

## **Influence of weeds on the growth of *Pinus pinea* L. during reforestation in Palencia (Spain)**

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A study was carried out on the influence of spontaneous vegetation on the growth of reforested *Pinus pinea* L. (stone pine) seedlings in abandoned cropland. Ninety seedlings were randomly selected. In half of them weeds were removed and the remaining 45 were not treated. The research lasted from November 1998 to October 1999. The studied area was located 7 km from Palencia city (Northern Spain). The pine trees were planted in ridges. Weed mean cover around the untreated seedlings was 12.38%. Greatest height growth in pine seedling occurred in April. Significant differences were observed between different treatments. Weeds reduce the height of the pine trees, although the effect was not very remarkable. There was a significant negative relation between tree diameter and weed. The average growth of the pine trees regarding height was 24.44% and 50.14% regarding diameter. In general, there was more growth in the diameter than in height, because the reforested species consume more energy-producing underground or supporting biomass in dry areas.

Key words: Reforestation, *Pinus pinea*, seedlings, growth, weed, competition, Spain

### **Introduction**

Farm land reforestation has been fostered within the common agricultural policy of the European Union since 1993. Spain took advantage of this project, and of more than 350,000 ha, 8000 ha have been reforested in Castilla y León over the last ten years. This policy is very important, because Spain is a country where desertification is clearly in progress. Water washes away more than 10<sup>9</sup> t soil every year (MESANZA 1985)

Some authors such as TRIPLETT et al. (1968) confirm that soils covered with vegetation have higher infiltration capacity due to probably greater porosity and better structure. Provisin of plant cover is the best way to fight erosion, especially herbaceous cover with low aspect (MORGAN 1991). The main aim of reforestation of this steppe area is the mitigation of erosion and desertification, and protection and improvement of soil, water, fauna and flora.

*Pinus pinea* L. is one of the most widely used species in the afforestation of semiarid areas of the Duero Plateau (Northern Spain). This heliophyte has a great colonising capacity

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and is native to the Mediterranean basin. The largest stands are in the Iberian Peninsula, and its plantation has been highly promoted by European policy of the afforestation of croplands (ÁLVAREZ et al. 2004).

Abandoned croplands have large seed banks, waiting for years to have the appropriate moment to germinate. The seed bank contributes significantly to the dynamics of plant communities (LEBRETON et al. 1991), and it is a reserve for population renewal and where a certain genetic variability can be found (CHRISTENSEN and MULLER 1975).

Weeds may compete with the seedlings of forest species. Weeds have a greater efficacy to uptake water from the soil after rain episodes because they explore the upper soil horizons (CHAVASSE 1980).

Spontaneous vegetation sometimes creates an unimportant microhabitat that does not affect reforested tree species, but that at some other times will present a marked competition with these plants (OCAÑA et al. 1996). Therefore, it is necessary to assess its advantages and disadvantages.

There are many studies on the competition between weeds and edible plants (WEAVER et al. 1987, HENRY and BAUMAN 1991), and on weed colonisation of abandoned fields (MARCO MOLINA 1995, PADILLA BLANCO 1998). Similarly, some studies have analysed the effects of herbicides on the growth of pine seedlings (CANELLAS et al. 1999, ORTEGA-QUERO et al. 2001). Also, works that have related weed colonisation with the growth of species reforested have been done generally with oak species (GORDON et al. 1989; KOLB and STEINER 1990; REY BENAYAS et al. 1994, 2003, 2005; REY BENAYAS 1998).

The aim of this study is to know the composition of pioneer adventitious species which grow in plots reforested with *Pinus pinea* in Northwest Spain and to analyse the effect of weed cover on the growth of *Pinus pinea* seedlings.

## Materials and methods

The study area was Cerro de las Yeseras (Villalobón, Palencia, Spain, 42° 05' N, 4° 30' W), at 775 m above sea level. The average annual rainfall is 392.9 mm, distributed homogeneously throughout autumn, winter and spring. The average temperature is 11.4 °C, the area has a long winters and short summers with marked temperature contrast. A physicochemical analysis of the soil was done in the area which had been reforested, using the standard method of analysis (MAPA 1994), taking samples up to 20 cm deep, in November 1998 (Tab. 1). Its texture ranges from silt to clay loam with a high quantity of gypsum. Soil is alkaline in nature. According to the classification of KLIGEBIEL and MONTGOMERY (1966), these plots would be included in group C, considered inappropriate for agriculture, but suitable for permanent vegetation. A high concentration of nitrogen was observed, since it was recently nevertheless used for agriculture. Since the percentage of total carbonates was very high, phosphorus content was reduced. The water regime in the soil is xeric, and the thermic regime is mesic.

