EVALUATION OF GREEN ASPARAGUS VARIETIES IN THE BÍO-BÍO REGION, CHILE

Evaluación de variedades de espárrago verde en la Región del Bío-Bío, Chile

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A B S T R A C T

A trial was established using three month old asparagus (*Asparagus officinalis* L.) plants in a volcanic soil at Chillán (36°32' S; 71°55' W). Experimental design was randomized complete blocks with four replicates. Plots had four 6 m long rows of plants. Distance between rows was 1.5 m and in-row 0.2 m. The evaluated cultivars were: 'Atlas', 'Grande' and 'Apollo' from Asparagus Seeds and Transplants (California), 'Jersey Giant', 'Jersey Gem', 'Jersey General', 'Jersey King', 'Jersey Knight' and 'Jersey Supreme' from Jersey Asparagus Farms (New Jersey), and the controls were 'UC-157' F_1 and F_2. Spears were trimmed 18 cm long after harvest. The highest cumulative marketable yield was obtained by 'Jersey Supreme' (43 Mg ha^{-1} in five years), and the lowest one by 'Apollo' (17.8 Mg ha^{-1}). Marketable yield of both control 'UC-157' F_1 (24.9 Mg ha^{-1}) and F_2 (24.3 Mg ha^{-1}) was similar ($P \leq 0.05$) to the other Jersey cultivars, but higher than 'Apollo'. The main disadvantage of 'Jersey Supreme' is the purple coloration of its bud scales, and a purple cast to the butt of the spear, therefore discarded for the fresh market, but suitable for freezing. Another disadvantage is that spears tend to open to a smaller height than 'UC-157', and 10% more of its production is destined to internal market (País category).

Key words: *Asparagus officinalis*, cultivar, number of spears, quality, yield.

R E S U M E N

Se estableció un ensayo con plantas de espárrago (*Asparagus officinalis* L.) de tres meses de edad, en un suelo derivado de cenizas volcánicas en Chillán (36°32' lat. Sur; 71°55' long. Oeste). El diseño experimental fue de bloques completos al azar con cuatro repeticiones. Las parcelas estuvieron compuestas por cuatro hileras de 6 m de largo. La distancia entre hileras fue de 1,5 m, y 0,2 m sobre la hilera. Los cultivares evaluados fueron: 'Atlas', 'Grande' y 'Apollo' de Asparagus Seeds and Transplants (California), 'Jersey Giant', 'Jersey Gem', 'Jersey General', 'Jersey King', 'Jersey Knight' y 'Jersey Supreme' de Jersey Asparagus Farms (New Jersey), y los testigos 'UC-157' F_1 y F_2. Los turiones se cortaron a 18 cm después de cosechados. El rendimiento comercial acumulado más elevado ($P \leq 0,05$) correspondió a 'Jersey Supreme' (43 Mg ha^{-1} en cinco años) y el inferior a 'Apollo' (17,8 Mg ha^{-1}). El rendimiento comercial de ambos testigos 'UC-157' F_1 (24,9 Mg ha^{-1}) y F_2 (24,3 Mg ha^{-1}) fue similar ($P \leq 0,05$) al de los otros cultivares Jersey, pero más alto que el de 'Apollo'. La principal desventaja de 'Jersey Supreme' es la coloración púrpura de sus brácteas y de la base de los turiones, lo que la descarta para el mercado fresco, pero es adecuada para congelado. Otra desventaja es que sus turiones tienden a abrirse a menor altura que 'UC-157', teniendo un 10% más de su producción destinada al mercado interno.

Palabras clave: *Asparagus officinalis,* cultivar, número de turiones, calidad, rendimiento.

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Received: 30 July 2006. Accepted: 16 october 2006.

INTRODUCTION

The selection of asparagus (*Asparagus officinalis* L.*)* cultivars is important because plantations must remain productive for several years to recover the initial investment and obtain good returns. The productive response of a variety depends on the interaction between its genotype and the environment. Therefore, the cultivars must be evaluated in the zone where they will be introduced.

It is estimated that 90% of the surface with asparagus in Chile is planted with the 'UC-157 F_1' and 'UC-157 F_2' varieties; the seed of the F_2 generation is produced in the country and the quality of the commercial product has been good, with a tight spear and deep green color. However, the fact that this production is based practically on one variety only is a risk from the sanitary point of view. The yields of asparagus in Chile have been decreasing during the last few years, sometimes down to levels that make cultivation barely profitable; this situation may be due to the variety cultivated and/or mistakes in the management of the plantations.

