Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture

Open Access

The Effectiveness of Phytosanitary Treatments in the Control of Oak Mildew, in the Current Climate Context

Ioan TĂUT[1,2], Mircea MOLDOVAN[1*], Vasile ȘIMONCA[1,2] Florin REBREAN[2], Mircea VARGA[2]

[1] *National Institute for Research and Development in Forestry (INCDS) "Marin Drăcea" Cluj*
[2] *Faculty of Forestry and Cadastre, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca*
** Corresponding author: M. Moldovan e-mail: moldo_mirk@yahoo.com*

RESEARCH ARTICLE

Abstract

In the technical process of afforestation, most of the compositions require the act of founding the new forest artificially produced seedlings. In some situations, obtaining them is a difficult process due to the complex diseases and pests that can cause significant losses in nurseries. Climatic factors influencing the health of crops in nurseries are: air temperature, amount of precipitation, atmospheric humidity, potential evapotranspiration. The data were recorded with the help of the CEM DT 172 device, with the help of which data regarding temperature and humidity were recorded within the Beclean and Valea Iușului Nurseries. It was observed that the experiments related to the control of the pathogen *Oidium alphitoides,* using *Proquinazid 200gr/l* were placed in three cultures, one one-year-olds and two two-year-old, the amount of solution being the same in each variant, differing only the concentration and effectiveness was performed on four degrees of attack. The situation was positively reflected at the time of determining the effectiveness, when, except for the control variant, in all the treated variants most seedlings were weakly or moderately attacked.

Keywords: oaks; powdery mildew; temperature; humidity; treatment

Received: 15 September 2022
Accepted: 11 December 2022
Published: 15 May 2023

DOI:
10.15835/buasvmcn-hort:2022.0031

INTRODUCTION

In the process of afforestation of forest lands, artificially produced seedlings are used almost exclusively in afforestation compositions. In some situations, obtaining the seedlings is a difficult process due to the complex of diseases and pests that can cause significant losses in forest nurseries. In nurseries, the aim is to obtain as many seedlings as possible per surface unit, through an effective use of the cultivated land. However, seedling production cannot exceed certain limits without having negative consequences on quality. In order to grow normally, each seedling needs a certain volume of soil and air, which ensures the minimum space for nutrition. Determined by the volume of the nutrition space, the size of the crops depends on the age and size of the seedlings, the demands of the species and the vegetation conditions (García-Cebrián, 2003).
Due to the large production of seedlings in small spaces, the conditions are created for outbreaks of infestation with different pathogens, which can cause significant damage to the saplings. In order for the damage to be at the lowest level, a series of measures and treatments are usually applied: using seeds obtained from resistant parents, crop rotation, bathing the seeds and applying treatments of seedlings with various fungicides (Marcais, 2014). The complex constituted by the host plant and the parasite that attacks it is subject to the direct influence of the environment, through its various factors, acts both on the

plant, changing its resistance, and on the pathogen, changing its virulence (Bobeș, 1983; Șimonca, 2017). For this reason, the study of plant diseases must be done in close connection with the microclimates in the nursery area, which gives it a pronounced regional character, certain particularities of the environment decisively influencing the success of certain treatments, schemes or technologies to combat and control diseases (Tăut, 2001; Demeter, 2021). Plant diseases are characterized by a decrease in the amount of organic substances produced and accumulated in the plant, respectively by morphological, anatomical, histological, cytological, physiological, biochemical changes, which means a decrease in the quality of seedlings. In general, plants obtained in nurseries are more sensitive than those obtained in natural regenerations, the main reason being the development in conditions different from the natural living conditions of their place of origin (Desprez-Loustau, 2019).

For the study of plant diseases, it is necessary to know the symptoms by which it manifests itself, the morphology and biology of the pathogen that causes it, the mutual relations between the host plant and the pathogen, as well as the influence exerted by environmental conditions (Chira, 2003, Pârvu, 2010).

One of the main factors of the natural environment and at the same time its most dynamic component is the climate. Climate is a complex concept, with different values, including all the meteorological elements (radiant energy, air temperature, atmospheric humidity, precipitation, wind) called in the specialized literature climatic elements or, more often, climatic factors. Climate changes in the environment and the impact these changes have on the state of vegetation and the health of forests constitute a topical and highly complex issue. The changes in the climate regime fall into a global context, but with particularities of the geographical region in which our country is located (Păltineanu, 2008).

Climatic factors that influence the health of crops in nurseries (to detect the evolution of a disease/attack/development phase, etc.) are air temperature, amount of precipitation, atmospheric humidity, potential evapotranspiration (Desprez-Loustau, 2010, Topalidou, 2016).

