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INFLUENCE OF DIFFERENT SOIL TILLAGE AND LEAF REMOVAL TREATMENTS ON YIELD, CLUSTER AND BERRY CHARACTERISTICS IN CV. SYRAH (*VITIS VINIFERA* L.)

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Abstract

KORKUTAL, I. and E. BAHAR, 2013. Influence of different soil tillage and leaf removal treatments on yield, cluster and berry characteristics in cv. Syrah (*Vitis vinifera* L.). *Bulg. J. Agric. Sci.,* 19: 647-658

The research was conducted 2011 vegetation period (40° 56' 7.46'' N; 27° 27' 7.11'' E) in Tekirdag, Turkey. The effects of 3 different soil tillage treatments and 3 leaf removal treatments on leaf water potential (Ψ_{leaf}), yield, cluster and berry characteristics of cv. Syrah were investigated in this study. The vineyard orientated E-W direction, vine spacing was 2.6 to 1m and the vines were pruned as bilateral cordon on a Modified Open Lyre Training System. Leaf removal treatments were performed at veraison. Different soil tillage applications affected cluster length and berry fresh and dry mass. The leaf removal treatments affected only total leaf area per vine ($m^2.vine^{-1}$). The results confirm that main leaf removal and lateral shoot leaf removal treatments there was no significant difference found in non leaf removal treatment according to exposable leaf area. In this trellising system, under these soil and climatic conditions, it could be advised conservative soil tillage alternatively to conventional soil tillage as to be more economical. Furthermore, leaf removal treatments under different climatic conditions physiologically should be researched more about the leaf water potential, photosynthesis, transpiration and stomatal conductance in canopy because of their different effects.

Key words: soil tillage, leaf removal, predawn leaf water potential, leaf area, *Vitis vinifera* L.

Introduction

Canopy management includes a range of techniques to alter the position and the amount of leaves, shoots and fruits in space (Carbonneau, 1980). Yield, berry maturation and wine quality are dependent on canopy structure (Carbonneau, 1995 and 1998). The studies in recent years are focused on the effect of canopy management in the vineyard (Sanchez-de-Miguel et al., 2010). Thus, it need to define new parameters that characterize grapevine canopy shape and could be used to explain vineyard capacity and its relationship with potential yield and must composition. Among these parameters, there are two indexes explaining the vineyard potential productivity, the leaf area index and the surface area (Smart, 1973). Costanza et al. (2004) using a non-destructive method for determination of total leaf area in Syrah grapevines found a strong relationship between leaf area and leaf fresh and dry mass also on the same shoot. They noted that secondary shoots and clusters were close in dry mass until veraison, after which berry dry mass increased significantly. A clear definition of physiological balances in grapevines requires measurements relating to the capacity of the vine, a term that represents vegetative growth, crop yield and grape composition (Winkler et al., 1974).

The total leaf area per vine is also an important factor in relation to carbohydrate production and it directly or indirectly determines the berry composition (Costanza et al., 2004), also it is an indicator of vegetative expression (Mabrouk et al., 1997). The total leaf area: crop load ratio may change the demand on the leaves for the supply of carbohydrates and therefore may affect the photosynthetic rate of individual leaves (Petrie et al., 2000a).

In grapevine, canopy structure-related variations may affect yield (Dry, 2000) and the quality of the berries (Downey et al., 2004). The berry is the primary sink for assimilates during the six weeks after veraison. During ripening and under non-stressing conditions, leaf photosynthesis is the only source of carbohydrates for berry development (Vasconcelos and Carniglioni, 2001).

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An improved canopy microclimate to secure the maximum photosynthetic activity of leaves as well as berry development before pea size should be obtained by other canopy management practices such as suckering, shoot positioning, tipping and topping (Hunter and Visser, 1990; Hunter, 2000; Kok, 2011; Kamiloglu, 2011). Leaf removing, cluster and berry thinning have different effects on berry size, cluster compactness, maturity index, precocity, coloring and vegetative growth (Ates, 2007).

Basal leaf removal tended to have negative effect on berry sugar accumulation, it occasionally has a positive effect on anthocyanin and total phenol concentrations, suggesting that excessive leaf removal can upset the source: sink balance such that berry sugar accumulation is reduced and that berry phenolic synthesis is not solely dependent upon berry sugar concentration. The cluster thinning and basal leaf removal together can result in the greatest changes in berry and must composition (Di Profio et al., 2011a). Leaf removal directly increases the rate of activity of the enzymes involved in the synthesis of phenolic compounds. It also underscores that it is important to exercise care in balancing photosynthetic capacity with photosynthate sinks and that leaf removal may result in delayed berry maturity (Di Profio et al., 2011b). However leaf removal at fruit set, is effective at modifying cluster weight, berry number, and yield per vine significantly reduces by early leaf removal (Diago et al., 2010).

Soil cultivation is one of the most important questions of the viticulture. It has an effect not only on the soil, but also indirectly on the plants as well (Göblyös et al., 2009). Conservation tillage has become an important management tool in production systems in the world (Horwath et al., 2008). Well-documented benefits of this tillage production include increased water infiltration and soil water storage; reduced labor, fuel and equipment use; improved soil tilt; increased cropping intensity; increased soil organic matter; and improved water and air quality (McLaughlin and Mineau, 1995). Beside all this, the degree of water competition between cover crops and vine must be carefully monitored and managed (e.g. by increasing mowing frequency) and adjustments in conventional irrigation management are necessary (Lopes et al., 2011).

This study was carried out to determine the effects of different soil tillage applications and leaf removal treatments on leaf water potential (water stress), yield, cluster and berry characteristics in cv. Syrah (*Vitis vinifera* L.).

Material and Methods

Vineyard

The experiment was conducted during the 2011 vegetation period on cv. Syrah grapevines (*Vitis vinifera* L.) grafted onto 110R, in the 40° 56' 7.46'' N; 27° 27' 7.11'' E latitude and longitude and, 150-200m altitude in Tekirdag, Turkiye. The vineyard was orientated E-W direction. Three soil tillage applications and three leaf remove treatments were imposed on the vines, with three replicates and two grapevines used of each combination. The six years old grapevines were grown in vineyard conditions. Vine spacing was 2.6 to 1m and the vines were pruned as bilateral cordon on a Modified Open Lyre Training System (Carbonneau, 1980). Shoots were balanced about 24, and clusters 26-28 numbers in pre-bloom.

