

**Steep slope viticulture: training systems in narrow terraces, Touriga Nacional,
Douro Region**

**Viticulture en fort pente: systèmes de conduite en banquettes étroites,
Touriga Nacional, Région de Douro**

**Viticultura en fuerte pendiente: sistemas de conducción en terrazas
estrechas para Touriga Nacional (región del Duero)**

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Abstract

More than 70% of the vineyards of Douro, the Port Wine Region, are planted in hillsides with a slope superior to 30%. After the inscription of the Douro Valley in the “World Heritage list - UNESCO”, in slopes higher than 30% is mandatory that vineyards are planted in terraces with less than 2.5 m wide and a single row of plantation.

However narrow terraces have the disadvantage of a low planting density and consequently a low yield potential, circumstance that discourages its use by grape growers. Because of that, an experiment was performed in a vineyard planted in terraces of 2.3 m wide, and a single row of vines, with two alternatives of training: i) the traditional Vertical Shoot Positioning - VSP and ii) a double cordon, trained upwards and downwards, the LYS 2/3. Additionally, two pruning alternatives had been introduced in the cordon trained downwards of LYS 2/3, spur pruning (Royat) and can pruning.

The variety used was Touriga Nacional, grafted in 110R.

The results obtained in 2005 and 2006 showed that yield in the LYS 2/3 system was 24 % higher than in the VSP. Regarding the quality parameters, both training systems reached good fruit sugar concentrations, 14.0 for VSP and 12.8% v/v for LYS 2/3.

As conclusion, Touriga Nacional, revealed high quality potential and narrow terraces proved to be a very good alternative in planting hillside vineyards, being LYS 2/3 a system able to reach an important improvement in yield, and even if with a lower sugar content, allowing to achieve a satisfactory quality.

Key words: Douro, Touriga Nacional, narrow terraces, training system, yield, quality.

Résumé

Plus de 70% des vignobles de Douro, la région de Vin Porto, sont plantés dans coteaux avec une pente supérieure à 30%. Après la inscription de la vallée de Douro dans la liste du “Patrimoine de l’Humanité de l’UNESCO », dans les pentes avec plus de 30% c’est obligatoire que les vignobles soient plantées dans les terrasses avec 2,5 m de large et une seule ligne de plantation.

Toutefois les terrasses étroites ont l’inconvénient d’une basse densité de plantation et par conséquent d’un bas potentiel de rendement, ce que discourages son utilisation par des viticulteurs. Pour une meilleure compréhension du problème, une expérience a été exécutée dans une vigne plantée dans terrasses de 2.3 m de large et une seule ligne de plantation, avec deux systèmes de conduite: i) le system traditionnelle à palissage ascendant - VSP et II) un double plan de palissage, ascendant et retombant au-dessus des talus, le LYS 2/3. En plus, deux solutions de taille avaient été appliquées dans le cordon retombant de LYS 2/3, cordon de Royat et taille à bois demi-longue.

La variété étudiée était Touriga Nacional, et le porte greffe le 110R.

Les résultats obtenus en 2005 et 2006 ont montré que le rendement dans le système LYS 2/3 était 24 % de plus que dans le VSP. Concernant les paramètres de qualité, les deux systèmes de conduite ont atteint des bonnes concentrations en alcool probable, 14,0 pour VSP et 12,8% v/v pour LYS 2/3.

En conclusion, le cépage Touriga Nacional, à montre un grand potentiel de qualité et les terrasses étroites se sont avérées comme une alternative en plantant des vignes en fort pente. Le système LYS 2/3 a été capable de une amélioration importante de rendement, et même ayant une diminution dans la concentration de sucre, avec une qualité satisfaisante.

Mots clés: Douro, Touriga Nacional, systèmes de Conduite, vignes en banquettes, rendement, qualité.

Resumen

Más del 70% de los viñedos del Douro, la región del oporto, están plantados en laderas cuya inclinación supera el 30%. Tras la inclusión del valle del Douro en la lista del Patrimonio de la Humanidad de la unesco, en las pendientes superiores al 30% es obligatorio cultivar las viñas en terrazas de hasta 2,5 m de ancho y con una sola hilera de plantación.