The forecasted climate trends for Romania according to the National Meteorological Agency and the data underlying the National Climate Change Strategy provide for the following:

- the average temperature at the beginning of the growing season has increased during the last four decades, with a maximum of 1°C in the southeastern regions;
- the amount of precipitation in the growing season was reduced by approx. 25-75 mm over the last four decades;
- the average minimum temperature in summer is already higher;
- the thickness of the snow layers decreased significantly in the north-east, center and west of Romania;
- average annual temperatures in Romania will continue to rise constantly, especially in summer and winter;
- the precipitation regime may not change significantly in the winter season, except for a slight increase in the northwest of the country and slight decreases in the southwest;
- a general decrease in precipitation in the summer season of up to 40% is expected, especially in the south and southeast of the country;
- the average daily rate of precipitation for Romania will be reduced by about 20% (Bouriaud, 2014).

Influence of temperature, air humidity and light intensity on conidial germination and mycelial development of the fungus *Oidium (f.c.Oidium) alphitoides* Griff. et Maubl. it has been studied so far under controlled (laboratory) conditions (Tăut, 1995, Takamatsu 2007, Buras, 2019).

This group of pathogens is characterized by a development within a large climatic amplitude (proof of the huge area in which the disease manifests itself, from the Mediterranean basin to Scandinavia), but certain particularities of the local climate, which coincide with the appearance of favorable periods can explain the galloping evolutions of island disease within this widespread area (Tăut, 2001, Vaštag, 2019).

Within the cultural control methods, we can talk about maintaining a reasonable limit of damage caused by the pathogenic spectrum by correctly performing the operations specific to the management of a nursery (Simionescu, 2000, 2012). Such prescriptions may dictate: seed quality and health, specific crop densities, soil and nutrient bed quality, fertilization and irrigation. These actions change the environment so that it becomes unfavorable for the establishment and/or manifestation of the disease (Kasprzyk, 2022, Kavková, 2007).

Chemical control methods are essentially based on the principle of prevention (the treatment should be applied before the onset of the disease and the active substance should function as a chemical or physiological barrier) (Markovic, 2014).

Once the infection is triggered, its cure becomes very difficult, in this situation the goal becomes that of limiting its spread and virulence (Man, 2012).

Although the chemistry of pesticides knows a special development, and the offer of companies producing these products is particularly rich, in the forestry field, unlike the agricultural one, difficulties arise, generated by certain additional criteria regarding the degree of toxicity and selectivity of the chemical product, by the specifics of the forest environment, etc. (Mazour, 2010, Mougou, 2008).

The determining criterion for placing a pesticide on the market is first the economic one, and the relatively small amounts used in forestry do not encourage producers, except in special cases, to produce fungicides specialized strictly against certain forest pathogens (Olchowik, 2017, Oszako, 2021, Pap, 2012).

In this article, was studied the effectiveness of some antifungal substances in the control of the disease produced by *Oidium (f.c.Oidium) alphitoides* Griffon et Maubl, a disease that causes significant damage in oak crops, this being followed in correlation with the climatic factors during the application of the treatments .

MATERIALS AND METHODS

To achieve the proposed objectives, two experimental blocks were placed (block 1 in one-year culture, block 2 in 2-year culture) within the Beclean Forest District, in the Beclean nursery (Figure. 1) and one in the Lechința Experimental Base, in the nursery Valea Iușului (block 3, two-year crop - Figure. 2).

Figure. 1. Beclean Nursery, (coordinates: 47.184.154; 24.191690)
(Source: Google Earth pro)

Figure 2. Valea Iușului Nursery, (coordinates: 46.947686, 24.242880)
(Source: Google Earth pro)

In the experimental devices Figure 3 and Figure 5 three treatments were carried out with the fungicide having the active substance *Proquinazid* 200gr/l (Talendo commercial product, produced by Corteva). The concentrations and doses used on the variants according to the crop year were:

- V1- 0,025%, 300 l/ha year I, 500 l/ha year II;
- V2 - 0,018%, 300 l/ha year I, 500 l/ha year II;
- V3 - 0,02%, 300 l/ha year I, 500 l/ha year II;
- V4 (M) – Control, untreated.

