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Effects of crop method and harvest seasons on yield and quality of green asparagus under tunnel in southern Italy

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Abstract: A three-year study (2007-2009) was carried out on green asparagus under tunnel in Campania (southern Italy) with the purpose of verifying both the possibility to practise organic management and annual double harvest in order to extend the eco-compatible production period and to avoid expensive imports. Comparisons among eight experimental treatments were made. Treatments were obtained by factorial combination of two crop methods (conventional and organic) and four spring and summer harvest periods of 90-day total duration (75 days in spring plus 15 in summer; 60 days in spring plus 30 in summer; 45 days in spring plus 45 in summer; as a control, 90 days in spring), arranging a split plot design with three replicates. The conventional management led to the highest yield, as a consequence of the higher spear number per plant, while the organic management resulted in both spear calibre and mean weight increase. Organic spears showed a higher level of residues and sugars but a lower content of nitrate and fibre. The treatment with 75-day harvest in spring and 15 in summer proved the best double harvest combination, leading to the highest comprehensive yield (11.5 t·ha^{-1}), not different from the control harvested only in spring for 90 days. Summer spears showed higher values of optical residue, glucose, fructose, vitamin C and some mineral nutrients; instead, spring spears attained lower nitrate and average fibre content. Asparagus annual double harvest revealed economically interesting results, but the profits are strictly related to the prices of summer spears, which were evidently higher in summer than in spring in the three years of research.

1. Introduction

Asparagus (*Asparagus officinalis* L.) is widely cultivated in Italy and the total surface area devoted to this crop is as much as 6347 ha, mainly located in Veneto (1610), Campania (1347) and Apulia (1070); notably, Campania is the only Italian region where the species is significantly grown in greenhouse (1052 ha) (ISTAT, 2012).

In the temperate area of the northern hemisphere, asparagus harvest begins after winter rhizome dormancy, when soil temperature is favourable to hypogeous bud resumption (McCormick and Geddes, 1996; Heißner *et al.*, 2006). Therefore, the latter is earlier at lower latitudes and gradually delayed towards the north: in fact, it starts in January in California desert valleys, in February in Italian southern regions and in south Carolina, in May in Holland, end of June in Michigan and in Washington districts (Dufault, 1994 a). The spring harvest duration in greenhouse in southern Italy is usually extended to ninety days, as it occurs in other areas with similar climatic conditions (Shou *et al.*, 2007). Indeed, in such cases the favourable season length allows the plants to completely recover rhizome reservoirs, insuring crop vigour and longevity (Takatori *et al.*, 1970). However, as in Italy the production period is exclusively concentrated in spring, in the other seasons of the year the product demand is satisfied by imports from warmer areas (South Africa, Chile, Mexico, southern California). As an alternative, asparagus production can be achieved by summer forcing, through total aerial biomass cutting and subsequent irrigation a few days before the scheduled harvest. The possibility of annual double harvest has also been proposed in South Carolina (Dufault, 1991, 1995 and 1996) and its convenience seems to be mainly dependent on the favourable season duration. Particularly, the crop forcing achieved at the end of spring or summer could reveal, respectively, too early or late and therefore damage the rhizome reservoir and consequently plant longevity. Instead, a second harvest

