

Lysophosphatidylethanolamine Treatment Stimulates Ripening in Table Grape

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Abstract. This study was initiated to investigate the effect of lysophosphatidylethanolamine (LPE) on ripening of two table grape varieties: 'Crimson' and 'Red Globe' (*Vitis vinifera* L.). The experiments were performed at USA and Chile in 2004 and 2005, respectively. It was found that application of LPE has noticeable effect on color enhancement. LPE treatment resulted in increase in yield, comparable to that achieved with Ethrel treatment in 'Crimson' and 'Red Globe' grapes. Efficacy of LPE on table grape ripening in Chile was identical with it shown in USA. Our expanded knowledge would lead to broader applications of this environment-friendly method in improving the quality and quantity of crop production, and would contribute to creating higher profits in commercial agriculture.

Additional key words: *Vitis vinifera*, ethrel, quality, skin color, storability, yield

Introduction

Lipids have been thought to play important roles as major constituents of membrane structure and as energy reserves. It is now evident that lipids and their metabolites act as mediators in signal transduction, cell activation, and cell proliferation (Divecha and Irvine, 1995; Ryu et al., 1997). Recent studies have provided evidence that lysophosphatidylethanolamine (LPE), a natural lipid, can accelerate ripening of tomato and cranberry fruits while prolonging shelf life at the same time (Farag and Palta, 1993; Ozgen et al., 2005). In addition, Hong (2006) reported that the influence of LPE on fruit tissue was dependent on the stage of ripening. Thus, in a mature fruit (ready to ripen) LPE stimulated ripening while in a ripened fruit LPE inhibited ethylene production and maintained fruit firmness thereby prolonging shelf life. These results, taken together, provide the evidences that LPE increase ripening without any fruit decay at the same time.

The grape (*Vitis* spp.) is a productive plant considered as the world's premier fruit that is consumed for wine, distilled liquors, juice, dried fruit (raisins), fresh consumption (table grape), and concentrate. Despite this major economic

importance, the process of grape maturation is still poorly understood (Coombe, 1992). Anthocyanin, major pigment in ripen-grape, biosynthesis commences only when ripening of the berry begins and normally continues throughout the ripening phase of growth. Factors such as variety, growing region, and growth conditions can influence the levels of anthocyanin production and profile of different pigments (Mazza and Miniati, 1993). The color of red and black grapes results from the accumulation of anthocyanins that are usually localized only in the skin of the berry. The quantity and quality of color in grape berries at harvest are crucial factors that influence wine making. Each species or variety of grapes has a unique set of anthocyanins and the anthocyanin profiles.

In Preliminary experiment, the effect and efficacy of LPE on fruit ripening and color development were confirmed by small field trials of tomatoes (Hong, 2006) and grapes (data not shown). For the commercial point of view, these experiments have been conducted with two cultivars in large scale at two foreign regions to eliminate the statistical and regional errors of LPE efficacy on table grape ripening. Our data would help us to take a step forward in commercializing LPE as an environment-friendly bio-regulator for agricultural industry.

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Materials and Methods

Trials in USA

The study was performed on 8-years old vineyards cv. 'Crimson' and 'Red Globe' (*Vitis vinifera* L.) table grapes, located at Tulare, CA. in 2004. The experimental design consisted of a randomized block with three replicates of 145 vines each. Two buffer vines were used between different experimental vines to limit drifting of spray material from adjacent treatments. In order to investigate the effects of double application on the performance, it was designed to make a sequential application of the same treatments, so that each plot received a second application of the same material at the same rate. The plots could be easily split by half, so only half of the plot received the sequential application, allowing us to compare the impact of sequential to single applications. All treatments were applied using grower equipment (typical orchard air blast sprayer delivering 600 LPA (liter per acre)).

In case of 'Crimson' grape, for single application studies, vines were foliar-sprayed with 50 mg·L⁻¹ LPE on June 29 or 50 mg·L⁻¹ Ethrel (ethephon) on August 2. For sequential treatment of LPE, foliar application with 50 mg·L⁻¹ LPE was carried on June 29, followed by 50 mg·L⁻¹ LPE on August 4. First, second and third harvest dates were on August 14, September 14, and October 12, respectively. All harvests were done by grower's commercial crew, ensuring that grapes were picked according to commercial standards. The number of boxes harvested from each row was recorded for each treatment on each harvest date, including grower standard area with Ethrel treatment. Each box contained 9 kilograms of grapes.

