'Italico' and 'Mediterraneo': Two *Seiridium cardinale* Canker-Resistant Cypress Cultivars of *Cupressus sempervirens*

R. Danti¹, A. Panconesi, V. Di Lonardo, G. Della Rocca, and P. Raddi
Istituto per la Protezione delle Piante, C.N.R. Area della Ricerca, Via
Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy

Additional index words. genetic improvement, breeding, clone, resistance, fungus, selection

Abstract. Common cypress (*Cupressus sempervirens* L.) is an integral feature of the landscape of many Mediterranean regions (particularly in Tuscany). Furthermore, common cypress has multiple uses as ornament, timber, windbreaks, recovery of deteriorated soils, protection of slopes and the production of essential oils. During the last three decades, *Seiridium cardinale* canker of cypress has caused severe losses in woods, windbreaks and ornamental plantings in the Mediterranean area, significantly limiting the use and cultivation of this tree.

In this paper we describe 'Italico' and 'Mediterraneo', two *C. sempervirens* varieties which were patented in 2004 for their resistance to cypress canker. Both varieties are particularly suitable for ornamental purposes because of their fastigiated columnar habit and the low production of male flowers and cones. 'Italico' and 'Mediterraneo' represent the recent result of the breeding programme on cypress, in progress since the 1970s. This program aims at: 1) obtaining a high number of canker-resistant cypress clones and multi-clonal varieties to be used for ornamental plantings and windbreaks and 2) finding mother trees for the production of improved seed for reforestation purposes.

Common or Italian cypress (*Cupressus sempervirens* L.) has always been closely linked with the history and culture of the Mediterranean populations. Since ancient times, it has been used as timber, has found applications in buildings, ships, joinery, and vineyard props and medicine, and also considered an ornamental and sacred tree (Andreoli and Xenopoulos, 1990).

Presence of cypress trees in gardens was reported as long ago as the time of ancient Babylonia and Persia; Etruscans and Romans used to plant this tree as an ornamental for their villas and around monuments and theaters. During the 15th century, cypress played a major role in Renaissance gardens in Italy, and, progressively, it became a representative and irreplaceable feature of the landscape, particularly in Tuscany.

Since the first half of the last century, cypress came under heavy attack by *Seiridium cardinale* (Wagner) Sutton & Gibson, a fungal pathogen that causes canker of the bark. Reported first in California in 1928 on *C. macrocarpa* Hartweg (Wagner, 1928), cypress canker disease in subsequent decades diffused worldwide, mostly in the form of epidemics, and caused major losses in woods, windbreaks, and ornamental plantings of most cypress species. The damage recorded has been particularly serious in the Mediter-

anean basin. Incidence of the disease has reached values as high as 70% in Central Italy and has exceeded 90% in the Peloponnese and on some of the Greek islands (Graniti, 1998; Panconesi, 1990).

The response to *S. cardinale* infection was found to be quite different among and within the various species of *Cupressus* (Andreoli and Ponchet, 1991; Raddi, 1979). Within *C. sempervirens*, considered a susceptible species, the variability of cypress response to bark canker was found to be sufficient for developing a successful breeding program without having to introduce the resistance genes through interspecific crosses. Studies evidenced that canker resistance in cypress is a quantitative characteristic under polygenic control and that it can be affected by environmental factors (Raddi et al., 1990; Santini et al., 1997). Regarding the pathogen, virulence was found to vary only slightly within the *S. cardinale* population, but not enough to affect a breeding program (Ponchet et al., 1990; Raddi and Panconesi, 1984).

The cypress breeding program, which was set up in the 1970s, has been directed toward practical aims, including the selection of a high number of resistant cypress clones and multiclonal varieties to be used for ornamental plantings and windbreaks. Four clones of *C. sempervirens* were patented between 1986 and 1990. Among these, 'Bolgheri' and 'Agrimed n.1' have been sold successfully as ornamental and windbreak trees, respectively (Raddi and Panconesi, 1994). 'Italico' and 'Mediterraneo' cypress cultivars are ornamental trees that were

patented in 2004 for their *Seiridium* canker resistance. They represent the recent results of the selection work on cypress, which is in progress and aims at widening the genetic basis of its resistance to bark canker as much as possible.