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period managed in July-August could allow the plants to reconstruct the aerial biomass both after the spring production and before the winter quiescence. In comparing the traditional spring three-month yield and the comprehensive production derived from the spring and summer harvest, it should be taken into account that the double harvest period can satisfy the consumer requirement in both seasons. Particularly, in summer higher economic profits could be achieved due to both a lack of asparagus spear offer at Italian markets and the potential product demand by tourists. Also, harvest season influences the quality of asparagus spears, which are considered a good source of essential minerals, vitamins, amino acids and dietary fibers (Lopez *et al.*, 1996). In fact, spear nutritional features are highly affected by environmental factors, especially temperature and light (Makus, 1994, 1995; Papadopoulou *et al.*, 2003). In addition, Bhowmik and coworkers (2001) proved that carbohydrate and organic acid contents in asparagus spears were season-dependent. Also fibrousness, though being a varietal peculiarity (Poll and van Kuistrum, 1990; Simón, 1990; Billau *et al.*, 1990; Gast *et al.*, 1991; Sanchez, 1996), is influenced by crop environment and seasonal climate. In particular, it was inversely correlated with rainfall (Keulder and Riedel, 1990) and temperature (Sosa Coronel *et al.*, 1976; Keulder and Riedel, 1990; Poll, 1996), which regulate the spear growth rate. Fibrousness is the consequence of wall lignification of the pericycle cells and vascular bundles (Baxter *et al.*, 1987). According to Haard *et al.* (1974), spear removal causes endogenous ethylene development at an amount stimulating the peroxidase activity involved in lignin synthesis. Also spear diameter influences fibrousness (Clore *et al.*, 1976; Billau *et al.*, 1990; Poll, 1996) because the fibrous bundle number does not change and thus the fibre has a lower relative incidence in higher calibre spears (Herner, 1973).

With the purpose of studying the different aspects mentioned above, research was carried out in Salerno province (southern Italy) on green asparagus under tunnel with the aim of evaluating the effects of crop method and annual double harvest on spear yield and quality.

2. Materials and Methods

Research was carried out in the period 2007-2009 in Fisciano (Salerno province) under tunnel (40°46' N, 14° 48' E, 150 m a.s.l.). The asparagus crop was planted in 2004 on clay-loam soil (Table 1), using cultivar Desto crowns spaced 1.20 m between rows and 0.40 m between the plants along rows. Temperature time course of the three research years are shown in Figure 1.

Eight experimental treatments were compared. Treatments were obtained by factorial combination of two crop methods (conventional and organic) and four spring and summer harvest periods of 90-day total duration (75 days in spring plus 15 in summer, labelled as 75+15; 60 days in spring plus 30 in summer, labelled as 60+30; 45 days in spring plus 45 in summer, labelled as 45+45; as a control, 90 days in spring). A split plot design was used, with three replicates, assigning the crop methods to plots and the harvest periods to sub-plots; the latter had a 17.3 m^2 surface area.

Table 1 - Soil characteristics

Constituents		
Coarse sand	%	24.2
Fine sand	%	29.8
Silt	%	27.2
Clay	%	18.9
Composition		
Organic matter (Walkley and Black method)	%	3.47
Total nitrogen (N) - Kjeldahl method	%	0.21
Available phosphate (P_2O_5) - Olsen method	ppm	12.5
Available potassium (K_2O) - ammonium acetate method	ppm	146.9
Reaction	pH	6.57

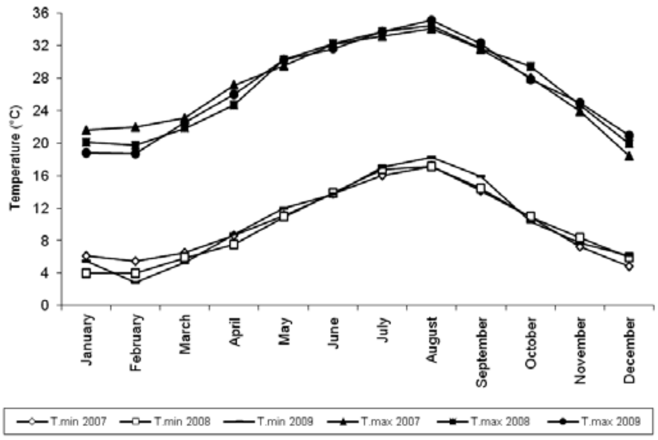

Fig. 1 - Trend of monthly temperatures in greenhouse.

Polytunnels, covered by thermal polyethylene, were made of three structural units, each of them 20 m long, 8 m wide, 2 m high at wall and 3.5 m at roof.

