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Comparative tree growth, phenology and fruit yield of several Japanese plum cultivars in two newly established orchards, organic and conventionally managed

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Abstract

The growth, phenology and fruit yield of 14 Japanese plum cultivars (*Prunus salicina* Lindl) were studied in two newly established experimental orchards under organic and conventional management. The experiment was conducted during 2005-2011 in the province of Seville (SW Spain), an important region of Japanese plum culture. Trunk cross-section areas (TCSA), flowering, yield and tree defoliation before winter dormancy were analysed over several years. After one year, TCSA were larger in the organically managed orchard (OMO) for most of the cultivars, in the next two years they were equal, and from the fourth year, several cultivars showed significantly larger TCSA in the conventionally managed orchard (CMO). Flowering in the conventional orchard started from 2 to 6 days before and lasted for 3 to 5 days more than in the OMO. Several cultivars produced significantly more fruit in the CMO, being the average fruit yield in the organic orchard about 72% of the conventionally managed orchard. Autumn defoliation was significantly advanced in the organic orchard, especially in cultivars highly susceptible to rust (*Tranzschelia pruni spinosae*), a disease not adequately controlled in the organic orchard.

Additional key words: conventional farming; defoliation; flowering; fruit yield; Japanese plum; organic farming; tree growth.

Introduction

The growth of fruit trees is affected by many different factors: plant genetics, soil type, rootstock (Webster, 1995), climatic conditions (sunlight, temperature, rainfall, humidity) (Legave *et al*., 2006) and there are also agricultural activities having a clear effect on fitness, vigour, and fruit quality of plants as the orchard system, irrigation, and fertilization (Hester & Cacho, 2003; Rufat *et al*., 2011; Kükükyumuk *et al*., 2012).

The different phenological stages of fruit trees, and their seasonal timing and duration, vary depending on local climatic conditions and fluctuate from year to year (Montagnon, 2007). Among the processes that directly influence the flowering of fruit trees is the accumulation of chill units during the winter (Albuquerque *et al*., 2007). Once the minimum number of required chill units is achieved, appropriate temperatures are needed to raise the swelling and germination of buds (Melgarejo, 1996). Also, phenology is influenced by variables such as temperature (Weinberger, 1956; Browning & Miller, 1992; Rodrigo & Herrero, 2002), wind (Dennis, 1979), frost (Rodrigo, 2000), rain and relative humidity (Gradziel & Weinbaum, 1999). In addition to the genetic characteristics of different cultivars, there are other factors that affect the phenology of flowering such as the type of fertilization (Williams, 1965), the age of the trees or branches (Robbie & Atkison, 1994) and even the orientation of the branches (Robbie *et al*., 1993). All these factors can also affect fruit yield and quality.

In this work, a comparative study of organic and conventionally managed orchards was conducted examining differences in tree growth, flowering, fruit yield and autumn defoliation in two similar experimental orchards of 14 Japanese plum cultivars.

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Abbreviations used: CMO (conventionally managed orchard); OMO (organically managed orchard); TCSA (trunk cross-section area).

Table 1. Physicochemical soil analysis in both orchards at the time of plum tree plantation (2005) and at the end of the study (2011)

Year	Management	OM	pH	EC	N	P	K	Ca	Mg	Fe	Mn	Zn	B
2005	Conventional	1.30	8.6	276	507	5.50	0.72	9.39	1.97	6.64	7.96	0.80	0.96
	Organic	1.10	8.6	272	482	9.30	0.68	10.44	1.84	7.28	10.04	0.52	1.06
2011	Conventional	1.60	8.03	435	823	6.03	0.93	58.30	2.46	71.83	99.47	2.83	2.30
	Organic	2.90	7.86	401	1,092	5.80	1.16	61.40	3.23	78.43	145.93	3.16	3.06

OM: organic matter. EC: electric conductivity. Units are given in % (OM), mS cm^{-1} (EC), mg kg^{-1} (N, P, Fe, Mn, Zn, B) and meq/100 g (K, Ca, Mg).

