of Plastic Roof on Fruit Quality and Yield of ‘Beauty Seedless’ Grape During Dry and Rainy Seasons

Ganesh Kumar Shrestha¹, Surasak Nilnond², Lop phavaphutanon², Niran Juntawong³ and Choopong Sukumalandana²

ABSTRACT

A study on the influence of plastic roof applied from pruning to harvest, pruning to color change and flowering to color change on fruit quality, total nonstructural carbohydrate in shoot, yield, cost and returns of ‘Beauty Seedless’ grape was conducted in the Northern Thailand during dry and rainy seasons. The results showed that the vines growing under plastic roof from pruning to color change stage produced high cluster weight, number of clusters, yield and profit during both dry and rainy seasons. Moreover, the berry size and berry weight were increased and the percent of yield loss was decreased and no disease score was found during the dry season. The vines growing under plastic roof from pruning to harvest stage gave an increase in total anthocyanin content and tended to contain no disease score during the dry season. Similar trend was found in an increase in berry size, berry weight and total soluble solids and a decrease in disease score, titratable acidity and the percent of yield loss during the rainy season. No differences on the total non-structural carbohydrate content in shoot of the vines during both dry and rainy seasons were found among the treatments. The treatments applied plastic roof on vines gave higher profit than the control in both seasons. However, the control gave a marginal net profit in the dry season and a profit loss remained in the rainy season.

Key words: grape, plastic roof, tropical grape, quality, yield, Thailand

INTRODUCTION

Many factors were found affecting the quality of grapes such as variety, climate, soil, cultural practices, irrigation, disease and insect control (Winkler et al., 1974). However, only these factors can not improve fruit quality of grape in the area where there are high rainfall and/or heavy dew during the crop cycle (pruning to harvest) as in the Northern Thailand.

In Thailand, one of the sites of table grape production is the northern region. The rainfall per annum, relative humidity, temperature and altitude of the site are characterized by the approximate ranges of 1,400-1,500 mm, 60-90%, 10°C-30°C and 1,300 m., respectively (Nilnond, 1997). The maximum rainfall is in the wet season (May-October) and less in the dry season (November to

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Grapevine cultivation was introduced to Northern Thailand under Royal Project in 1981 to promote the living standard of hill tribes and grape was used as one of the substitute crops for opium poppy. Among the introduced table grape cultivars, ‘Beauty Seedless’ is the most popular one in the area, but the quality and yield have become the serious problems in affecting grape grower’s profit especially during the rainy season (Nilnond, 1997). Good quality table grapes represents a combination of medium size of uniformly large, perfect berries with the characteristic color, pleasing flavor and texture of the variety (Winkler et al., 1974).

Initially plastic roof was used to protect the crops from low temperature in temperate areas, but now the main purpose of using plastic roof is to protect fruit from the wind, rain and birds. According to Masaki (1987), it is used to reduce disease and insect damage on crops and produce high quality crops.

The effect of plastic roof on fruit quality during the rainy season had been studied by Fitprayoon (1992). However, there is a paucity of information on this aspect during both dry and rainy seasons. Thus, this study was conducted during dry and rainy seasons to determine the influence of plastic roof on fruit quality, total non-structural carbohydrate (TNC) in shoot, yield, cost and returns of ‘Beauty Seedless’ grape under which plastic roof on vines was being applied at different time periods.

MATERIALS AND METHODS

Five years old ‘Beauty Seedless’ vines grown at the Royal Khunklang Station, Chiang Mai Province (98°30’E to 99°30’E and 18°00’N to 19°30’N) were used in this study. Thirty-two vines of uniform growth were selected and pruned during the dry season in November 1998. Another 32 vines of uniform growth were selected and pruned during the rainy season in May 1999. The experiments were arranged in randomized complete block design. There were 4 treatments and 4 replications using 2 vines as one replicate in each treatment during both dry and rainy seasons. The treatments were: without plastic roof (control), plastic roof from pruning to harvest (PPH), plastic roof from pruning to color change (PPC), and plastic roof from flowering to color change (PFC).