The organic system was managed according to EC Regulation 834/2007, using only substances permitted under the law. For the crop, three fertilizations per year were achieved, before and after spring harvest and after summer harvest, each with 60 kg·ha^{-1} of N, 40 of P_2O_5 and 70 of K_2O, using mineral fertilizer for the conventional method and manure for the "organic". Moreover, weed control was undertaken using linuron chemical treatment (0.75 l·ha^{-1} of a. p.), at spear pre-emergence, in conventional plots and by hand in organic. Drip irrigation was activated at 80% soil available water consumption.

Harvest was carried out twice a year, in spring and in summer, except for the control harvested only in spring. Spear emission in summer was urged by cutting the crop aerial biomass and, at the same time, activating irrigation. In particular, these interventions were made at the beginning of July for the 45+45 treatment, at mid-July for 60+30 and at the end of July for 75+15.

Harvest was practised by hand when the spears emerged 150 mm out of soil and it began on 28 February, 3 March and 2 March, respectively in 2007, 2008 and 2009. At each picking, the plot product was separated in marketable and waste fractions. The latter included the folded, damaged or less than 10 mm thick spears. After harvesting, marketable spears were cut at 30 mm from the base and their calibre was measured on 30-unit random samples.

Moreover, with the aim of estimating product prices during spring harvests, data published by Infomercati (www.infomercati.com) were used. Informercati is a consortium of the main Italian fruit and vegetable wholesale markets, which records and processes the daily prices of each product. In July and August the prices were detected by local sellers to whom the research spears were given, as in summer no asparagus transactions were recorded.

In order to evaluate spear qualitative characteristics, random 30-unit samples were collected in each plot (for three replicates) both in conventional and organic treatments. In the control, this procedure was achieved 45 days after beginning of harvest; in the 75+15, 60+30 and 45+45 treatments sample collection was made 37, 30 or 22 days, respectively after spring harvest and 7, 15 or 22 days after summer harvest. Spears were immediately transferred to the Experimental Station for the Food Preserving Industry, Angri (Salerno) Branch, where the following determinations were made:

- dry residue: in an oven at 70°C under vacuum until steady weight;
- optical residue (expressed in °Brix): on spear sap after squeezing, at a temperature of 20°C, by means of a digital refractometer, model R.F.M81, from BS (Bellingham+Stanley);
- reducing sugars (glucose and fructose) and sucrose: by HPLC, using the 600E Waters chromatographic system and a column Sugar-pak Waters at 85°C, EDTA-Ca in water solution as eluent (50 $mg \cdot l^{-1}$);
- titratable acidity: expressed as grams of monohydrate citric acid per 100 g of product in agreement with the official analysis methods for vegetable preserves of the Italian Ministry of Agriculture and Forestry (MiPAF, 1973);
- proteins: with the Kjeldahl method, utilising a Foss Tecator digestor with a Kjeltec 2300 distiller;
- lipids: measured in accordance with the official analysis methods for vegetable preserves of the Italian Ministry of Agriculture and Forestry (MiPAF, 1973);
- vitamin C: by HPLC using the model 600E Waters chromatographic system, equipped with a 486 Waters UV detector set to 410 nm λ and a column Biorad mod. HPX87H at 35°C;
- fibre: the SIGMA Chemical Company Enzymatic kit was used. The samples were weighed, dried (105°C), gelatinized in the presence of heat-resistant α–amylase and digested enzymatically by proteases and amydoglucosydase, to remove proteins and starch, whereas soluble fibre was precipitated by ethanol. The residue, filtered, washed with ethanol and acetone, dried and weighed, was split into two fractions used to determine, respectively, proteins and ash. Fibre content was obtained by the difference between the weights of the residue and the proteins and ash;
- free amino acids: by means of HPLC with a Waters 600E chromatographic system, connected to a personal computer using Millenium32 software, version 3·05·01, and equipped with a Waters 717 autosampler and a fluorescence detector set at a λ of 205 nm-395 nm. The measurements were carried out utilising: a Waters AccQTag column (spherical C-18, 4 μm 150 x 3.9 mm, at a temperature of 35°C; in condition of gradient with eluent A, or a 140 mM sodium acetate trihydrate buffer, TEA, EDTA-Na2, sodium azide, eluent B, consisting of acetonitrile, and eluent C, which consists of water and with an injection volume equal to 5 μL;
- mineral anions (chlorides, nitrates, phosphates): by HPLC with 600E Waters system, a mod. 717 autosampler and a Dionex column (mod. AS11, 4 x 250 mm);
- mineral cations: (calcium, magnesium, potassium, sodium, iron, copper, zinc): by atomic adsorption spectrophotometry, after sulpho-nitric mineralization, with a model 1100 Perkin-Elmer spectrophotometer.

