**Running title:** Pollinizers Enhance the Berry Set and Quality in Grapes

**Intervarietal Pollinizers Enhance Berry Set and Quality of ‘Alphonse Lavallée’ (*V. vinifera* L.) Table Grape Cultivar**

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**Novelty statement**

Insufficient pollination and subsequent loses in grape yield and quality is a worldwide problem adversely affecting the sustainability of viticulture. However, there are insufficient experimental study in pollination biology of grapevine cultivars probably due to complexity in fertilization and flower morphology of *Vitis* genotypes. The present study provided precious information on disadvantages of monovarietal grape production, remarkable contribution of pollinizers for both grape growers and breeders.

**Abstract**

Millerandage (shot berries on cluster) is a common problem resulting from pollination insufficiency in grapes although majority of the cultivars have hermaphroditic flowers with a normally developed pistil and upright anthers. Therefore, accurate implementations to improve pollination intensity are generally required to guarantee satisfactory yield and quality in sustainable viticulture. The present study was performed to investigate the impacts of different pollination types on berry set and agronomic features of ‘Alphonse Lavallée’ grapes in a climate and environment controlled glasshouse. For cross pollination, the inflorescences of ‘Alphonse Lavallée’ were emasculated before bloom and covered with cheesecloths to avoid uncontrolled pollination by external pollens. When pistils attain peak receptivity, hand pollination was performed while the inflorescences of self-pollination were led to pollinate inside the isolation bags. Flowers belonging to self pollination application were led to bloom in the cheesecloth bags to self-pollinate while the clusters belonging to free pollination group were left without isolation. Cross-pollination with ‘Pembe Cekirdeksiz’ pollens yielded higher berry set (20.2%) other pollinations. Self-pollination resulted in a low berry set (9.1%) though this cultivar has hermaphroditic flowers. The greatest berry and cluster weights were also obtained from the pollination with ‘Pembe Cekirdeksiz’ while, self-pollination resulted the lowest values for many parameters. Cross pollination provided significant contribution to agronomy of ‘Alphonse Lavallée’. Overal findings indicated that proper cross pollinizer would be effective for achieving high yield and quality from the globally popular ‘Alphonse Lavallée’ table grape cultivar.

**Keywords:** Viticulture; Fertilization biology; Pollinizer; Xenia; Hybridization

**Introduction**

The genus *Vitis* comprises about 70 species of dioeciously vines with wind and insect-pollinated flowers. The most common species of this genus is the cultivated grapevine, *Vitis vinifera* L., which was domesticated from the wild grape, *V. vinifera* ssp. *sylvestris* (*V. sylvestris*) (Aradhya *et al*. 2003) with selection and artificial or natural hybridization. The grapevine genome is highly heterozygous with many self- or cross pollinating species (This *et al*. 2006). Grapevine cultivars are generally self-compatible plants, but may nevertheless greatly benefit from pollinator visitation (Sabir 2015), as has been reported for other self-compatible horticultural crops (Klein *et al*. 2003; Kodad and Socias 2008). Cross pollination is very advantageous for breeding new genotypes with favorable agronomic features as it provides a great diversity, particularly when pollination control and offspring’s strict selection are performed. Previously, studies on pollinizers were mainly conducted to investigate effects on berry set and seed development, but currently, possible effects on grape quality have become of increasing importance as berry quality is described by necessarily definable parameters such as shape, size, color, firmness and other biochemical features. Reliable knowledge on pollination dynamics of grape cultivars are essential not only in terms of genetics and fruit breeding, but also from a practical point of view, for providing economically high and regular cropping as the level of satisfactory pollinations will determine the grape yield and quality. In a study to better understand pollination biology of ‘Narince’ grape cultivar, Sabir (2015) evaluated five different pollen sources and found strong xenic and metaxenic effects. Studies on pollination biology of *Vitis* species revealed that insufficient berry set in most grape cultivars is a common problem directly affecting the yield and quality causing significant economic loss to growers (Dry *et al*. 2010). A special situation of poor berry set in grapes is called millerandage (also known as shot berries or hen and chickens). In this undesired case, each grape cluster contains large (hen) and small (chickens) berries that ripen unevenly at harvest. Many globally popular grape cultivars such as ‘Merlot’ and ‘Chardonnay’ appear to be particularly susceptible to millerandage. In fact, a great variation on pollination efficiency of grapevine cultivars have been reported regardless of flower types, ranging from satisfactory berry set following spontaneous (Martignago *et al*. 2017) to cross-pollination by wind or insects, or simultaneous self- and cross-pollination (Gurasashvili and Vashakidze 2004). Due to complexity in flower types and reproductive features in *Vitis* genotypes, there are still controversies among the scientists about the contribution of pollinizer genotypes to the quantity and quality of maternal grapes. But it is clear from the present literature that the pollens coming from different grapevine genotypes significantly improve the berry set (Ergul and Marasali 1997; Sabir 2015), as the relationship within the cultivars regarding to crossing compatibility and potential is an important process for berry set. There are thousands of grape cultivars that show a great variation for features like ripening time and berry color, but little is proven experimentally regarding their reproductive potential, especially flowering and xenic or metaxenic effects of pollinizers (Ibáñez *et al*. 2020). ‘Alphonse Lavallée’ is a high quality grape cultivar commercilly cultivated by grape growers around the world and used by many scientists for hybridization studies for new cultivar breeding (Todorov 2000). However, this cultivar frequently displays millerandage (Ibáñez *et al*. 2020; VIVC, 2023) and insufficient coloration problems (Sabir *et al*. 2020) although it has genetically uniform dark blue color. Therefore the present study were conducted to reveal the effects of three different pollinizers and pollination types (namely, selfing and free pollination) on agronomic features of ‘Alphonse Lavallée’, a globally popular table grape cultivar with its large black seeded berries and fruitful vines. Findings were evaluated with respect to breeders, grape producers and grape related industries.