Origin

'Italico' was derived by grafting from an adult *C. sempervirens* var. *stricta* (ortet) tree, selected for its healthy appearance as well as for its fastigiated and dense crown, within an ornamental grove located in the Comune of Cinigiano in the province of Grosseto. This tree is registered in the IPP-C.N.R. Book of Mother Trees as number 2440.

'Mediterraneo' was derived by grafting from an adult *C. sempervirens* var. *stricta* (ortet) tree, selected for its healthy appearance and for its fastigiated habit, within a row lining a country road located in the Comune of Chiusi in the province of Siena. This tree is registered in the IPP-C.N.R. Book of Mother Trees as number 2546.

Description

The description of both the 'Italico' and 'Mediterraneo' clones is based on the traits shown by 12-year-old ramets grafted on *C. sempervirens* seedling rootstocks, which were grown in 2 different localities in central Italy (for climatic description of the sites, see the paragraph on inherent disease resistance).

'Italico' has a fastigiate, columnar habit and is characterized by a monopodial growth. It grows rapidly and has a diameter increment slightly higher than that of the fast-growing benchmark 'Bolgheri' (Table 1) in both sites (difference not significant). The stem is monocormic with a round section. The crown is flame-shaped, very dense, concealing the stem completely from top to bottom (Fig. 1). It is distinctly wider than that of 'Bolgheri,' which is considered very narrow ($P < 0.01$ in both sites). Its maximum width is at one third height. The bark is smooth and grayish brown (199b; Royal Horticultural Society 1966) with sparse grayed purple (RHS 183/c) patches. The main branches are erect, numerous, and rather long. They are inserted unevenly in the trunk, forming a 30° to 45° angle, and grow close to the trunk. The branches of a second order are thin and long; they are bright green (RHS 141/c) in the distal herbaceous part and grayed orange (RHS 177/b) in the proximal wooded part. The branchlets are alternate, rounded in section, 2 to 3 cm long, completely covered by the leaves, and evenly arranged around the branches. The foliage is scentless; the adpressed leaves are deep green in color (RHS 137/b) and convex on the back; the glands are inconspicuous and do not secrete resin.

The micro- and macrosporophylls, which are few, ripen simultaneously from February to March. The cones are produced in small quantities and are somewhat denser at two thirds height of the crown. These are borne

Received for publication 24 Feb. 2006. Accepted for publication 10 Apr. 2006.

¹To whom correspondence should be addressed; e-mail r.danti@ipp.cnr.it.

Table 1. Mean annual growth increments of height, diameter (measured at 1.2 m from the ground) and mean crown width of 'Italico' and 'Mediterraneo' cypress compared with the cultivar 'Bolgheri' (released by IPP-C.N.R. in 1990 and used as a benchmark for growth).²

Cultivar	Height increment (cm)		Diameter increment (cm)		Crown width (cm)	
	Roselle	Antella	Roselle	Antella	Roselle	Antella
Italico	68.5 a	71.3 ab	1.14 ab	1.04 a	114.5 c	110.5 c
Mediterraneo	71.6 ab	74.8 b	1.16 b	1.10 ab	99.2 b	94.6 ab
Bolgheri	69.2 ab	74.0 b	1.08 a	1.02 a	88.5 ab	85.2 a

²Increment data were obtained from the mean of measurements made during the first 12 years of age; crown width was taken in the 12th year of age. Data refer to ramets (5 per cultivar per site) obtained by grafting and grown in 2 experimental sites (Roselle and Antella; see text for site description). Differences among means were evaluated by 2-way analysis of variance. Site effect was significant ($P < 0.01$) for height and diameter increment, whereas cultivar effect was significant ($P < 0.001$) for crown width. Means not sharing same letters are significantly different for LSD test ($P < 0.05$).

