ACTA BIOLOGICA CRACOVIENSIA Series Botanica 51/1: 35–37, 2009

SEED GERMINATION OF SEVERAL INVASIVE SPECIES POTENTIALLY USEFUL FOR BIOMASS PRODUCTION OR REVEGETATION PURPOSES UNDER SEMIARID CONDITIONS

ILIAS S. TRAVLOS*

Department of Weed Science, Benaki Phytopathological Institute, 8 Delta st., GR-145 61 Kifisia, Athens, Greece
Department of Crop Production, Agricultural University of Athens, 75 Iera Odos st., 11855 Athens, Greece

Received October 20, 2008; revision accepted January 20, 2009

The introduction of several plant species to areas beyond their natural distribution has been a global phenomenon that poses critical problems and challenges for the conservation and management of many agricultural and natural ecosystems. Shrub medick (*Medicago arborea* L.), Spanish broom (*Spartium junceum* L.) and chaste tree (*Vitex agnus castus* L.) are three of the most important native shrubs in arid and semiarid Mediterranean regions, being noxious invasive species for some areas but in some cases remarkably useful for several purposes. An understanding of their seed germination and seedling emergence should prove useful for their management. Laboratory and greenhouse experiments were done to examine the effects of high temperature on seed gemination and seedling emergence. Dry heat benefitted (or at high temperatures damaged) seed germination and emergence. This implies potential effects of fire on the dynamics of populations of *M. arborea*, *S. junceum* and *V. agnus castus*, a factor which should be taken into account as fire is a frequent component of Mediterranean-type ecosystems.

Key words: *Medicago arborea, Spartium junceum, Vitex agnus castus*, temperature, invasive weeds, biomass, Vonitsa.

INTRODUCTION

The introduction of plant species to areas beyond their natural distribution has been a global phenomenon that poses critical problems and challenges for the conservation and management of many agricultural and natural ecosystems (Economou et al., 2008). It has been suggested that introduced species may succeed or fail to establish depending on complex interactions between a species and its target community. Hence the idea that biological invasions are fundamentally context-specific processes (Crawley, 1987).

Shrub medick (*Medicago arborea* L., Fabaceae), Spanish broom (*Spartium junceum* L., Fabaceae) and chaste tree (*Vitex agnus castus* L., Verbenaceae) are three of the most important native shrubs in arid and semiarid Mediterranean regions; they are noxious invasive species in some areas (Hickman, 1993). On the other hand, these woody species show some desirable characters. *M. arborea* is very drought and cold tolerant; it can reduce soil erosion (Andreu et al., 1994; ICARDA, 1998) and may act as a strategic forage species supporting conventional resources in forage systems for sheep farming in semiarid environments (Papanastasis et al., 1998; Amato et al., 2004). *S. junceum* can grow in poor soils, can prevent soil erosion, is drought tolerant and nitrogen fixing, and could potentially be used as a biomass plant and as a source of fibers for composite materials (Angelini et al., 2000; Travlos et al., 2007c). *V. agnus castus* is very desirable in some rehabilitation programs in degraded lands since it can grow in poor soils and dry regions, and it has nutritional, medicinal and other uses (Hirobe et al., 1997).

Seed germination is a crucial element of their development and life cycle, but little information has been available on the influence of several abiotic factors (such as fire) on their seed germination and seedling emergence (Belhadj et al., 1998; Travlos and Economou, 2006; Travlos et al., 2007c). The

*e-mail: htravlos@yahoo.gr

PL ISSN 0001-5296

purpose of this study was to examine the seed germination and seedling emergence responses of these three species to several temperature pretreatments employing dry heating. The protocols use temperatures frequently occurring during fires in Mediterranean areas. *M. arborea*, *S. junceum* and *V. agnus castus* are invasive species but beneficial ones, so there is a need to contain them and also a need to use them in controlled cultivation for biomass production and revegetation. This study should serve both of those management goals.

MATERIALS AND METHODS

Seeds of these species were randomly collected from ruderal habitats in Vonitsa, Greece (38°40'N, 20°43'E), in August 2006. Laboratory and greenhouse experiments were conducted in the Laboratory of Agronomy of the Agricultural University of Athens (AUA) and the Laboratory of the Weed Department of Benaki Phytopathological Institute (BPI), in order to assess the germination percentages of untreated seeds and seeds subjected to 5-minute hot air treatments (60°C, 80°C, 100°C, 120°C, 140°C) in a laboratory oven (Thermo scientific precision mechanical convection oven, EW-52501-01, Cole-Parmer Instrument Co., UK). The selected experimental temperatures are likely to be reached at the soil surface or in the first few centimeters below ground in bush fires (De Bano et al., 1998). The germination experiments lasted three weeks and were carried out in a complete randomized design under laboratory conditions in incubators (Conviron T 38/Lb/AP) at constant 30°C and total darkness.