Clear plastic 0.1 mm thick was used as roofing on the vine (Figure 1). Intercultural operations were undertaken as and when it is necessary and the following parameters were recorded after pruning:

1) Fruit characters recorded as width and length of berries, cluster and berry weight, number of clusters per vine, total yield per vine, yield loss due to diseases and insect pests, total soluble solids of the juice, titratable acidity by titrating fruit juice with 0.1 N. NaOH.

2) Total anthocyanin content was determined by a method described for cranberries (Fuleki and Francis, 1968) with modifications for grapes (Watada and Abbott, 1975).

3) Diseased leaf area was scored every month on the basis of Brydson Method (1989).
the sample leaves were selected for the 5th, 6th, and the 7th leaves from the base of the shoots and labeled for measuring diseased leaf area.

4) Total non-structural carbohydrate (TNC) analyzed as described by Smith et al. (1964) and samples of shoot were taken at the pruning, blooming, color change, harvest and one month after the harvest from the 6th bud of vines.

5) Rainfall recorded everyday and a comparative cost and returns of each treatment were made.

Analysis of variance (ANOVA) and Duncan’s multiple range test (DMRT) were performed by using IRRISTAT program.

RESULTS

Experiment 1 Influence of Plastic Roof on Fruit Quality and Yield of ‘Beauty Seedless’ Grape during Dry Season

Cluster and berry characters and yield
1. Cluster weight
   The PPC gave the highest cluster weight of 455.8 g, but this was not significantly different from that of the control treatment of 419.2 g. The lowest cluster weight of 300.1 g was recorded in the PFC, which was significantly different from that of the control and the PPC treatments. Moreover, the cluster weight of the PPH was significantly lower than that of the PPC and the control treatments (Table 1).

2. Number of clusters per vine
   The number of clusters were significantly different among treatments in which the PPC produced the highest number of fruit clusters of 27.9/vine followed by the PPH of 25.0/vine, which were significantly different from that of the control treatment of 11.6/vine. The lowest number of fruit clusters was noted in the control treatment, but it was not significantly different from the PFC treatment of 14.4/vine (Table 1).

3. Length, width and weight of berry
   The PPC gave the longest and widest berries of 1.75 and 1.42 cm, respectively, which were significantly different from those of the control treatment (Table 1). The shortest berry length of 1.52 cm and width of 1.27 cm were found in the berries of the control treatment, but these dimensions were not significantly different from the PPH.

Table 1 Characteristics of cluster and berry, fruit quality and diseased leaf area of ‘Beauty Seedless’ grape during dry season in 1998/99 as influenced by plastic roof.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit cluster weight (g)</th>
<th>Cluster (No.)</th>
<th>Berry Length (cm)</th>
<th>Berry Width (cm)</th>
<th>Berry Weight (g)</th>
<th>Total yield (kg/vine)</th>
<th>Fruit quality TSS (%)</th>
<th>Fruit quality TA (%)</th>
<th>Total anthocyanin (mg/100g fw)</th>
<th>Diseased leaf area (score)</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>419.2 a</td>
<td>11.6 c</td>
<td>1.52 c</td>
<td>1.27 b</td>
<td>0.8 b</td>
<td>4.3 b</td>
<td>17.50 a</td>
<td>0.55 a</td>
<td>78.2 b</td>
<td>2.73</td>
<td>11.9</td>
</tr>
<tr>
<td>PPH</td>
<td>324.8 b</td>
<td>25.0 ab</td>
<td>1.60 bc</td>
<td>1.34 b</td>
<td>1.1 a</td>
<td>10.1 a</td>
<td>15.25 ab</td>
<td>0.43 b</td>
<td>89.5 a</td>
<td>0</td>
<td>34.3</td>
</tr>
<tr>
<td>PPC</td>
<td>455.8 a</td>
<td>27.9 a</td>
<td>1.75 a</td>
<td>1.42 a</td>
<td>1.2 a</td>
<td>12.2 a</td>
<td>16.00 ab</td>
<td>0.57 a</td>
<td>75.2 b</td>
<td>0</td>
<td>4.4</td>
</tr>
<tr>
<td>PFC</td>
<td>300.1 b</td>
<td>14.4 bc</td>
<td>1.63 b</td>
<td>1.34 b</td>
<td>1.1 a</td>
<td>4.3 b</td>
<td>14.06 b</td>
<td>0.41 b</td>
<td>82.7 ab</td>
<td>2.65</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Means followed by a similar letter in the same column are not significantly different at the 5 % level by DMRT.
The highest berry weight of 1.2 g was found in the PPC followed by the PFC and the PPH of 1.1 g each, which were significantly greater than those of the control treatment (Table 1).