In order to capture the situation as correctly as possible, the intensity of the attack was determined, both before and after the application of the treatments, and then was made the placement in one of the four classes, as follows:

- NA (0) – seedlings not attacked;
- SA (1) – weakly attacked seedlings, where powdery mildew spots cover up to 25% of the leaves;
- MA (2) – moderate attacked seedlings, where the powdery mildew spots cover between 25-50% of the leaves;
- PA (3) – heavily attacked seedlings, where powdery mildew spots cover more than 50% of the leaves.

Also, the degree of attack was determined, according to the formula introduced by Townsend and Heuberger (Stevic et al., 2010):

$$GA(\%)=\frac{\sum(nxv)}{NxV}x100$$

where: n- the degree of infection established according to a certain scale; v- the number of individuals in the respective category; N- the total number of classes; V- the total number of individuals and the effectiveness of the treatments.

According to the formula:

$$E=100-Z,\ Z=\frac{GAvx100}{GA\ m}$$

where E - the effectiveness; GAv(m) - the degree of attack, in the treated and control variants; Z - the ratio between the degree of attack in the treated and control variants (Tăut, 1995).

In order to analyze the climatic data, Data Logger CEM DT 172 devices were placed, with the help of which data related to temperature (in degrees Celsius) and relative humidity in % RH hourly were collected Figure 4 and Figure 5 and regarding precipitation, the data were obtained from the Bistrita Weather Station.

Figure 3. Installation of a climate data measuring device in the Beclean nursery

Figure 4. Placement of experimental variants in the Beclean nursery

Figure 5. Installation of climatic data measuring device and experimental variants in the Valea Iuşului nursery

RESULTS AND DISCUSSIONS

Health status of seedlings within the experimental blocks

At the time of application of the treatments, the infestation was in the early phase in all variants, affected saplings being in a very low percentage, an aspect followed in the effective progress of the treatments.

From the evaluations, it was found that the health status of the seedlings in experimental block 1 before the application of the treatments was good (July 16, 2020), the number of medium and strongly affected seedlings being low. With the increase in temperature and humidity, associated with the fragility of one-year-old seedlings, after the application of the treatments, at the evaluation on August 19, a slight increase in the number of medium-sized seedlings attacked, especially in variants one (10%) and three (30%), one of the causes being the age of one year when the seedlings are more sensitive Figure 6.

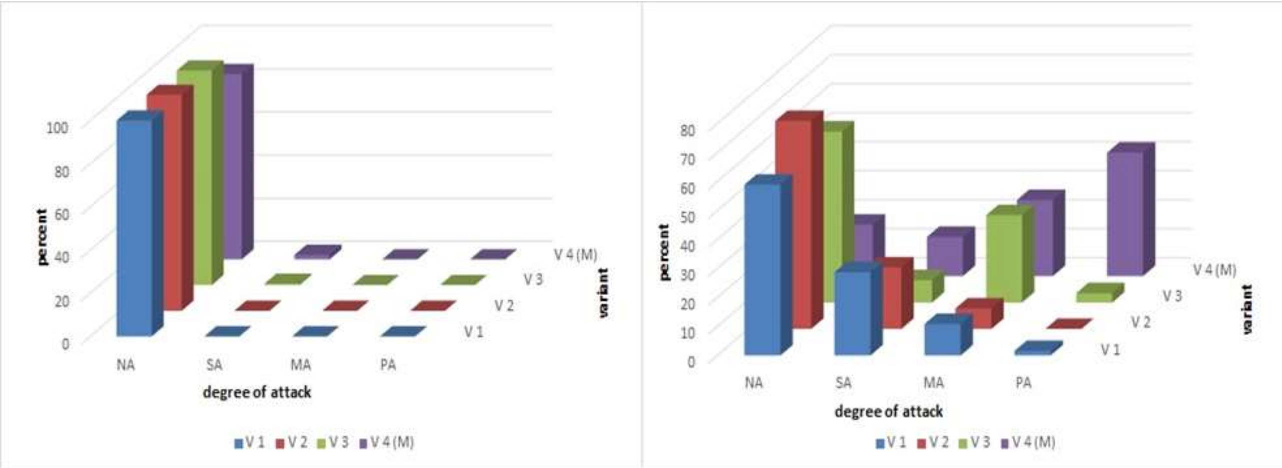

Figure 6. The distribution of the seedlings by degree of attack, before (left) and after (right) the application of the treatments, in the control of powdery mildew in the experimental block 1, Pepiniera Beclean

In experimental block 2, before the treatments, it was found that the average percentage of seedlings attacked is 4% in variant 1 and approximately 1% in the other variants. After applying the treatments, the average number of attacked seedlings decreases in variant 1, below 1%, increasing to approximately 3% in variant 2 and 4% in variant 3 Figure 7. Within block 3 (Pepiniera Valea Iușului, BE Lechința), the treatment options were the same, the initial situation being more favorable, the weakly attacked seedlings being 29% in variant 1, respectively 21% in variant 2 and 3.