Material and methods

Description of the experimental plots

The study was conducted during 2005-2011 in two similar experimental orchards (5,500 m^2 each) located at the IFAPA Centro "Las Torres-Tomejil" in the province of Seville in the Guadalquivir River Valley (SW Spain) (37° 30' 48" N; 5° 57' 46"W). The soil was classified as a Xerofluvent (Soil Survey Staff, 1999). Both plots were selected on the basis of a similar physicochemical soil composition (Table 1) and were 200 m apart from each other to avoid interference between the different pesticide treatments. The region has a Type C Mediterranean climate, according to the Köppen classification. Relevant agroclimatic conditions registered in the zone during the time of the study are shown in Table 2.

In both plots, 14 Japanese plum cultivars (*Prunus salicina* Lindl), which matured from late May to mid-September, were planted in January 2005. Characteristics of the cultivars are described by García-Galavís *et al*. (2009). Each experimental plot was subject to a different type of management, one in organic and the other in conventional agriculture. In both orchards, the experiment was set up in a randomised block design with three replications, each containing 6 trees of each cultivar.

Table 2. Agroclimatic conditions registered in the study area

Year	Temperature (°C)	Relative humidity (%)	Rainfall (mm)	Chilling hours
2007	13.51	69.00	110	617
2008	14.75	63.57	253.80	495.50
2009	12.66	64.01	160.20	749
2010	13.60	79.43	402.40	404
2011	14.43	73.75	195.40	494

Temperature, relative humidity and rainfall are the average for February-April period (current year). Chilling hours are the period from November 1st (previous year) until February 15 (current year).

Major field work conducted in both orchards

Fertilization in the organic plot consisted of the application of animal manure (3-4 kg m^{-2} yr^{-1}) and sowing of several cover greens containing legumes (Table 3). A soybean (*Glycine max* L.) cover green was also sown in the summer of 2004 before planting the trees. The conventional plot received annual applications of mineral manures, including complex formulations (11-11-11), ammonium nitrate and potassium sulphate, to 155 units of nitrogen, 55 of phosphorus and 150 of potassium.

The different pest and disease treatments in each plot were adjusted to regulations in integrated production [RD1201/2002 (BOE, 2002); D245/2003 (BOJA, 2003)] and in organic farming [Commiss. Regul. (EC) 834/2007 (OJ, 2007) and 889/2008 (OJ, 2008)]. Specific products and timing of treatments in both orchards have been described previously (García-Galavís *et al*., 2009). Soil and foliar analyses were conducted as described by Herencia *et al*. (2007).

Both plots were irrigated during the dry season by gravity along two rows parallel to the line of trees with identical volumes and frequency. Each year, depending on climatic conditions, from 6 to 9 irrigations were applied (350,000 L ha^{-1} each).

Land management consisted of reduced tillage. When necessary, the grass in the line of trees in the conventional orchard was removed through the use of authorized herbicides and in the organic one by a pass from bleachers with an orchard tractor. The plum trees had a similar pruning training vessel, taking care that pruned trees bear a similar width and height in both orchards.

Table 3. Gross contribution in dry matter and major macronutrients of the different cover crops used in the organic orchard

Cover	Sowing	Buried	kg ha^{-1}			
			Dry matter	N	P	K
Soybeans (in pre-plant)	May 2004	August 2004	10,060	320	34	206
Bean	October 2005	March 2006	6,320	180	14	185
Rape + Vetch	December 2006	April 2007	2,500	70	8	75
Spontaneous		March 2008	2,913	56	9	75
Vetch + Oat	October 2008	March 2009	8,320	180	19	220
Bean	October 2009	March 2010	10,353	225	24	274
Vetch + Oat	October 2010	March 2011	4,100	140	12	120

Tree growth and fruit yield

Growth and vigour of the trees were evaluated yearly in November at the end of the growing season by calculating the cross-section area of the trunk (TCSA) 20 cm above the graft (Layne, 1994; Lepsis & Blanke, 2006).

The fruit yield of each variety (kg tree^{-1}) was calculated taking into account the total fruit collected in each orchard, tree replicates with 6 trees each. The cumulative production was obtained by joining the yields obtained in previous years.