Data were processed by analysis of variance and Duncan multiple range test was used for mean separation at 0.05 and 0.01 probability levels (n = 3).

3. Results and Discussion

From the data reported in Table 2 it can be stated that there are no significant differences among the research

Table 2 - Asparagus yield results as influenced by crop method and harvest seasons

	Marketable spears			
Treatment	Yield $t \cdot ha^{-1}$	no. per plant	Mean weight g	Calibre mm
Year				
2006	10.3	14.3	35.8	15.6
2007	10.1	14.6	34.4	15.5
2008	10.2	15.1	33.9	15.3
	NS	NS	NS	NS
Crop method				
Conventional	10.7	15.6	34.0	15.1
Organic	9.7	13.7	35.3	15.8
	*	*	*	*
Harvest seasons				
Spring 90 days	11.7 a	16.4 a	35.4 a	15.8 a
Spring 75 days + Summer 15 days	11.5 a	16.5 a	35.1 a	15.6 a
Spring 60 days + Summer 30 days	9.5 b	13.7 b	34.7 a	15.5 a
Spring 45 days + Summer 45 days	8.1 c	12.1 c	33.4 b	14.9 b

NS= not significant; * significant at $p \leq 0.05$.
Means followed by different letters are significantly different according to the Duncan test at $p \leq 0.05$ (n=3).

years in terms of yield. This means that spring harvest did not condition the subsequent summer plant productive behaviour and summer harvest did not condition the crop performances in following year's spring. Moreover, no plant density reductions were recorded.

Conventional asparagus management caused the highest yield, as a consequence of the higher spear number per plant (Table 2). This is consistent with Poll and van Kruistum (1987) referring to a correlation between spear number and yield. Organic management, instead, resulted in spear calibre and mean weight increase. These differences between the two crop methods are the consequence of the yield differences recorded both in spring and summer (Table 3), though the conventional method resulted in higher production than the organic one by 14.2% in spring but only by 6% in summer. Contrary to our results, in previous research (Warman, 1991) no significant difference was detected between the two crop methods.

As for the comparison among the annual double production periods (Table 2), the 75+15 treatment (75-day spring harvest plus 15 days in summer) caused the highest comprehensive yield (11.5 t·ha^{-1}), owing to the highest spear number, calibre and mean weight. However, it was not different from the control harvested only in spring for 90 days. The lowest production was attained by the combination of 45-day spring harvest plus 45 days in summer (8.1 t·ha^{-1}). Notably, the comprehensive yield obtained by the double harvest crops was influenced to a greater extent by spring results than by summer ones, as in the first season more remarkable differences among the treatments were recorded (Table 3). In fact, in spring the production increases caused by the 75+15 treatment were, respectively, by 54% and 170% in comparison with 60+30 and 45+45, though correspondingly the harvest period was 25% and 67% longer. In summer, however, an opposite yield trend was shown by the annual double harvest treatments, but unable to balance the spring results. In fact, in summer the 45+45 treatment had a longer harvest period than 60+30 and 75+15, respectively, by 100% and 200%, to which the same percentage yield increases correspond-ed. The productive results were, therefore, affected by the lower temperatures recorded in March which, in agreement with previous reports (Heiβner *et al.*, 2006), conditioned the shooting rate. The latter was, instead, favoured by the gradual temperature increase, which allowed in the 75+15 treatment to get more than 60% of the whole spring production in the last 30 days of harvest. In fact, quick spear emission is promoted by an air temperature of about 24°C (Bouwcamp and McCully, 1975) or soil temperature of about 20°C and it is correlated with the total yield (Poll and van Kruistrum, 1987; Keulder and Riedel, 1996). Therefore, summer temperature was always very favourable to spear immediate and continuous emission, in agreement with the reports of Dufault (1994 b), thus differences among the harvest treatments were not so remarkable as those recorded in spring. But in summer, yield results were conditioned by spear calibre, with values showing an inverse relation with temperature, consistent with previous findings (Wagenvoort *et al.*, 1980; Pill *et al.*, 1993). Notably, both in spring and summer spear calibre and mean weight decreased from the shortest to the longest harvest period, confirming the effects of harvest pressure on these variables (McGrady and Tilt, 1990).