**Materials and Methods**

**Experimental layout**

The present study was established in Research and Implementation Glasshouse (38°01.814 N, 032°30.546E, and 1158m altitude) and pomology laboratory of Selcuk University Agriculture Faculty, Konya (Türkiye). Experimental grapevines consisted of one maternal cultivar (‘Alphonse Lavallée’ one of the most widespread grape cultivar around the world) and three Turkish well-known grape cultivars having different agronomic features (‘Pembe Cekirdeksiz’ with pink attractive seedless berries, ‘Tarsus Beyazi’ with white seeded early maturing berries, and ‘Trakya Ilkeren’ with black seeded berries generated from ‘Alphonse Lavallée’ x ‘Perlette’ pedegree). The three years old grapevines of the each cultivar was grown individually in about 70 L (solid volume) pots containing perlite and sterile peat mixture in a climate controlled experimental glasshouse. The grapevines were placed in north and south oriented lines in the glasshouse with the distance of 0.5×1 m. At the beginning of the vegetation period, experimental grapevines were spur pruned to ensure 6–8 winter buds on 3–4 canes for each plant. The summer shoots were fixed with thread to wires 2.3m above the pots to ensure grapevines elongate on a perpendicular design for equally exposing to the sunlight. The vines received the same cultural practice and were homogenously watered with drip irrigated using individual emitter per vine one each grapevine row. Irrigations were arranged on the basis of soil water matrix potential (Ψm) levels using soil tensiometers (The Irrometer Company, Riverside, CA) to ensure easily available moisture in the growth medium as previously expressed by Sabir and Sari (2019). Day and night temperature controlled inside the study glasshouse were around 25 ± 6 and 18 ± 6 °C respectively, as the distribution, germination and tube growth of the grape pollen are favored by high temperature (27 °C day and 22 °C night) as demonstrated by Staudt (1982) and Rajasekaran and Mullins (1985).