Phenological studies

For phenological studies, data capture was carried out on nine trees per cultivar (3 per block) and treatment. According to the BBCH scale (Hack *et al*., 1992), the following phenological periods were analysed: opening of the first flowers, full flowering (> 50% flowers open) and end of flowering (all petals fallen), and the duration of flowering was also determined. The kinetics of falling leaves during senescence was evaluated. The fall of the leaves was recorded weekly from October to December. Defoliation was evaluated using a 0-5 scale, where 0 is 0% fallen leaf; 1, 20% fallen leaf; 2, 40% fallen leaf; 3, 60% fallen leaf; 4, 80% fallen leaf and 5, total defoliation. Evaluation of rust disease incidence was as described by García-Galavís *et al*. (2009).

Statistical analysis

Statistical analyses were performed using Statistix software (version 9.0, NH Analytical Software, USA). Analysis of variance (ANOVA) was used to analyze TCSA and fruit yield data, and defoliation and rust incidence data were analyzed with the Kruskal-Wallis nonparametric test at the $p < 0.05$ level of significance.

Results

Tree growth, soil and foliar analyses and fruit yield

The TCSA from 2005 to 2011 are shown in Table 4. In 2005, eight cultivars showed significantly higher TCSA in the OMO and the other six cultivars showed non-significant differences between the two management systems. In 2006 and 2007, most of the cultivars displayed similar values in both orchards, except for 'Angeleno' in 2006 (higher in the organic) and 'Red Beaut' in 2007 (higher in the conventional). In 2008, 2009, 2010 and 2011, a total of six, seven, nine and eight cultivars, respectively, showed significantly higher TCSA values in the CMO, showing mean increases of between from 15 to 20%. In these four years, the other cultivars also showed larger TCSA in the CMO, but without significant differences. According to the TCSA values, 'Souvenir', 'Red Beaut', 'Angeleno' and 'Golden Japan' were the most vigorous and 'Friar' and 'Sapphire' the least, in both types of management.

Physico-chemical soil composition of both orchards in 2011 is shown in Table 1. Except for organic matter, significantly higher in the organic plot, no relevant differences were observed. Foliar composition of a strong cultivar ('Golden Japan') and other one feeble ('Sapphire') in 2007, 2009 and 2010 is shown in Table 5. No relevant differences were observed in the major macro or micronutrients between the two management systems.

Table 4. Dynamics of the trunk cross-sectional area (cm^2) from 2005 to 2010 of the different cultivars in the organic (O) and conventionally (C) managed plum orchards

Cultivar	2005		2006		2007		2008		2009		2010		2011	
	O	C	O	C	O	C	O	C	O	C	O	C	O	C
Larry-Ann	10.84	9.60	30.43	41.43	62.99	71.90	72.15	100.04	102.95	137.03*	113.78	155.74*	120.16	193.57*
Fortune	10.75	10.71	41.31	44.01	77.46	80.27	99.98	112.51*	138.44	164.96*	155.37	178.45*	179.73	212.68*
Souvenir	17.31	13.65	61.68	61.81	108.08	109.26	151.92	176.15*	203.39	236.86*	238.75	282.43*	295.11	333.91*
Songold	7.79	7.50	28.02	30.17	58.79	62.60	79.00	92.73*	126.83	136.72	119.96	149.06*	153.68	193.09*
Sapphire	7.64	7.07	31.24	34.68	54.43	68.01	73.53	90.58*	92.44	115.76	102.75	132.75*	118.64	151.55*
Red Beaut	15.36	9.57*	55.29	49.52	104.31	126.84*	148.46	178.40*	205.39	248.32*	245.35	285.34*	293.61	330.19
Laetitia	11.48	8.72*	39.46	40.79	85.49	100.11	117.10	131.51	150.61	198.26*	185.94	220.18	218.72	250.18
Black Amber	11.92	8.62*	35.22	31.96	67.11	70.22	83.21	90.31	124.85	132.34	139.93	151.31	182.88	184.92
Primetime	13.62	9.58*	43.10	43.50	68.26	80.54	100.41	133.10*	141.09	185.55*	166.75	200.06*	200.63	251.80*
Santa Rosa	10.05	7.10*	40.28	35.35	67.56	77.98	95.05	117.27	160.72	174.39	180.73	210.05	232.25	257.84
Angeleno	12.46	8.30*	49.26	41.83*	94.22	94.08	135.39	152.68	185.99	216.41	219.09	271.36*	277.94	329.95*
Golden Japan	13.10	9.58	53.39	48.77	95.72	95.94	131.34	144.97	191.81	207.70	229.90	271.69	281.23	330.58
Friar	6.83	3.42*	22.57	22.70	52.13	48.16	68.72	70.12	74.77	91.53*	100.31	122.88*	116.14	144.29*
Showtime	9.95	6.49	37.26	36.85	56.06	62.71	91.84	87.33	111.13	154.87	137.58	183.52	181.44	235.38
Mean	11.41	8.55*	40.73	40.26	75.72	82.33	103.44	119.84*	143.60	171.48*	166.87	201.06*	203.73	242.85*

