VI. FOREST BIOLOGY

GERMINATION OF *TANACETUM CINERARIIFOLIUM* SEEDS ON DIFFERENT SOIL TYPES

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Abstract: *Tanacetum cinerariifolium* (Trevir.) Sch. Bip. is a species of great economic importance because it contains Pyrethrins – natural insecticides with the potential to be the ideal means for pest control. Soil samples from different soil types (Skeletal Fluvisols, Rendzic Leptosol, Luvic Chernozem, Chromic Luvisols, Dystric-Eutric Cambisol, Pellic Vertisols) have been studied in order to determine the physicochemical soil indicators and the regressions between the soil characteristics and seed germination. Four hundred seeds (4x100) were planted in each soil type (in pots) under controlled conditions. Reliable statistically significant regressions, both negative (bulk density, sand fraction, available phosphorus) and positive (total porosity, silt and clay fractions, pH(H₂O), CaCO₃, Total Kjeldahl Nitrogen, Soil Organic Matter) with regard to seed germination have been established. The seeds planted in Rendzic Leptosol have shown the highest germination percentage, and the ones planted in Skeletal Fluvisols have shown the lowest germination percentage.

Key words: *Pyrethrum cinerariifolium* Trev., *Chrysanthemum cinerariifolium* Bocc, seed germination, soil.

INTRODUCTION

The Dalmatian pyrethrum – *Tanacetum cinerariifolium* (Trevir.) Sch. Bip., also referred to as *Pyrethrum cinerariifolium* Trev., *Chrysanthemum cinerariifolium* Bocc [1, 2, 3] is a perennial herbaceous plant of the Asteraceae family [4, 5, 6]. The genus *Tanacetum* is found throughout Europe, temperate Asia, North Africa and North America. This genus comprises more than 150 species, including those previously regarded as belonging to the separate genus *Pyrethrum* Zinn [5, 6, 7]. *T. cinerariifolium* is indigenous to the eastern Adriatic coast, and is also found in Croatia, Bosna and Herzegovina, and Montenegro [5, 8, 9].

The insecticidal activity of *T. cinerariifolium*, resulting from its pyrethrin content [5], was discovered by accident on the Adriatic coast of Croatia in 1840 [1, 10]. Natural pyrethrins have the potential to be the ideal means in the fight against insect pests [11-13]. They are very effective against a wide range of insects [4, 14-17] acting as a contact insecticide [5], and the probability that resistance will develop is low. The immediate knockdown paralysis of insects which ensures their death is particularly valuable [5, 11, 18]. Natural pyrethrins are with low toxicity to mammals and other warm-blooded animals as they are easily broken down into inactive forms and quickly leave the body [5, 11, 19]. Being environmentally friendly, they are a leading insecticide in organic farming [5]. Many authors point out that pyrethrins are the most widely used botanical insecticide [20-23], and Jovetić refers to it as the most important natural insecticide [11]. Another application of pyrethrins is as a repellent for

food protection [5, 11]. If added to the food, pyrethrum may be effective against gastrointestinal, lung and liver parasites in animals [24, 25]. Pyrethrins are unstable and rapidly degrade when exposed to UV light, oxygen, water and increased temperatures [4, 5, 26].

The species was first produced commercially in Armenia [18], and it is currently widely cultivated in many countries around the world [4, 5, 27, 28]. The germination rate of the seeds of *T. cinerariifolium* is not high, especially of the naturally-occurring populations [29-31]. According to a study carried out by Delač, et al. the germination rate of seeds collected from naturally-occurring populations of the species ranges from 6.67 to 27.00% [31]. According to various authors there is a linear downward trend in the viability and germination rate of *T. cinerariifolium* seeds [26, 32, 33]. In a study of seed germination on different soil types Sladonja et al. point out that the seeds of the species germinate on all soil types studied, but the germination rate is not high and the differences between the different soil types are statistically significant [34].

MATERIALS AND METHODS

The object. One-year-old seeds (stored in the dark at 4°C) taken from a natural pyrethrum population in Croatia (MAPO2804 – Accession number from Croatian Plant Genetic Resources Database) germinated on different soil types (Skeletal Fluvisols, Rendzic Leptosol, Luvic Chernozem, Chromic Luvisols, Dystric-Eutric Cambisol, Pellic Vertisols [35]), 4x100 seeds on each soil type.

Methods of study. Fifteen soil pits were dug at representative plots of each soil type. A systematic sampling design was used [36]. The samples were taken at a depth of 0-20 cm. Fifteen soil samples of each soil type were homogenized and reduced to a weight of 2 kg, thus obtaining an average sample for each soil type.

The following soil characteristics were analyzed by using the respective methods:

- Bulk density (BD, g.cm^{-3}), according to the DIN ISO 11272:1998, 2001 [37];
- Total porosity (TP, %) by calculating bulk density and relative density [38];
- Soil texture (Sand - 2 mm - 63 μm , %; Silt - 63 μm - 2 μm , %; Clay < 2 μm , %), using the sedimentation method [39];
- Soil acidity (pH in water extraction) – measured potentiometrically by WTW 720 pH meter [40];
- CaCO_3 – Volumetric method [41];
- Soil Organic Mater (SOM, %) by ISO 14235:1998 [42];
- Total Kjeldahl Nitrogen (TKN, %) content, with a modified version of the classic Kjeldahl method [43];
- P_2O_5 (mg.100g^{-1}) – extraction with Ammonium Acetate and Calcium Lactate-pH 4.2 (UV-VIS spectrophotometer Perkin Elmer Lambda 5) [44];

- K_2O (mg.100g^{-1}) – extraction with Ammonium Acetate and Calcium Lactate-pH 4.2 (Flame photometer Jenway php 7) [44].