'UC-157' is one of the most planted green asparagus cultivar on the warm and temperate zones of the world. Many trials have been conducted in different places to find new alternatives of asparagus cultivars using 'UC-157' as control (Carballo *et al*., 1992; McCormick and Thomsen, 1995; Mullen *et al*., 1996; 1999; 2002; Cueto and Lesnick, 1999; Garrison *et al*., 1999; Stone and Roose, 1999; Drost, 2002), plus the International Asparagus Cultivar Trials (IACT) organized by the Asparagus Working Group of the International Society for Horticultural Science (Knaflewski, 1996; Paschold *et al*., 1996; Van Oordt *et al*., 1999; Benson, 2002; Jinsong, 2002). In general, 'UC-157' yield is very low in cold climates localities in Europe, where the German and Dutch cultivars predominate (Knaflewski, 1996b; Paschold *et al*., 1996).

Asparagus cultivars evaluation trials have been conducted in different zones of Chile from the beginnings of the 90 decade, with the objective to find new cultivars that could replace or complement 'UC-157' (Krarup and Henzi, 1993; Krarup, 1996; González and del Pozo, 1999; 2002).

The Second IACT was established in 1994 in the Central Zone (Metropolitan Region, 33°40' lat. South) and South Zone (Lakes Region, 39°48' lat. South) of Chile. Among 14 asparagus cultivars assessed in the central zone, 'UC-157' reached first place in commercial yield. Among 27 cultivars assessed in the South, 'UC-157' occupied the fifteenth place, after eight harvest seasons in both assays (Benson, 2002). The first place in the southern zone was reached by 'Jersey Giant'.

In the Bío-Bío Region (36°29' lat. South) preliminary results indicated that the commercial yield of 'UC-157 F_2' was similar to that of 'Jersey Giant' and 'Jersey Knight', but higher than 'Apollo' (González and del Pozo, 1999). In another trial, where some German varieties were compared to the Californian varieties 'Atlas', 'Apollo', and 'Grande', the 'UC-157 F_2' control was exceeded by the latter, both in total as well as commercial and export yields, but not by the German varieties (González and del Pozo, 2002).

The purpose of this trial was to compare the behavior in yield and quality of some promising asparagus cultivars of the Jersey and other types from California, to UC-157 F_1' and 'UC-157 F_2'.

MATERIALS AND METHODS

The trial was established on December 21 1999, using 14 week old plantlets obtained in the greenhouse in the Quilamapu Regional Research Center of the National Institute of Agricultural Research, Chillán (36°32' lat. South; 71°55' long. West), in a soil of volcanic origin classified as Dystrandepts. The climate is a typical Mediterranean one, mean yearly precipitation 1,200 mm and average yearly temperature 13.1 °C, minimum 3.0 °C in July and maximum 28.6 °C in January (del Pozo and del Canto, 1999).

The experimental design was a completely randomized blocks, four repetitions, and plots constituted by four 6 m long rows. The planting distance was 1.5 m between rows and 0.2 m between plants in the row, and a planting depth of 20 cm. Cultivars evaluated were: 'Atlas', 'Grande' and 'Apollo' of Asparagus Seeds and Transplants (California) (Benson *et al*., 1996), 'Jersey Giant' (Ellison and Kinelski, 1985), 'Jersey Gem', 'Jersey General', 'Jersey King', 'Jersey Knight', and 'Jersey Supreme' of Jersey Asparagus Farms (New Jersey) (Ellison *et al*., 1990), and the controls 'UC-157' F_1 and F_2.

The soil was fertilized before planting, with 138 kg ha^{-1} P_2O_5, 50 kg ha^{-1} K_2O and 48 kg ha^{-1} N, applied as triple superphosphate, muriate of potash, and sodium nitrate, respectively. One month after planting, an application of 48 kg ha^{-1} N took place. During the second year (2001) 135 kg N ha^{-1} were applied as sodium nitrate; on the third year (2002) 180 kg N ha^{-1} as potassium nitrate; the fourth year (2003) 135 kg N ha^{-1} as sodium nitrate; the fifth year (2004) 135 kg N ha^{-1} as urea and in the sixth year (2005) 80 kg N ha^{-1} as potassium nitrate were applied, divided in three equal portions during the summer (aerial growth period). During the first year, weeds were controlled manually, and from the second year on, metribuzine (1 L i.a. ha^{-1}) was applied during winter, before harvest, continuing with hand weeding during and after harvest, complemented by rotary tiller passes between the rows. Plants received furrow irrigation after harvest, until March of the next year, on an average of seven irrigations per season.