The general situation was also positively reflected at the time of determining the effectiveness when, with the exception of the control variant, although less than 1% of seedlings were strongly attacked in all three variants, the percentage of weakly attacked seedlings dropped to 10% in variant 1 and 2, respectively at 13% in option 3.

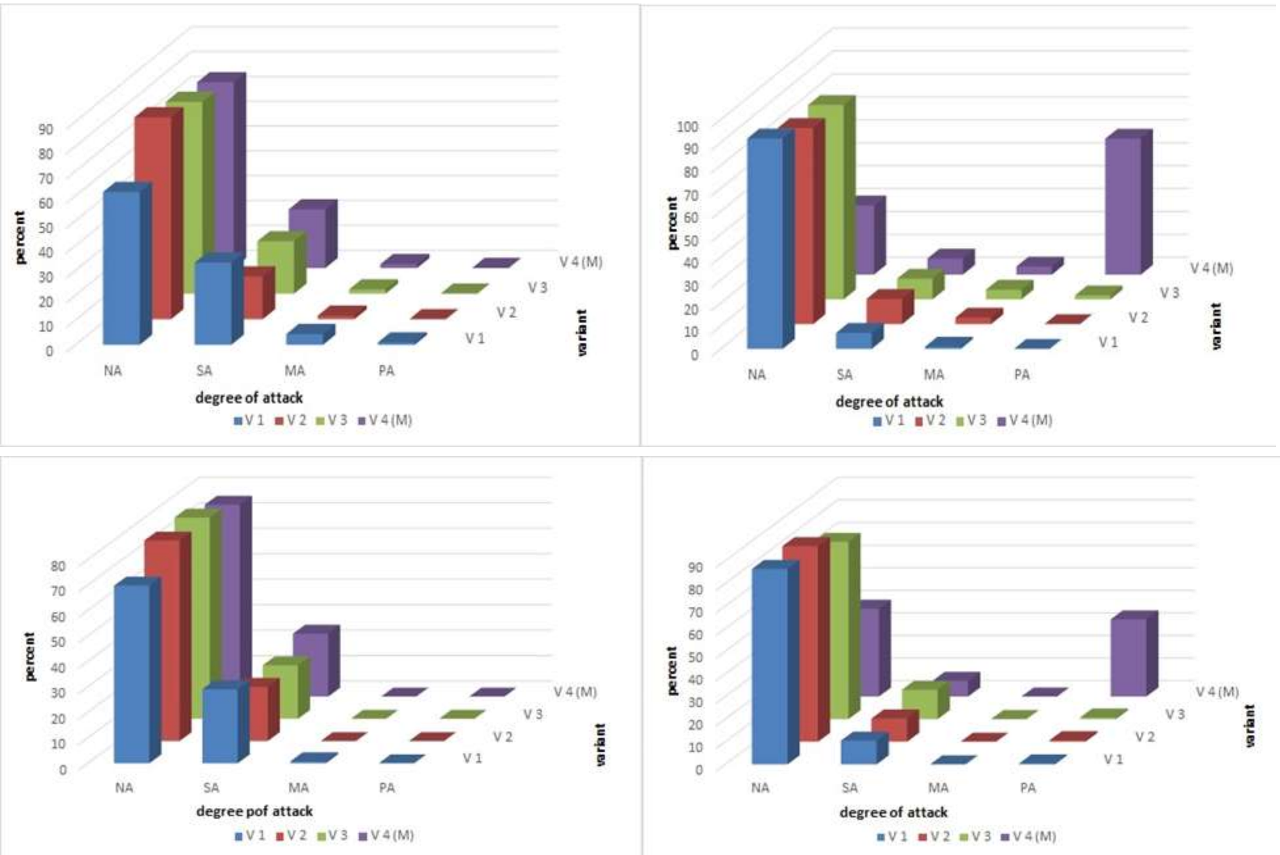

Figure 8. The distribution of seedlings by degree of attack, before (left) and after (right) the application of the treatments, in the control of powdery mildew in the nursery Valea Iușului.