Soil Tillage Applications

The soil of vineyard classified as a loamy. The properties of experimental vineyards soil, was given in Table 1. Three soil tillage applications (STA) were performed. The soil of experimental vineyard was tillage superficially with a cultivator in autumn 2009. Later on all the STA were carried out during 2010 vegetation period in accordance with the methods below. As to determine the effect of soil tillage applications the experiment was established in 2011 vegetation period. Inter-rows were tillage regularly in all STA. Then no-tillage was performed in between-rows for conservative soil tillage (CST) during experiment and it was left to the natural grassing. When their length reached 30-40 cm they were mowed routinely. For conservative soil tillage+rain remove application (CST+RRA) the soil was tillage in 2009 autumn, then in first January 2010 rain gutters were established in two sides of the rows to remove 30% rain. Cover crops mowed could be beneficial because they reduce the reflected radiation without competing for water and nutrients with grapevines (Nazrala,

Table 1
Soil properties of vineyard 2011

						Useful nutrient matter for plant	
Soil depths, cm	Water holding capacity, %	pH of water holding capacity	Total salt, %	Lime ($CaCO_3$), %	Organic matter	Phosphorus (P_2O_5), kg/da	Potassium (K_2O), kg/da
0-30	38	6.80	0.032	0.30	1.16	11.36	38.19
30-60	40	6.62	0.035	0.20	0.91	5.77	33.09
60-90	49	6.74	0.035	0.39	0.47	1.24	30.57

2007). Therefore, the grasses, which were placed between-rows, mowed routinely when their length were reached 30-40cm. It remained the same during 2011. In conventional soil tillage (CNST) soil was tillage inter-row and between-row on a regular basis in the region. Soil was generally tillage in the spring and autumn with plough, twice with cultivator and twice with rotator machine (6 times tillage) till the veraison in conventional way.

Some climatic data of vegetation period (April - October 2011) were presented in Figure 1. The average precipitation of many years in Tekirdag was 590mm/year. Also in vegetation period, it was about 180 and 200 mm. During the vegetation period in experimental year (2011), precipitation was (552.8mm) about three times more than the average of previous years (Figure 1).

Leaf Removal Treatments

Three Leaf Removal Treatments (LRT) were performed at veraison (05.08.2011). Lateral Shoot Leaf Removal (LSLR): All lateral shoots leaves were removed. Main Shoot Leaf Removal (MLR): All main leaves were removed and for each lateral shoot, three leaves were left. None Leaf Removal (NLR): The grapevines consist of main and lateral shoots leaves. However, for each lateral shoot three leaves were left.

Plant water stress levels [as Predawn Leaf Water Potential (Ψ_{pd})] were measured by Scholander Pressure Chamber at 03:00 to 05:00 a.m., each leaf measured (Ψ_{pd}) by vine based and two weeks intervals during vegetation period.

Harvest was done 51 days after leaf removal treatments in early morning of September 26. Harvest date was fixed based on the ripening dynamics and the all clusters were transported to the laboratory. Cluster and berry characteristics were measured immediately. Then yield was calculated as kg.vine^{-1}. Cluster number was counted (number), and cluster width and length (cm) was measured. Cluster weight (g) determined by electronic balance (Sartorius pt 600 type portable) and cluster volume (cm^3) was measured.

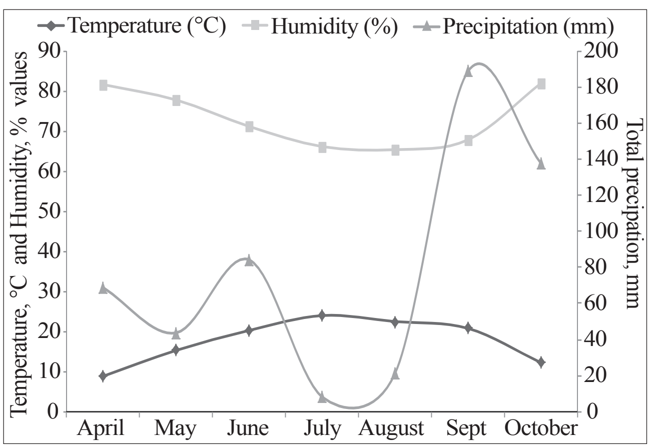


Fig. 1. Some climatic data of experimental area in 2011.
* The total precipitation in September 2011 was 188.8mm only in 21st and 22nd days

Berry number in cluster (number) was counted. To determine fresh mass (g) 200 berries were sampled from different parts of various clusters for each treatment, and weighed. Then the berry volume was measured (cm^3) (De Villiers, 1987). These berries were oven dried at 65°C for 4 days (Costanza et al., 2004) for determine the dry mass (g). Total soluble solid was measured using an Abbe type refractometer equipped with a temperature control system (Cemeroglu, 2007). Berry surface/volume ratio was calculated (where surface area = 4 πr^2 and volume = 4/3 πr^3) (Barbagallo et al., 2011).

In the 22nd day of October all leaves from 54 grapevines were picked up and transported to the laboratory for determine the leaf number, leaf fresh mass (g) according to application groups. Ten percent of the leaves were sampled, and scanned with HP scanner to determine the leaf area. Average leaf area for each grapevine was determined using by Fläche Computer Software (Daur et al., 2010). After fresh weighing, they were dried in to oven at 65°C and 24-48 hours (Costanza et al., 2004).

Exposable leaf area was calculated by using the following relation for Modified Lyre trellising system (Carbonneau, 1980). The azimuth in 40°56' N latitude changed with the June to September (72.1°, 70.1°, 62.2° and 51°) respectively (Senpinar, 2006). According to these values, mean azimuth was calculated 63.85° (The N side of rows was ignored in calculation of ELA).

ELA (m^2/ha) = 10000 / E x (1 – t/D) EA,

where:

10000/E = total length of vine rows/ha of plantation,

(1 – t/D) = lack of canopy on the length of rows and,

EA = external area of the canopy (m^2/m of row).