4. Yield per vine
The PPC produced the highest total yield of 12.2 kg/vine followed by the PPH treatment of 10.1 kg/vine, which were significantly different from those of the control and the PFC treatments of 4.3 kg/vine each (Table 1).

**Fruit quality**

1. Total soluble solids
Berries from the control treatment had the highest total soluble solids (TSS) of 17.50 % followed by the PPC and the PPH, but they were not significantly different from each other. However, the lowest TSS % was found in the PFC, which was significantly different from berries of the control treatment (Table 1).

2. Titratable acidity
The PPC produced fruits with the highest titratable acidity (TA) of 0.57 %, but it was not significantly different from that of the control treatment of 0.55 % (Table 1). The lowest TA of 0.41 % was found in the PFC, which was significantly different from fruits of the control treatment (Table 1).

3. Total anthocyanin content
The PPH produced the berries with the highest total anthocyanin content of 89.5 mg/100 g fresh weight, which was significantly different from berries of the PPC and the control treatments. The lowest total anthocyanin content was found in the PPC, but this was not significantly different from that of the control and the PFC treatments (Table 1).

4. Diseased leaf area
Fungicides for diseases especially for downy mildew and anthracnose were sprayed regularly. So, those vines applied the PPH and the PPC did not show disease score in their leaves. But the vines grown under the PFC and the control treatment showed the disease symptom on their leaves. Leaves from the control treatment had the highest score of 2.73 (Table 1).

**Total non-structural carbohydrate**
There was no significant difference in total non-structural carbohydrate (TNC) content of shoots among treatments at all stages. The trend of TNC content of shoots indicated that it decreased from the pruning (November) to the blooming stage (January) and sharply increased from the blooming to the color change stage (March) of berries, after which it slightly decreased from the color change to the harvest stage (April) and slightly increased from the harvest to one month after the harvest. However, the average TNC contents in shoot were 85.5, 56.0, 92.3, 77.4 and 92.1 mg/g dry weight at the pruning, blooming, color change, harvest and one month after the harvest, respectively (Figure 2).

**Cost and returns**
The highest cost of production per 100 vines was noted in the PPH and the PPC of 23,183 baht each followed by the PFC, however, the lowest cost of production was recorded in the control treatment of 12,570 baht. However, the highest net profit per 100 vines was showed in the PPC of 206,817 baht followed by the PPH and the PFC. The lowest profit was noted in the control treatment of 31,430 baht (Table 2).

**Climatic data**

**Rainfall**
There were 23 rainy days during the experimental period (8 November 1998 to 22 April 1999) with 3, 2, 1, 0, 2 and 15 days of rainfall in November, December, January, February, March, and April, respectively. The total rainfall was 218
Figure 2  TNC content in shoot at different stage of crop cycle of ‘Beauty Seedless’ grapes during dry season in 1998/99.