Sin embargo, las terrazas estrechas presentan el inconveniente de su baja densidad de plantación y, en consecuencia, su escaso potencial de rendimiento, circunstancia que no contribuye a potenciar el uso de dichas terrazas entre los viticultores. Para llegar a entender mejor este problema, se realizó un experimento en una viña plantada en terrazas de 2,3 m de ancho y una sola hilera de plantación, donde se instalaron dos sistemas de conducción: 1) el sistema tradicional de espalderas ascendentes (vps), y 2) un sistema de cordón doble, ascendente y descendente sobre los taludes: el lys 2/3. Además se habían introducido dos alternativas de poda en el cordón descendente del lys 2/3: la poda en palmeta (poda en cordón Royat) y la poda larga. La variedad empleada fue Touriga Nacional, y el portainjerto, el 110R.

Los resultados obtenidos en 2005 y 2006 muestran que el rendimiento conseguido con el sistema lys 2/3 fue un 24% superior al del vsp. Con respecto a los parámetros de calidad, los dos sistemas de conducción produjeron buenas concentraciones de fructosa: 14,0 en el caso del vsp y al 12,8% en el del lys 2/3.

En conclusión, la variedad Touriga Nacional presentó un gran potencial de calidad y las terrazas estrechas se revelaron como una muy buena alternativa para la plantación de viñedos en pendientes muy marcadas. Con el sistema lys 2/3 fue posible alcanzar una importante mejora del rendimiento, incluso con un menor contenido de azúcar, lo cual permite obtener una calidad satisfactoria.

Palabras clave: Douro, Touriga Nacional, terrazas estrechas, sistema de conducción, rendimiento, calidad.

1 Introduction

The Douro Region is characterized by having mountain viticulture, with more than 70% of vineyards planted in hillsides with a slope superior to 30%. For this reason the method used to systematize the initial hillside is of major importance.

In the “traditional” planting systems, vines were planted on terraces supported by dry stone walls, originating the spectacular landscape, built by man, but requiring more than 1000 hours per hectare of arduous manual labour (Guimaraens & Magalhães, 2006).

In the 1980s two planting models were introduced: Vertical planting on hillsides with the slope inclination up to 35-40%, and the large terraces, 3.6 to 4.0 m wide, planted with two rows of vines and supported by earthen embankment.

However the large terraces present significant inconveniences, the height of the embankment leads to subsequent problems of instability and erosion, and the use of chemicals for weed control is unavoidable (Castro *et al.*, 2007). Moreover, rules governing the Douro Valley’s recognition as a “World Heritage of Mankind” by UNESCO, require that in slopes greater than 30% or when planting vines in hillsides supported by stone walls, the terraces must narrow, with less than 2.5 m width, and have a single row of vines.

Despite the fact that several authors studied alternatives for establishing and training vineyards on hillsides (Koblet & Faust, 1994; Cargnello, 1995; Castro *et al.*, 1998; Murisier *et al.*, 2001; Magalhães, 2002) and former works from Félix & Guerra (1998) showed several advantages of one row narrow terraces in the Douro Region, grape growers generally regard this system as having the disadvantage of low planting density, and as a consequence, a lower production potential than the large terraces.

This view held by grape growers meant that it was important to study alternatives in vine training in narrow terraces and due to that an experiment was performed in a vineyard planted on terraces of 2.3 m width, with two training alternatives: i) the traditional Vertical Shoot Positioning – VSP, and ii) a double cordon, trained upwards and downwards, the LYS 2/3 with two different distances between vines (0.80 m and 1.20m). Additionally, two pruning alternatives had been introduced in the cordon trained downwards of the LYS 2/3.

2 Material and methods

Field trials were conducted in 2006 and 2007, at the private estate "Quinta de Santo António", property of "The Fladgate Partnership Vinhos S.A.", located in the central part of the Douro Region (Upper-Corgo) - 41° 14' N, 7° 31' W, 275 meters above sea level, with a C1B'3sb'4 climate (Thorntwaite) (Figure 1).

The vineyard was planted in 2002, on a hillside with an initial slope of 50%, systematised in 2.3 m wide horizontal narrow terraces (Figure 2), with Touriga Nacional, a noble Portuguese variety (Queiroz, *et al.*, 1998), bench grafted on 110R rootstock.

The hillside has a predominantly S-SE exposure and the soil, of schistose origin, contains a high percentage of stones.

The trial was designed as a split-plot experiment with training system assigned to the main plot and distance between vines assigned to the subplot, with 4 replications and a total number of plants studied of 184.