Table 1. Effectiveness of applied treatments expressed in percentages

Repetition	Treatment option	Beclean 1 year	Beclean 2 years	Valea Iușului 2 years
1	V1	92.68	90.63	96.86
	V2	85.52	91.18	94.03
	V3	86.18	79.02	92.43
2	V1	94.33	64.57	87.28
	V2	87.06	78.02	89.90
	V3	81.37	3.65	81.60
3	V1	98.04	38.31	68.82
	V2	97.91	64.28	76.70
	V3	96.30	57.57	67.29
Average	V1	95.28	71.55	88.34
	V2	91.10	81.76	88.10
	V3	88.24	59.92	78.84

Note: After establishing the degrees of attack, the effectiveness of the fungicide used was determined, a situation presented in Table 1, where it can be seen that the highest effectiveness was in experimental block 1, in the Beclean nursery, and the lowest in experimental block 2, in the same nursery.

Climate data results

The climate of each area directly influences the production of saplings, especially those of *Quercinea*, therefore the microclimate conditions were analyzed in each of the studied locations.

From the analysis of the climate data recorded between July 11 and August 22, it can be seen Figure 9 that there are differences in the thermal regime between the two locations, thus in the Valea Iușului nursery there were 3 days with an average temperature below 18°C during the analyzed period; 8 days with values between 18-20°C; 13 days with values between 20-21 °C; 7 days with values between 21-22°C; 3 days with values between 22-23°C; 3 days with values between 23-24°C; 3 days with values between 24-25°C and 3 days with values above 25°C.

During the same period, the values recorded (Figure 9) in the Beclean nursery were: one day with an average temperature below 18°C; 5 days with values between 18-20°C; 3 days with values between 20-21 °C; 7 days with values between 21-22°C; 7 days with values between 22-23°C; 5 days with values between 23-24°C; 3 days with values between 24-25°C and 12 days with values above 25°C.

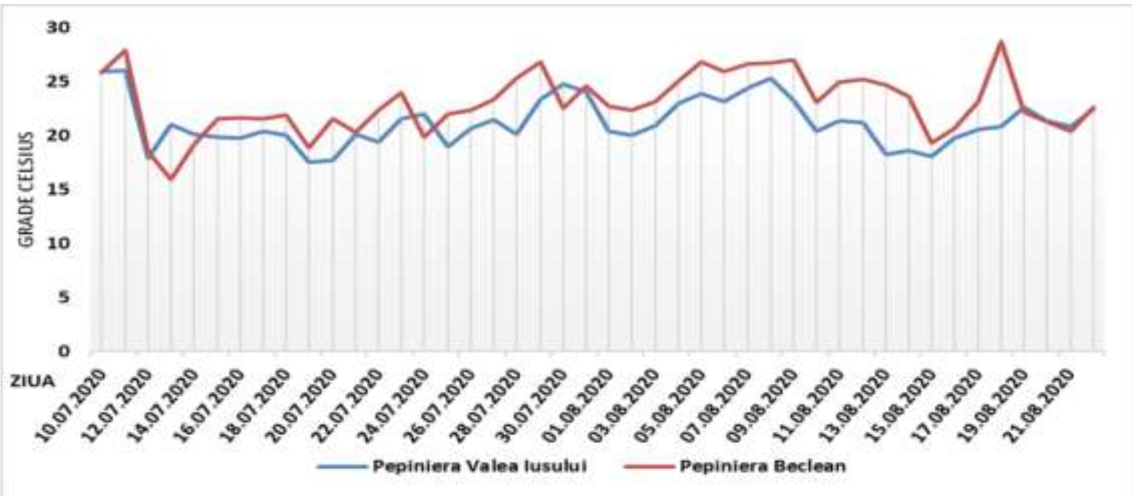

Figure 9. Evolution of the average daily temperature during the studied period

Regarding the atmospheric humidity Figure 10, it is found that in the two locations, the two evolution curves follow the same amplitude of variation, which we correlate with the precipitation regime of the studied period (moderate to excessively rainy). For this climatic indicator in Beclean nursery, during most of the analyzed period, were recorded between 60-80% (31 days out of 43) and there was only one day with exceeding this value, while in the nursery Valea Iușului recorded 7 days with atmospheric humidity over 80%, of which 2 were even over 90%.