Table 2  Cost and returns of ‘Beauty Seedless’ grapes based on 100 vines in each treatment during dry season in 1998/99 as influenced by plastic roof.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost of chemical and fertilizer (baht)</th>
<th>Labor cost (baht)</th>
<th>Cost of materials and labors for roofing and trellis (baht)</th>
<th>Total cost (baht)</th>
<th>Yield (kg)</th>
<th>Price/kg grapes (baht)</th>
<th>Gross income (baht)</th>
<th>Net profit (baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3,156</td>
<td>5,681</td>
<td>3,733</td>
<td>12,570</td>
<td>220</td>
<td>200</td>
<td>44,000</td>
<td>31,430</td>
</tr>
<tr>
<td>PPH</td>
<td>2,487</td>
<td>5,137</td>
<td>15,559</td>
<td>23,183</td>
<td>930</td>
<td>200</td>
<td>186,000</td>
<td>162,817</td>
</tr>
<tr>
<td>PPC</td>
<td>2,487</td>
<td>5,137</td>
<td>15,559</td>
<td>23,183</td>
<td>1150</td>
<td>200</td>
<td>230,000</td>
<td>206,817</td>
</tr>
<tr>
<td>PFC</td>
<td>2,487</td>
<td>5,075</td>
<td>15,559</td>
<td>23,121</td>
<td>290</td>
<td>200</td>
<td>58,000</td>
<td>34,879</td>
</tr>
</tbody>
</table>

1/ Labor cost for pruning, spraying pesticide, irrigating, fertilizing, manuring, weeding, thinning, cutting climbers, harvesting, etc.

The labor cost was 100 baht/day/person

Note: US $1=38 baht

mm in the period. The maximum rainfall was 135 mm in April (Figure 4).

Experiment 2 Influence of Plastic Roof on Fruit Quality and Yield of ‘Beauty Seedless’ Grape during Rainy Season

Cluster and berry characters and yield

1. Cluster weight
   The highest cluster weight of 415.9 g was found in the PPC treatment followed by the PPH and the PFC, which were significantly different from that of the control treatment of 117.4 g (Table 3).

2. Number of clusters per vine
   The treatments under plastic roof had significantly higher number of clusters than that of the control treatment. The PPC produced the highest number of fruit clusters of 42.4/vine, but it was not significantly different from other treatments under
plastic roof (Table 3).

3. Length, width and weight of berry

The PPH treatment gave the longest and the widest berries of 1.94 and 1.51 cm, respectively, but these dimensions were not significantly different from those berries of treatments under plastic roof. However, the shortest berry length of 1.70 cm and width of 1.39 cm were found in the control, which were significantly different from those of treatments under plastic roof (Table 3).

The highest berry weight of 2.8 g was found in the PPH followed by the PPC and the PFC, which were significantly lower than that of the control treatment of 2.0 g. The PPH was significantly higher than the PFC (Table 3).

4. Yield per vine

The PPC treatment gave the highest total yield of 14.5 kg/vine followed by the PPH and the PFC treatments, which were significantly different from that of the control treatment of 1.1 kg/vine (Table 3).

Fruit quality

1. Total soluble solids

The PPH treatment produced berries with the highest total soluble solids (TSS) of 15.10%, which was significantly different from the treatments PPC and PFC, but it was not significantly different from the control treatment (Table 3). The lowest TSS was found in berries from the PFC of 13.85%, but this was not significantly different from the PPC and the control treatments (Table 3).

2. Titratable acidity

Berries from the control treatment had the highest titratable acidity (TA) of 1.02%, which was significantly different from those of treatments applied plastic roof. The lowest TA of 0.82% was found in the PPH (Table 3).

3. Total anthocyanin content

Berries from the PFC had the highest total anthocyanin content of 64.6 mg/100 g fresh weight, which was significantly different from that of the control treatment of 64.2 mg/100 g fresh weight. However, berries from the control treatment had the lowest total anthocyanin content, but it was not significantly different from that of the PPH and the PPC (Table 3).