Defining the optimum level of cropping will be in terms of leaf area required per unit weight of fruit, expressed as m^2/kg (Kliewer and Dokoozlian, 2005). Exposable leaf area (ELA, m^2/ha) expresses the size of leaf area, which may be exposed to direct solar radiation, in one ha of vine plantation. 1.0-1.2 m^2 ELA for ripeness under normal conditions of 1kg of grapes (Murisier, 1996; Intrieri and Filippetti, 2000), one may calculate the quantitative limits for obtaining quality yields. The exposable leaf area/yield ratio was calculated (ha/kg).

Statistical Method

The experiment was laid out in a completely randomized block design with each treatment comprising three replications. Statistical analysis was performed with the aid of the MSTAT-C program. Treatment effects were compared by LSD test.

Results and Discussion

Predawn leaf water potential

Predawn leaf water potentials (Ψ_{pd}) were done between 198th and 254th calendar days in 2011. Ψ_{pd} changes during this period according to STA were arranged from highest to lowest; CST+RRA between the -0.06 to -0.41MPa, CST between the -0.06 to -0.30MPa and CNST -0.06 to -0.28MPa respectively. These data were in mild to moderate stress group.

According to main effect of LRT Ψ_{pd} data in MLR -0.05 to -0.35MPa, NLR -0.06 to -0.30MPa, and LSLR -0.06 to -0.29MPa were respectively (Figure 2). These first data were in no stress group (0 to -0.2MPa) and the last measurements were in mild to moderate stress group (-0.2 to -0.4MPa) according to Carbonneau et al. (1998) and Deloire et al. (2004). However, because of an extreme rainfall just before harvest in both applications (STA and LRT) Ψ_{pd} values did not decrease to the expected levels (between -0.4 and -0.6MPa).

Yield

The effects of soil tillage applications and leaf removal treatments on the yield were indicated in Figure 3. Neither STA nor LRT affected yield statistically. STA main effect on yield was for CST (2.032kg.vine^{-1}), for CST+RRA (2.285kg. vine^{-1}), and for CNST (2.341kg.vine^{-1}) respectively. The highest yield value was obtained from CNST. The results agree with Monteiro and Lopes (2007). They reported that the conservation tillage did not affect yield. On the contrary, Lopes et al. (2011) noted that the competition for water by the cover crop induced also a significant reduction in yield. Our results were not in same direction with Lopes et al. (2011) due to low intense natural grasses and excessive precipitation.

According to LRT, yield was in NLR (2.204 kg.vine^{-1}), in LSLR (2.205 kg.vine^{-1}) and in MLR (2.249 kg.vine^{-1}) applications respectively. The little increase in yield was received from the MLR application. Hunter (2000) explained this result, as the activity of lateral leaves in the canopy makes an important contribution to the attainment of maximum yield and grape quality. Concurrently, lateral shoots should never be removed above the cluster area because they supply sugars for fruit maturation and are thus directly involved in the final fruit quality. Additionally the time of the leaf removal is very important to determine the yield (Vasconcelos and Koblet, 1990). Hunter (2000) indicated that the presence of lateral shoots and correctly applied and timed canopy manage-

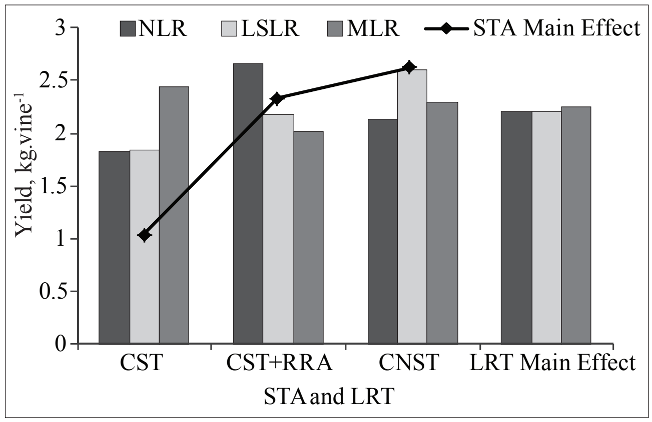
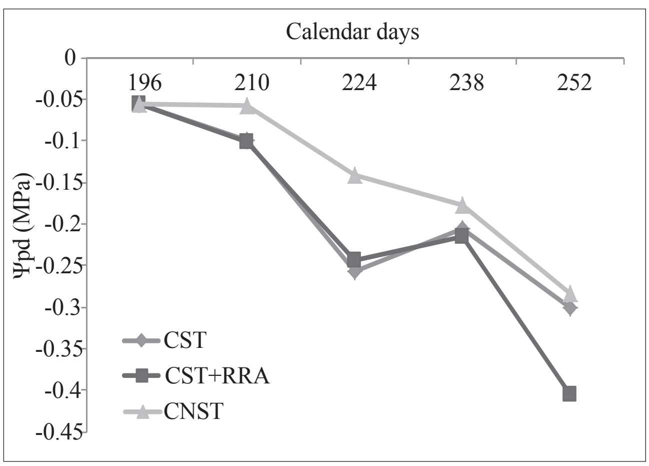


Fig. 3. Yield changes according to different soil tillage and leaf removal applications
[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]



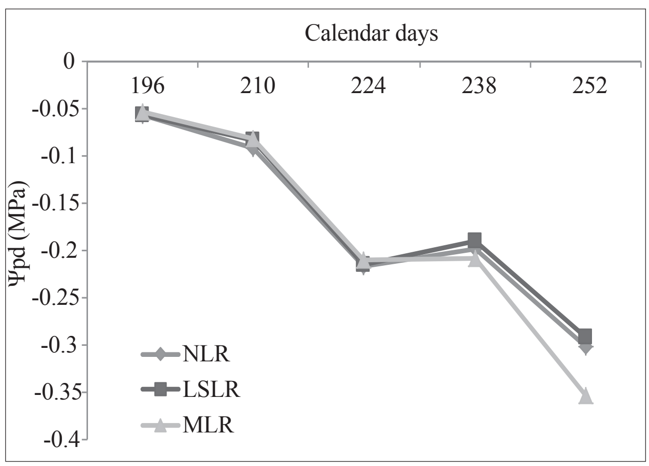


Fig. 2. Predawn leaf water potentials changes according to different soil tillage and leaf removal applications
[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

ment during the period just after budding to pea berry size will have a positive role in attainment of maximum yield and grape quality. Contrary to this, the authors argues that the basal leaf removal had few effects on yield components (Di Profio et al., 2011a), and grape yield is not affected by leaf removal (Bavaresco et al., 2008). Our data indicated that yield per vine was not affected by LRT applications in veraison, but the impact of extreme rainfall should not be ignored.