In case of 'Red Globe' grape, for single application studies, vines were foliar-sprayed with 50 mg·L⁻¹ LPE on June 30 or 50 mg·L⁻¹ Ethrel on July 29. For sequential treatment of LPE, foliar application with 50 mg·L⁻¹ LPE was carried on June 30, followed by 50 mg·L⁻¹ LPE on August 4. Ripened 'Red Globe' grapes were harvested on August 24, September 4, and September 24, respectively.

Trials in Chile

Trials in Chile were performed on 10-years old vineyards located at Rancagua in 2005. Two trials were sprayed on

'Crimson' and 'Red Globe' table grapes. Each trial was approximately 5 acres in size and each acre has 6 rows with 75 plants. One buffer vines were used between different experimental vines as same as USA trials. Vines were foliar-sprayed with 2, 10, 50 mg·L⁻¹ LPE at 4 weeks before harvest (sprayed on February 7, 2005 and harvested on March 10, 2005). All treatments were applied using grower equipment (typical orchard air blast sprayer delivering 400 LPA (liter per acre)). All harvests were done by grower's commercial crew, ensuring that grapes were picked according to commercial standards. The number of boxes harvested from each row was recorded for each treatment on each harvest date. Each box contained 10 kilograms of grapes.

Statistical Analysis

Data were evaluated using GLM procedures in the SAS 6.12 statistical package (SAS Institute, Inc. Cary, N.C.). Differences between treatment means were determined using Fisher's least significant difference (LSD), $P < 0.05$.

Results and Discussion

Effect of LPE on table grape ripening in USA

It was thought that sequential application of LPE can be improved yield and color development on grape with some growing period interval. In order to investigate the effect of sequential application on grape yield, LPE was sprayed on two table grapes of 'Crimson' and 'Red Globe'. Same amounts of LPE at same concentration were sprayed on whole plant with 1 month interval. Because of grower conditions, grapes were started to have first harvest from 4-6 days after second application.

In 'Crimson' grape, LPE and Ethrel treatment showed almost same effects on the grape (Fig. 1). Total yield increased 50-58% with LPE and Ethrel treatment compared to control. There was no significant advantage in sequential treatment over the single treatment. LPE treatment gave increase in yield in grape. However, it does not mean that LPE application on grape hastened the ripening and colorization. As shown in Fig. 2, grape yield in first harvest of 'Crimson' was much higher in Ethrel treatment (29%) compared with. 13% of control and 19% of LPE treatment. LPE looks helpful for early harvest, but difference was not big enough.

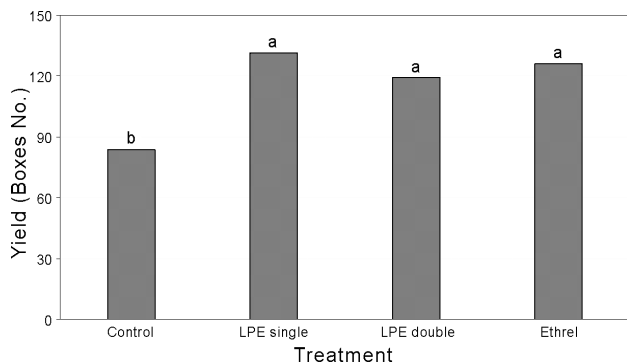


Fig. 1. Effect of LPE and Ethrel application on total yield in 'Crimson' table grape in USA. Grapes were harvested three times by commercial crews as indicated Material and Methods. Each box contained 9 kilograms of grape. Means with different letters are significantly different at $p < 0.05$ using Fisher's LSD.

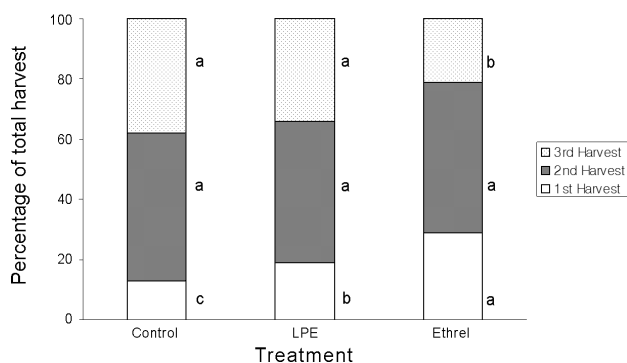


Fig. 2. Effect of LPE and Ethrel application on harvest proportion of each harvesting time in 'Crimson' table grape in USA. Across the treatment, means within harvesting time with different letters are significantly different at $p < 0.05$ using Fisher's LSD.