alone or in small groups of 4 to 5 units; their mean dimensions are 40×37 mm when mature. Each cone consists of 12 scales with a dull or inconspicuous umbo, grey-green (RHS 197/c) at maturity, and grey-brown (RHS 199/d) during the first year; the peduncle is short. More than 100 seeds are produced per cone (10–20 per scale), and the latter have mean dimensions of 7 to 8×4 to 5 mm. They are reddish brown at maturity, showing a light hylum; moreover, resin glands are absent. In the last decade, our selection has favored genotypes producing fewer male cones to face up the growing number of people suffering the allergy to cypress pollen. The production of numerous female cones generally has a negative aesthetic value; moreover, the weight of the cones can induce the long branches to come out from the silhouette.

'Mediterraneo' has a fastigiated, columnar habit and a monopodial growth. It grows more rapidly than both 'Italico' and 'Bolgheri.' Diameter growth recorded at Roselle for 'Mediterraneo' was significantly higher than that of the fast-growing benchmark

'Bolgheri' ($P < 0.05$) (Table 1). The stem is monocormic and rounded in section. The crown is dense, somewhat thin at the base, quite narrow, and cylindrical in shape (maximum width is maintained along two thirds of the entire height) and tapered in the upper third (Fig. 2). The crown was significantly narrower compared with 'Italico' in both the testing sites but was slightly wider compared with 'Bolgheri' (difference not significant) (Table 1). The bark is smooth, yellowish green (RHS 148/a) in color with sparse grayed orange (RHS 175/d) patches. The main branches are erect and are inserted unevenly in the trunk, forming a 30° to 50° angle. They are numerous and long and grow close to the trunk. The branches of a second order are shorter than those of 'Italico.' They are bright green (RHS 144/b) in the distal herbaceous part and grayed orange (RHS 174/a) in the proximal wooded part. The branchlets are alternate, rounded in section, 2 to 4 cm long, and are completely covered by leaves. Foliage traits are the same as those shown by 'Italico' except for the color, which is slightly grayish green (RHS 138 a). There are few microsporophylls and even fewer macrosporophylls. They ripen simulta-

neously from February to March, and both are located at the upper half of the crown. The few cones, which are distributed sparsely in the central third of the crown, are borne alone or in groups of 2 to 4 units. Cones are fairly oblong, smaller than 'Italico' with mean dimensions of 33×25 mm when mature. Each cone consists of 10 to 12 scales with an opaque umbo; they are gray-brown (RHS 199/d) at maturity and relatively darker (RHS 199/b) with green reflexes during the first year. The peduncle is short. More than 100 seeds are produced per cone with mean dimensions at maturity of 6 to 7×3 to 5 mm. They are reddish dark brown in color and have a light hylum and an unpronounced mucro; resin glands are absent.

Propagation

'Italico' and 'Mediterraneo' are easily propagated from scions taken in January and February and grafted on *C. sempervirens* one-year-old seedlings as rootstock grown in small pots containing a mixture of 3 peat: 1 compost: 1 perlite (v/v/v). At the end of spring, grafts should be transplanted into bigger pots (volume 4–5 L), where they should be kept for at least 2 years.

Disease Resistance

To verify the stability of the response to bark canker under different climatic conditions, 10 two-year-old grafted ramets for both 'Italico' and 'Mediterraneo' were transplanted in 1995 in the field in two localities (5 ramets per clone per site). The Antella location ($43^\circ 43'$ N; $11^\circ 22'$ E; 170-m elevation), near Florence, has a temperate Mediterranean climate characterized by hot summers and cold winters. The Roselle location ($42^\circ 48'$ N; $11^\circ 05'$ E; 5-m elevation) in the province of Grosseto has a typically Mediterranean climate with long, dry summers and relatively mild winters. Previous assays showed that, as a result of climatic factors, canker severity was always markedly greater at Antella than at Roselle. After 2 years (when plants were in their fourth year of growth), the ramets were artificially inoculated in April with the *S. cardinale* isolate ATCC 38654 (obtained from *C. sempervirens* near Florence). Inoculation was performed where the stem was approximately 1 cm in diameter by using a cork borer to remove a 3-mm circular plug of bark extending into the cambium. The bark plug was replaced with a plug of the same size taken from the margin of a colony of the fungus grown on a potato dextrose agar (PDA) plate for 15 d at 25° C. The inoculation site was covered with cotton and wrapped with tape, both of which were removed after 5 d. Each year, the progress of the canker was examined and evaluated based on a score of 1 to 3 with 0.33 gradations, in which 1 represented complete healing of the necrotic lesion, 2 represented small cankers without resin and forming scars, and 3 represented severe infection with expanding necrosis, resin exudation, stem deformation