Cluster width and length

In cluster length criteria there was statistically significance found in main effect of STA. However, there was not found any significant effect in cluster width. CNST effected cluster length positively (16.78cm). In accordance with the main effect of STA on cluster width was arranged highest to lowest CST, CST+RRA and CNST. Highest cluster width values were found in conservative soil tillage (Figure 4). Interestingly the cluster of CNST was long and narrow while for CST short and wide.

The main effect of LRT was arranged in cluster width as NLR, LSLR and MLR high to low respectively. Thus, NLR tended to expand the width and length of the cluster.

Cluster mass and volume

In Figure 5, the highest cluster mass was seen in CST+RRA (137.87 g). On contrary to this, the lowest cluster

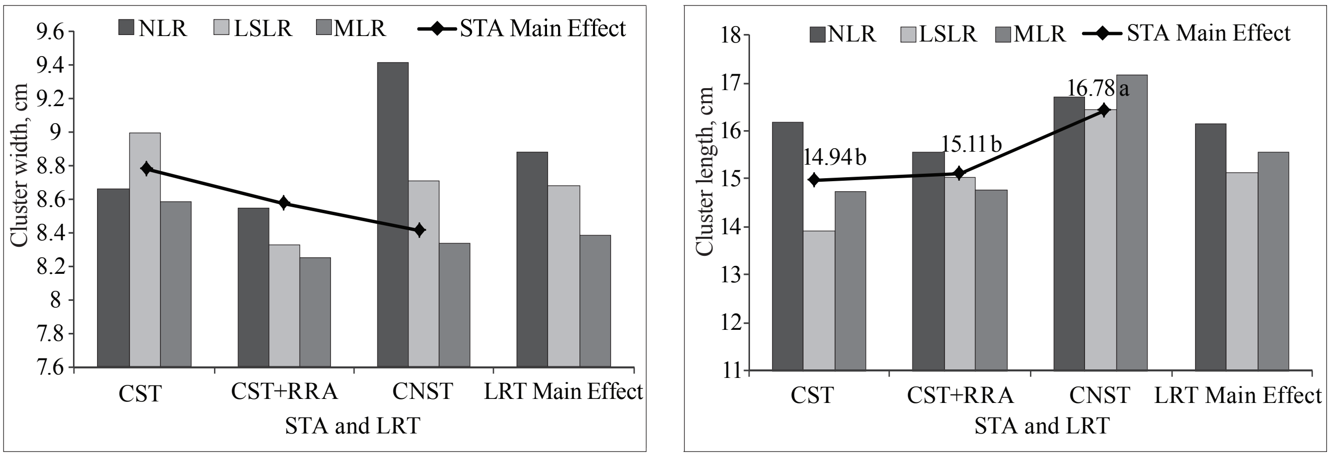


Fig. 4. Cluster width and length changes according to different soil tillage and leaf removal applications

Cluster length STA Main Effect LSD 5%=1.258128

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

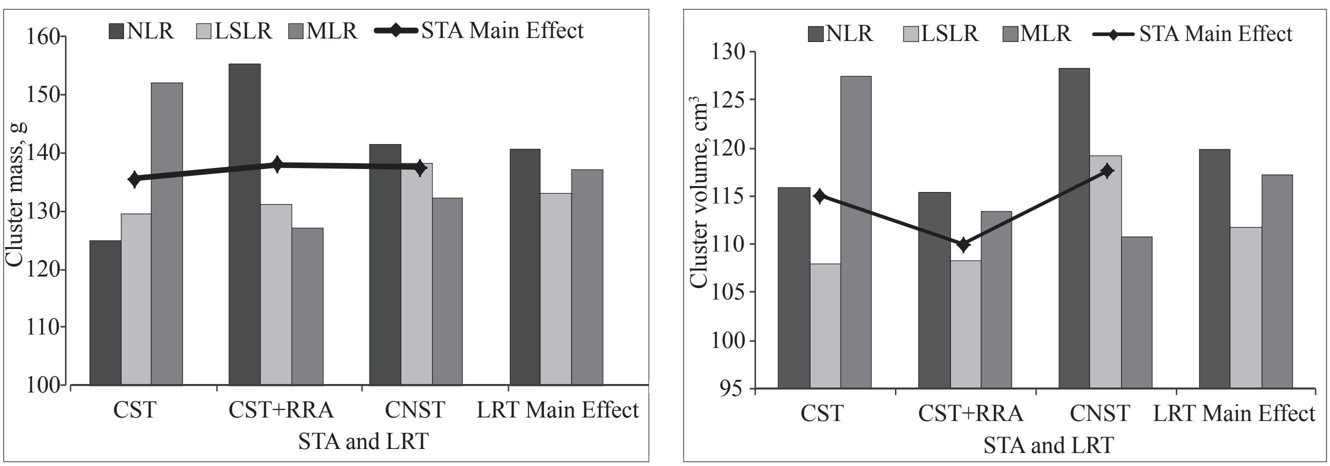


Fig. 5. Cluster mass and volume changes according to different soil tillage and leaf removal applications

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

volume was seen in the same STA (112.36 cm³). However, CST (117.08cm³) had a less difference in volume than CNST (119.44cm³). According to this result the CST tillage group did not decrease cluster mass and volume dramatically.

While examining the LRT main effect, the NLR had a highest value of cluster mass (140.53 g) and volume (119.86 cm³). However, this effect was not substantial.

Berry number per cluster

When the values evaluated, the main effects of STA; in CST (97.53), in CST+RRA (93.44) and in CNST (102.64) were respectively. Briefly, CNST effected berry number in cluster positively. Tardaguila et al. (2010) reported that post-flowering leaf removal was ineffective at modifying fruit set, number of berries per cluster, or yield per shoot (Figure 6). Same in this study, LRT applications were done in veraison, not affected berry number per cluster. However, numerically NLR (101.39) application increased berry number per cluster more than the MLR (99.17) and LSLR (93.06).