The plots were harvested from Mondays to Saturdays from the first appearance of spears, until October 12 on 2001; December 2 on 2002; November 29 on 2003; December 3 on 2004, and December 2 on 2005. Spears were weighed immediately after harvest, before cutting and selection, this was the field yield. Later on, the spears were cut to 18 cm long and were weighed to determine the total yield. Total yield was composed of the commercial yield and rejects; the commercial yield was divided into exportable yield and "País" or domestic market portion. The reject was formed by spear having a diameter below 7 mm, open tips, twisted (angle > 90º), severely damaged by insects, diseases or frost. The "País" category was composed of spears less twisted than the hulls (between 45 and 90°), flat, with slight damage from larvae and slugs, stained by *Stemphylium vesicarium* and/or those where bud scales had started to open (swollen tip). The remainder of the commercial quality was made up by exportable calibers (diameter > 7 mm), tight heads and no damages. The export market spears were divided into two categories: those with a diameter (measured 2 cm away from the cut) between 7 and 17 mm (Small, Standard and Large) and the ones thicker than 17 mm (Extra Large and Jumbo).

The results obtained were subjected to variance analysis, comparing means through a least significant difference (LSD) test with the statistics program IRRISTRAT (IRRI, 2003).

RESULTS AND DISCUSSION

J. Supreme cultivar showed the uppermost accumulated yield of five seasons in all categories (field, total, commercial and export markets). The variety showing the lowest yield was Apollo, which did not differ statistically from some Jersey type cultivars, but was below the controls 'UC-157' F_1 and F_2 (Table 1). During trials carried out in Michigan and harvested through seven seasons, "J.

Table 1. Cumulative yield of different asparagus cultivars over five harvest seasons (2001-2005).
Cuadro 1. Rendimiento acumulado de diferentes cultivares de espárrago en cinco temporadas de cosecha (2001-2005).

Cultivar	Yield (Mg ha^{-1})			
	Field	Total	Commercial	Export
Jersey Supreme	71.8 a	47.6 a	43.0 a	23.3 a
Jersey Gem	42.5 b	28.6 b	24.8 b	12.2 de
Jersey King	39.6 b	26.9 bc	23.8 bc	12.3 de
Jersey General	39.3 bc	27.1 bc	24.9 b	14.6 bcd
Jersey Knight	39.2 bc	24.9 bc	23.5 bc	12.4 de
Jersey Giant	37.8 bc	25.8 bc	22.7 bc	12.5 cde
Grande	43.6 b	30.4 b	26.8 b	16.5 b
Atlas	42.9 b	30.3 b	26.4 b	16.3 bc
Apollo	29.1 c	20.1 c	17.8 c	10.5 e
UC-157 F_1	41.2 b	29.0 b	24.9 b	15.6 bcd
UC-157 F_2	40.3 b	28.4 b	24.3 b	14.9 bcd
VC (%)	16.8	16.8	17.1	18.1

According to the LSD test ($P \leq 0.05$), means followed by the same letter in the columns do not differ significantly.
VC: Variation coefficient; LSD: Least significant difference.

Supreme" was the variety with the highest yield among 36 cultivars evaluated (Garrison *et al.*, 1999). It has also been pointed out as one of the most promising varieties for the Connecticut area of the United States (Elmer *et al.*, 1999). The main disadvantage of 'J. Supreme' as well as that other varieties of the Jersey type, is the intense antocianin coloration of its bud scales –this would limit its export as fresh produce but not when frozen– as this includes a blanching process which eliminates this color and turns it to green.

The lack of differences between the yield of the control 'UC-157 F_1' and 'J. Giant' (Table 1), which is catalogued as a variety with intermediate yield as compared to 'UC-157 F_1', considered of low yield, on the basis of the photosynthetic efficiency of its foliage (Faville *et al.*, 1999) is noteworthy. However, in the Second International Asparagus Cultivar Trial, where both varieties were used as controls 'UC-157 F_1' was superior in commercial yield to 'J. Giant' in five of the six temperate climate localities used as trial sites, and in two of them it occupied the first place (Benson, 2002). 'UC-157' may possibly have a better adaptation capacity to different environments. In this regard, Contreras and Krarup (2000) determined that 'UC-157' F_1 and F_2 were the cultivars with better capacity of response to environmental improvements, as compared to 'Atlas', 'J. Giant' and 'Mary Washington'.