Fig. 1. The 'Italico' cypress (arrow).

Fig. 2. The 'Mediterraneo' cypress (arrow).

Table 2. Mean score of *Seiridium cardinale* canker development estimated for 5 years after stem inoculation on 10 ramets of 'Italico' and 'Mediterraneo' cypress grown in 2 sites (4 ramets per cultivar per site).^z

Site	Cultivar	Disease rating (years after inoculation)				
		1	2	3	4	5
Roselle	Italico	3.0 a	2.7 cd	1.6 a	1.2 a	1.0 a
	Mediterraneo	3.0 a	2.5 bc	1.8 ab	1.0 a	1.0 a
	Bolgheri	3.0 a	2.3 ab	1.8 ab	1.2 ab	1.0 a
	243	3.0 a	2.9 d	2.7 c	2.7 c	2.6 b
Antella	Italico	3.0 a	2.1 a	1.8 ab	1.3 ab	1.0 a
	Mediterraneo	3.0 a	2.3 ab	1.7 ab	1.2 ab	1.0 a
	Bolgheri	3.0 a	2.4 b	2.0 b	1.5 b	1.0 a
	243	3.0 a	2.8 cd	2.8 c	2.7 c	2.7 b

^zThe two selections were compared with 'Bolgheri' and '243', two cultivars known to be resistant and susceptible, respectively, from previous tests and included here as controls. Scores vary on a scale of 1 to 3 with 0.3 gradations, in which 1 represents complete healing of the necrosis and 3 represents severe infection with expanding necrosis, resin exudation, and stem deformation. For description of the two sites, see text.

Differences among means were evaluated by 2-way analysis of variance. Cultivar ($P < 0.001$), site ($P < 0.01$) and cultivar $\times$ site ($P < 0.01$) effects were significant in the second year. Cultivar effect was significant ($P < 0.0001$) in the third, fourth, and fifth years. Means not sharing same letters within each column are significantly different for LSD test ($P < 0.05$).

and sometimes dieback resulting from the girdling of the stem. Intermediate points on the scale indicated intermediate levels of canker severity. Symptoms were compared with the clones 'Bolgheri' and '243' known to be resistant and susceptible, respectively.

Yearly disease evaluations of the two selections and of the two control clones are shown in Table 2. The primary colonization of the bark occurred during the first year after inoculation, until the defense reaction of the host was activated. From the third year on, symptoms on 'Italico,' 'Mediterraneo,' and the resistant control 'Bolgheri' were significantly different from that of the susceptible control at both sites. Healing of the necrotic lesion and complete restoration of the trunk occurred for both 'Italico' and 'Mediterraneo' as well as for resistant control 'Bolgheri' within 5 years after inoculation at both the testing sites. Cankers continued to develop on all the stems of the susceptible control '243'.

In non-susceptible cypresses, host reaction leads to varying degrees of resistance, even to canker compartmentalization and exclusion of the pathogen from plant tissues (Ponchet and Andreoli, 1990; Spanos et al., 1999). A testing clone is considered to be a resistant candidate only when all its ramets show an equal reaction and are able to block

the infection and heal the canker in all the testing localities. A resistant candidate will be then evaluated for its growth traits in relation to all cypress functions. In the case that it has useful characteristics, it will be proposed for a patent to the Italian National Research Council (CNR).