Berry fresh and dry mass

CST+RRA had a highest berry fresh (1.812 g) and dry mass (0.495 g) (Figure 7) and these effects were important statistically. It was expected that, the berries had a highest mass because of the shadow effect of rain gutters' and natural grasses. Because of the low evaporation, the berries were heavier than the others were.

Dai et al. (2011) specifically reviewed the variation range in berry weight and composition among *Vitis* genotypes, the environmental and viticulture practices that cause variability for a given cultivar, the genetic clues underlying the genotypic variation, and the putative genes controlling berry weight and composition.

Moreover, McCarthy (1999) recorded that the cv. Syrah berry weight at harvest was insensitive to water stress applied prior to harvest (when the juice was about 23-24°Brix). As mentioned above our results were in parallel with author.

Between the all LRT, LSLR (1.749g) had positive effect on berry mass. These berries were heavier than the others were, but this difference was numerically. In addition, the highest dry mass percentage was found in CST+RRA soil tillage as 27.32% (Figure 8). In accordance with LRT main effect the

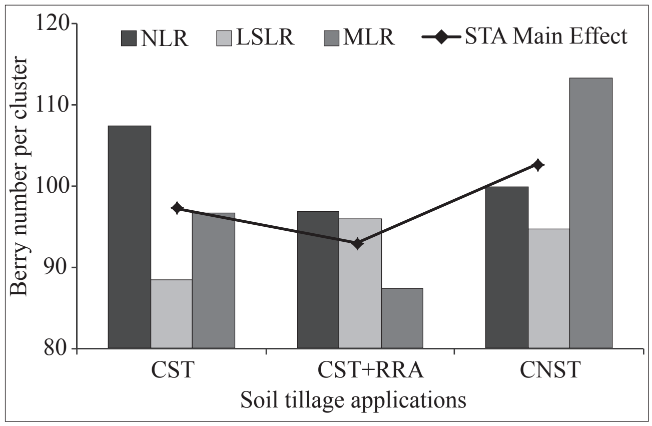
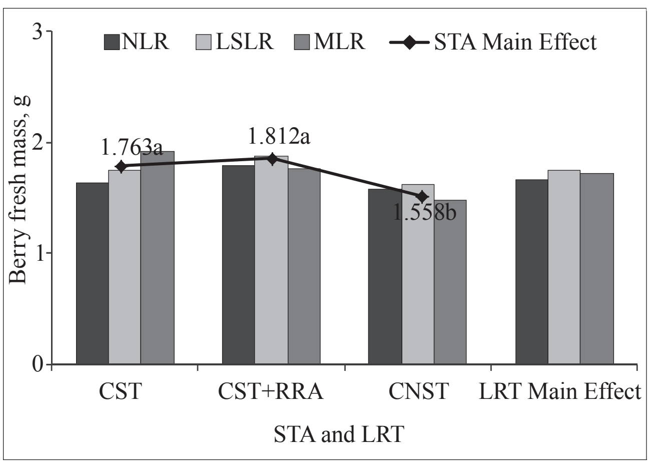


Fig. 6. Berry number per cluster changes according to different soil tillage and leaf removal applications
[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]



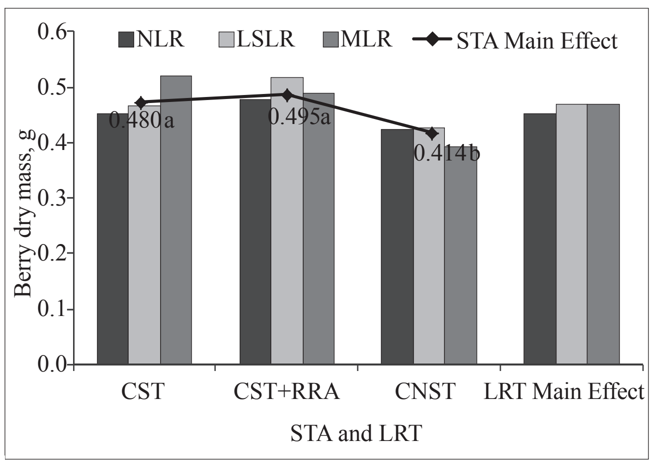


Fig. 7. Berry fresh and dry mass changes in cluster according to different soil tillage and leaf removal applications
Berry fresh mass STA Main Effect LSD 1%=0.1741618; Berry dry mass STA Main Effect LSD 1%=0.0435404
[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

highest ratio was maintained in that MLR (27.33%) application. This result was parallel with TSS (24.02°Brix) value, which was given from MLR.

Berry volume

The LRT main effect on berry volume was sorted by high to low; MLR was 1.57 cm^3, NLR was 1.53 cm^3 and LSLR was 1.48 cm^3. Syrah berries had the lowest volume in LSLR application. It means that LSLR application caused small berry volume.

In addition, the LRT main effect on berry mass/volume ratio arranged high to low be; MLR and NLR 0.92 g/cm^3 and LSLR 0.85 g/cm^3. These results showed that the berry mass/volume ratio was not affected much by LRT.

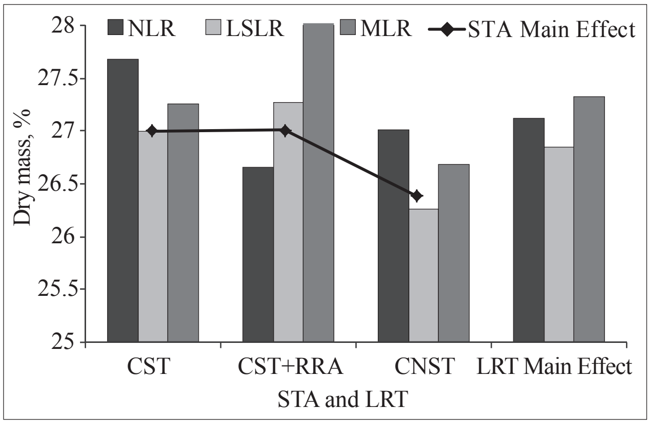


Fig. 8. Dry mass % according to different soil tillage and leaf removal applications

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

Among the STA, CST+RRA (1.59 cm^3) berry volume was positively affected, but did not have a statistically importance (Figure 9). Becker and Zimmermann (1984) introduced that when water deficit occurs from veraison through to harvest is caused little reduction in berry size. In despite of this, Williams and Matthews (1990) reported that there was no effect on berry size in response particularly with deficit imposed between flowering and veraison. Our results supported these authors. Contrary to this, McCarthy (1997) showed that the final berry size is more influenced by water deficits between veraison and maturity. As well, Bahar and Yasasin (2011) argued that the extreme water stress reduce the values of berry weight, berry volume and TSS.