In former trials (González and del Pozo, 1999; 2002) 'UC-157 F_2' always showed a lower yield than 'UC-157 F_1', but this condition was not observed in this case (Table 1). 'UC-157 F_1' is a clonal hybrid, product of the crossing of two varieties that are not homozygous, and both descending from the older north-American cultivar Mary Washington (Knaflewski, 1996a), so some seeds coming from a plantation of this hybrid could eventually give similar yield results. In this case, the 'UC-157 F_2' seeds were collected from vigorous 'UC-157 F_1' plants, and this could explain the good results. During a study carried out in Chillán, the aerial and subterranean growth of both cultivars was assessed during the first year and no differences were observed between 'UC-157 F_1' and 'UC-157 F_2' in any of the parameters evaluated (Pertierra *et al.*, 2006). On the other hand, it is well known that it is very difficult to distinguish between a F_1 and a F_2 of a clonal hybrid. This fact has led the search for molecular markers of different alleles for which the parents of that hybrid cultivar would be homozygous (Roose and Stone, 1996).

The J. Supreme cultivar had the highest yield from the first harvest season, and showed a marked difference from the rest of the varieties only from the second year (Table 2). The behavior of asparagus in the first harvest year may not be a good indicator of what could happen later on. This is

Table 2. Marketable yield (Domestic market + Export) of different asparagus cultivars over five harvest seasons (2001-2005).

Cuadro 2. Rendimiento comercial (País + Exportación) de diferentes cultivares de espárrago durante cinco temporadas de cosecha (2001-2005).

Cultivar	Marketable yield (Mg ha^{-1})				
	2001	2002	2003	2004	2005
Jersey Supreme	2.96 a	8.68 a	8.89 a	12.17 a	10.30 a
Jersey Gem	1.92 cde	5.20 b	5.50 b	6.66 bc	5.50 bc
Jersey General	2.16 be	4.31 bc	5.55 b	6.13 bc	5.16 bc
Jersey King	2.44 ad	5.11 b	4.73 bc	6.22 bc	5.28 bc
Jersey Giant	2.65 ab	4.56 bc	4.23 bc	5.62 bc	5.65 bc
Jersey Knight	1.76 e	5.31 b	5.49 b	6.12 bc	4.82 bc
Grande	2.61 ab	5.74 b	5.50 b	6.97 b	6.02 b
Atlas	2.69 ab	5.35 b	5.77 b	7.08 b	5.49 bc
Apollo	2.51 abc	2.85 c	3.39 c	4.78 c	4.25 c
UC-157 F_1	2.52 abc	4.07 bc	5.21 bc	6.87 b	6.39 b
UC-157 F_2	1.83 de	4.84 bc	5.66 b	6.46 bc	5.53 bc
VC (%)	16.7	28.9	23.9	19.3	18.6

According to the LSD test ($P \leq 0.05$), means followed by the same letter in the columns do not differ significantly.
VC: Variation coefficient; LSD: Least significant difference.

clearly seen in the commercial yield of 'Apollo'; it was the lowest of all, starting from the second year, although it was among the highest during the first year. The correlation coefficient between the yield in the first year (2001) and in the last year (2005) was 0.55, and a linear regression gave a R^2 equal to 0.3. The correlation coefficients between the first year and the intermediate years (2002 to 2004) were smaller, varying from 0.24 to 0.27. This shows the lack of relationship between the yield obtained during the first year and the following years. In a previous trial where 'J. Supreme' was included but which was assessed during two seasons only due to an intense Fusarium attack, showed a commercial yield slightly superior to controls 'UC-157', but the export yield was lower than the controls (González and del Pozo, 2002). In almost all varieties, a decrease in commercial yield was observed during the last season, except for 'J. Giant' which maintained its yield of the previous year (Table 2).

When analyzing production over time during the last harvest season (Figure 1) it can be seen that the controls 'UC-157' started harvest during the last week of August, and were met by 'J. Supreme' as to volume produced towards the end of September; the latter becoming quickly differentiated from the rest of the varieties. Production of all varieties fell down during October, due to the drop of mean temperatures below 10 ºC (Keulder and Riedel, 1996). 'J. Supreme' and 'Apollo' can be differentiated easily from the rest of the varieties in Figure 1, as they show extreme yields, but 'UC-157 F_1' can also be distinguished in the upper section of the group.

The number of spears harvested per surface unit, which is the main yield component in asparagus, was much higher in J. Supreme variety from the second year on (Table 3), and coincides with what is determined in commercial yield (Table 2). The 'UC-157' controls followed 'J. Supreme' as to the total of spears harvested during the five seasons, but did not differ from 'J. Giant' (Table 3).

It is important to evaluate the proportion of thin spears (diameter 7-17 mm) in the production, as foreign markets now prefer this type of caliber rather than thick spears. 'J. Supreme' and the 'UC-157' control varieties were uppermost in this respect, as they produced a larger percentage of thin spears and an export production superior to the average of all cultivars. J. Giant, J. King, and Apollo cultivars also had a high proportion of thin spears, but their export yield was low (Figure 2).