Data are the mean of 18 trees for each cultivar and treatment. For each year, the asterisk indicates the existence of significant differences of the marked variety between the two types of management ($p < 0.05$).

Fruit production of the different cultivars in the period 2008-2011 is shown in Table 6. In 2008, ten cultivars had a significantly more fruit production in the CMO and no variety was higher in the organic treatment. This year, the mean fruit yield was three times higher in the conventional treatment.

In 2009, only 'Fortune', 'Red Beaut' and 'Black Amber' produced significantly more fruit in the CMO. The rest of the cultivars did not show significant differences. No significant differences were obtained in mean yields of both management types, even though the organic plot produced around 20% less fruit.

Table 5. Foliar composition of 'Golden Japan' and 'Sapphire' plum cultivars in the two orchards in 2007, 2009 and 2010

Cultivar	Management	N	P	K	Ca	Mg	Fe	Mn	Zn	B	Cu
					2007						
Golden Japan	Conventional	3.25	0.21	2.34	2.20	0.44	206	112	23	30	1
	Organic	2.99	0.22	2.14	2.35	0.45	199	103	25	31	12
Sapphire	Conventional	2.58	0.15	2.08	3.03	0.59	334	309	51	< 5	5
	Organic	2.78	0.21	1.92	1.31	0.42	289	162	24	13	9
					2009						
Golden Japan	Conventional	3.63	0.26	2.09	1.26	0.41	322	75	25	33	12
	Organic	3.14	0.23	1.73	0.97	0.43	217	72	22	30	10
Sapphire	Conventional	2.47	0.22	2.63	1.62	0.42	279	58	21	33	12
	Organic	2.95	0.23	2.05	1.30	0.42	193	77	24	30	11
					2010						
Golden Japan	Conventional	2.76	0.21	1.97	0.88	0.33	194	76	18	32	9
	Organic	2.65	0.24	1.72	0.83	0.33	192	90	19	36	10
Sapphire	Conventional	1.95	0.21	2.27	1.14	0.36	190	96	18	31	10
	Organic	2.56	0.20	1.85	1.10	0.34	181	100	20	33	10

Units are given in % (N, P, K, Ca, Mg) and mg kg^{-1} (Fe, Mn, Zn, B, Cu).

Table 6. Comparative fruit production (kg tree^{-1}) of several Japanese plum cultivars from organic (O) or conventionally (C) managed orchards from 2008 to 2011

Cultivar	2008		2009		2010		2011		Accumulated		
	O	C	O	C	O	C	O	C	O	C	O/C
Larry-Ann	1.16	14.50*	16.33	17.16	12.66	24.66*	22.88	9.44	33.54	64.77*	0.52
Fortune	0.66	5.16*	13.16	18.83*	12.33	17.33	25.55	28.00	51.55	69.00	0.74
Souvenir	1.66	5.00*	16.83	26.50	9.33	16.33	12.66	33.88*	40.32	81.54*	0.49
Songold	5.16	14.00*	19.83	18.66	35.83	72.16*	15.00	6.16*	75.67	110.49*	0.68
Sapphire	4.16	7.33	23.00	35.66	14.66	10.66	13.55	19.11	55.21	74.44	0.74
Red Beaut	0.83	9.00*	5.50	14.50*	9.00	9.50	9.33	16.33	24.66	49.33*	0.49
Laetitia	2.33	6.16	42.00	24.16	14.50	15.00	26.11	35.55*	84.44	80.88	1.04
Black Amber	6.00	8.50	8.33	23.00*	38.66*	22.16	3.88	49.09*	56.54	102.75*	0.55
Primetime	1.33	15.00*	12.83	27.33	20.50	52.33*	5.72	2.88	40.05	97.21*	0.41
Santa Rosa	0.50	2.33*	9.33	16.16	7.16	6.50	10.11	6.72	26.77	31.38	0.85
Angeleno	ND	ND	ND	ND	5.33	23.33*	ND	ND	ND	ND	ND
Golden Japan	14.00	27.50*	63.16	51.66	56.00	66.33*	62.22	55.00	195.38	200.49	0.97
Friar	0.50	12.33*	36.16	48.50	2.50	2.50	37.77	55.27	76.77	118.27*	0.65
Showtime	3.83	7.33*	21.66	25.00	35.00	30.16	28.05	11.44*	88.55	73.94	1.19
Mean	3.24	10.29*	21.34	27.52	19.19	26.70	20.98	25.29	64.75	89.80	0.72
Ratio O/C	0.31		0.77		0.71		0.82		0.72		