Treatment consisted of two training systems: i) the traditional "Vertical Shoot Positioning" (VSP), spur pruned, used as control (Figure 3) and ii) a double cordon with part of the canopy trained upwards and part downwards, the LYS 2/3 (Figure 4, 5 and 6), two different distances between vines (0.80 m and 1.20m) - data about distances between vines available only for 2007 harvest. Additionally two pruning alternatives were introduced in 2007 in the cordon trained downwards of LYS 2/3 (spur pruning) and cane pruning). Measurements of water leaf potential and photosynthetic rate were made on July 26th, during the maturation period, with the final daily determination being made at 17h00, due to the shadow that affects the trial field after that hour. Foliar Surface Index was assed following the methodology proposed by Lopes & Pinto (2005) on 9th of June, 9th of July (data presented in this paper) and 12th August.

Results of comparison of mean values are expressed as the level of significance. Where resulting differences were significant, individual means were compared using the Duncan's multiple range test ($p \leq 0.05$). For statistical analysis, the SPSS v.15 program was used.

3 Results and discussion

Yield value expressed in kg by linear meter, was, in the double cordon LYS 2/3 (considering the two plans of canopy), 68% higher than in the VSP system in 2006, - with yield values of 2.60 and 1.55 kg per linear meter of row, and 23% in 2007, with yield values of 6.06 and 4.92 kg (Figure 7). This difference results from the number of bunches per linear meter, consequence of the bud number, retained at winter pruning and of the bunch weight. In effect in 2006 the VSP had 9.8 bunches while the double cordon LYS 2/3 had 18.8, and in 2007, 21.4 and 29.8 respectively. The bud number per linear meter was greater in the double cordon LYS 2/3, with 10.6 (in the two curtains) than in VSP with 5.1 in 2006, and 16.9 and 9.7 respectively, in 2007. Concerning the bunch weight (Table 1) the values were similar in 2006 but statistically different in 2007, and fruitfulness (in average 2.5 bunches per bud in 2006 and 1.6 in 2007) were similar in both training systems.

Regarding the quality parameters (Table 1), the potential alcohol concentration (converted after fruit sugar concentration) was very satisfactory for Port Wine production in both systems. In 2006 VSP reached 15.5 % (v/v) and the double cordon LYS 2/3 13.7 % (v/v), a smaller value due to a relative overcrop. In 2007 both systems reached 12.4 % (v/v), value which reflects the influence of rain in the week preceding the harvest, since the maturation controls made the previous week reached values superior to 13.0 % (v/v). For the other quality parameters no significant differences between variants were detected, except in berry weight in 2007, which was lower in the LYS 2/3 (Table 1). These values are consistent with those founded by Murisier *et al.* (2001) that refer increases in yield whilst maintaining quality, in variants with a double plan of canopy, trained in narrow terraces.



Figure 1 – General sight of “Quinta de Santo António” field trial (Douro).

Figure 1 – Vue général du champ d’essais “Quinta de Santo António” (Douro).



Figure 2 – Narrow terraces at “Quinta de Santo António”.

Figure 2 – Banquettes étroites à “Quinta de Santo António”.



Figure 3 – Traditional Vertical Shoot Positioning (VSP).
Figure 3 – Système traditionnelle à palissage ascendant (VSP).



Figure 4 – Double cordon LYS 2/3 in summer.

Figure 4 – Cordon double LYS 2/3 pendant l’été.



Figure 5 – Double cordon LYS 2/3 Winter pruned.

Figure 5 – Cordon double LYS 2/3 après la taille d’hiver.



Figure 6 – Double cordon LYS 2/3 at maturation.

Figure 6 – Cordon double LYS 2/3 à la maturation.

Table 1 – Effect of training systems on quality components, berry and bunch weight (Touriga Nacional, 2006 and 2007).

Tableau 1 – Effet du system de conduite sur les composants de qualité, poids de la baie et de la grappe (Touriga Nacional, 2006 et 2007).

Modalities	Fruit Sugar Concentration (% v/v)		Titrable Acidity (gr. Tart. Ac./ l)		pH		Berry weight (g)		Bunch weight (kg)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
VSP	15.5	12.4	4.03	4.49	3.91	3.50	1.28	1.74	0.161	0.233
LYS 2/3	13.7	12.4	3.72	4.22	3.84	3.53	1.24	1.53	0.139	0.204
Sig(1)	***	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	**	<i>n.s.</i>	***

Note: (1) *n.s.* – non significant, * - significant at 0.05, ** - significant at 0.01, *** - significant at 0.001.

Table 2 – Effect of distance between vines along the row on quality components, berry and bunch weight (Touriga Nacional, 2007).