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**Table 3** Characteristics of cluster and berry, fruit quality and diseased leaf area of ‘Beauty Seedless’ grape during rainy season in 1999 as influenced by plastic roof.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit cluster Weight (g)</th>
<th>Cluster (No.)</th>
<th>Berry Length (cm)</th>
<th>Width (cm)</th>
<th>Weight (g)</th>
<th>Total yield (kg/vine)</th>
<th>Fruit quality TSS (%)</th>
<th>TA (%)</th>
<th>Total anthocyanin (mg/100g fw)</th>
<th>Diseased leaf area (score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>117.4 b</td>
<td>8.6 b</td>
<td>1.70 b</td>
<td>1.39 b</td>
<td>2.0 c</td>
<td>1.1 b</td>
<td>15.56 ab</td>
<td>1.02 a</td>
<td>64.2 b</td>
<td>4.55 a</td>
</tr>
<tr>
<td>PPH</td>
<td>362.8 a</td>
<td>30.8 a</td>
<td>1.94 a</td>
<td>1.51 a</td>
<td>2.8 a</td>
<td>12.3 a</td>
<td>15.10 a</td>
<td>0.82 b</td>
<td>64.3 ab</td>
<td>0.17 c</td>
</tr>
<tr>
<td>PPC</td>
<td>415.9 a</td>
<td>42.4 a</td>
<td>1.91 a</td>
<td>1.46 a</td>
<td>2.6 ab</td>
<td>14.5 a</td>
<td>14.04 b</td>
<td>0.85 b</td>
<td>64.3 ab</td>
<td>1.59 b</td>
</tr>
<tr>
<td>PFC</td>
<td>353.0 a</td>
<td>32.9 a</td>
<td>1.89 a</td>
<td>1.50 a</td>
<td>2.4 b</td>
<td>11.3 a</td>
<td>13.85 b</td>
<td>0.85 b</td>
<td>64.6 a</td>
<td>1.90 b</td>
</tr>
</tbody>
</table>

CV (%) 14.4 25.5 3.8 2.6 7.1 30.2 4.3 5 0.4 12

Means followed by similar letter in the same column are not significantly different at the 5 % level by DMRT.
**Diseased leaf area**

Those treatments using plastic roof gave significantly lower diseased scores in leaves than that of the control treatment of 4.55. The lowest diseased score of 0.17 was found in the PPH, which was significantly different from that of the PPC and the PFC (Table 3).

**Total non-structural carbohydrate**

There was no significant difference in total non-structural carbohydrate (TNC) content of shoots among treatments at all stages. The trend of TNC content of shoots indicated that it sharply decreased from pruning (May) to the blooming stage (July) and sharply increased from the blooming to the color change stage (September) of berries, after which it slightly decreased from the color change to the harvest stage (October) and slightly increased from the harvest to one month after the harvest. However, the average TNC contents in shoot were 90.9, 72.6, 96.8, 93.7 and 97.8 mg/g dry weight at the pruning, blooming, color change, harvest and one month after the harvest, respectively (Figure 3).

**Cost and returns**

The highest cost of production per 100 vines was noted in the PPH of 24,788 baht followed by the PPC and the PFC, while, the lowest cost of production was recorded in the control treatment of 13,450 baht. However, the highest net profit per 100 vines was showed in the PPC of 187,705 baht followed by the PPH and the PFC, whereas the control treatment remained a loss of 12,850 baht (Table 4).

**Climatic data**

**Rainfall**

There were 115 rainy days during the experimental period (23 May 1999 to 16 October 1999) with 6, 28, 26, 27, 19, and 9 days of rainfall in May, June, July, August, September and October, respectively. The total rainfall was 1312.5 mm in the period. The maximum rainfall was 459 mm in August (Figure 4).

**DISCUSSION**

As the treatments under plastic roof was found to have higher berry size and weight and number of clusters as compared to the control treatment, the rather large berry size and weight and the number of clusters in the treatments under plastic roof might be due to no disease score (PPH and PPC) and lower disease score (PFC) in leaves than that of the control (Table 1). The results agreed with those reported by Kinuma & Kawabuchi (1984) and Fitprayoon (1992) that the treatment...
under plastic roof increased berry weight and size.