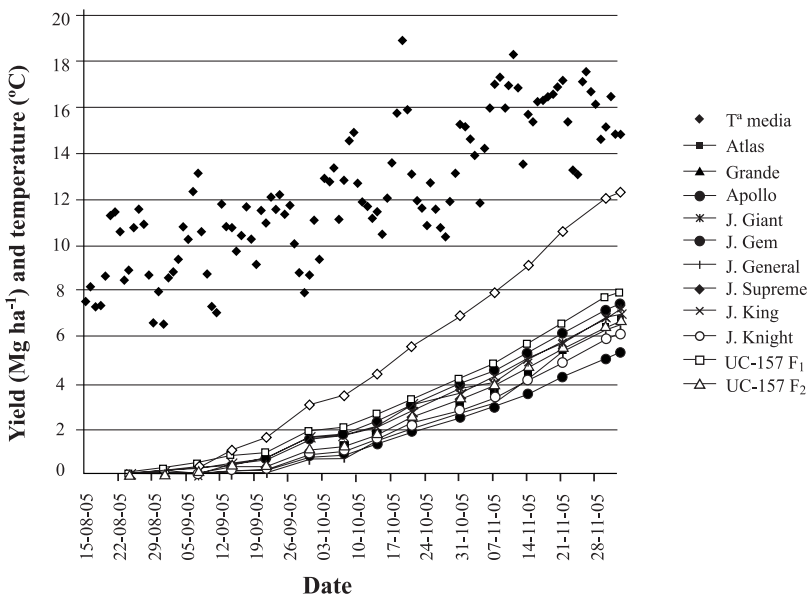

Figure 1. Cumulative total yield of asparagus cultivars during 2005 harvest season, and mean temperature during the harvest period.

Figura 1. Rendimiento total acumulado de las variedades de espárrago en la temporada de cosecha 2005 y temperatura media del período de cosecha.

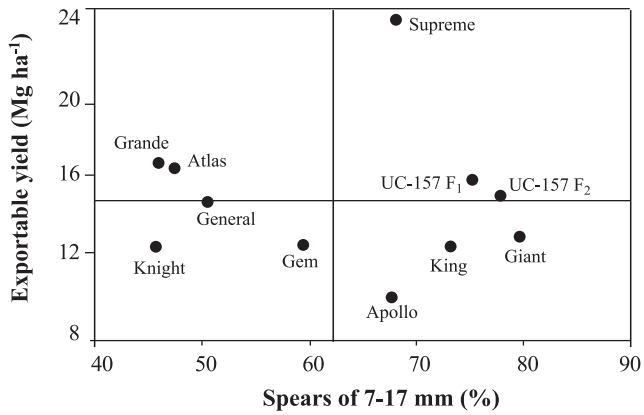

Figure 2. Relationship between cumulative exportable yield in five seasons (2001-2005) and percentage of exportable spears with 7-17 mm diameter (average of five seasons, 2001-2005). Perpendicular lines in each axis correspond to the average of all cultivars. LSD (P ≤ 0.05) of exportable yield is 3.84, and of the percentage of 7-17 mm spears is 6.56.
LSD: Least significant difference.

Figura 2. Relación entre el rendimiento exportable acumulado de cinco temporadas (2001-2005) y el porcentaje de turiones exportables de 7-17 mm de diámetro (promedio de cinco temporadas, 2001-2005). Las líneas perpendiculares en cada eje corresponden al promedio de todos los cultivares. DMS (P ≤ 0,05) de rendimiento exportable es 3,84 y del porcentaje de turiones de 7-17 mm es 6,56.
DMS: diferencia mínima significativa.

Table 3. Number of harvested spears of different asparagus cultivars per unit area, over five harvest seasons (2001-2005).

Cuadro 3. Número de turiones cosechados por unidad de superficie en diferentes cultivares de espárrago durante cinco temporadas de cosecha (2001-2005).

Cultivars	Number of spears m^{-2}					
	2001	2002	2003	2004	2005	Total
Jersey Supreme	17.0 a	47.7 a	47.7 a	53.7 a	59.2 a	225.2 a
Jersey Giant	16.6 a	28.4 cd	30.7 be	28.9 cd	39.8 bc	144.4 bc
Jersey Gem	9.8 bcd	27.9 cd	28.8 def	31.1 bc	36.5 cd	134.1 cd
Jersey King	12.8 b	26.8 cd	32.9 bcd	27.8 cd	33.4 de	133.7 cd
Jersey General	9.2 cd	26.9 cd	25.2 efg	25.8 cd	30.9 de	117.3 cde
Jersey Knight	7.7 d	23.5 de	21.8 g	23.2 d	26.2 e	102.5 e
Atlas	13.0 b	26.8 cd	29.3 cde	28.8 cd	33.1 de	130.9 cd
Grande	11.5 bc	25.6 d	29.2 cde	29.4 cd	32.9 de	128.6 cde
Apollo	12.4 b	18.6 e	22.6 fg	26.7 cd	32.7 de	113.1 de
UC-157 F_1	16.1 a	32.6 bc	35.5 bc	37.7 b	45.7 b	167.4 b
UC-157 F_2	11.8 bc	35.8 b	36.4 b	37.1 b	44.3 bc	165.9 b
VC (%)	16.0	16.2	14.1	16.7	15.2	13.7