Tableau 2 – Effet de la distance de plantation sur la ligne sur les composants de qualité, poids de la baie et de la grappe (Touriga Nacional, 2007).

Modalities	Fruit Sugar Concentration (% v/v)	Titrable Acidity (gr. Tart. Ac./ l)	pH	Berry weight (g)	Bunch weight (kg)
1.20 m	11.9	4.38	3.48	1.58	0.203
0.80 m	12.9	4.20	3.56	1.58	0.230
Sig(1)	*	<i>n.s.</i>	*	<i>n.s.</i>	***

Note: (1) *n.s.* – non significant, * - significant at 0.05, ** - significant at 0.01, *** - significant at 0.001.

Table 3 – Effect of pruning system (spur or cane pruning) of the canopy trained downwards (double cordon LYS 2/3), on quality components, berry and bunch weight (Touriga Nacional, 2007).

Tableau 3 – Effet du system de taille (en courson ou baguette) dans le cordon retombant de LYS 2/3, sur les composants de qualité, poids de la baie et de la grappe (Touriga Nacional, 2007).

Modalities	Fruit Sugar Concentration (% v/v)	Titrable Acidity (gr. Tart. Ac./ l)	pH	Berry weight (g)	Bunch weight (kg)
SPUR	12.3	4.25	3.57	1.53	0.204
CANE	12.2	4.26	3.51	1.43	0.202
Sig(1)	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>	<i>n.s.</i>

Note: (1) *n.s.* – non significant, * - significant at 0.05, ** - significant at 0.01, *** - significant at 0.001.

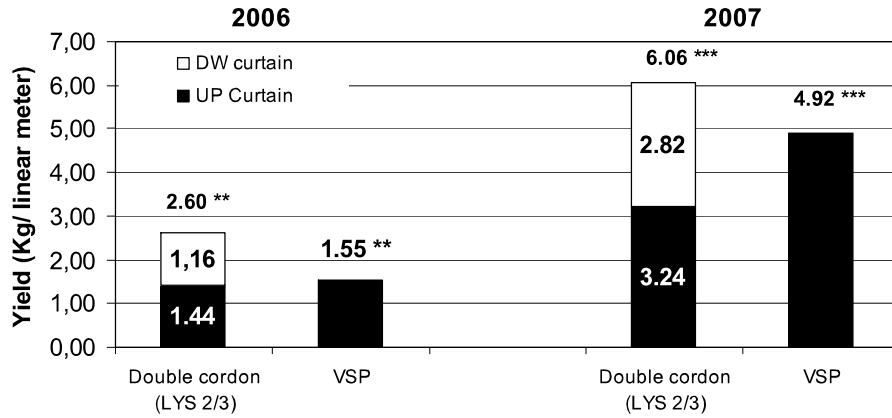


Figure 7 - Effect of training systems on yield (kg/linear meter of row) (Touriga Nacional, 2006 and 2007)
 Figure 7 - Effet du system de conduite sur la production (kg/mètre de ligne de plantation) (Touriga Nacional, 2006 et 2007)

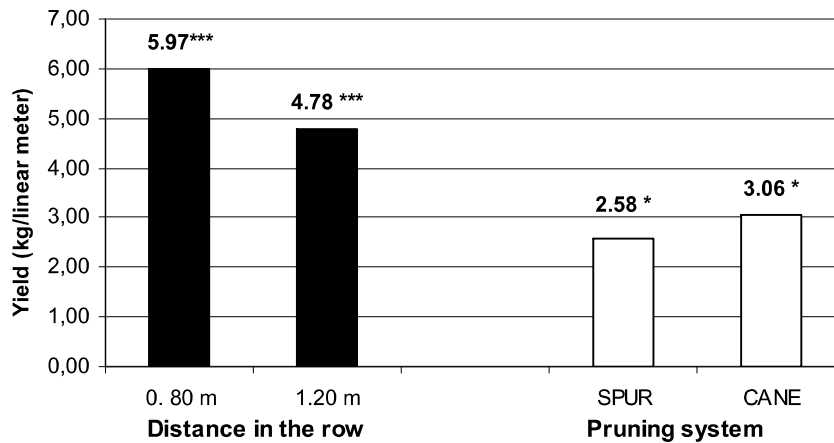


Figure 8 - Effect of planting distance and pruning system – presented value only of the downward cordon- on yield (kg / linear meter of row)
 Figure 8 - Effet de la distance de plantation sur la ligne et du système de taille – valeur seulement du cordon retombant – sur la production (kg/mètre de ligne de plantation) (Touriga Nacional, 2007).