Berry skin surface/berry volume ratio

Berry skin surface/volume ratio was calculated (where surface area = 4 π r^2 and volume = 4/3 π r^3) (Barbagallo et al., 2011). The skin: flesh ratio changed only when berry flesh weight was affected in vines subjected to water stress after veraison (Roby and Matthews, 2004). The berry skin surface (cm^2)/volume (cm^3) ratio decreased by CST+RRA application (4.16 cm^2/cm^3). Though the main effect of STA; CST (4.21 cm^2/cm^3) and CNST (4.29 cm^2/cm^3) applications were followed CST+RRA increasingly. It means that bigger berries therefore had a smaller skin surface to berry/volume ratio (Van Schalkwyk, 2004). CNST had the highest ratio due to small volume compared with the others. This was expected in wine grapes (Figure 10).

The highest main effect of LRT was obtained in LSLR (4.26 cm^2/cm^3) treatment in berry surface to volume ratio. A high berry mass therefore means that more juice may be recovered seeing that there was a bigger pulp to skin ratio, while less juice may be recovered from lighter berries due

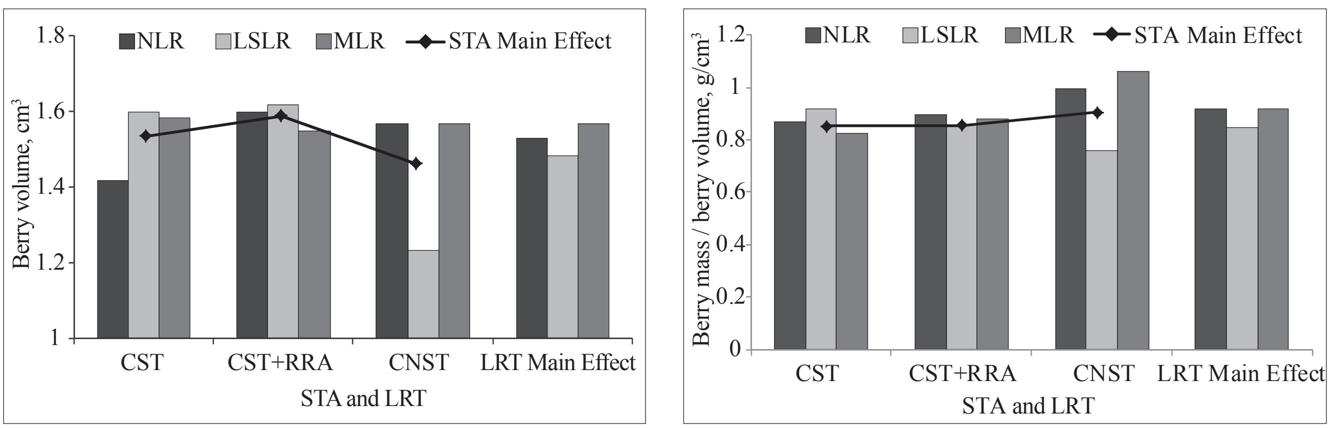


Fig. 9. Berry volume and berry mass/volume changes according to different soil tillage and leaf removal applications

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

to the smaller pulp to skin ratio. The NLR (4.21cm²/cm³) and MLR (4.18 cm²/cm³) followed this treatment respectively.

Total Soluble Solids (ºBrix)

The TSS was the same about (~23ºBrix) in all STA group. In STA main effect, CST (23.97ºBrix) application got the highest TSS value. CST+RRA (23.94ºBrix) and CNST (23.17ºBrix) values followed this application. However, this difference was not important statistically. This result in same direction of Monteiro and Lopes (2007), different soil tillage did not affect berry sugar (Figure 11).

The plants bearing lateral shoot leaves TSS quantity positively effected as a 24.02ºBrix value (MLR). As, Vasconcelos and Castagnoli (2001) mentioned that if the canopies composed only of lateral leaves generates fruit with higher soluble solids. Lateral leaves, being the youngest leaves in the canopy, may play a major role in metabolic processes occurring during fruit ripening. In addition, the Vasconcelos and Koblet (1990) reported the accumulation of sugar in the berries probably depends on the available active leaf surface during the period between veraison and fruit harvest. During this period, the lateral shoots are already source organs and provide the bunch with assimilates more efficiently than the main leaves. Hence, the lateral leaves play the main role in fruit ripening. In this situation, our results provided support in this direction. Besides this, Di Profio et al. (2011a) notified that the leaf removal result little or no increase in ºBrix.

Leaf fresh and dry mass

In STA, CNST application affected leaf fresh and dry mass (2.75 g and 0.61 g) positively, when compared to the other treatments (Table 2).

Table 2
Leaf fresh and dry mass changes according to different soil tillage and leaf removal applications

		LRT			
	STA	NLR (beared ML+LSL)		LSLR (beared ML)	MLR (beared LSL)
		ML	LSL	ML	LSL
Leaf fresh mass	CST	4.265	1.054	3.473	1.060
	CST+RRA	4.423	0.757	3.390	0.930
	CNST	4.402	1.031	4.413	1.150
Leaf dry mass	CST	0.948	0.275	0.823	0.257
	CST+RRA	0.960	0.270	0.780	0.270
	CNST	0.929	0.218	1.020	0.270

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal, ML: Main Shoot Leaves, LSL: Lateral Shoot Leaves]