According to the LSD test (P ≤ 0.05), averages followed by the same letter in the columns do not differ significantly.
VC: Variation coefficient; LSD: Least significant difference.

The proportion of the total production destined to the domestic market (País) and the discards varied in every season, depending on environmental conditions. Table 4 shows the five seasons average percentage of "País" production and its causes; it can be appreciated that this production fluctuated by about 40%, the Californian varieties showing the lowest percentages.

The main causes of the production destined to the domestic market were open and twisted spears. In this respect the 'UC-157' controls were singled out by a lesser proportion of open spears. Male asparagus plants tend to branch out at a lower height than female plants (Roose and Stone, 1999); this would explain the greater proportion of open

Table 4. Criteria for the selection of spears for the domestic market (País) and their percentages as to the total yield, in different asparagus cultivars. Average of five harvest seasons (2001-2005).

Cuadro 4. Causas de selección de los turiones para el mercado interno (País) y sus porcentajes en el rendimiento total, en diferentes cultivares de espárrago. Promedio de cinco temporadas de cosecha (2001-2005).

Cultivars	Total yield percentage					
	Open	Twisted	Stained	Damaged	Flat	'País' total
Jersey King	18.31 b	10.31 fg	9.48 abc	4.35 ab	1.22 cd	43.67 a
Jersey Gem	20.93 a	11.95 ef	5.65 g	2.75 ab	2.17 a	43.44 a
Jersey Knight	14.54 c	14.22 bc	9.73 ab	1.85 b	1.81 ab	42.15 ab
Jersey Supreme	14.43 c	10.98 efg	10.66 a	4.24 ab	1.13 cd	41.44 ab
Jersey Giant	15.01 c	10.13 g	9.95 ab	4.93 a	0.78 def	40.79 ab
Jersey General	13.65 c	12.39 de	9.00 bcd	3.26 ab	0.56 ef	38.85 bc
Apollo	13.67 c	10.14 g	7.80 def	4.40 a	0.31 f	36.36 cd
Grande	8.93 d	14.07 bcd	7.03 efg	3.19 ab	1.25 cd	34.47 de
Atlas	9.50 d	13.79 cd	6.38 fg	3.02 ab	1.39 bc	34.08 de
UC-157 F_2	4.49 e	16.50 a	7.33 ef	3.80 ab	0.88 de	33.01 de
UC-157 F_1	3.28 e	15.70 ab	7.97 cde	3.93 ab	0.92 cde	31.81 e
VC (%)	12.4	9.8	12.8	13.3	29.4	6.3

According to the LSD test ($P \leq 0.05$), means followed by different letters in the columns differ significantly.
The data about damaged spears were transformed by square root for their statistical analysis, but the original values are set out.
VC: Variation coefficient; LSD: Least significant difference.

spears in the Jersey-type varieties, which have only male plants, as compared to 'UC-157', which has male and female plants in similar proportions. Another difference between male and female plants is that the former produce 80% more spears than the second, because the weight of the root system, the carbohydrate content and the number of buds on the rhizome of male plants are much higher than those of female plants (Sinton and Wilson, 1999). This aspect would favor the varieties having male plants only, as is the case of 'J. Supreme'.

The third cause determining the "País" production was the purple spot (*Stemphylium vesicarium*), whose intensity of attack varied during the different harvest seasons (Table 5), depending on spring

Table 5. Total production of spears damaged by purple spot in different asparagus cultivars during five harvest seasons (%)[1].

Cuadro 5. Producción total de turiones dañados por mancha púrpura en diferentes variedades de espárrago durante cinco temporadas de cosecha (%)[1].