Data are the mean of 18 trees for each cultivar and treatment. ND: not determined. For each year the asterisk indicates the existence of significant differences between both types of management ($p < 0.05$).

In 2010, five cultivars had significant higher fruit yields in the CMO. Fruit production of 'Sapphire', 'Showtime' and 'Black Amber' was higher in the organic orchard, although only the last cultivar showed a significant difference. Again this year the mean fruit yield did not show a significant difference.

In 2011, 'Souvenir', 'Laetitia' and 'Black Amber' produced significantly more fruit yield in the conventional orchard, while 'Songold' and 'Showtime' produced significantly more in the organic system. Significant differences were not observed in the average yield.

Except for 2008, with a production still erratic, the average fruit production of the organic orchard ranged between 71% and 82% of the conventional one. The 2008-2011 cumulative production showed seven cultivars with a significant higher yield in the CMO.

Flowering

The accumulation of chill units during the cold season (from November 1 to February 15), and the temperatures, relative humidities and rainfall in the flowering periods (the average of the months of February, March and April) are shown in Table 2.

The 2007-2010 periods of flowering of the different cultivars are shown in Fig. 1. In 2007, 'Sapphire', 'Friar', 'Black Amber', 'Songold', and 'Santa Rosa' showed a significantly earlier flowering in the CMO. A non-significant earlier flowering in the OMO was observed in 'Laetitia' and 'Larry-Ann'. The cultivars 'Red Beaut', 'Fortune', 'Souvenir', 'Showtime' and 'Angeleno' began to flower at the same time in both treatments. 'Songold', 'Red Beaut', 'Santa Rosa', 'Angeleno' and 'Sapphire' showed a flowering period significantly longer in the CMO, whereas only 'Friar' had a significantly longer flowering in the organic orchard.

In 2008, 'Larry Ann', 'Fortune', 'Red Beaut', 'Black Amber' and 'Angeleno' initiated flowering simultaneously in both orchards, whereas the other cultivars showed an earlier flowering in the CMO, specially 'Friar', 'Laetitia' and 'Showtime' (Fig. 1).

In 2009, only 'Fortune' initiated flowering simultaneously in both orchards and the remaining 13 cultivars showed a significant earlier flowering in the CMO, exception made for 'Primetime'.

In 2010, 12 cultivars displayed an earlier onset of flowering in the conventional plot, showing significant differences in nine of them, 'Fortune', 'Songold', 'Laetitia', 'Golden Japan', 'Black Amber', 'Primetime', 'Santa Rosa', 'Angeleno' and 'Showtime'.

