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Harmful impact of exceptional cold air outbreak in april 1997 on silver fir in Croatia

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Abstract. After a severe outbreak of cold air in mid and late April in 1997, locally occurring damages on twigs and needles of silver fir were recorded in some forests in Croatia. Field examinations in the first half of July 1997 revealed the damages on one-year and older needles while fully developed twigs of current year growth were left intact. Southern and western slopes with fir growing forests represented typically affected sites. Further laboratory analyses confirmed the field observation that no harmful insect or pathogens were the cause of these damages. Spread of symptoms, expressed more heavily at lower elevations, indicated a probable connection with recent exceptionally cold air outbreak in mid-April. Physiological disturbances caused by potassium deficiency are discussed in the light of specific occurrences of damage symptoms on silver fir trees.

Key words: Abies alba, cold air damages, potassium.

Introduction

Abiotic damages on forest trees are well documented and known in forest science and practice for a long time (EDLIN & NIMMO 1956). Among the commonest are injuries caused by cold air and late or early frost (REIF & PAPP 1995). Very often, such damages occur on tree species not fully adapted to their artificial habitat (such as plantations) or plants growing in the border zones of their natural area of spread. In the case of silver fir (*Abies alba* Mill.) cold air damages are not common but are documented and known in the literature (HARTMANN & al. 1988). This paper deals with the rare event of atypical damages on silver fir in natural forest stands of central Croatia in the spring of 1997. Change of needle colour and dieback of twigs and branches was recorded in a relatively isolated area of roughly 40 ha with no visible cues to known biotic agents. At the same time, it was the year of extraordinary atmospheric events and cold air outbreak which occurred during mid and late April and hit the whole country, especially the maritime and mountainous region (BRZOVIĆ 1999). As with the other tree species, the nature of cold hardiness of silver fir is strongly correlated with potassium physiology as potassium is known to increase frost resistance. Potassium deficient plants are more prone to winter damage (BAULE & FRICKER 1970, MENGEL & KIRKBY 1987, BERGMANN 1992).

Based on the data of Diagnostic and Prognostic Service of Forest Research Institute Jastrebarsko, on reported atypical symptoms on silver fir trees in May 1997, in the north Vinodol area (NW Croatia), this research was initiated to find out the possible causes. Impacts of phenological, climatic and physiological factors were analysed in relation with spatially and temporally occurring damages in the research area.

Materials and methods

Samples were collected and trees were analysed on July 10, 1997, at two locations Treskavac and Kalić in the north Vinodol area. Both sites are located at altitudes between 900 and 960 m, with inclination from 0 and 10 °. The site Treskavac covers an area of 17.11 ha, with various expositions, and the site Kalić covers an area of 19.92 ha, with SW exposition. Sampled fir trees were randomly selected, felled and debarked to find out the possible presence of defoliators, suckers or xylophages (expectedly, bark beetles) and pathogenic fungi (wood decay and root rot fungi).

Samples of needles, twigs and branches, with observed visible symptoms, were collected from sampled trees and randomly selected young firs. Standard laboratory analyses were carried out to examine the presence of possible harmful insect fauna or pathogenic fungi.

In the year 2000, the second study was conducted to determine the possible influence of nutrient dynamics on cold hardiness of silver fir, 5 plots (each 100 x 100 m) were chosen in the region of Gorski kotar: Belevine – at altitude of 800 m, SW exposition; Kupjački vrh – at altitude of 1000 m, SW exposition; Leska S – at altitude of 697 m, NW exposition; Leska D – at altitude of 708 m, NW exposition. Aerial distances between these plots and sites Treskavac and Kalić are approximately 20 km. The 5th plot Sljeme was chosen on Medvednica (near Zagreb), at altitude of 954 m, S exposition. Current and 1-year old needles from a total of 141 trees were sampled monthly from February to November. Samples (24-36 trees per location, representing a 30 % size sample of all dominant and co-dominant trees) were pooled by location into a composite sample. Samples were dried at 105 °C and ground. After wet digestion (H_2SO_4 / $HClO_4$) potassium was determined through flame photometer Eppendorf (AOAC 1996).

Climatic data for 1996 and 1997 were obtained from the State Hydrometeorological Institute Zagreb.

Results

Field examinations of affected silver firs revealed irregularly distributed dead needles and twigs resulting with reddish tint of some parts of the crowns or whole trees. In adult trees some branches, randomly positioned in the crowns, showed the abovementioned symptoms. A definitive pattern of damage symptoms was observed on smaller trees and fir saplings: significantly highest proportion of one-year old needles was affected (those developed a year before). In most cases there was also an inexistence of current growth on these shoots. All of these symptoms were recorded with greater intensity at lower elevations in the research area.

Examination of sampled trees in the field obtained no visible attack of sap suckers, defoliators, secondary xylophages nor wood decay or root rot fungi. Laboratory analyses of samples confirmed the field results. There were no pathogenic fungi, neither insect pests as possible causal agents of described symptoms in sites Treskavac and Kalić.