Data analysis. Descriptive statistics was done using Numbers and Excel on MacOS. T-testing (Excel on MacOS) was used to prove statistical differences in germination. SPSS for MacOS was used to determine the statistical reliability of linear and polynomial regressions (ANOVA), as well as boxplots.

RESULTS AND DISCUSSION

Seed germination. There are statistically significant differences ($p < 0.05$) in seed germination between all soil types with the exception of Pellic Vertisols/Luvic Chernozem ($p = 0.168$) and Chromic Luvisols/Dystric-Eutric Cambisol ($p = 0.137$). The germination rate was highest on Rendzic Leptosols (Fig. 1) in which the natural populations of the species grow and which are characterized as dry, with a high CaCO_3 content, highly water permeable, stony [1; 25; 45]. Many authors suggest that *T. cinerariifolium* doesn't have high soil requirements and grows well both on forest soils and on Vertisols [1; 46]. However, there are significant statistically reliable differences between forest soils (Chromic Luvisols, Dystric-Eutric Cambisol) and chernozemic soils (Chernozem, Vertisols) although Luvic Chernozems were formed under broad-leaved tree vegetation [47].

Fig. 1. Boxplot of seed germination on different soil types.

Regression between soil characteristics and seed germination. There are reliable linear regressions between the studied physical parameters and the germination rate of the soil. There is a negative statistically significant linear regression between bulk density and seed germination (Fig. 2).

Fig. 2. Linear regression between BD and seed germination.

The negative correlation between bulk density and total porosity [48] means that there is a positive statistically significant linear regression between total porosity and seed germination. These data confirm those from previous studies that the species grows well on water permeable soils [1; 6; 25; 4]

Fig. 3. Linear regression between TP and seed germination.

The correlations between soil texture components and bulk density and total porosity [48] also determine the regression relationships between sand, silt and clay fractions and seed germination. There are linear regressions between soil texture fractions and seed germination. These data confirm those of previous studies on the silt fraction [49] and do not confirm those on the lack of correlations between the sand and clay fractions and seed germination [49].

The influence of the sand fraction on seed germination is described by a negative statistically significant linear regression (Fig. 4). There is a statistically significant regression between the silt fraction and seed germination (Fig. 5), which confirms the presence of a correlation between seed germination and the silt fraction suggested by other authors [49]. There is a linear regression between the clay fraction and seed germination (Fig. 6).

Fig. 4. Linear regression between the sand fraction and seed germination.

Fig. 5. Linear regression between the silt fraction and seed germination.

Fig. 6. Linear regression between the clay fraction and seed germination.

There are statistically significant positive linear regressions between pH(H₂O) (Fig. 7), CaCO₃ (Fig. 8) and seed germination, which are probably due to the fact that the natural populations of *T. cinerariifolium* in Croatia can be found both on

calcareous soils as well as on hard limestone substrate [6, 49, 50, 51]. In their study Sladonja et al. mention the presence of a correlation between pH and seed germination, but not between CaCO₃ and seed germination [51].

Fig. 7. Linear regression between pH (H₂O) and seed germination.

Fig. 8. Linear regression between CaCO₃ and seed germination.

There are statistically significant regressions (polynomial) between SOM (Fig. 9), TKN (Fig. 10) and seed germination.

There is a linear regression between P₂O₅ and seed germination (Fig. 11) and there is no statistically significant regression between K₂O

and seed germination. The data on SOM, TKN and P₂O₅ do not confirm those published by Sladonja et al. on the lack of correlations, and the data on K₂O are consistent with those published by Sladonja et al. on the lack of correlations [49].

Fig. 9. Polynomial regression between SOM and seed germination.

Fig. 10. Polynomial regression between TKN and seed germination.

Fig. 11. Linear regression between P_2O_5 and seed germination.

A lot of plant species require specific soil conditions to develop or specific physicochemical soil characteristics for their optimal growth [52, 53, 54]. The natural populations of *T. cinerariifolium* grow on well-drained skeletal soils with $CaCO_3$ content, but are also found on hard limestone substrate [6, 49, 50, 51]. This is most likely the reason for the high germination rate of *T. cinerariifolium* seeds on Rendzic Leptosols, which are characterized by having favourable physical properties, e.g. water-resistant crumb and granular structure, porosity and bulk density [55]. The favourable physical and hydrophysical properties of Rendzic Leptosols [55] prevent waterlogging, which

is one of the causes for certain and rapid death of *T. cinerariifolium* [1], and the physical and hydrophysical properties make these soils suitable for the cultivation of a number of crops [56]. The ability of calcium to form organomineral complexes, the antagonism between calcium and other basic ions [55, 57], and the fact that *T. cinerariifolium* grows on soils with $CaCO_3$ content are the most likely reason why the species is considered to be undemanding to soil conditions [45, 46]. The common thread among the tree soil types characterized by a high seed germination rate is the chenzem type of soil formation [55, 58].

CONCLUSIONS AND RECOMMENDATIONS

The germination rate of *T. cinerariifolium* seeds is directly related to physicochemical soil characteristics. The average and low bulk density, high total porosity, neutral to slightly alkaline reaction, the presence of carbonates and moderate nutrient availability determine the high seed germination rate. The best results were obtained with Leptosols (Rendzic), Chernozems and Vertisols.

The low germination rate of *T. cinerariifolium* seeds and the limiting physicochemical soil properties mean that the success of seed crop cultivation depends on soil conditions.

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