Cultivars	Stained spears (% of total yield)			
	2002	2003	2004	2005
Jersey Supreme	10.5 a	4.2 ab	26.1 bc	12.5 a
Jersey Giant	9.9 a	1.6 cd	27.8 ab	10.4 ab
Jersey Knight	7.9 abc	5.3 a	27.9 ab	7.6 cd
Jersey King	8.4 ab	1.5 cd	29.6 a	7.8 c
Jersey General	6.2 bcd	5.1 a	27.3 ab	6.4 cd
Jersey Gem	2.3 e	1.9 bcd	18.0 e	6.0 cd
Apollo	5.4 cd	3.8 abc	23.3 cd	6.6 cd
Grande	5.5 cd	2.1 bcd	21.6 d	6.0 cd
Atlas	4.8 de	0.9 d	20.7 de	5.5 cd
UC-157 F^1	8.1 abc	1.9 bcd	21.8 d	8.0 bc
UC-157 F^2	6.7 bcd	2.1 bcd	22.8 cd	5.0 d
VC (%)	26.9	15.3	9.8	24.2

According to the LSD test ($P \leq 0.05$) means followed by the same letter in the columns do not differ significantly. The 2003 data were transformed by square root for their statistical analysis, but the original values are set out.
VC: Variation coefficient; LSD: Least significant difference.
[1] The disease did not appear during 2001.

environmental conditions, and favored by high relative humidity. The larger effect of this disease upon yield took place during 2004, when all varieties suffered an attack of over 20% with the exception of 'J. Gem', during all seasons this was the one that suffered the less, with the smaller percentage of stained spears at the end of the five seasons (Table 4). The year 2001 is at the other extreme, the disease did not show up and therefore does not appear in Table 5. No resistance to *S. vesicarium* has been detected in the improved varieties and significant differences in the susceptibility to this disease have been identified, the French varieties being much more susceptible than the North-American ones (Broadhurst, 1996). Generally speaking, the damage is greater when the attack takes place in summer, affecting the foliage; this can cause a loss of up to 20% of the yield in J. Giant and J. Knight varieties if it is not controlled with fungicides (Meyer *et al.*, 2000). Summer attacks are quite unusual in Chillán; this is generally a dry season in this zone.

The average levels of rejects for the five seasons fluctuated between 7.8 and 14.3% of the harvested total, although it rose over 20% in some years (data not shown). The main causes of reject were malformed and damaged spears, also those affected by frost, especially in some seasons. The varieties that showed a lesser proportion of spears affected by frost started harvest a little later than those which were more strongly affected, as was the case of the controls 'UC-157' and 'Atlas', which are early (Figure 1). The reject caused by open spears was not important, and did not exceed 1.8% of the total production. As was the case with the País category, the 'UC-157' controls showed a lesser proportion of open spears, but did not differ from Californian variety 'Grande'.

CONCLUSIONS

The Jersey Supreme hybrid appears to be a good alternative, due to its high commercial yield, very superior to that of all varieties assessed. However, its quality is inferior to that of 'UC-157', due to both the antocianin coloration of the bud scales and the propensity of the spear to open at a low height; these aspects would make it suitable for frozen produce market only.

The UC-157 variety at present in use in Chile is still the best alternative for the fresh market; its yield is similar to that of other varieties although lower than that of 'Jersey Supreme'.

LITERATURE CITED

Benson, B.L. 2002. Second International Asparagus Cultivar Trial Final Report. Acta Hortic. 589:159-166.

Benson, B.L., R.J. Mullen, and B.B. Dean. 1996. Three new green asparagus cultivars: Apollo, Atlas and Grande and one purple cultivar, Purple Passion. Acta Hortic. 415:59-65.

Broadhurst, P.G. 1996. Stemphylium disease tolerance in *Asparagus officinalis* L. Acta Hortic. 415:387-391.

Carballo, B.M., J. Bernalte, y A. Pérez. 1992. Evaluación agronómica e industrial de siete variedades de espárrago cultivadas en verde en Extremadura. Investigación Agraria, Producción y Protección Vegetal 7:151-158.

Contreras, S., y C. Krarup. 2000. Interacción genotipo por ambiente en cinco cultivares de espárrago (*Asparagus officinalis* L.). Cien. Inv. Agr. 27:133-139.

Cueto, G.G., and D.J. Lesnick. 1999. Yield performance of new asparagus cultivars at Dole Tropifresh, Polomolok, Philippines. Acta Hortic. 479:163-167.

Del Pozo, A., y P. del Canto. 1999. Áreas agroclimáticas y sistemas productivos de la VII y VIII regiones. Serie Quilamapu Nº 113. 115 p. Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación Quilamapu, Chillán, Chile.

Drost, D. 2002. Asparagus cultivar trials in Utah. Acta Hortic. 589:167-171.

Ellison, J.H., S.A. Garrison, and J.J. Kinelski. 1990. Male asparagus hybrids: 'Jersey Gem', 'Jersey General', 'Jersey King', 'Jersey Knight', and 'Jersey Titan'. HortScience 25:816-817.