Table 3 - Asparagus spring and summer yield results as influenced by crop method and harvest seasons

	Marketable spears							
	Yield (t ha^{-1})		No. per plant		Mean weight (g)		Calibre (mm)	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Year								
2006	8.0	3.0	10.6	4.9	38.2	31.0	16.5	14.1
2007	7.9	3.0	11.0	4.9	36.4	30.6	16.3	13.9
2008	8.0	2.9	11.5	4.8	35.7	30.4	16.2	13.8
	NS	NS	NS	NS	NS	NS	NS	NS
Crop method								
Conventional	8.4	3.1	11.8	5.1	36.0	30.1	15.9	13.7
Organic	7.6	2.9	10.2	4.6	37.6	31.2	16.8	14.1
	*	*	*	*	*	*	*	*
Harvest seasons								
Spring 90 days	11.7 a		16.4 a		35.4 c		15.8 c	
Spring 75 days + Summer 15 days	10.0 b	1.5 c	14.1 b	2.4 c	35.7 c	31.4 a	15.7 c	14.6 a
Spring 60 days + Summer 30 days	6.5 c	3.0 b	8.8 c	4.9 b	37.1 b	30.6 b	16.5 b	13.8 b
Spring 45 days + Summer 45 days	3.7 d	4.4 a	4.8 d	7.4 a	38.9 a	30.0 c	17.2 a	13.4 c

NS = not significant; * significant at p≤ 0.05.
Means followed by different letters are significantly different according to the Duncan test at p≤0.05 (n=3).

Table 4 - Asparagus spear quality as influenced by crop method and harvest seasons

Treatment	Dry residue (g·100 g-1 FW)	Optical residue (°Brix)	Glucose (g·100 g-1 DW)	Fructose (g·100 g-1 DW)	Sucrose (g·100 g-1 DW)	Acidity (g·100 g-1 DW)	Protein (g·100 g-1 DW)	Lipids (g·100 g-1 DW)	Vitamin C (mg·100 g-1 DW)
Crop method									
Conventional	8.38	6.72	4.54	7.54	1.55	4.93	31.4	6.20	659.9
Organic	9.11	7.26	5.40	8.41	1.77	5.02	32.4	6.26	673.0
	*	*	*	*	*	NS	NS	NS	NS
Harvest seasons									
Spring	8.64	6.81	4.83	7.78	1.63	4.87	31.7	6.13	627.0
Summer	8.85	7.18	5.11	8.17	1.69	5.08	32.1	6.33	705.9
	NS	*	*	*	NS	NS	NS	NS	*

NS= not significant; * significant at p≤ 0.05 (n=3).