**Pollination applications**

A total of 45 healthy inflorescences (flower bud clusters) were chosen according to uniformity and their similar positions on the shoots of the grapevine plant. The pollination applications conducted on three replicates comprising 3 clusters each (nine cluster born on three vines per application group). The clusters consisting of about 150-200 flower buds were labeled and covered with cheesecloth bags (except for free pollination) to avoid fertilization by undesired external pollens (Sabir 2015). The flower buds of the pollen source genotypes (pollinizers) were also isolated using cheesecloth bags to prevent the contamination of undesired external pollens. For cross pollination groups, the clusters of ‘Alphonse Lavallée’ were emasculated 5-6 d before bloom early in the morning between 07:00 and 11:00 A.M. before dehisced (Chkhartishvili *et al*. 2006) leaving 120±20 undamaged pistils for each cluster. To achieve this goal, the anthers were removed together with calyptra (corolla) which is structurally made up of five greenish petals, using forceps with fine tips. The pistil parts of the flowers were left on clusters at equal intervals and the remaining excessive flower buds including the damaged pistils in the cluster were plucked off (Fig. 1a). Extra attention was paid to be sure that there was not any part of anther tissue remaining that may cause an unwanted selfing. After emasculation, the clusters were covered with cheesecloth bags and periodically controlled for the existence of a moisture bead on the stigma, for 2-3 days so that the pistils mature enough further and reach peak receptivity. At receptivity stage, pollens of each pollinizer were harvested by shaking the flowered clusters on petri dishes when majority of their flowers were at full bloom stage. Cross pollinations with three different pollinizer cultivars were performed for each cross-combination using a soft paintbrush with the desired male pollen, which had been harvested freshly from the same experimental glasshouse (Fig. 1b). Different paintbrushes were used for each pollen sources and they were disinfected by dipping into ethanol before each use. Flowers belonging to self pollination application were led to bloom in the cheesecloth bags and self-pollinate. The pollinated stigmata were immediately isolated again using cheesecloth bags to prevent undesired cross pollination (Fig. 1c). The pollination was replicated for two more consecutive days in the morning between 09:00-11:00 A.M. Same cultivation practices such as equal pruning, trellising, drip irrigation and fertigation were applied to the experimental grapevines (Fig. 1d). In the experiment area, air movement and honeybee activity were allowed by opening the side wall windows (counting about 20% of glasshouse area) of the glasshouse for supporting free pollination to simulate intact ecosystem conditions of commercial vineyard. Two weeks after the berry set (at the stage of 3 mm berry development), the isolation bags were removed and the developing clusters were led to full sun during the berry growth and maturation. The clusters were collected individually when they ripened (Fig. 1e).

**Measurement and analyses**

Grape clusters were collected in early morning when total soluble solid content (SSC) in berry juice attains at least 14.0 °Brix units an acceptable SSC level for table grapes. After harvest, clusters were immediately transported to the pomology laboratory. Each cluster was weighed with precision balance in the laboratory. Skin color of the grapes (L\*; lightness, C\*; (chroma), and h°; Hue angle) was recorded with a colorimeter Minolta® CR-400 using a total of 60 random berries per treatment born on the middle of each cluster (McGuire 1992). The berry set percentage (%) was found by counting the number of seeded and parthenocarpic berries on each cluster (Sabir 2015). Then the seeded berries from the middle of each cluster were gathered as described in the norms of the Office International de la Vigne et du Vin (O.I.V., 1983) and weighed in the laboratory (Samaan *et al*. 1981) to average single berry weight. After berry investigations, seeds were isolated from each berry by pressing them in cheesecloth and washed to separate pulp. For seed size measurements, 60 seeds per pollination combination or selfing were coincidentally gathered and length, width (front section) and thickness (slide view) were recorded using a digital calipers (Sabir and Kucukbsmaci 2020). The filtered must (berry juice) of each application was used for biochemical analysis. SSC (°Brix) was quantified with a hand-held refractometer (Atago 9313). TA content was analyzed by titrating 10 mL of the homogenized must using a 0.1 N NaOH solution to a reaction endpoint of pH 8.1 and defined as the percentage of tartaric acid. pH of the must was read with a pH meter. All assays per application were carried out in triplicate.

**Data analysis**

Numerical row data were evaluated using one-way ANOVA. Statistical differences were recorded as significant at P < 0.05, and analyses means were compared with Student’s test LSD (least significant difference) test using SPSS version 17.0 (SPSS Inc., Chicago, IL, USA).

**Results**

As depicted in Fig. 2, the berry set percentage of maternal ‘Alphonse Lavallée’ cultivar was significantly affected by pollen sources. All the cross pollinations with different pollinizers yielded higher berry set than self pollination. The highest berry set occurred after pollination with ‘Pembe Cekirdeksiz’ (20.2%), and was followed by ‘Tarsus Beyazi’ (16.7%) and free pollination (15.1%). On the other hand, self-pollination application resulted in the lowest berry set with a very low rate 9.1% and this rate was 122% lower than that of cross pollination with ‘Pembe Cekirdeksiz’.

Pollen sources significantly affected the berry weight of ‘Alphonse Lavallée’ cultivar (Fig. 3). Similar to berry set findings, the greatest values on berry weight was obtained from pollination with ‘Pembe Cekirdeksiz’ (6.9 g with a 15% increase compared with self pollination). ‘Trakya Ilkeren’ and free pollination gave similar berry weight values (6.8 and 6.7 g, respectively), significantly higher than self pollination. On the other hand, the lowest berry weight was obtained from self pollination (6.0 g).