Study plot was 1 ha that had been reforested. The plot is an abandoned dry field which had been cultivated with cereal the previous year. Trees were planted in ridges, leaving a 2 m distance between plants and ridges. In this plot 90 seedlings of pine tree were marked at random. In 45 seedlings weeds were removed monthly (treated plants) and the other 45 seedlings were not treated. The reforestation had been carried out with one-year-old *Pinus pinea* plants in April 1998. There was a monthly monitoring for one year, from November 1998 to October 1999.

**Tab. 1.** Physicochemical characteristics of the soil studied.

	Abandoned field
Orientation	S-W
Slope (%)	3
Altitud (m)	760
Sand (%)	27.35
Silt (%)	63.7
Clay (%)	8.95
Texture	silt-loam
pH	7.9
N (mg kg <sup>-1</sup> )	753.3
P (mg kg <sup>-1</sup> )	8
Ca+ (cmol kg <sup>-1</sup> )	72.3
Total Carbonates (%)	56.9
Mg+ (cmol kg <sup>-1</sup> )	0.2
K+ (mg kg <sup>-1</sup> )	235
Ca/Mg ratio	361.5
Ca/K ratio	120.5
Na+ (cmol kg <sup>-1</sup> )	0.1
Organic matter (%)	1

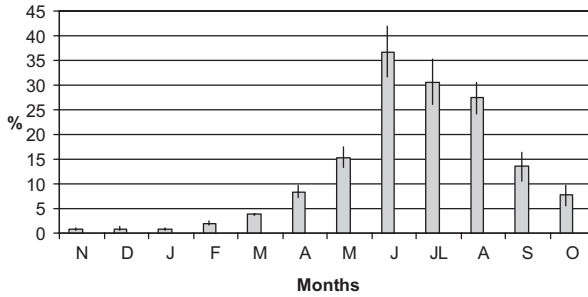
The sampling unit was a 2500 cm<sup>2</sup> circular surface around each untreated pine tree plant. The species which grew in these areas were identified, using keys and handbooks (TUTIN et al. 1964–1993, CASTROVIEJO et al. 1986–2003). Weed cover was visually estimated, using a rule as well, establishing the shadow projected (perpendicular to the soil surface) by this species within the limits of the area studied. The height of the pine trees was measured root collar to the upper needles. The diameter of the pine trees was also measured at the third ramification level during the first and last month of the study.

Statistical analyses were made with the SPSS software system (1998), using the procedures for simple linear regression and a t-student test.

## Results and discussion

The average cover of adventitious plants around untreated pines was 12.38% and the maximum cover was 36.8%, which occurred in June (Fig. 1). From June to November, weed cover decreased. The cover of weed and growth of the pine trees were considerable. This could be due, to a certain extent, to the presence of mineral nutrients remains since this plot had been used for a barley crop recently.

It was observed that the plants of pine trees were mostly surrounded by weeds with smaller cover. The cover of weeds had a negative influence upon the growth of the pine trees. The elimination of weeds allowed *Quercus ilex* seedling to increase their growth (REY BENAYAS et al. 2005) and the same was observed with stone pine seedlings (CANELLAS et al. 1999). However, this influence was not very remarkable since there was not a marked shortage of water during the year of the study.



**Fig. 1.** Evolution of weed cover around *Pinus pinea* seedlings where weeds were not removed after plantation (untreated seedlings) in abandoned cropland. Data are means.

The presence of weeds played a very important role in reducing erosion. In areas where there was no cover of spontaneous plants, the stem of some pine trees was partly buried.