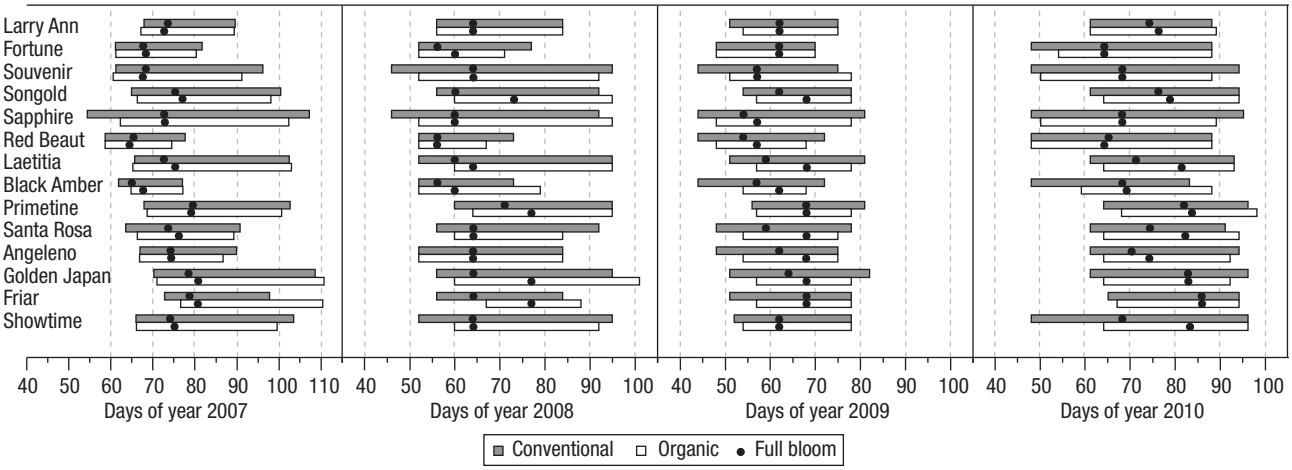

Figure 1. Flowering period of the different Japanese plum cultivars in both orchards in 2007-2010.

Average data of the flowering period in all the four years revealed that flowering in the conventional orchard started from 2 to 6 days before and lasted for 3 to 5 days more than in the OMO (Table 7).

Leaf fall

Defoliation was evaluated several years from October to December. Fig. 2 shows a detailed defoliation rate for all of the cultivars in both orchards in 2008. At the first sampling in third week of October, 10 cultivars showed significantly less foliage in the OMO. In two subsequent samplings, performed in the first and fourth week of November, all the cultivars showed a significantly higher leaf drop in the OMO. In the second week of December, all of the cultivars were completely defoliated in the organic orchard. In the conventional plot, 'Red Beaut', 'Black Amber', 'Friar' and 'Showtime' were also completely defoliated at this time and for the other cultivars 100% of defoliation was achieved by the fourth week of December. An average premature defoliation was detected in the OMO all the years (Fig. 3).

'Showtime', 'Friar', 'Larry-Ann', 'Santa Rosa' and 'Sapphire' showed the higher degree of premature defoliation in the organic plot, while 'Souvenir' and 'Golden Japan' had minor differences in both orchards, and the other cultivars showed an intermediate behaviour. Susceptibility of different Japanese plum cultivars to rust disease caused by *Tranzschelia pruni spinosae* was evaluated, and as shown in Fig. 4, the most defoliated cultivars were those which showed the greatest sensitivity to rust infection.

Table 7. Characteristics of 2007-2010 flowering periods in organic and conventionally managed plum orchards

Year	Treatment	Period of flowering			
		Beginning	Full	End	Duration (days)
2007	Organic	March 6	March 17	April 3	28
	Conventional	March 4	March 19	April 4	31
2008	Organic	February 26	March 6	March 28	30
	Conventional	February 22	March 2	March 28	34
2009	Organic	February 22	March 4	March 16	22
	Conventional	February 18	March 1	March 17	27
2010	Organic	March 1	March 16	April 2	33
	Conventional	February 24	March 13	April 2	38

Data are the average of the 14 cultivars.