Cluster weight showed significant differences in response to the pollen sources (Fig 4). All of the pollination treatments provided significantly higher cluster weight than self pollination. The greatest cluster weight was obtained from the pollination with ‘Pembe Cekirdeksiz’ cultivar (187.0 g with a 19.7% increase in comparison to self pollination) and was followed by ‘Tarsus Beyazi’ (174.0 g). The lowest cluster weight was obtained from self pollination (156.2 g) similar to berry weight findings.

The pollen sources significantly affected the seed number per berry (Fig. 5). The highest seed number was obtained from self pollination (2.5 seed per berry), and was followed by ‘Pembe Cekirdeksiz’ (2.3). The other pollen sources have similar effects on seed number ranging from 2.0 (‘Tarsus Beyazi’) to 2.2 (self pollination).

As depicted in Fig. 6, there were significant variation in 100 seed weight ranging from 6.2 g (‘Trakya Ilkeren’) to 6.0 g (‘Pembe Cekirdeksiz’). On the other hand, free pollination (5.3 g) and self pollination (5.2 g) treatments resulted in markedly lower seed weights in comparison with the controlled cross pollinations with three different cultivars.

A correlation analysis was carried out to investigate the relationship between bery and seed developments. There was a significantly high correlation (R2=0.5537) between seed number per berry and berry weight (Fig. 7).

Pollination treatments significantly affected the width and thickness of the seeds of the maternal cultivar ‘Alphonse Lavallée’, although the length of the seeds did not significantly varied in response to the pollens (Table 1). All the pollinizer cultivars provided larger seeds than those of both free- or self-pollination. ‘Pembe Cekirdeksiz’ pollen resulted in the production of the seeds with the highest values in both width (4.39 mm and thickness (2.9 mm), followed by ‘Trakya Ilkeren’ and ‘Tarsus Beyazi’ with very similar values.

Color features of ‘Alphonse Lavallée’ grapes were not significantly affected by different types of pollination as presented in Table 2. Although the numerical measurements did not show statistical significance in ANOVA analyses, it should be underlined that visual and color wheel chart investigations obviously revealed that pollination with ‘Tarsus Beyazi’ or ‘Pembe Cekirdeksiz’ cultivars yielded more darker berries, an attractive visual quality parameter for consumers, than both free or self pollination.

As presented in Table 3, biochemical features such as SSC, TA and pH of ‘Alphonse Lavallée’ grape cultivar were not significantly affected by different pollen sources. Nonetheless, slight differences in SSC and TA values would most propable be due to variation in cluster and berry weights both of which were significantly modulated by pollen sources.

**Discussion**

In grape production, the berry set stage is one of the essential phenological features as it is directly related with potential grape yield and quality (Mullins *et al*. 1992; Ergul and Marasali 1997). However on grape inflorescences not every flower is pollinated and/or fertilized normally, with a great many unfertilized flowers ranging according to the cultivars (Dry *et al*. 2010), as well environmental conditions (Hardie and Aggenbach 2008; Ibáñez *et al*. 2020). The berry set evaluation is currently the most widespread used parameter to test effect of pollen source in grape cultivars, thus identifying the best pollinizers or pollination type. In the present study, satisfying data were recorded in all pollination combinations with respect to berry set of ‘Alphonse Lavallée’ cultivar. Berry set values are quite different from a previous study conducted on ‘Narince’ wine grape variety (Sabir 2015) in which the highest berry set (about 30%) was found in free pollination application. This may prove the existence of a wide range in biological features of grapevines in terms of pollination types as indicated by Samaan *et al*. (1981) in Egyptian grapes, Chkhartishvili *et al*. (2006) in Georgian grapes and Sabir (2015) in Turkish grapes. Normally, berry set for grapevines in *Vitis vinifera* L. can as high as 40% but commonly is between 20 and 30% in vineyard condition depending on the pollen availability and environmental condition (Mullins *et al*. 1992). In the present study, the low berry set percentage from the selfing application, in contrast to the high set of cross-pollination treatments, may indicate the importance of pollinizer availability for ‘Alphonse Lavallée’. Such positive effect of cross-pollination on fruit set was also demonstrated by Kodad and Socias (2008) in almonds.