The treatments under plastic roof produced higher yield than the control treatment. This result was in consistent with the report that the navel orange tree with plastic roof gave higher yield compared with the trees grown in the open (Ueda et al., 1983). However, the PFC and the control treatments attributed the lower yield may be due to the attack of more diseases in leaves (Table 1). The control and the PFC treatments gave higher percentage of yield loss than those of the PPC and the PPH treatments because of diseases (Ueda et al., 1983) and rains during ripening and harvesting (Winkler et al., 1974) which caused fruit rot.

Even though the PPC did not have any influence statistically on chemical composition, there were lower TSS and anthocyanin content and higher TA of harvested fruits as compared to the control treatment. Indeed, Kimura and Kawabuchi (1984) supported these results in parts that juice of

**Table 4** Cost and returns of ‘Beauty Seedless’ grapes based on 100 vines in each treatment during rainy season in 1999 as influenced by plastic roof.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cost of chemical and fertilizer (baht)</th>
<th>Labor cost (baht)</th>
<th>Cost of materials and labors for roofing and trellis (baht)</th>
<th>Total cost (baht)</th>
<th>Yield (kg)</th>
<th>Price/kg grapes (baht)</th>
<th>Gross income (baht)</th>
<th>Net profit (baht)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4,639</td>
<td>5,081</td>
<td>3,733</td>
<td>13,450</td>
<td>30</td>
<td>20</td>
<td>600</td>
<td>-12,850</td>
</tr>
<tr>
<td>PPH</td>
<td>3,986</td>
<td>5,243</td>
<td>15,559</td>
<td>24,780</td>
<td>1,150</td>
<td>180</td>
<td>207,000</td>
<td>182,212</td>
</tr>
<tr>
<td>PPC</td>
<td>3,986</td>
<td>5,150</td>
<td>15,559</td>
<td>24,695</td>
<td>1,180</td>
<td>180</td>
<td>212,400</td>
<td>187,705</td>
</tr>
<tr>
<td>PFC</td>
<td>3,986</td>
<td>4,931</td>
<td>15,559</td>
<td>24,476</td>
<td>700</td>
<td>180</td>
<td>126,000</td>
<td>101,524</td>
</tr>
</tbody>
</table>

1/ Labor cost for pruning, spraying pesticide, irrigating, fertilizing, manuring, weeding, thinning, cutting climbers, harvesting, etc

The labor cost was 100 baht/day/person

Note: US $1 = 38 baht

**Figure 4** Monthly rainfall and number of rainy days during dry and rainy seasons in 1998/99.
‘Kyoho’ grown under plastic roof, contained slightly less soluble solids. Because well exposed fruits to the sun contain more sugar and less acid than poorly exposed fruits (Koblet, 1986; Coombe, 1987). The values of TSS and TA reported in the study (Table 1) were lower than reported earlier in ‘Beauty Seedless’ grapes by Chanda and Randhawa (1974). The rather low values of TSS and TA in this study may be due to the high rainfall for many days during the harvest month (135 mm rainfall for 15 days). The anthocyanin results were within the range as described by Watada and Abbott (1975) that the anthocyanin content of Concord grapes of different maturity ranged from 30-120 mg/100 g fresh weight. The result varied in anthocyanin content may be due to environmental factors, such as light, temperature and soil moisture as explained by Winkler et al. (1974).

The control treatment showed the higher disease infection in the leaves of the vines than other treatments. This was as explained by Dwiastuti (1990) that rainfall and duration of leaf wetness increased the intensity of downy mildew. The attack of diseases in leaves of the PFC was higher than those of other treatments under plastic roof which might be due to the effect of rainfall and dew since the vines were grown in the open before flowering for approximately one and a half months. Rains early in the growing season make disease and pest control difficult (Winkler et al., 1974).

The trend of TNC contents in shoot indicated that it decreased at the blooming stage (January) and sharply increased at the color change stage (March) of berries, after which it slightly decreased at the harvest (April) and increased again one month after harvest. These results were in the line with that revealed by Keller and Loescher (1989) on sweet cherry that reserved TNC in shoots decreased before bud break shortly after full bloom the content began to increase. This implied that the photosynthetic rate of vines under plastic roof was not affected and that the carbohydrate storage remained the same level as explained by Keller and Loescher (1989) at different stages in shoot.