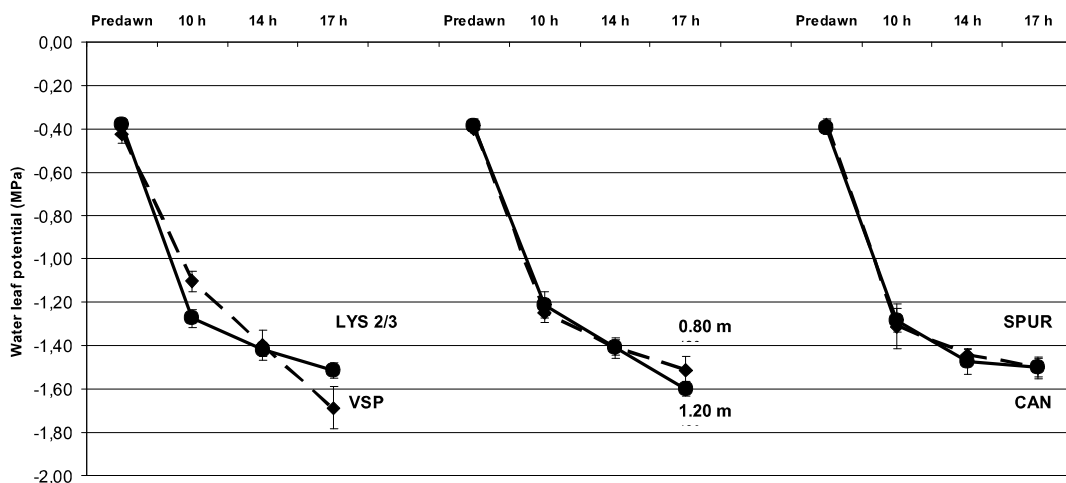


Figure 9 - Effect of training system, planting distance along the row and pruning system on water leaf potential (MPa), July 26th, Touriga Nacional, 2007).
 Figure 9 - Effet du system de conduite, distance de plantation sur la ligne et system de taille sur le potentiel hydrique foliaire (MPa), 26 Juillet, Touriga Nacional, 2007).

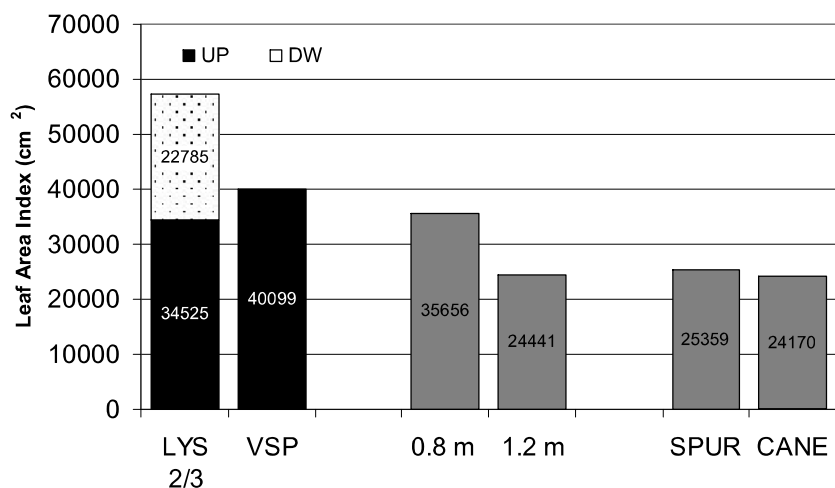


Figure 10 - Effect of training system, distance along the row and pruning system on the leaf area index (cm²/linear meter of row) (Touriga Nacional, 9th July, 2007)

Figure 10 - Effet du system de conduite, distance de plantation sur la ligne et system de taille sur Indice de Surface Foliaire (cm²/ mètre de ligne de plantation) (Touriga Nacional, 9 Juillet, 2007)