Our research showed that the goal of annual double harvest is pursuable in terms of yield in irrigation regime, if the traditional spring harvest is reduced from 90 to 75 days and integrated with 15 days of summer harvest. Alternative double harvest combinations, represented by 60-day spring harvest plus 30-day summer harvest or by 45-day harvest both in spring and summer, caused significantly lower yields than the control. Nevertheless, their economic profits are strictly related to the prices of summer spears. In this regard, the mean prices of green asparagus spears recorded in the three years of research were evidently higher in summer (5.5 €·kg^{-1} in July and 6.0 in August) than in spring (3.45 €·kg^{-1} in March, 2.68 in April and 2.36 in May).

From the statistical processing of spear quality data no significant differences were recorded both between the examined years (2008 and 2009) and among the different harvest durations within the same season. Therefore, only the results concerning the comparison between conventional and organic methods and between spring and summer harvest are reported (Tables 4, 5, 6 and 7).

With regard to quality indicators (Table 4), organic management resulted in higher values of dry and optical residues, glucose, fructose and sucrose than conventional cultivation, whereas acidity, proteins and lipids were not affected by crop method.

Also the harvest season had significant influence on quality, as summer spears showed higher values of optical residue, glucose, fructose and vitamin C than the spring ones; instead, no significant change was detected for dry residue, sucrose, titratable acidity, lipids and proteins. The latter result was similar to that of Shou *et al*. (2007) but, differently from our findings, these authors reported a decreasing trend for dry residue and reducing sugars and an increasing trend for acidity. Among the sugars, fructose attained higher incidence than glucose and sucrose, as also it resulted in our research. With respect to ascorbic acid, both Esteve *et al*. (1995) and Shou *et al*. (2007) found a content decrease in summer spears compared with spring ones.

Fibre content was affected by crop method (Table 5), as organic spears attained lower values than conventional ones. Also significant differences were recorded between spring and summer spears, as the latter showed higher average fibrousness, consistent with previous reports (Shou *et al*., 2007). Presumably, in summer the spear fibre increase caused by calibre reduction prevailed the opposite effect of temperature; in fact, the latter is inversely correlated with fibre content during spear growth, as reported by Sanchez (1996).

With respect to the fibre content of each 5 cm fraction obtained by spear split, the organic method led to higher values than the conventional in all the comparisons (Table 5). Regarding harvest season, it was found that summer spears showed higher fibre content than the spring ones only from the basal to the middle fraction. As for fibre content along the spear, the highest value was detected in the white basal fraction and it was as much as 2.6 times higher than the one recorded in the green tip (respectively, 28.1 and 11.0%). Haard *et al*. (1974) stated that fibre reduction towards the spear tip is the consequence of isoperoxidase changes, which start from the cut surface and gradually extend to the tip.

Table 5 - Asparagus spear fibrousness as influenced by crop method and harvest seasons

Treatment	Spear fibre content	Fibre content per spear section from tip to base (cm) 0-5 (g·100 g-1 DW)	5-10 (g·100 g-1 DW)	10-15 (g·100 g-1 DW)	15-20 (g·100 g-1 DW)	20-25 (g·100 g-1 DW)
Crop method						
Conventional	18.8	11.7	12.8	14.1	24.8	30.7
Organic	15.9	10.3	11.1	11.7	20.8	25.5
	*	*	*	*	*	*
Harvest seasons						
Spring	16.6	11.0	11.6	12.1	21.6	26.5
Summer	18.1	10.9	12.3	13.7	24.0	29.7
	*	NS	NS	*	*	*

NS= not significant; * significant at p≤ 0.05 (n=3).

Concerning the amino acids, we have reported only the mean composition and the statistical differences among the individual compounds (Table 6), as both crop method and harvest season did not cause any significant effect on this variable. With regard to composition, glutamine and asparagine showed the highest content in the asparagus spears, whereas cystine, methionine, tyrosine and histidine displayed the lowest. These results are consistent with those reported by other authors (Shou *et al*., 2007; Slupski *et al*., 2010).