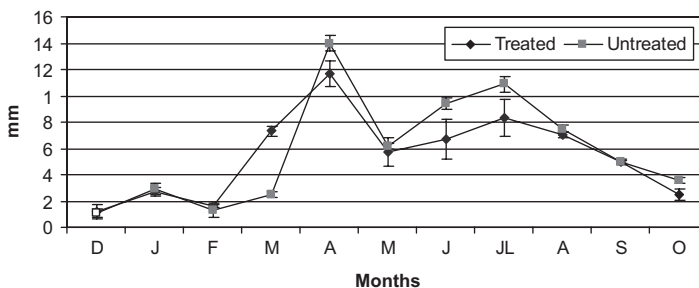
Figure 2 shows the average monthly height growth in both treatments of the pine trees regarding height in both treatments. The average growth over the whole period was  $6.20 \pm 2.16$  cm ( $n=90$ ). The height growth ranged between 1.7 and 8.6 cm. Three stages can be distinguished. The first one coincides with the autumn-winter period, when both pines and weed hardly grew at all. During a second stage, from March to July, pines trees grew fast, coinciding with good weather conditions. Height growth rate was higher in treated plants. Weed cover increased fast during the final period of this stage. During the third stage, the growth rate of the pine trees, diminished coinciding with the onset of summer.

The final growth reached by the pine trees at the end of the study was higher in the group of treated seedlings. These growth percentages regarding height were 23.57% in the untreated seedling and 25.32% in the group treated ones.

The growth of the pine trees concerning diameter was 49.18% for the group of pines without treatment and 51.11% in the group of treated pine trees, over the year of the study.

The correlation coefficients between height and diameter growth and weed cover were very low,  $r = -0.078$  and  $r = -0.223$  respectively. A significant negative relation was found between diameter growth and weed cover,  $P\text{-value} = 0.085$ , significant at the 90% confidence level.

Diameter increase is significantly different between weed treatments,  $t = 13.617$ ; significant at the 95% confidence level.



**Fig. 2.** Average monthly height growth (mm) of *Pinus pinea* seedlings in an abandoned field.

Annual height increments are very big for *Pinus pinea* seedlings, coinciding with those by some authors (PEÑUELAS 1996, STERNBER et al. 2001). As a result to their adaptation to a dry climate, the allocation of biomass to the below ground part is important, contributing to a very substantial growth of diameter of pine trees. Some authors observed a positive effect of the weed cover upon the reforested species, which was explained by the shade provided by weeds (KOLB and STEINER 1990, KOUKOURA and MENKE 1995, REY BENAYAS 1998, REY BENAYAS et al. 2002). It should be mentioned that some these data were obtained in experimental plots that were watered.

Survival of seedling was a very high during the first year. None of the marked seedlings died, which contrasts with the results of PEÑUELAS (1996), who observed that the survival of the pine seedlings was poor three years later. Herbicides, which sometimes cause significant mortality (ORTEGA QUERO et al. 2001), were not used in this reforestation. However, other authors (STERNBER et al. 2001) found that seedling mortality significantly increased with decreasing intensities and frequencies of simazine applications. However, height and crown diameter of the surviving seedlings were not always significantly correlated to the amounts of herbicide sprayed.

Sixty nine species were recorded, belonging to 22 families (Tab. 2). The families represented by highest number of species were: Asteraceae (18 species), Brassicaceae (9 species), Poaceae (8 species), Leguminosae (7 species).

**Tab. 2.** List of recorded species in the studied plot, classified by biological type and chorological distribution.

Species	Biological type	Chorology
<i>Achillea odrata</i> L.	Hemicryptophytes	Mediterranean
<i>Alyssum alyssoides</i> L.	Terophytes	Mediterranean
<i>Anacyclus clavatus</i> (Desf.) Pers.	Terophytes	Mediterranean
<i>Androsace maxima</i> L.	Terophytes	Eurasian
<i>Arabis verna</i> (L.) R.Br.	Terophytes	Mediterranean
<i>Astragalus glaux</i> L.	Camephytes	Mediterranean
<i>Avenula bromoides</i> (Gouan) H.Scholz	Hemicryptophytes	Mediterranean
<i>Avenula sulcata</i> Gay ex Boys.	Hemicryptophytes	Mediterranean
<i>Barbarea intermedia</i> Boreau	Hemicryptophytes	Eurosiberian
<i>Biscutella auriculata</i> L.	Terophytes	Mediterranean
<i>Bromus rubens</i> L.	Terophytes	Cosmopolitan
<i>Bupleurum baldense</i> Turra	Terophytes	Mediterranean
<i>Bupleurum rotundifolium</i> L.	Terophytes	Eurasian
<i>Carduus tenuiflorus</i> Curtis	Terophytes	Eurasian
<i>Centaurea aspera</i> L.	Terophytes	Cosmopolitan
<i>Chenopodium album</i> L.	Terophytes	Cosmopolitan
<i>Cirsium arvense</i> (L.) Scoop.	Geophytes	Eurasian
<i>Convolvulus arvensis</i> L.	Terophytes	Cosmopolitan
<i>Coronilla scopioides</i> (L.) Koch.	Terophytes	Mediterranean
<i>Crepis vesicaria</i> L.	Hemicryptophytes	Mediterranean
<i>Dactylis glomerata</i> L.	Hemicryptophytes	Mediterranean
<i>Daucus carota</i> L.	Hemicryptophytes	Mediterranean
<i>Echinops ritro</i> L.	Hemicryptophytes	Central European