Berry weight is greatly affected by the number and healthy development of seeds per berry (Clingeleffer 2001) which positively correlate with pollination intensity (Sabir 2011). Physiologically, plant hormones such as auxins, brassinosteroids, cytokinins and gibberellins produced by seeds (Kang *et al*., 2013) accelarate the activity and strength of fruits as sink organs, a metabolism determining the fruit size (Fischer *et al*. 2012). Remarkable changes in berry weight of ‘Alphonse Lavallée’ grapes in response to pollination treatments verified the strong metaxenic effect in grapes. Self pollinated clusters displayed heterogeneities in berry weight which could adversely affect the visual quality of grapes as uniformly of berries on cluster is one of the agronomic characters determining the market quality of table grapes. The present investigations on berry and cluster weights indicated that the use of pollinizer cultivar, particularly ‘Pembe Cekirdeksiz’, in vineyard establishment could remarkably increase the grape yield of ‘Alphonse Lavallée’ although this is one of the self fertil (autogam) grape cultivars (Ibáñez *et al*. 2020). Findings demonstrated that pollination with ‘Pembe Cekirdeksiz’ provided 20% increase in cluster weight when compared with self pollination.

The growth of seeds within the grape berry depends on the weather, the pollen source, genotype, water availability, boron nutrition at and after flowering (Hardie and Aggenbach 2008). In grapes, like in other fruits such as apples ([2005](http://hortsci.ashspublications.org/content/47/10/1430.full#ref-7)), the number of seeds for each fruit affects berry and seed weight as often reported by different researchers on various cultivars (Ummarino and Di Stefano 1997; Roby and Matthews 2004; Sabir 2015). In the present study, the improvement in berry weight is directly attributable to number of viable seed per grape berry. The berry containing higher number of seeds is generally larger due to greater endocarp and mesocarp development. This aspect is particularly essential in table grape cultivars, which should have good-sized berry. This is also desired in grape seed oil industry because the berry with no normal seeds is smaller and contains less oil. As reported in this study, grape berries generally contain two seeds which represent approximately 5% of berry weight (Ribéreau-Gayon *et al*. 2006), although the number and weight of seeds vary according to berry maturity stage. Furthermore, the presence of normally developed seeds in the berry is essential in breeding studies because seed health has direct effect on germination and seedling quality in hybrids. In spite of these facts, interestingly, there have been insufficient experimental research on the influences of various cultivar/pollenizer combinations on seed characteristics in grapes. Sabir (2015) revealed that the seed weight was consistently higher in ‘Narince’ grape cultivar when pollinated with either of three different *V. vinifera* L. cultivars than those of self- or free-pollination. The results of this study regarding the pollinizer impacts on seed characteristics (xenia) are similar to those reported by Samaan *et al*. (1981) and Sabir (2015) who reported significant differences in seed characteristics of maternal grape genotypes in response to external pollen sources. Studying on the pollination biology of ‘Bagrina’ (*V. vinifera* L.) grape cultivar, Fotiric *et al*. (2003) recorded significant variations in dependence on pollen sources. Therefore, present findings along with the mentioned literature assumed that the significant contribution of external pollinizer is found for ‘Alphonse Lavallée’ cultivar. This knowledge may be particularly important for conditions under multiple environmental stress conditions on the face of climate change event because pollinator shortfalls can lead to decrease annual grape yield in grapes.

A uniform cultivar specific coloration is one of desired features for both table and wine grapes as it indicates anthocyanin richness in the skin (Martinez *et al*. 1998). Berry color of ‘Alphonse Lavallée’ grape was much more uniform and darker when ‘Tarsus Beyazi’ or ‘Pembe Cekirdeksiz’ cultivars were used as pollinator in comparison to other pollination types. Color coordinates such as lightness (L), chroma (C) and Hue angle values of these berries were very close to those of Sabir *et al*. (2021) who studied the postharvest quality maintenance of grapes.