As for spear chemical composition (Table 7), sodium and copper showed significant higher contents in organic crops, whereas the conventional method led to higher nitrate accumulation; the other ions examined were not affected by crop management. In previous research (Warman, 1991) no significant differences were recorded between conventional and organic methods with regard to spear mineral nutrients. With respect to harvest season, summer spears showed higher sodium, iron and zinc than the spring ones. In the latter season, contrary to the findings of other authors (Shou *et al*., 2007), a significantly higher nitrate content was detected, which was however lower than the one recorded in other research (Shalaby *et al*., 2004).

Table 6 - Asparagus spear amino acid composition (average of crop methods and harvest seasons)

Amino acids	Content ($g \cdot 100\ g^{-1}$ DW)
Alanine	1.18 bd
Arginine	1.24 bc
Asparagine	3.60 a
Cystine	0.16 h
Glutamine	3.97 a
Glycine	0.76 cf
Histidine	0.40 fh
Isoleucine	1.03 ce
Leucine	1.11 bd
Lysine	1.23 bd
Methionine	0.29 gh
Phenylalanine	0.62 eg
Proline	1.56 b
Serine	1.05 cd
Threonine	0.74 df
Tyrosine	0.37 fh
Valine	0.97 ce

Means followed by different letters are significantly different according to the Duncan test at $p \leq 0.05$ (n=3).

4. Conclusions

A three-year investigation (2007-2009) was carried out on green asparagus under tunnel in Salerno province (Campania, Italy) in order to investigate the effects of crop method and annual double harvest on spear yield and quality. Organic crops did not give as high yields as the conventional, but produced better spear quality in terms of higher level of residues and sugars and lower content of nitrate and fibre. Asparagus summer forcing, achieved through the plant aerial biomass cut and irrigation, did not limit the crop productivity but revealed interesting economically. Compared with the traditional 90-day harvest period, the annual double production practised for 75 day in spring and 15 in summer did not significantly differ in terms of yield. However, production decreased with the other spring-summer combinations, made up of 60-day harvest in spring plus 30 in summer or of 45-day harvest in both seasons. Nevertheless, the annual double harvest effectiveness also depends on asparagus market receptivity, which in summer is potentially interesting owing to tourist demand. This perspective is supported by the investigation conducted during our research: higher spear prices in summer than in spring (on average, respectively 5.75 $€ \cdot kg^{-1}$ vs 2.83) due to the lack of Italian product offer. From a qualitative point of view, summer spears showed higher

Table 7 - Asparagus spear chemical composition as influenced by crop method and harvest seasons

Treatment	Calcium ($mg \cdot 100\ g^{-1}$ DW)	Magnesium ($mg \cdot 100\ g^{-1}$ DW)	Potassium ($mg \cdot 100\ g^{-1}$ DW)	Sodium ($mg \cdot 100\ g^{-1}$ DW)	Iron ($mg \cdot 100\ g^{-1}$ DW)	Copper ($mg \cdot 100\ g^{-1}$ DW)	Zinc ($mg \cdot 100\ g^{-1}$ DW)	Chlorides ($mg \cdot 100\ g^{-1}$ DW)	Phosphates ($mg \cdot 100\ g^{-1}$ DW)	Nitrates ($mg \cdot 100\ g^{-1}$ DW)
Crop method										
Conventional	25.0	22.2	249.6	3.5	1.19	0.12	0.95	57.1	62.4	45.9
Organic	23.5	21.7	263.9	4.2	1.16	0.15	0.93	57.7	66.7	14.2
	NS	NS	NS	*	NS	*	NS	NS	NS	*
Harvest seasons										
Spring	24.0	21.7	254.0	3.7	1.11	0.13	0.89	55.2	63.9	43.2
Summer	24.5	22.2	259.5	4.0	1.24	0.14	0.99	59.6	65.3	16.9
	NS	NS	NS	*	*	NS	*	NS	NS	*

NS= not significant; * significant at $p \leq 0.05$ (n=3).

values of optical residue, glucose, fructose, vitamin C and some mineral nutrients, compared with the spring product. Nevertheless, the latter attained lower fibre content, though only from the middle to the basal fraction.

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