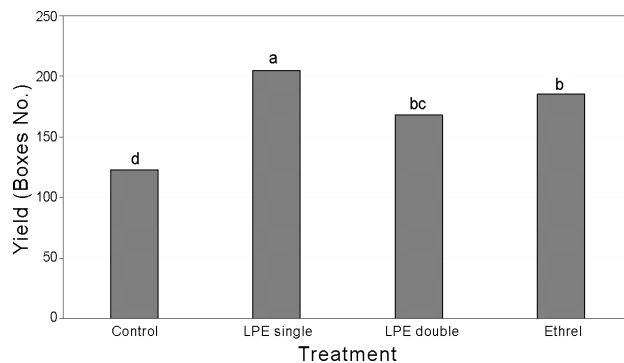


Fig. 3. Effect of LPE and Ethrel application on total yield in 'Red Globe' table grape in USA. Grapes were harvested three times by commercial crews as indicated Material and Methods. Each box contained 9 kilograms of grape. Means with different letters are significantly different at $p < 0.05$ using Fisher's LSD.

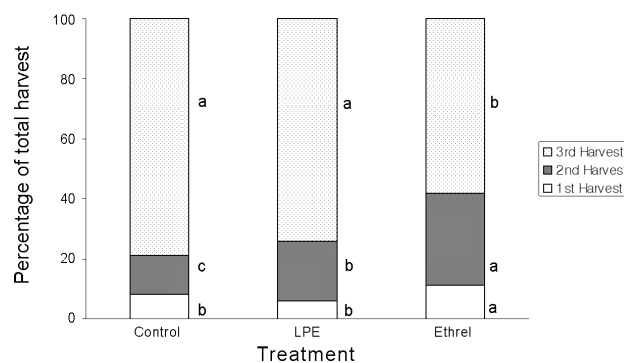


Fig. 4. Effect of LPE and Ethrel application on harvest proportion of each harvesting time in 'Red Globe' table grape in USA. Across the treatment, means within harvesting time with different letters are significantly different at $p < 0.05$ using Fisher's LSD.

This kind of result was similar in 'Red Globe' (Fig. 4). Relative proportion of grape yield in first and second harvest for Ethrel, LPE, and control were 42%, 26%, and 21%, respectively. Ethrel treatment was effective for early harvest in red coloring table grapes such as 'Crimson' and 'Red Globe'. Grapes with LPE application caught up the ripening and colorization rate at the normal ripening season, which means that detailed study on optimum time for LPE application is needed.

In 'Red Globe' grape, single LPE treatment increased total yield by 67% compared to control (Fig. 3), showing larger effect on yield than Ethrel treatment. All treatments increased yield over the untreated. Best improvement in yield came from LPE single treatment followed closely by Ethrel. Ethrel treated grapes had the highest percentage of total yield harvested in first two picks with faster colorization

(Fig. 4). The advantage of sequential applications was not found.

Effect of LPE on table grape ripening in Chile

There are many factors for inconsistent color development of fruit. The efficacy with LPE treatment on plant also can be influenced by many factors such as growth stage, variety, temperature, regional differences, soil and fertilizer, moisture, use of pesticide and/or plant growth regulator and so on. Color development of grape has been checked by LPE treatment in Chile. If confirmed the LPE efficacy in Chile, problems of efficacy inconsistency with regional issues can be overcome.

All LPE treatments in 'Crimson' grape increased yield by more than 50% compared to control (Fig. 5). LPE of $2 \text{ mg} \cdot \text{L}^{-1}$ treatment showed the best increase of yield. All

LPE treatment showed noticeable increase in yield in ‘Red Globe’ grape (Fig. 6). There was no significant difference in yield between 2 mg·L⁻¹ and 10 mg·L⁻¹ LPE treatments. For both ‘Crimson’ and ‘Red Globe’ table grape, LPE treatment in Chile showed very consistent efficacy for color development with results given in USA.

The firmness of harvested grape was checked after storage at 4°C for 1 month. The firmness in LPE treated ‘Red globe’ grape was almost same as that of control. In case of ‘Crimson’ grape, LPE treatment increased the firmness by 15% (data not shown). This means LPE treatment does not cause any side effect on fruit softening and gives the possibility that LPE treated grape may prolong in the storage condition than grape from control.

Absciscic acid (ABA) has a prominent role in ripening of grapes. ABA is relatively high in berries shortly after bloom (Inaba et al., 1976), then decreases to low levels followed

by a substantial increase at veraison (beginning of stage III of development) (During, 1974). The increase of ABA level at veraison is only evident in the berry flesh, with little change of ABA in seeds. ABA applied to berries in stage II of development will initiate ripening (Inaba et al., 1974). Once ripening is initiated, endogenous ABA levels generally decline as the grapes become more mature (During, 1974). Therefore, our results indicate that LPE may play an important role in plant hormone (especially ABA)-coordinated regulation of berry ripening. However, the mechanisms by which LPE results in incompatible effect remain unknown. We expect future studies will provide more insight on this.