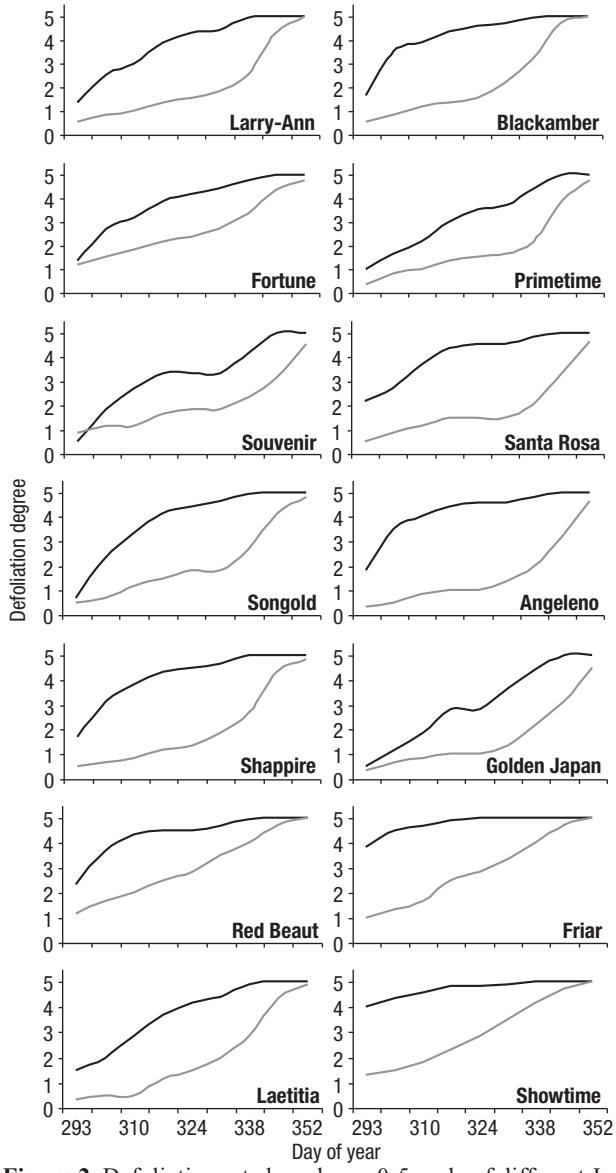

Figure 2. Defoliation rate based on a 0-5 scale of different Japanese plum cultivars in both orchards from October 15 to December 31, 2008. Black line, organically managed orchard; grey line, conventionally managed orchard.

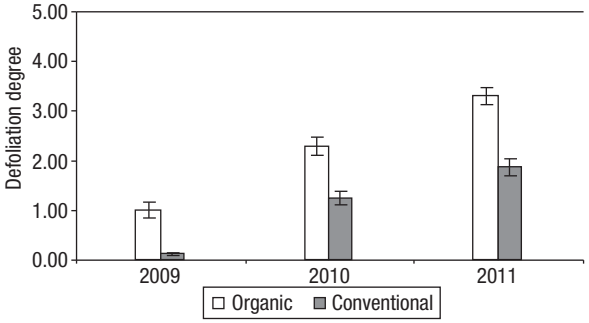

Figure 3. Defoliation degree in each orchard in 2009, 2010 and 2011. Data correspond to the third week of October each year and are media of the 14 cultivars used in the study.

Discussion

Organic farming has been regulated in Europe for almost two decades. Among the strengths of this system is a great respect for the environment, food quality and safety (Pfiffner & Niggli, 1996; Hole *et al*., 2005; Gabriel & Tscharntke, 2007), whereas the weaknesses are often lower yields and the difficulty of controlling pests and diseases (Leake, 1999; Weibel *et al*., 2007; De Ponti *et al*., 2011). Organic tree plantations can be completed through a conversion period of three years from a conventional pre-established planting or starting the organic management from 'scratch'. In this study, we evaluated the effect of two types of management, conventional and organic, on tree growth, yield and some phenological events of different Japanese plum cultivars in two newly established orchards.

After the first year of growth in 2005, we observed that several cultivars had larger TCSA in the organic orchard. During 2005, fertilizers were not added to both orchards, but during the summer of 2004 a highly nutritious soybean plant cover was planted and incorporated into the OMO, which could explain these differences. In the next two years, 2006 and 2007, no differences were found between treatments, but from the fourth year, when fruit production began, various cultivars had larger TCSA in the conventional orchard, and differences still persisted seven years after planting. It seems that likely the difference of vigour may be because of the type of fertilizer applied, though a similar foliar content was observed, and even they were within the optimum ranges (Sanz *et al*., 1991).

The lower tree vigour observed in the OMO might be the cause of the delay in the initiation of bud breaking and flowering and the shorter flowering period. The difference of vigour also led to different yields in both orchards for most of the cultivars.