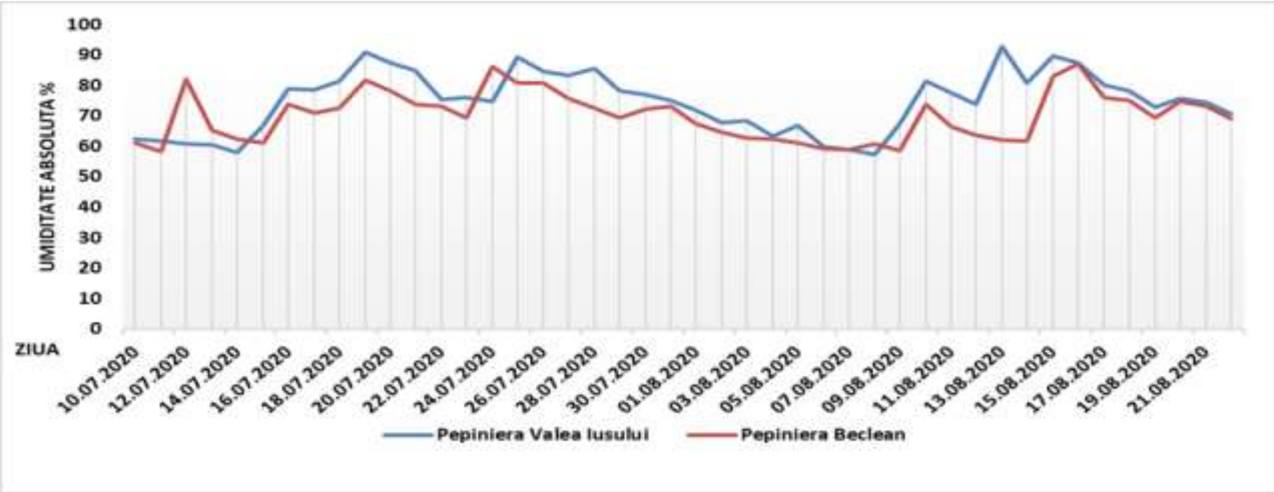

Figure 10. Evolution of relative humidity of the air during the studied period

According to Figure 11, there was a total of 111.73 mm of precipitation in July (moderately rainy, only in 2014 there were 173 mm, in the last 3 years between 58-71 mm, and the multiannual average is 77 mm), and in August were 33.79 mm (within the range of the multi-year average - 32 mm).

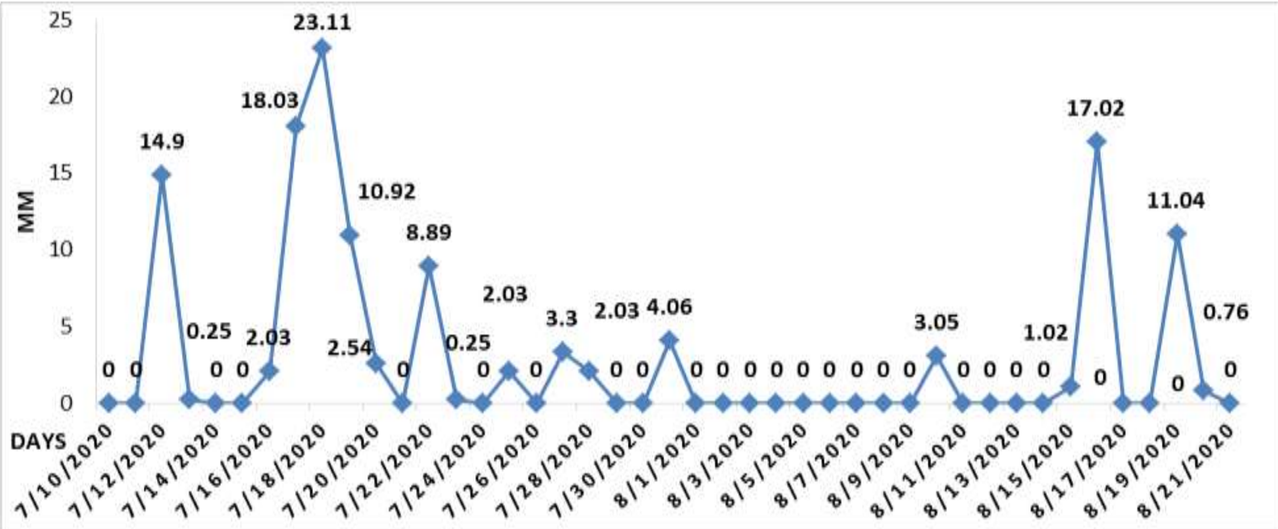

Figure 11. The amount of precipitation recorded in July and August (Bistrita Weather Station)

CONCLUSIONS

Analyzing the distributions by degrees of attack in the three experimental blocks, it was observed that in the case of block 1 the moderat attacked and strong attacked seedlings are more numerous compared to experimental blocks 2 and 3, a fact explained by the age of one year, the seedlings being more sensitive to mildew attack.