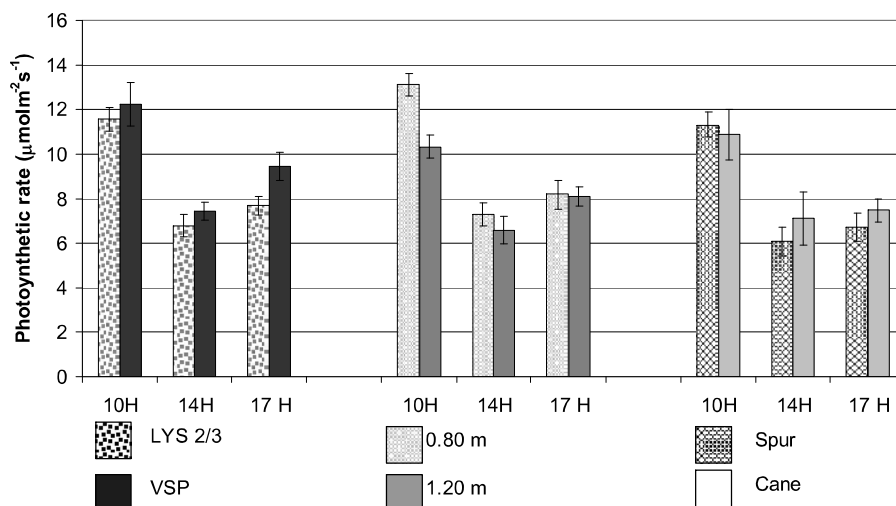


Figure 11 - Effect of training system, planting distance along the row and pruning system on photosynthetic rate (µmolm⁻²s⁻¹), 26th July, Touriga Nacional, 2007).

Figure 11 - Effet du system de conduite, distance de plantation sur la ligne et system de taille sur l'évolution journalière de la photosynthèse (µmolm⁻²s⁻¹), 26 Juillet, Touriga Nacional, 2007).

The effect of row distance (data available for 2007 only) shows that planting at 0.80m allowed a higher yield to be reached than at 1.20m (Figure 8). This difference results from a higher number of bunches per linear meter in the 0.80 m distance - 26.3 versus 23.3 in the 1.20m and to superior bunch weight in the 0.80m distance (Table 2).

The quality parameters (Table 2), show higher alcohol values in the 0.80m than in the 1.20m modality. This difference and the pH values of both modalities, allows us to conclude that the grapes reached a higher maturation level in the 0.80 m modality.

In order to optimize the double cordon LYS 2/3, in 2007 winter's pruning two different pruning systems were introduced in the cordon trained downwards: spur pruning (*Royat*) and cane pruning. Values for yield presented in figure 8 (regarding only the production of the downward cordon) show that cane pruning reached a higher value than spur pruning, due to a higher number of bunches (15.3 for cane pruning and 12.9 for spur, due to higher bud fertility, 1.7 and 1.5 respectively) even though their weights are similar (Table 3). In terms of quality, both pruning systems reached similar parameters (Table 3).

In terms of water leaf potential, the values found in predawn can be considered moderated and adequate for quality production (Figure 9). Values for treatments appear similar, except in training system at 10H00, less negative in VSP and, at 17H00 with a higher value in the double cordon LYS 2/3. Even if the Foliar Area Index is substantially higher in the double cordon LYS 2/3, as expected, than in VSP (Figure 10), no differences were found in predawn values, therefore water available for vines can be considered similar in both systems.

Concerning photosynthetic rate (Figure 11) it was found that the values were high through the day, with a slight depression in the 14H00 measurement, as expected. Small differences between variants were found in training systems with double cordon presenting smaller values than VSP, and 1.20m smaller than the 0.80m.

3 Conclusions

Results, although under reserve due to the short period of the experiment (two years), allow, nevertheless, to conclude that, in terms of yield the double cordon LYS 2/3 is a good alternative since it shows a higher production potential, linked to the possibility of doubling the pruning level. However, if in this trial the quality parameters show differences only when the double cordon LYS 2/3 overcrop and are similar to VSP when yield is in balance with vine potential, it is necessary that a longer experimental period give the necessary support to these results.

Concerning the distance between vines along the row, it is clear that 0.80m has advantages in terms of yield with quality improvement, due to a greater foliar index, seeming that, in a non irrigated viticulture, vines attain equilibrium in advance thus allowing the vineyard to reach its “cruise velocity” earlier. Additionally, with distances wider than this, planting density established by Port and Douro Wines Origin Control legislation is not achieved.

In terms of pruning alternatives for the canopy trained downwards of double cordon LYS 2/3, cane pruning seems to be the best alternative, even if spur pruning is easier to perform, and makes the work on vegetation easier.

According to these results, it can be concluded that narrow terraces proved to be a good alternative in planting hillside vineyards using Touriga Nacional, 0.80m distance of vines along the row being the best alternative, and the double cordon LYS 2/3 a system able to reach an important yield improvement while ensuring a satisfactory quality.

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