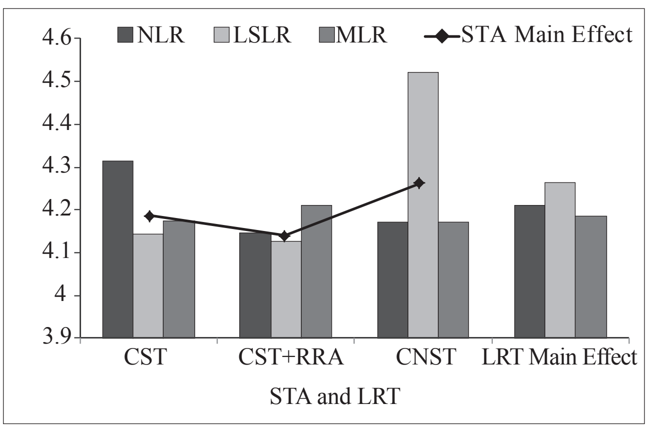


Fig. 10. Berry surface/volume ratio changes according to the STA and LRT

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

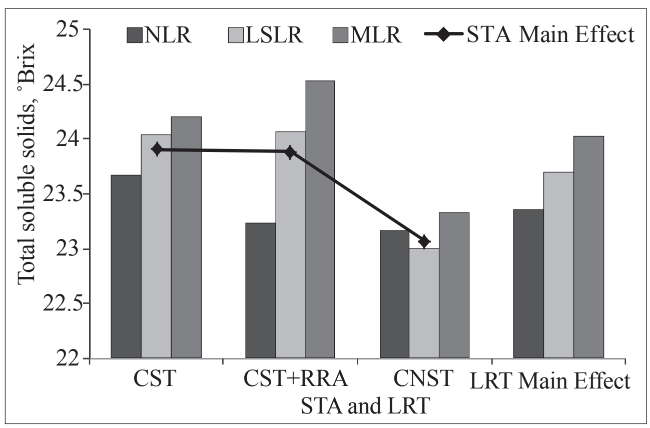


Fig. 11. Total soluble solids changes according to different soil tillage and leaf removal applications

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

As an expectedly in LRT, NLR (ML+LSL) treatment (4.36+0.95 = 5.31 g) affected leaf fresh and dry mass positive. Main leaves in NLR group had a big value of fresh (4.36 g) and dry (0.95 g) mass. Petrie et al. (2000b) reported that the full leaf removal treatment decreased average area per leaf and average dry weight per leaf. It was seen in MLR (0.27g) and LSLR (0.87g) treatment in leaf dry mass. Leaves of main and lateral shoots differ in their physiological age, which is closely related to leaf photosynthesis (Schultz, 1993).

Total leaf area per vine

The average leaf areas were sorting the STA effect; CST (5.645 $m^2.vine^{-1}$), CNST (5.156 $m^2.vine^{-1}$) and CST+RRA (5.681 $m^2.vine^{-1}$). CST increased the leaf area. However, Cloete et al. (2006) remarked that since no further increase in leaf number or leaf area was found after veraison.

The LRT influenced leaf areas in different levels. NLR (9.073 m^2) had a larger leaf area than the others. This was normal because NLR hold all the leaves from main and lateral shoot (each lateral shoot have three leaves). Cloete et al. (2006) indicated that the primary leaves of the normal shoots comprised a much larger percentage of the total leaf area per shoot. Although this, NLR had a lowest TSS (23.57°Brix) ratio and the yield (2.143 $kg.vine^{-1}$). This result provided that big leaf area did not mean high TSS and / or high yield. In addition, Vasconcelos and Castagnoli (2001) indicated that the complete removal of lateral shoots decreased total leaf area by 43% and 45% as compared to treatments with trimmed

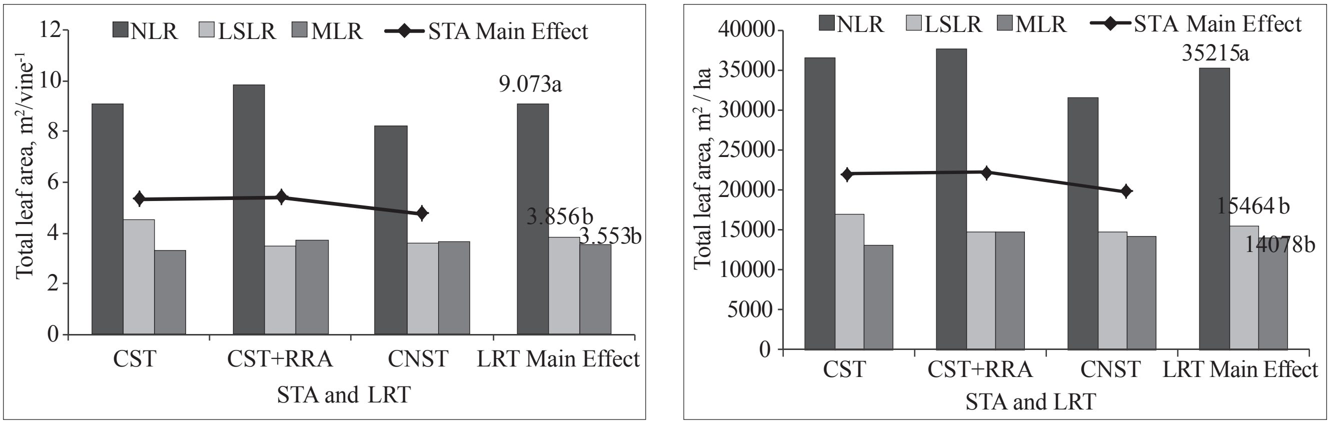


Fig. 12. Total leaf area per vine and total leaf area per ha changes according to different soil tillage and leaf removal applications