Following the application of phytosanitary treatments, their effectiveness was calculated, thus resulting in greater effectiveness in experimental blocks 1 and 3, compared to block 2.

The variants were treated when the initial situation was very favorable, the application of the first treatments took place when the infection had not appeared or was incipient. The situation was also positively reflected at the time of determining the effectiveness, when, with the exception of the control variant, in all the treated variants the vast majority of seedlings were weakly or moderately attacked, the strongly attacked ones did not exceed 4%.

The climate of each area directly influences the production of saplings, especially of *Quercinea*, that is why each microclimate in which the experiments were placed was analyzed. The data were recorded using the CEM DT 172 device.

The evolution of air temperature and humidity over decades reveals the fact that there were no major differences in the regime of the two factors involved, a slight deviation being registered for the period August 1-10, which turned out to be the warmest and driest period of the 43 analyzed days.

Author Contributions: I.T. and V.Ș Conceived and designed the analysis; M.M., V.Ș. and M.V. Collected the data; F.R. and M.M. Contributed data or analysis tools; F.R. and V.Ș.. Performed the analysis; M.M. and I.T Wrote the paper.

Funding Source:
This research was funded by the project " Modernizarea tehnologiilor de control al patogenilor din culturile silvice, in actualul context climatic " (PN 19070205), Cresforlife.

Conflicts of Interest
The authors declare that they do not have any conflict of interest.

REFERENCES

1. Bálint J, Nyárádi I-I, Fora CG. Substanțele active ale pesticidelor. Ed. Erdélyi Múzeum-Egyesület, Cluj Napoca. 2021; 274-275.
2. Buras A, Rammig A, Zang CS. Quantifying impacts of the drought 2018 on European ecosystems in comparison to 2003. Biogeosciences Discussions. 2019; 1-23.
3. Bobeş I,. Atlas de fitopatologie şi protecţia agrosistemelor, Ed.Ceres Bucureşti, 1983.
4. Bouriaud L. Recomandări și concluzii privind adaptarea gestionării pădurilor la schimbările climatice în studierea rolului comportamentului uman în adaptarea gestionării pădurilor la schimbările climatice, 2014.
5. Chira D, Tăut I, Chira F. Cap. III. Bolile. Protecţia pădurilor. RNP, Ed. Muşatinii Grup, Suceava. 2003; 460-613.
6. Demeter L, Molnár ÁP, Öllerer K, Csóka G, Kiš A, Vadász C and Molnár Z. Rethinking the natural regeneration failure of pedunculate oak: The pathogen mildew hypothesis. Biological Conservation. 2021; 253, 108928.
7. Desprez-Loustau M.L., Robin C, Reynaud G, Déqué M, Badeau V, Piou D, Husson C, Marçais B. Simulating the effects of a climate change scenario on geographical range and activity of forest pathogenic fungi. In: Loustau D (ed) Response of temperate and Mediterranean forests to climate change: effects on carbon cycle, productivity and vulnerability.2010; QUAE, Paris, p. 253–280.
8. Desprez-Loustau M L, Hamelin F & Marçais B. The ecological and evolutionary trajectory of oak powdery mildew in Europe. Wildlife Disease Ecology: Linking Theory to Data and Application (Ecological Reviews). Cambridge University Press (Cambridge). 2019; 429-457.
9. FSC. FSC List of 'highly hazardous' pesticides. FSC-STD-30-001a EN. Forest Stewardship Council. +. 2019.
10. García-Cebrián F, Esteso-Martínez J, Gil-Pelegrín E. Influence of cotyledon removal on early seedling growth in *Quercus robur* L. Ann. For. Sci. 2003; 60, 69–73.
11. Kasprzyk W, Baranowska M, Korzeniewicz R, Behnke-Borowczyk J, & Kowalkowski W. Effect of irrigation dose on powdery mildew incidence and root biomass of sessile oaks (*Quercus petraea* (Matt.) Liebl.). Plants, 2022; 11(9), 1248.
12. Kavková M, Curn V, Kubátová B, Desprez-Loustau ML, Dutech C, & Marcais B. Oak powdery mildew (Mıcrosphaera alphitoides): biology, epidemiology and potential control in Europe. Commun Inst For Bohemicae. 2007; 23, 73-81.
13. Man SR, Oroian I, Odagiu A, Man A, & Braşovean I. Influence of fertilizations upon the intensity of Microsphaera abbreviata attack in oak nurseries. Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Agriculture. 2012; 69(2).
14. Marçais B, & Desprez-Loustau ML. European oak powdery mildew: impact on trees, effects of environmental factors, and potential effects of climate change. Annals of Forest Science, 2014; 71(6), 633-642.
15. Markovic M, Rajkovic S, Rakonjac L, & Lucic A. Suppression of oak powdery mildew through use of biofungicides. In Book of proceedings: Fifth International Scientific Agricultural Symposium" Agrosym 2014", Jahorina, Bosnia and Herzegovina, October 23-26, 2014. University of East Sarajevo, Faculty of Agriculture, 538-543.
16. Mazur S, & Wojdyła A. Protection of pedunculate oak against powdery mildew and its effect on plant growth. Ecological Chemistry and Engineering. 2010; 17(9), 1141-1146.
17. Mougou A, Dutech C, & Desprez-Loustau ML. New insights into the identity and origin of the causal agent of oak powdery mildew in Europe. Forest Pathology.2008; 38(4), 275-287.