Application of ethephon (Ethrel) can stimulate differential ripening responses in grapes, depending upon time of application. If applied during stage I or early stage II of development, ethephon retards grape ripening (Inaba et al., 1974), possibly by delaying an endogenous increase of absciscic acid. If applied during the last week of stage II, ripening can be stimulated, possibly due to induced increases in absciscic acid. Ethephon has been used successfully with many *Vitis vinifera* cultivars to improve color, soluble solids, and ripening uniformity (Blommaert et al., 1975; Chakrawar and Rane, 1977). However, the response to ethephon is cultivar-dependent, and many do not even respond. *Vitis labrusca* cultivars ‘Delaware’ (Inaba et al., 1974) and ‘Concord’ (Morris and Cawthon, 1981) show no beneficial quality response to ethephon when applied during stage III of berry development, even though fruit abscission is easily induced.

In general, Ethrel is used by table grape growers for color development and harvest in early season. However, the usage of this product is limited by growers or field managers because this product is considered as a product which gives many stresses to vine and fruits (Splittstoesser and Vandemark, 1971). Thus, there exists a need to develop materials to replace Ethrel. Our results suggest that LPE may be one of them to use for color development without side effects.

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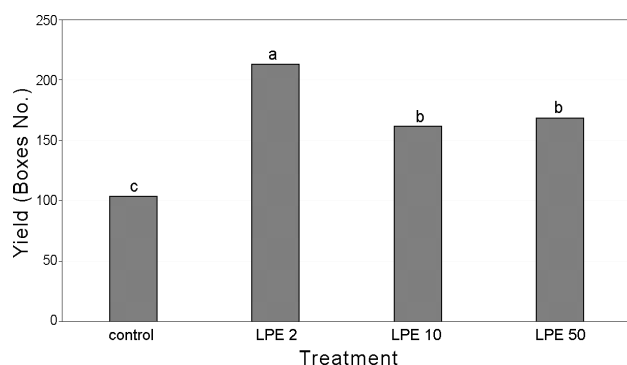


Fig. 5. Effect of LPE treatment on yield in ‘Crimson’ table grape in Chile. Vines were foliar-sprayed with 2, 10, and 50 mg·L⁻¹ LPE. Each box contained 10 kilograms of grape. Means with different letters are significantly different at $p < 0.05$ using Fisher’s LSD.

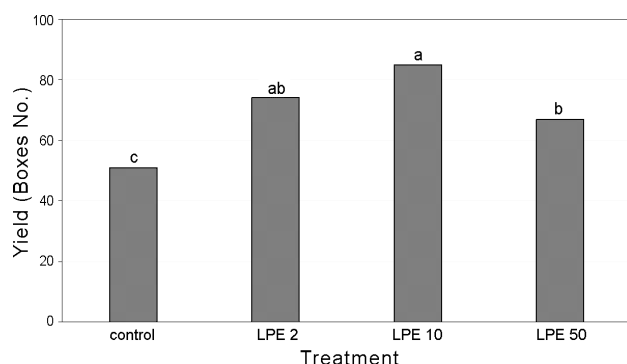


Fig. 6. Effect of LPE treatment on yield in ‘Red Globe’ table grape in Chile. Vines were foliar-sprayed with 2, 10, and 50 mg·L⁻¹ LPE. Each box contained 10 kilograms of grape. Means with different letters are significantly different at $p < 0.05$ using Fisher’s LSD.

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Lysophosphatidylethanolamine 처리가 포도의 숙성에 미치는 효과

홍지훈

두산 Glonet BU 바이오텍연구소

초 록. 본 실험은 Lysophosphatidylethanolamine(LPE)이 포도 '크림슨'과 '레드글러브' 두 품종의 과실 숙성에 미치는 영향을 알아보기 위하여 2004년 미국, 2005년 칠레에서 각각 수행되었다. 실험결과로부터 LPE 시용에 의한 착색촉진이 분명함을 관찰 할 수 있었다. '크림슨'과 '레드글러브' 품종 모두에서 LPE 처리구의 수확량은 에스렐 처리구의 수확량과 비슷한 수준을 보였다. 칠레에서 진행된 실험에서 LPE의 과실숙성에 대한 효능은 미국 실험결과에서 보여진 것과 유사하였다. LPE가 처리된 포도는 품질과 수확량이 증대되고, 환경친화적 재배가 가능하여 고소득을 창출하는데 공헌할 수 있을 것으로 기대된다.

추가 주요어 : *Vitis vinifera*, 에스렐, 품질, 과피색, 저장성, 수확량