'Italico' and 'Mediterraneo' have shown good tolerance to winter cold in the two localities where they grow. Symptoms resulting from infection by other pathogens or to common pests such as *Cinara cupressi* Buckton have not been observed.

Availability

'Italico' and 'Mediterraneo' will be available from commercial sources under license from the CNR. Inquiries can be addressed to Il Terzo, Loc. Casoni del Terzo, 58100 Roselle (GR) and to Umbrador, vivaio Il Castellaccio, Strada Prov. Stazione di Cannara, 06038 Spello (PG).

Literature Cited

Andreoli, C. and J. Ponchet. 1991. Potential use of exotic cypress species resistant to canker disease, Pp. 150–157. In Panconesi, A. (ed.), Il Cipresso. Proposte di valorizzazione ambientale e produttiva nei Paesi Mediterranei della

Comunità Economica Europea. CNR, Regione Toscana, CEE, Firenze.

Andreoli, C. and S. Xenopoulos. 1990. Use of cypress, Pp. 14–25. In Ponchet, J. (ed.), Agrimed research programme. Progress in EEC research on cypress diseases. Rep. EUR 12493 EN, Luxembourg.

Graniti, A. 1998. Cypress canker: a pandemic in progress. Annu. Rev. Phytopathol. 36:91–114.

Panconesi, A. 1990. Pathological disorders in the Mediterranean basin. Pp. 54–81. In Ponchet, J. (ed.), Agrimed research programme. Progress in EEC research on cypress diseases. Rep. EUR 12493 EN, Luxembourg.

Ponchet, J. and C. Andreoli. 1990. Compartmentalization and reactions in the host. Pp. 96–111. In Ponchet, J. (ed.), Agrimed research programme. Progress in EEC research on cypress diseases. Rep. EUR 12493 EN, Luxembourg.

Ponchet, J., C. Andreoli, S. Xenopoulos, M.F. Caetano, P. Raddi, and A. Panconesi. 1990. Pathogenic variability in *Seiridium*. Pp. 112–126. In Ponchet, J. (ed.), Agrimed research programme. Progress in EEC research on cypress diseases. Rep. EUR 12493 EN, Luxembourg.

Raddi, P. 1979. Variabilità della resistenza al cancro nel cipresso comune (*C. sempervirens*) e di altre specie. Pp. 185–193. In Grasso, V. and P. Raddi (eds.), Il Cipresso: malattie e difesa. Com. Econ. Eur., Agrimed, Firenze.

Raddi, P. and A. Panconesi. 1984. Pathogenicity of some isolates of *Seiridium (Coryneum) cardinale*, agent of cypress canker disease. Eur. J. For. Path. 14:348–354.

Raddi, P. and A. Panconesi. 1994. Present and future of cypress canker disease research. Pp. 12–117. In Capretti, P., U. Heiniger, and R. Stephan (eds.), Shoot and Foliage Disease in Forest Trees. Proc. Joint. Meet. IUFRO Working Parties. Università degli Studi di Firenze, CNR, Vallombrosa (Firenze).

Raddi, P., A. Panconesi, S. Xenopoulos, P. Ferrandes, and C. Andreoli. 1990. Genetic improvement for resistance to canker disease, Pp. 127–134. In Ponchet, J. (ed.), Agrimed research programme. Progress in EEC research on cypress diseases. Rep. EUR 12493 EN, Luxembourg.

Royal Horticultural Society. 1966. Colourchart. Royal Hort. Soc., London.

Santini, A., N. Casini, V. Di Leonardo, and P. Raddi. 1997. Canker resistance stability of some *Cupressus sempervirens* clones to *Seiridium cardinale*. J. Genet. Breed. 51:269–277.

Spanos, K.A., A. Pirrie, S. Woodward, and S. Xenopoulos. 1999. Responses in the bark of *Cupressus sempervirens* clones artificially inoculated with *Seiridium cardinale* under field conditions. Eur. J. For. Path. 29:135–142.

Wagener, W.W. 1928. *Coryneum* canker of cypress. Science 67:584.