Total leaf area per vine LRT Main Effect LSD 1%=0.9049711

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

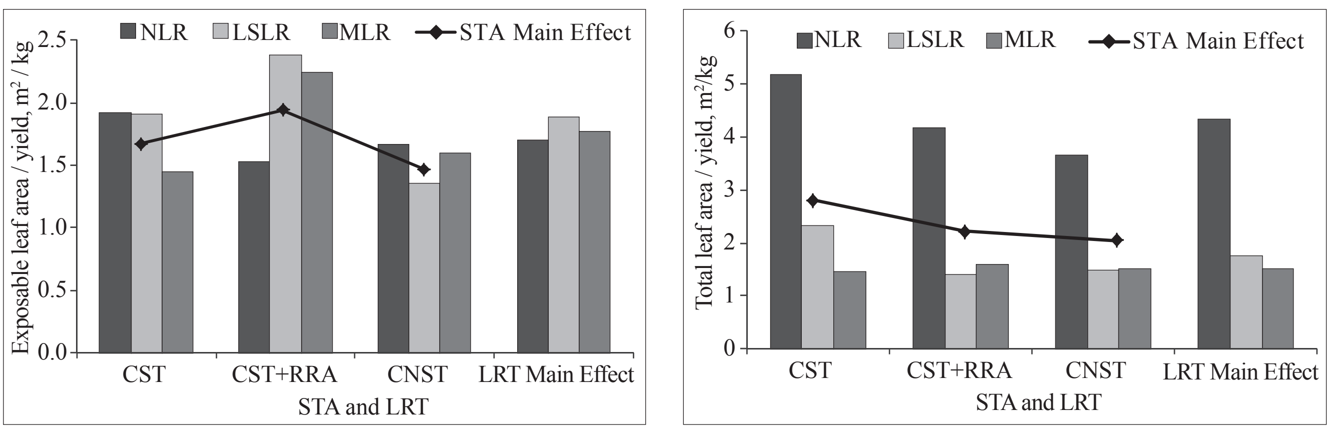


Fig. 13. Exposable leaf area/yield and total leaf area/yield changes according to different soil tillage and leaf removal applications

[CST: Conservative Soil Tillage, CST + RRA: Conservative Soil Tillage + Rain Remove Applications (30% prevent rain fall), CNST: Conventional Soil Tillage, NLR: Non Leaf Removal, LSLR: Lateral Shoot Leaf Removal, MLR: Main Shoot Leaf Removal]

laterals and long laterals respectively. In this research, LSLR and MLR decreased average leaf area per vine 30% and 37% respectively (Figure 12).

Exposable leaf area (ELA)

ELA was calculated 13499.46 m^2/ha, according to Modified Lyre trellising system. In NLR treatment total leaf area was calculated 35215 m^2/ha. In LSLR and MLR applications in this area were 15464 and 14078 m^2/ha respectively. In both applications between 85-95% of leaves might consider as an exposed leaf area. This value was almost equal to the ELA (data not shown).

Lateral leaves, being the youngest leaves in the canopy, may play a major role in metabolic processes occurring during fruit ripening. This was seen in the same effect on TSS value. It was clear that with comparing TSS value and total leaf area. Due to the Modified Lyre Trellising System, most of the leaves in MLR and LSLR were well exposed. In Lyre system; the heads of vine were open, for that reason, all shoots were fully exposed and it had a double surface. In this condition, the absence of ML or LSL caused a minimal shadow effect on canopy. In addition, did not forget, the training system was affected the distribution of leaf area density and the position of lateral leaves (Schultz, 1993).

Exposable leaf area/yield ratio

There were different opinions about leaf area: yield ratio. Hunter (2000) stated that the total leaf area/g fruit was never less than the generally accepted norm of 12 cm^2. Smart and Robinson (1991), notified that the leaf area: yield ratio <0.5 $m^2.kg^{-1}$ if vigour is low; y>2 $m^2.kg^{-1}$ if vigour is high. CST+RRA application increased exposable leaf area: yield ratio (2.04 m^2/kg). CST (1.76 m^2/kg) and CNST (1.54 m^2/kg) were following this (Figure 13). This result stemmed from the difference in yield according to STA. In addition, Vasconcelos and Castagnoli (2001) inform that the leaf to fruit ratio from 15 to 10 cm^2/g for 1g fruit. Kliewer and Weaver (1971) adjusted crop levels in Tokay and they found that 1 to 1.4 m^2 of leaf area was required to attain maximum berry mass, maturity and color. Although, Kliewer and Dokoozlian (2005) stated that 0.8 to 1.2 m^2 leaf areas per kg fruit is needed to mature fruit trained to single canopy trellis system. In addition, Bowen (2009) argues that the several *V. vinifera* grape varieties required per kg of fruit to ripen 0.8 and 1.4 m^2 leaf area. Considering authors as Howell (2001), who mention values of 7 to 14 cm^2 of leaf area per gram of ripen fruit, the three cultivars in the evaluated conditions had enough leaf area as to ripen adequately the production level (Echenique et al., 2007). To sum up all researcher opinions, it could be said that our leaf area: yield ratio was adequate. In this research while total leaf area/yield (4.327 m^2/kg) was about twice higher than ELA: yield (1.708 m^2/kg) in NLR was not seen great difference among the other criterian. In addition, this indicated that ELA was more effective than total leaf area. Although MLR and LSLR had a half of total leaf area than NLR the difference was not important according to ELA.

It was further found that same as the Cloete et al. (2006) the primary leaves of the normally developed shoots in the shaded canopies comprised a larger percentage of the total leaf area per shoot than in the exposed canopies, due to the higher number of leaves per shoot as well as the larger mean primary leaf area.

Conclusion

Different soil tillage applications affected cluster length, berry fresh and berry dry mass but it did not influence the other criteria. This was thought to be because of the extreme rainfall during the vegetation period and strong development of root in the Modified Lyre trellising system. In addition, it could be concluded that predawn leaf water potential (Ψ_{pd}) did not fall down to the expected values between veraison and harvest.

The leaf removal treatments affected only total leaf area per vine ($m^2.vine^{-1}$). However while total leaf area/yield was about twice higher than exposable leaf area/yield great difference was not obtained among the other criteria. It might be said that exposable leaf area was more effective than total leaf area due to its shadow effect. In the result of main leaf removal and lateral shoot, leaf removal treatments caused more effective exposure leaf area with decrease of the compactness and shadow effect of canopy. It was suggested that the younger and active lateral shoot leaves did not give greater differences than the non-leaf removal treatment. Although in main leaf removal and lateral shoot leaf removal treatments there was no significant difference found with non-leaf removal treatment according to exposable leaf area.

Finally, in this trellising system, under these soil and climatic conditions, it could be advised conservative soil tillage alternatively to conventional soil tillage as to be more economical. Furthermore, leaf removal treatments under different climatic conditions physiologically should be researched more about the leaf water potential, photosynthesis, transpiration and stomatal conductance in canopy because of their different effects.

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