Another relevant difference observed between both orchards was that defoliation occurred approximately one month earlier in the OMO, and this symptom was especially evident for cultivars suffering high levels of rust disease. García-Galavís *et al*. (2009) evaluated the susceptibility of the cultivars used in this assay to different pests and diseases and they found that rust fungal disease affected more intensively the OMO. Therefore, in organic plum orchards, in addition to optimizing the application of organic fertilizers, it is important to

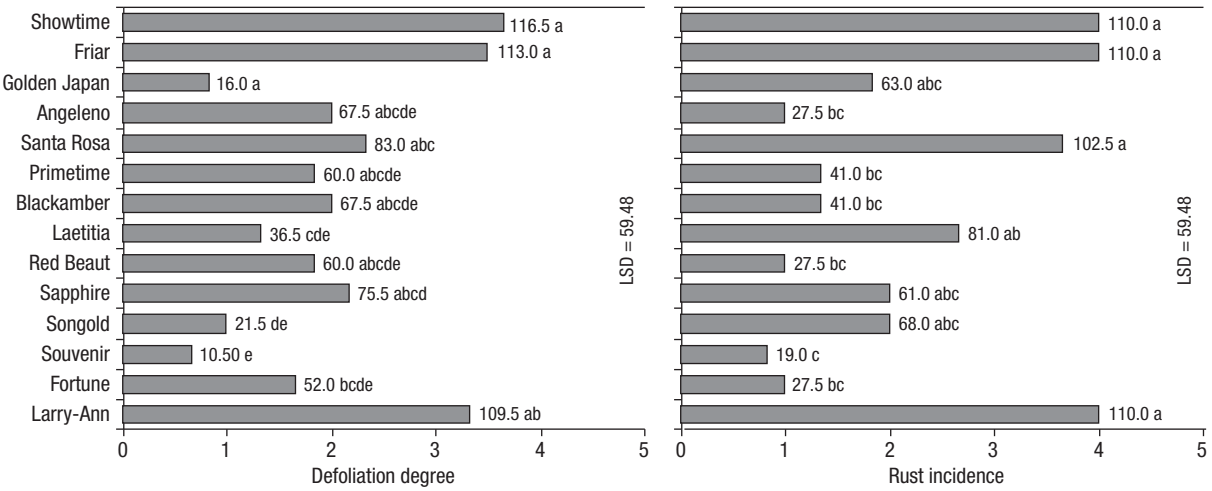

Figure 4. Defoliation degree (left) and rust incidence (right) on different Japanese plum cultivars in an organically managed orchard in the third week of October, 2007. The length of the bars represents the defoliation degree or the disease level on the 0-5 scale. Numbers indicate the mean values in the Kruskal-Wallis test. Different letters indicate that the means are significantly different at $p < 0.05$. LSD, least significant difference.

achieve adequate control mechanisms against rust disease or to use the least susceptible cultivars to this fungus. However, other physiological factors could be involved, because cultivars with low susceptibility to rust disease, such as 'Red Beaut' and 'Souvenir', also showed an earlier leaf drop in the OMO (Fig. 2).

As local weather conditions during the years of the study can be considered normal, it is conceivable that they may have not caused an atypical distortion in the observed results. Only specific aspects deserve to be highlighted; for example in 2010 the cultivar 'Friar' only sparsely flowered due to the low number of chilling hours, and this occurred equally in both orchards. Moreover, technical difficulties prevented to determine adequately the yield of the late variety 'Angeleno'. Fruit quality parameters were reported recently (Daza *et al*., 2012).

We think that this study highlights on some physiological and phenological aspects of the stone fruit trees managed in organic agriculture and could explain the lower yield usually observed in the organic systems (De Ponti *et al*., 2012).

Thus, it seems clear that even on fertile soil, as was in this study, the OMO leads to plum trees with lower vigour than the CMO. Given that leaf and soil compositions did not show nutrient differences that would adequately explain the differences likely the premature defoliation observed in the organic treatment causes a decreases in the accumulation of nitrogen and carbohydrate reserves in the roots and branches before the winter dormancy phase, which might also influence the vigour of trees and also the productivity. We are currently working on this hypothesis, but this is complex to analyze in mature trees, and our results are still preliminary.

In this work was not conducted a comprehensive study of the economic cost in both types of management, but we can indicate some general aspects. The cost of the products used to combat pests and diseases was about 20% higher in the organic orchard. Irrigation and tillage were similar, and fertilization was somewhat more costly in the organic system, but pruning was more economical. In conclusion, we believe that organic plum production was somewhat more expensive mainly due to its lower yield.

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