**Conclusion**

Cultivated grapevine cultivars have broad and complex fertilisation biology probably due to their heterozygous genome features. Therefore, understanding the pollination characteristics with the xenic and metaxenic effects of each cultivar will be beneficial for many scientific and commercial aspects such as a successful breeding study, commercially high yield and quality, and pharmacologically high functionality. This study was thus carried out to reveal the effects of different pollination types (cross pollination with three common Turkish cultivars ‘Tarsus Beyazi’, ‘Trakya Ilkeren’ and ‘Pembe Cekirdeksiz’, and self or free pollinations) on berry set, visual quality, seed characteristics and biochemical features of ‘Alphonse Lavallée’, a globally popular table grape cultivar with its large black seeded berries and fruitful vines. Most agronomic characteristics of ‘Alphonse Lavallée’ cultivar were significantly improved by cross pollination in comparison to self pollination. Among the pollinizers, the most effective one was ‘Pembe Cekirdeksiz’ which provided the greatest berry set, berry weight and cluster weight. In contrast, self pollination resulted in the lowest values for most parameters investigated. Therefore, inclusion of a pollinizer cultivar, particularly ‘Pembe Cekirdeksiz’, would be beneficial for grape growers to obtain high yield and quality from ‘Alphonse Lavallée’ table grape cultivar. Pollinizer dependent changes in berry and seed characteristics of maternal cultivar revealed the existence of xenia and metaxenia in grapes. Therefore, accurately selection of the pollen donor should be beneficial for breeders to obtain a rich genotypic variation when establishing breeding strategies.

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**Author Contributions**

AS planned the study, written the manuscript, statistically analyzed the data and made illustrations, GS performed the cultural practices and treatments.

**Conflict of Interest**

All authors declare no conflict of interest

**Data Availability**

Data presented in this study will be available on a fair request to the corresponding author

**Ethics Approval**

Not applicable to this paper

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Figure 1. Certain stages of the study; (1) emasculation, (2) pollination, (3) isolation, (4) cultivation, (5) harvest.

Figure 2. Changes in berry set percentage of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources. Bars sharing different letter superscripts are significantly different from each other at P < 0.05 using LSD test.

Figure 3. Changes in berry weight (g) of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources. Bars sharing different letter superscripts are significantly different from each other at P < 0.05 using LSD test.

Figure 4. Changes in cluster weight of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources. Bars sharing different letter superscripts are significantly different from each other at P < 0.05 using LSD test.

Figure 5.Changes in seed number of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources. Bars sharing different letter superscripts are significantly different from each other at P < 0.05 using LSD test.

Figure 6. Changes in 100 seed weight of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources. Bars sharing different letter superscripts are significantly different from each other at P < 0.05 using LSD test.

Figure 7. Relationship between seed number per berry and berry weight (g).

Table 1. Changes in seed development of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources.

|  |  |  |  |
| --- | --- | --- | --- |
| Pollinizer | Seed length (mm) | Seed width  (mm) | Seed thickness  (mm) |
| ‘Tarsus Beyazi’ | 6.5 | 4.35±0.1a | 2.8±0.1a |
| ‘Trakya Ilkeren’ | 6.3 | 4.38±0.1a | 2.8±0.0a |
| ‘Pembe Cekirdeksiz’ | 6.6 | 4.39±0.0a | 2.9±0.1a |
| Free | 6.4 | 4.16±0.1b | 2.7±0.0b |
| Self | 6.0 | 4.16±0.0b | 2.6±0.0b |
| LSD | ns | 0.05 | 0.11 |
| Means with different letters in a column are significantly different according to Student’s *t* test (P < 0*.*05), ns: not significant. | | | |

Table 2. Changes in berry lighness ((L), chroma (C) and hue angle (H) values of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources.

|  |  |  |  |
| --- | --- | --- | --- |
| Pollinizer | L | C | H |
| ‘Tarsus Beyazi’ | 28.5 | 1.7 | 324.4 |
| ‘Trakya Ilkeren’ | 28.6 | 1.7 | 305.9 |
| ‘Pembe Cekirdeksiz’ | 27.8 | 1.5 | 321.3 |
| Free | 29.3 | 1.8 | 285.4 |
| Self | 28.7 | 1.8 | 305.5 |
| LSD | ns | ns | ns |
| Means with different letters in a column are significantly different according to Student’s t test (P < 0.05). ns: not significant | | | |

Table 3. Changes in total soluble solid content (SSC), titratable acidity (TA) and pH values in must of ‘Alphonse Lavallée’ grape cultivar in response to different pollen sources.

|  |  |  |  |
| --- | --- | --- | --- |
| Pollinizer | SSC (°Brix) | TA (%) | pH |
| ‘Tarsus Beyazi’ | 14.1 | 0.52 | 4.1 |
| ‘Trakya Ilkeren’ | 14.8 | 0.51 | 4.3 |
| ‘Pembe Cekirdeksiz’ | 14.1 | 0.51 | 4.0 |
| Free | 15.0 | 0.58 | 4.0 |
| Self | 14.1 | 0.59 | 4.1 |
| LSD | ns | ns | ns |
| ns: not significant | | | |