Tab. 2. – continued

Species	Biological type	Chorology
<i>Erodium ciconium</i> (L.) L. Hér	Hemicryptophytes	Mediterranean
<i>Erodium cicutarium</i> (L.) L. Hér	Terophytes	Mediterranean
<i>Eruca vesicaria</i> (L.) Cav.	Terophytes	Mediterranean
<i>Erucastrum gallicum</i> K. Presl.	Terophytes	Mediterranean
<i>Euphorbia serrata</i> L.	Geophytes	Mediterranean
<i>Fedia cornucopiacea</i> (L.) Gaertner	Terophytes	Mediterranean
<i>Filago vulgaris</i> Lam.	Terophytes	Mediterranean
<i>Fumaria officinalis</i> L.	Terophytes	Palaeotemperate
<i>Fumaria parviflora</i> Lam.	Terophytes	Mediterranean
<i>Galium aparine</i> L.	Terophytes	Eurasian
<i>Helianthemum croceum</i> (Desf.) Pers.	Camephytes	Mediterranean
<i>Hieracium pilosella</i> L.	Terophytes	Palaeotemperate
<i>Hipocrepis multisiliquosa</i> L.	Terophytes	Mediterranean
<i>Koeleria vallesiana</i> (Honk) Gaudin	Hemicryptophytes	Mediterranean
<i>Lactuca serriola</i> L.	Hemicryptophytes	Palaeotemperate
<i>Linum trigynum</i> L.	Terophytes	Mediterranean
<i>Lolium perenne</i> L.	Hemicryptophytes	Circumboreal
<i>Matthiola fruticulosa</i> (L.) Maire.	Camephytes	Mediterranean
<i>Medicago sativa</i> L.	Hemicryptophytes	Mediterranean
<i>Muscari racemosum</i> (L.) Lam.	Geophytes	Mediterranean
<i>Omphalodes linifolia</i> (L.) Moench	Terophytes	Mediterranean
<i>Ononis tridentata</i> L.	Camephytes	Mediterranean
<i>Onopordum nervosum</i> Boiss.	Hemicryptophytes	Mediterranean
<i>Papaver dubium</i> L.	Terophytes	Palaeotemperate
<i>Papaver hybridum</i> L.	Terophytes	Palaeotemperate
<i>Papaver rhoeas</i> L.	Terophytes	Mediterranean
<i>Petrorhagia prolifera</i> (L.) P.W. Ball & Heywood	Terophytes	Mediterranean
<i>Picris echioides</i> L.	Terophytes	Mediterranean
<i>Poa annua</i> L.	Terophytes	Cosmopolitan
<i>Polygonum aviculare</i> L.	Terophytes	Cosmopolitan
<i>Rapistrum rugosum</i> (L.) All.	Hemicryptophytes	Mediterranean
<i>Sanguisorba minor</i> Scop.	Hemicryptophytes	Mediterranean
<i>Scolymus hispanicus</i> L.	Hemicryptophytes	Mediterranean
<i>Scorpiurus muricatus</i> L.	Terophytes	Mediterranean
<i>Scorzonera hispanica</i> L.	Hemicryptophytes	Mediterranean
<i>Senecio vulgaris</i> L.	Hemicryptophytes	Cosmopolitan
<i>Silene conoidea</i> L.	Terophytes	Mediterranean
<i>Sinapis arvensis</i> L.	Terophytes	Palaeotemperate
<i>Sonchus oleraceus</i> L.	Hemicryptophytes	Cosmopolitan
<i>Taeniantherum caput-medusae</i> (L.) Nevski.	Terophytes	Mediterranean
<i>Taraxacum officinale</i> Weber	Hemicryptophytes	Eurasian
<i>Trigonella polyceratia</i> L.	Terophytes	Mediterranean
<i>Vaccaria pyramidata</i> Medicus	Terophytes	Mediterranean
<i>Valerianella echinata</i> (L.) DC.	Terophytes	Mediterranean
<i>Veronica arvensis</i> L.	Terophytes	Cosmopolitan
<i>Xeranthemum inapertum</i> (L.) Miller.	Terophytes	Mediterranean

The species with most cover were: *Centaurea aspera* L., *Papaver rhoeas* L., *Filago vulgaris* Lam, *Euphorbia serrata* L., *Onopordum nervosum* Boiss. and *Eruca vesicaria* (L) Cav.