There was great difference in net profit between the treatments under plastic roof except the PFC treatment and the control treatment (Table 2). The PPC and the PPH treatments gave 5.6 and 4.2 times higher in net profit, respectively, compared to the control treatment. The higher net profit in those treatments might be due to no effect of diseases in the leaves, less yield loss, no effect on fruit quality and storage and utilization of the TNC in shoot by applying plastic roof on the vines. It is clear that they got better environment and produced higher yield so that higher net profit achieved. On the contrary, the PFC and the control treatments had disease infection because of rainfall on leaves, consequently lower yield and net profit were achieved than those other treatments under plastic roof. These results showed to some extent as those results revealed by Suh et al. (1984) that through covering plastic, grapevines increased the proportion of marketable fruit and reduced disease incidence more than half compared with uncovered grapevines.

The characteristics of harvested fruits showed that the treatments under plastic roof gave significantly higher weight and size of clusters and berries and size of berries than the control treatment (Table 3). The treatments under plastic roof increased berry size (Fitprayoon, 1992), berry weight (Kimura and Kawabuchi, 1984) and cluster weight (Sangudom, 1989). Those results might be due the differences of rains on leaves between control and other treatments under plastic roof.

The description of the yield component was almost the same as that in dry season.

Even though the PPH gave the highest TSS of 15.10%, it had much lower percent than the value of 18-21 % reported earlier in ‘Beauty Seedless’ grapes (Chanda and Randhawa, 1974).
In case of TA, the value of 0.6-1.0 % was reported in ‘Beauty Seedless’ grapes by Chanda and Randhawa (1974), and while the control treatment showed higher TA value, other treatments were within the range of the value. Well-exposed fruits with the sun contain more sugar and less acid than poorly exposed fruits (Koblet, 1986; Coombe, 1987). On the contrary, this experiment was in adverse condition since most of the time vines received low light intensity due to cloudy and rainfall (Figure 4). The anthocyanin content was the same as that in dry season.

The control and the PPH had significantly the highest and the lowest diseased scores in leaves, respectively (Table 3). The reason may be due to rainfall since the vines of the control were grown in the open, whereas the vines of the PPH were grown under plastic roof in the crop cycle. The results were supported by Dwiastuti (1990) who stated that rainfall and duration of leaf wetness increased the intensity of downy mildew.

The trend of the TNC contents in shoot was almost the same as that in dry season.

The control produced lower yield and quality than that of the treatments under plastic roof and the fruits of the control treatment were sold at 20 baht/kg, while the fruits of other treatments were sold at 180 baht/kg. Thus, the control treatment remained a profit loss. Suh et al. (1984) indicated a support of those results that through covering plastic, grapevines increased the proportion of marketable fruit and reduced disease incidence more than half compared with uncovered grapevines. Similarly, navel orange tree gave higher yield by covering for 3 months from just before flowering with vinyl film roof compared with growing the tree in the open (Ueda et al., 1983). It was also mentioned that crops damage caused by diseases and insect pests were reduced and stable production of high quality vegetables was achieved by cultivating them under plastic rain shelter (Masaki, 1987).

**CONCLUSION**

The treatment under plastic roof from pruning to color change revealed the highest performance of cluster weight and number, size and weight of berry, fruit quality, yield and profit, the lowest yield loss and no disease score in leaves during dry season. The treatment under plastic roof from pruning to harvest gave the highest performance of size and weight of berry and fruit quality, the lowest yield loss and disease score in leaves during rainy season. The treatments under plastic roof gave higher profit than the control and did not show the differences in TNC content in shoot during both seasons. However, the treatment without plastic roof had marginal profit in dry season, whereas a profit loss remained in rainy season.

**LITERATURE CITED**


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