Ellison, J.H. and J.J. Kinelski. 1985. 'Jersey Giant', a male asparagus hybrid. HortScience 20:1141.

Elmer, W.H., J.A. LaMondia, and G.S. Taylor. 1999. Asparagus cultivar trials in Connecticut. Acta Hortic. 479:189-194.

Faville, M.J., T.G.A. Green, W.P. Silvester, and W.A. Jermyn. 1999. Genetic variation in the rate of asparagus fern photosynthesis. Acta Hortic. 479:93-99.

Garrison, S.A., C. Chin, J. Bakker, and J.F. Kelly. 1999. Performance of cultivars and lines of asparagus in Michigan and New Jersey. Acta Hortic. 479:183.

González, M.I., y A. del Pozo. 1999. Variedades. *In* M.I. González y A. del Pozo (eds.). El cultivo del espárrago. Boletín INIA N° 6. p. 53-63. Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación Quilamapu, Chillán, Chile.

González, M.I., and A. del Pozo. 2002. Asparagus cultivar trials in Bío-Bío (VIII) Region of Chile. Acta Hortic. 589:117-121.

IRRI. 2003. IRRISTAT 4.0 Windows. International Rice Research Institute. Biometrics Unit. Available in: www.irri.org/science/software/irristat.asp Accessed March 2003.

Jinsong, Y. 2002. Primary report of the Second International Asparagus Varieties Estimate Trials. Acta Hortic. 589:173-178.

Keulder, P.C., and C.A.H. Riedel. 1996. Influence of low temperatures during harvest on asparagus yield. Acta Hortic. 415:45-49.

Knaflewski, M. 1996a. Genealogy of asparagus cultivars. Acta Hortic. 415:87-91.

Knaflewski, M. 1996b. Results of the international asparagus cultivar trial in Poland. Acta Hortic. 415:393-398.

Krarup, A. 1996. Evaluation of twenty eight asparagus genotypes after three years of harvest at Valdivia, Chile. Acta Hortic. 415:105-113.

Krarup, A., y X. Henzi. 1993. Producción anual y acumulada de siete cultivares de espárrago bajo las condiciones de Valdivia, Chile. Agro-Sur 21:128-135.

McCormick, S.J., and D.L. Thomsen. 1995. Hybrid asparagus cultivars: regional suitability and productivity for processing and fresh export in Waikato, New Zealand. N.Z.J. Crop Hortic. Sci. 23:205-212.

Meyer, M.P., M.K. Hausbeck, and R. Podolsky. 2000. Optimal fungicide management of purple spot of asparagus and impact on yield. Plant Dis. 84:525-530.

Mullen, R.J., T.C. Viss, R. Chavarria, R.K. Reeder, and R.W. Whitely. 1996. Asparagus cultivar evaluation in the Sacramento-San Joaquin Delta Region of California. Acta Hortic. 415:93-96.

Mullen, R.J., T.C. Viss, and R.S. Whiteley. 1999. Asparagus cultivar evaluation trials in the Northern San Joaquin Valley of California. Acta Hortic. 479:177-181.

Mullen, R.J., R.S. Whiteley, T.C. Viss, M.L. Goff, and C.A. Cancilla. 2002. Asparagus cultivar evaluation trials in the Sacramento-San Joaquín Delta Region of California. Acta Hortic. 589:81-89.

Paschold, P.J., G. Hermann, and B. Artelt. 1996. Comparison of international asparagus cultivars under Rhine-Valley conditions in Germany. Acta Hortic. 415:257-262.

Pertierra, R., J. Campos, y F. Carrasco. 2006. Caracterización del crecimiento en el primer año de cultivares de espárrago (*Asparagus officinalis* L.) en maceta. Agric. Téc. (Chile) 66:98-106.

Roose, M.L., and N.K. Stone. 1996. Development of genetic markers to identify two asparagus cultivars. Acta Hortic. 415:129-135.

Roose, M.L., and N.K. Stone. 1999. Genetics and breeding of asparagus at the University of California, Riverside. Acta Hortic. 479:101-107.

Sinton, S.M., and D.R. Wilson. 1999. Comparative performance of male and female plants during the annual growth cycle of a dioecious asparagus cultivar. Acta Hortic. 479:347-353.

Stone, N.K., and M.L. Roose. 1999. Field evaluation of new asparagus varieties at the University of California, Riverside. Acta Hortic. 479:185-188.

Van Oordt, E., F. Vaccari, J.M. Carrillo, P. Velásquez, and W. Apaza. 1999. Preliminary results of the Second International Asparagus Cultivar Trial in Ica, Perú. Acta Hortic. 479:149-156.