There are a high proportion of therophytes. The species of *Matthiola fruticulosa* (L.) Maire, *Androsace maxima* L. and *Globularia vulgaris* L. have a fibrous root, which contributes to their early warming, making them flower very early.

Species with a taproot such as *Euphorbia serrata*, *Papaver rhoeas* and *Onopordum nervosum* flower later but they have a very high cover rate in a short time. These species have a lower competitive effect for water than fibrous grass root species, coinciding with the results of GORDON et al. (1989). *Cirsium arvense* (L.) Scoop. and creeping species such as *Polygonum aviculare* L. and *Convolvulus arvensis* L. grow at the end of the summer.

In June, most of the therophyte plants, except for the Asteraceae family, finished their life cycle although they remained in the plot as necromass.

Regarding the chorology, 62.3% of the species had a Mediterranean origin and 14.7% of them were cosmopolitan.

The presence of gypsum favoured the invasion of gypsicolous species. An abundance of calcium causes a block of micronutrients such as Fe, Bo, Zn, Cu, and macronutrients such as P, K and Mg (COBERTERA 1993). It is very difficult to improve these soils, since the output of P precipitates with calcium, preventing its assimilation. The presence of silt causes bad drainage and aeration of the soil, exacerbated by excess of gypsum. This restricts the growth of this species of pine due to the soil necessities (PRADA et al. 1997). However, the growth of the pine seedling was scarcely affected during the first year.

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### References

- ÁLVAREZ, J. B., TOLEDO, M. J., AVELLANAS, B., MARTÍN, L. M., 2004: Use of megatophyte storages proteins as markers of the genetic diversity in stone pine (*Pinus pinea* L.) in Andalucía, Spain. Genet. Resour. Crop Ev. 51, 621–617.
- CANELLAS, I., FINAT, L. BACHILLER, A., MONTERO, G., 1999: Behaviour of *Pinus pinea* plants in nursery and field: trial of plan production, fertilization and herbicides. Invest. Agrar. Sist. Recur. For. 8, 335–359.
- CASTROVIEJO, S. et al. (eds.), 1986–2003: Flora Ibérica, Plantas vasculares de la Península Ibérica e Islas Baleares, 1–8, 10, 14. Consejo Superior de Investigaciones Científicas, Madrid.
- CHAVASSE, C. G. R., 1980: Planting stocks quality: a review of factors affecting performance. New Zeal. J. For. 25, 144–171.
- CHRISTENSEN, N. L., MULLER, C. H., 1975: Effect of fire on factor controlling plant grown in *Adenostema* chaparral. Ecol. Monogr. 45, 29–55.
- COBERTERA, E., 1993: Edafología aplicada. Ed. Cátedra, Madrid.