There were six replicates of 20 seeds each for every temperature treatment; untreated seeds were the control for each experiment. The 20 seeds were placed between two Whatman No. 1 paper filter disks (Whatman Ltd., Maidstone, England) in a glass Petri dish and 5 ml distilled water was added. The seeds were considered germinated upon emergence of the radicle (Bewley and Black, 1994).

Next, seedling emergence (as a percentage of the germinated seeds) was recorded in two pot experiments in a glasshouse under natural day length of 13–15 h with minimum/maximum air temperature 20/40°C and relative humidity 40/60%. Twenty pregerminated (radicle length 1–3 cm) seeds from each treatment were sown at 1–2 cm depth, 5 seeds per plastic pot (15 cm diameter) filled with 2.4 l slightly calcareous sandy clay loam (SCL) soil (pH = 7.4).

The percentages of germination and emergence (after arcsin transformation) were subjected to one-way ANOVA using the Statgraphics package (ver. 5.0, Statistical Graphics Corporation, Englewood Cliffs, NJ, U.S.A.). Means were compared with Fisher's least significant difference (LSD) test (P = 0.05).

TABLE 1. Seed germination of *Medicago arborea*, *Spartium junceum* and *Vitex agnus castus* in response to several temperature treatments. Means within a column followed by the same letter do not significantly differ by Fischer's least significant difference test at p = 0.05

	Seed germination (%)		
	M. arborea	*S. junceum*	*V. agnus castus*
Control	28±0.6 b	64±0.4 a	44±0.3 c
60°C	29±0.4 b	67±0.6 a	48±0.5 bc
80°C	33±0.7 ab	69±0.6 a	57±0.5 b
100°C	36±0.8 a	73±0.9 a	61±0.7 b
120°C	35±0.4 a	68±0.8 a	64±0.5 ab
140°C	32±0.6 ab	50±0.4 b	72±0.2 a

RESULTS

The germination experiments showed that dry heat can promote and in some cases inhibit seed germination (Tab. 1). Germination of *Spartium junceum* was highest (73%) after the 100°C hot air treatment, followed by the 80°C treatment. In contrast, the 140°C treatment significantly reduced *S. junceum* seed germination to 50%, even lower than the rate for the control seeds (64%). *Vitex agnus castus* seed germination was highest after the 140°C (72%) and 120°C (64%) treatments, significantly higher than for the control seeds (44%) and seeds subjected to 60°C (48%). The effects of high temperatures on *Medicago arborea* seed germination were less significant: the 100°C treatments and 120°C treatments proved slightly more effective than the others (Tab. 1).

There were clearly harmful effects of very high temperature on seedling emergence, especially in *S. junceum* and *V. agnus castus*, as well as beneficial effects at lower heat. The 140°C treatment reduced seedling emergence to 64% in *S. junceum* (vs. 71% in control) and to 62% in *V. agnus castus* (vs. 70% in control). Seed emergence was optimal for *V. agnus castus* after the 80°C and 100°C treatments, and for *M. arborea* after the 100°C or 120°C treatments. The relative effects of high temperature on *S. junceum* seedling emergence were not significant (Tab. 2).

DISCUSSION

Seed production is an important mode of propagation in *M. arborea*, *S. junceum* and *V. agnus castus*; successful seedling emergence is the first step towards their proliferation. The present study is the second part of a continuing project begun in 2004 (Travlos and Economou, 2006; Travlos and Karamanos 2007; Travlos et al., 2007a). So far our results have shown that the most of the tested dry

TABLE 2. Seedling emergence of *Medicago arborea*, *Spartium junceum* and *Vitex agnus castus* in response to several temperature treatments. Means within a column followed by the same letter do not significantly differ by Fischer's least significant difference test at p = 0.05