18. Olchowik J, Bzdyk RM, Studnicki M, Bederska-Błaszczyk M, Urban A, & Aleksandrowicz-Trzcińska M. The effect of silver and copper nanoparticles on the condition of English oak (*Quercus robur* L.) seedlings in a container nursery experiment. Forests, 2017; 8(9), 310.
19. Oszako T, Voitka D, Stocki M, Stocka N, Nowakowska JA, Linkiewicz A, ... & Malewski T. Trichoderma asperellum efficiently protects Quercus robur leaves against Erysiphe alphitoides. European Journal of Plant Pathology. 2021; 159(2), 295-308.
20. Pap P, Ranković B, & Maširević S. Significance and need of powdery mildew control (Microsphaera alphitoides Griff. et Maubl.) in the process of regeneration of the pedunculate oak (*Quercus robur* L.) stands in the Ravni Srem area. Periodicum Biologorum. 2012; 114(1), 91-102.
21. Paltineanu C., Chitu E., Tanasescu N. Using the crop water stress index in irrigation scheduling in apple orchards on southern Romania. Scientific Papers of the Research Institute for Fruit Growing Pitesti, Invel Multimedia. 2008; 24, 126-137.
22. Pârvu M. Ghid practic de fitopatologie. Ed. Presa Universitară. 2010; 316-321.
23. Simionescu A & Mihalache G. Protecția pădurilor. RNP, Ed. Mușatinii Grup, Suceava, 2000.
24. Simionescu A, Chira D, Mihalciuc V, Ciornei C, Tulbure C. Starea de sănătate a pădurilor din România din perioada 2001-2010. Ed. Mușatinii, Suceava, 2012.
25. Șimonca V, Oroian I, Chira D, & Tăut I. Methods for quantification of the decline phenomenon and determination of the vulnerability degree for the oak stands in Northwestern Transylvania, Romania. Notulae Botanicae, Horti Agrobotanici, Cluj-Napoca. 2017; 45(2), 623-631.
26. Stevic M, Vulsa P and Elezovic I. Resistance of Venturia inaequalis to Demethylation Inhibiting (DMI) Fungicides. Zemdirbyste Agriculture. 2010; 97, 65-72.
27. Sucharzewska E. The development of Erysiphe alphitoides and E. hypophylla in the urban environment. Acta Mycologica. 2009; 44(1), 109-123.
28. Takamatsu S, Braun U, Limkaisang S, Kom-Un S, Sato Y, & Cunnington J H. Phylogeny and taxonomy of the oak powdery mildew Erysiphe alphitoides sensu lato. Mycological Research. 2007; 111(7), 809-826.
29. Tăut I. Cercetările privind combaterea ciupercii Microsphaera abbreviata (f.c. *Oidium alphitoides*). Revista pădurilor. 1995; 2, 26-31.
30. Tăut I. Agenți patogeni identificați in culturile silvice. Prevenire și combatere. Anale ICAS. 2001; 1, 68-71.
31. Tăut I, Holonec L. New technologies to control *Microsphaera abbreviata* Peck, In Methodology of Forest Insect and Diseases Survey in Central Europe. 2001; 172-177.
32. Topalidou ET & Shaw MW. Relationships between oak powdery mildew incidence and severity and commensal fungi. Forest Pathology. 2016; 46(2), 104-115.
33. Vaštag EE, Kastori RR, Orlović SS, Bojović MM, Kesić LA, Pap PL, & Stojnić SM. Effects of oak powdery mildew (*Erysiphe alphitoides* [Griffon and Maubl.] U. Braun and S. Takam.) on photosynthesis of pedunculate oak (*Quercus robur* L.). Zbornik Matice srpske za prirodne nauke. 2019; 136, 43-56.