- GORDON, D. R., WELKER, J. M., MENKE, J. W., RICE, K. J., 1989: Competition for soil water between annual plants and blue oak (*quercus douglasii*) seedlings. *Oecologia* 79, 533–541.
- HENRY, W. T., BAUMAN, T. T., 1991: Interference between soybean (*Glycine max*) and jimsonweed (*Datura stramonium*) in Indiana. *Weed Technol.* 5, 759–764.
- KLIGEBIEL, A. A., MONTGOMERY, P., 1966: Land capability classification. *Agriculture Handbook* 210. Soil Conservation Service, Washington.
- KOLB, T. E., STEINER, K. C., 1990: Growth and biomass partitioning of Northern red oak and yellow-poplar seedlings: Effects of shading and grass root competition. *Forest Sci.* 36, 34–44.
- KOUKOUODRA, Z., MENKE, J., 1995: Competition for soil water between perennial bunch grass (*Elymus glaucus* B.B.) and blue oak seedlings (*Quercus douglasii* H. et A.). *Agr. Syst.* 32, 225–235.
- LEBRETON, L. S., DEBUSSCHE, M., LEPART, J., 1991: Nested spatial patterns in seed bank and vegetation of Mediterranean old fields. *J. Veg. Sci.* 2, 367–376.
- MARCO MOLINA, J. A., 1995. Colonización vegetal en terraza de cultivos abandonados en el SE peninsular. *Proc. 14 Nac. Congr. Geography, Salamanca (Spain)*, 38–42.
- MESANZA, B., 1985: España es el único país en claro proceso de desertización. *Agricultura* 650, 967–968.
- MAPA, 1994: Métodos oficiales de análisis, 3. Ministerio de Agricultura, Pesca y Alimentación, Secretaría General Técnica, Madrid.
- MORGAN, R. C. P., 1991: Erosion and soil conservation, *Curso de Agricultura Sostenible*. Instituto Mediterráneo de Agronomía de Zaragoza, Zaragoza.
- OCAÑA, L., RENILLA, I., DOMÍNGUEZ, S., 1996: Plantaciones de encinas y coscojas en tierras agrícolas. *Quercus* 120, 16–19.
- ORTEGA QUERO, M., FERNÁNDEZ GARCÍA, J. C., VILLARROYA FERRUZ, M. GARCÍA-BAUDÍN, J. M., 2001: Efecto de la época de siembra en la respuesta de *Pinus pinea* L., *P. halepensis* Mil., *P. pinaster* Ait., a aplicaciones herbicidas en implantaciones sobre tierras agrícolas. *Proc. Congr. Sociedad Española de Malherbología, León (Spain)*, 211–214.
- PADILLA BLANCO, A., 1998: Colonización vegetal en campos abandonados de la provincia de Alicante. *Publicaciones de la Universidad de Alicante, Alicante*.
- PEÑUELAS, J. L., 1996: Forestation experiments on agricultural land. *Cah. Options Mediterr.* 20, 123–138.
- PRADA, M. A., GORDO, J., MIGUEL, J., MUTKE, S., CATALÁN-BACHILLER, G., IGLESIAS, S., GIL, L., 1997: Regiones de procedencia de *Pinus pinea* L. en España. *Organismo Autónomo Parques Nacionales, Madrid*.
- REY BENAYAS, J. M., 1998: Growth and survival in *Quercus ilex* L. seedlings after irrigation and artificial shading on Mediterranean set-aside agricultural land. *Ann. Sci. For.* 55, 801–807.
- REY BENAYAS, J. M., PASTOR, J., HERNÁNDEZ, A. J., SÁNCHEZ, A., GIMENO, A., 1994: Técnicas de cultivo para reforestar con encinas. *Quercus* 105, 31–33.



- REY BENAYAS, J. M., LÓPEZ-PINTOR, A., GARCÍA, C., CÁMARA, N., STRASSER R., GÓMEZ SAL, A., 2002: Early establishment of planted *Retama sphaerocarpa* seedlings under different levels of light, water and weed competition. *Plant Ecol.* 159, 201–209.
- REY BENAYAS, J. M., ESPIGARES, T., CASTRO-DÍEZ, P., 2003: Simulated effects of herb competition on planted *Quercus faginea* seedlings in Mediterranean abandoned cropland. *Appl. Veg. Sci.* 6, 213–222.
- REY BENAYAS, J. M., NAVARRO, J., ESPIGARES, T., NICOLAU, J. M., ZAVALA, M. A., 2005: Effects of artificial shading and weed mowing in reforestation of Mediterranean abandoned cropland with contrasting *Quercus* species. *Forest Ecol. Manag.* 212, 302–314.
- SPSS/PC, Trends TM., 1998: SPSS Inc., Chicago.
- STERNBER, M., DANIN, A., NOY-MEIR, I., 2001: Effects of clearing and herbicide treatments on coniferous seedling establishment and growth in newly planted Mediterranean forest. *Forest Ecol. Manag.* 148, 179–184.
- TRIPLETT, G. B. Jr., VAN DOREN, D. M., SCHMIDT, B. L., 1968: Effect of corn (*Zea mays* L.) stove mulch on no-tillage corn yield and water infiltration. *Agron. J.* 60, 236–239.
- TUTIN, T. G., HEYWOOD, V. H., BURGESS, N. A., MOORE, D. M., VALENTINE, D. H., WALTER, S. M., WEBS, D. A., (eds.), 1964–1993: *Flora Europaea*, 1–5. Cambridge University Press, Cambridge.
- WEAVER, S. E., SMITS, N., TAN, C. S., 1987: Estimating yield losses of tomatoes (*Lycopersicon esculentum*) caused by nightshade (*Solanum* spp.) interference. *Weed Res.* 18, 231–241.