	Seedling emergence (%)		
	M. arborea	*S. junceum*	*V. agnus castus*
Control	71±1.2 ab	70±0.8 b	68±0.6 b
60°C	74±0.4 a	72±0.9 b	75±0.6 ab
80°C	72±0.7 a	81±0.9 ab	76±1.6 ab
100°C	69±1.3 ab	84±1.4 a	78±0.8 a
120°C	70±0.4 ab	76±0.6 b	81±1.4 a
140°C	64±0.9 b	62±1.6 c	72±0.9 b

heat treatments effectively stimulate seed germination and seedling emergence in these and other species (Tarrega et al., 1992; Travlos et al., 2007b,c) and in other biotypes of the same species (Travlos and Economou, 2006; Travlos and Karamanos 2007; Travlos et al., 2007a). This well documented positive (or negative at high temperature) effect of dry heat underlines the role of fire as a sometimes effective method for controlling the local seed bank and germination rate of these invasive woody plants in Mediterranean-type ecosystems and other arid and semi-arid regions (Thanos and Goerghiou, 1988). More specific field experiments, monitoring and laboratory studies will further optimize the techniques used to achieve rapid and uniform seed germination and seedling emergence. This will contribute to effective management of the large seed bank of these woody species and will help realize their potential use for biomass production, revegetation or other purposes.

REFERENCES

Amato G, Stringi L, and Giambalvo D. 2004. Productivity and canopy modification of *Medicago arborea* as affected by defoliation management and genotype in a Mediterranean environment. *Grass Forage Science* 59: 20–28.

Andreu V, Rubio JL, and Cerni R. 1994. Use of a shrub (*Medicago arborea*) to control water erosion on steep slopes. *Soil Use and Management* 10: 95–99.

Angelini LG, Lazzeri A, Levita G, Fontanelli D, and Bozzi C. 2000. Ramie (*Boehmeria nivea* (L.) Gaud.) and Spanish Broom (*Spartium junceum* L.) fibres for composite materials: agronomical aspects, morphology and mechanical properties. *Industrial Crops and Products* 11: 145–161.

Bewley JD, and Black M. 1994. *Physiology of Development and Germination*. Plenum Press, London.

Crawley MJ. 1987. *Colonization, succession and stability*. Gray AJ, Crawley MJ, Edward PJ [eds.]. Blackwell Scientific, London, England.

Economou F, Travlos I, and Kotoula E. 2008. The current situation of invasive plants in Greece. 2nd *International Symposium*: *Intractable Weeds and Plant Invaders*, 14–18 September 2008, Osijek, Croatia.

Hickman SC. 1993. *The Jepson Manual: Higher Plants of California*. University of California Press. Berkeley, CA.

Hirobe C, Qiao ZS, Takeya K, and Itokawa H. 1997. Cytotoxic flavonoids from *Vitex agnus-castus*. *Phytochemistry* 46: 521–524.

Icarda. 1998. Performance of some forage shrubs in cold environments. *ICARDA Annual Report* 1997 Aleppo, Syria: International Center for Agricultural Research in the Dry Areas, 43–44.

Papanastasis VP, Platis PD, and Dini-Papanastasiou O. 1998. Effects of age and frequency of cutting on productivity of Mediterranean deciduous fodder tree and shrub plantations. *Forest Ecology Management* 110: 283–292.

Tarrega RL, Calvo L, and Trabaud L. 1992. Effects of high temperature on seed germination of two woody Leguminosae. *Vegetatio* 102: 139–147.

Thanos CA, and Georghiou K. 1988. Ecophysiology of fire-stimulated germination in *Cistus incanus* sp. *creticus* (L.). Heywood and C. *salvifolius* L. *Plant, Cell Environment* 11: 841–849.

Travlos IS, and Economou G. 2006. Optimization of seed germination and seedling emergence of *Medicago arborea* L. *International Journal of Botany* 2: 415–420.

Travlos IS, and Karamanos AJ. 2007. Influence of heat on seed germination and seedling emergence of Chaste Tree (*Vitex agnus castus* L.). *Journal of Agronomy* 6: 25–28.

Travlos IS, Economou G, and Karamanos AJ. 2007a. Seed germination and seedling emergence of *Spartium junceum* L. in response to heat and other pre-sowing treatments. *Journal of Agronomy* 6: 152–156.

Travlos IS, Economou G, and Karamanos AI. 2007b. Germination and emergence of the hard seed coated *Tylosema esculentum* (Burch) A. Schreib in response to different pre-sowing seed treatments. *Journal of Arid Environments* 68: 501–507.

Travlos IS, Economou G, and Karamanos AJ. 2007c. Effects of heat and soil texture on seed germination and seedling emergence of Marama Bean, *Tylosema esculentum* (Burch) A. Schreib. *Journal of Food, Agriculture & Environment* 5: 153–156.