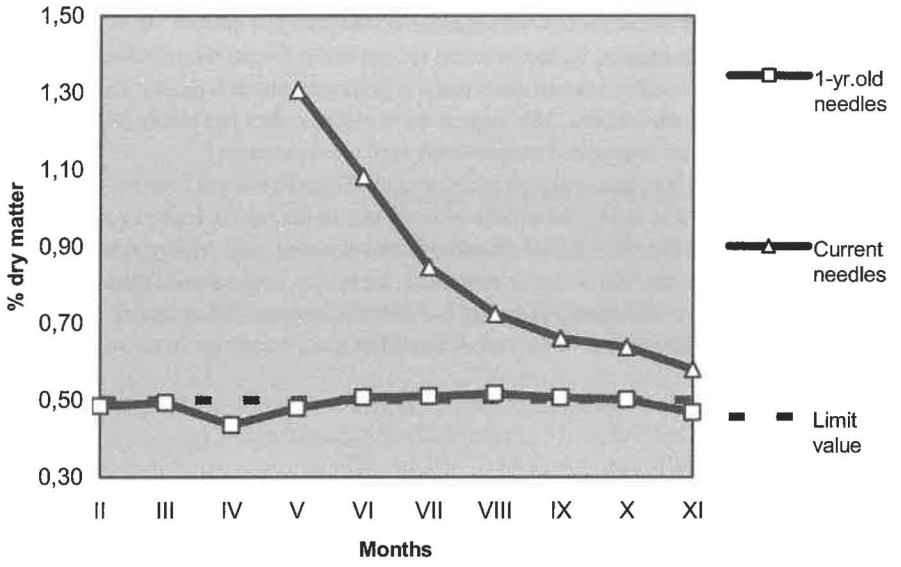

Figure 1: Seasonal dynamics of potassium concentrations in silver fir needles in the year 2000 (averaged values from five locations). Limit value (0.50 %) after BERGMANN (1992).

Dynamics of potassium concentrations in needles revealed a drop of K^+ concentration in older needles due to its redistribution into younger tissues (Figure 1). Translocation of K^+ from one-year old needles (developed in 1999) towards buds is apparent just before the budburst in April, resulting in strong potassium deficiency and high K^+ concentrations in current-year needles.

Discussion

The hypothesis on biotic complex as causal agents for the new case of silver fir dieback, based on the aetiology of already recorded damages in the area, was rejected. In spite of the large amount of wind-felled trees and woody debris, detailed field analysis of newly affected trees and laboratory check-up could not confirm the presence of any significant biotic agent. Spatial distribution of damaged trees, as well as their age-class structure, suggest that some abiotic factor must have had been involved in this event.

A period of exceptionally low temperatures in mid and late April 1997 (both distinct minima, April 16th and 21th, were lower than two standard deviations of the 30-year average) served as a basis for case study by which BRZOVIĆ (1999) explained the mechanisms of local modifications of larger scale atmospheric processes in the area of Northern Mediterranean.

What we consider highly relevant for this study is (I) the fact that the outbreak of cold air in April was one of the strongest ever recorded and (II) the affected area is considered a border zone of naturally growing fir because of the milder climate due to the strong maritime influence from the west. This conforms to the conclusions by FORSTER & al. (1988) and FORDERER & al. (1990) in the case of similar large scale damages recorded in Switzerland after the winter 1986/87.

According to BERGMANN (1992) potassium deficient plants are more prone to winter damage. Older leaves (needles) first reveal symptoms of potassium deficiency (ANIĆ 1973). The dynamics of potassium in the silver fir needles, as shown in the second study, reveals the translocation of potassium from one-year old needles towards buds that are becoming physiologically active, leading to potassium deficiency in older tissues. This drop of K^+ in older needles just before budburst in April coincided in 1997 with the outbreak of exceptionally cold air in the area.

Synthesis of all available data, gathered in the area of affected trees and from the separate study analyzing the nutrient status and cold hardines of silver tree in the region, lead to a conclusion that it must have been a 1997 exceptional cold air outbreak that initiated such damage symptoms. This is further backed up by the fact that at higher elevations, hit by the same climatic phenomenon, were no damages recorded. It is reasonable to deduct that the phenological differences of fir trees in different altitudes acted as key factors in the distribution of damage symptoms in the wider area.

References

ANIĆ, J 1973: Plant nutrition. Faculty of Agriculture, University of Zagreb, 180 pp.

AOAC 1996: Official methods of analysis of AOAC International, Association of Official Analytic Chemists International, Arlington, VA.

BAULE, H. & C. FRICKER 1970: The fertiliser treatment of forest trees. BLV-Verlagsges, Munchen, 223 pp.

BERGMANN, W. 1992: Nutritional Disorders of Plants – Development, Visual and Analytical Diagnosis. Gustav Fischer Verlag Jena etc., 361 pp.

BRZOVIĆ N. 1999: A case study of a cold air outbreak on 20 April 1997 over Croatia. Croatian meteorological journal, **33/34**: 1-18.

EDLIN H. L. & M. NIMMO 1956: Tree injuries. Thames & Hudson, London – New York, 167 pp.

FORDERER L., J. THUDIUM, J. HERTZ, P. BUCHER, R. PANI, R. HUBER & M. KNECHT 1990: Untersuchungen in Zusammenhang mit den Nadelverrotungen des Winters 1986/87 am Flascherberg (St. Luzisteig). Schweizerische Zeitschrift für Forstwesen, **141** (10): 837-849.

FORSTER B., E. JANSEN, H. SCHERRER, M. LEIDIG, H. TURNER, R. HASLER, W. SCHONENBERGER, N. KUHN, W. KELLER, P. LUSCHER, J. BUCHER & W. LANDOLT 1988: Verrotungen immergruner Nadelbaume im Winter 1986/87 in der Schweiz. Berichte Eidgenossische Anstalt für das Forstliche Versuchswesen, No. 307, 90 pp.

HARTMANN G., F. NIENHAUS & H. BUTIN 1988: Farbatlas Waldschäden. Diagnose von Baumkrankheiten. Verlag Eugen Ulmer, Stuttgart, 256 pp.

MENGEL, K. & E.A. KIRKBY 1987: Principles of Plant Nutrition. International Potash Institute, Bern, 686 pp.

REIF A. & V. T. PAPP 1995: Spatfrostschaden in Sudwestdeutschland im Mai 1995. Allgemeine Forst Zeitschrift für Waldwirtschaft und Umweltvorsorge, **50** (23): 1282-1286.