ЛЕСОВОССТАНОВЛЕНИЕ И ЛЕСОРАЗВЕДЕНИЕ
FOREST REGENERATION AND FOREST GROWING

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M. Alam, I. V. Voitau, V. V. Nosnikov
Belarusian State Technological University

ENHANCING FOREST PLANTATIONS SURVIVABILITY THROUGH HYDROGEL, FERTILIZERS, AND GROWTH REGULATORS

Lebanonis facing several social and climatic stresses that are impacting its forest cover and reforestation. In spite of numerous initiatives undertaken by the government, there are indications of an increasing drought like conditions due to climining yearly temperatures and lower precipitation over the past decades. There is an urgent need to take action in terms of not only policymaking but also making available practical and actionable insights that can assist in reforestation efforts. This study aimed to explore the scope of using hydrogel, fertilizers and growth regulators to enhance survivability of seedlings and to ensure their high growth. The findings have provided insights about effectiveness of using a 1% concentration of urea or ammonia for the most effective moisture retention in the hydrogel and showed the possibility of their joint use. The study also found Cornevin to provide best results with 1% concentration. Epin showed slightly worse results, but can also be used in conjunction with hydrogel. When creating forest plantations, treatment of root systems with the growth regulator Epin together with a hydrogel increases the survival rate of seedlings, their weight and height, which can be recommended for sandy soils, including arid conditions. In addition, high survival rates and biometric indicators were shown by the use of containerized seedlings, which can also be recommended for the creation of forest plantations in such conditions.

Keywords: arid conditions, pine (*Pinus sylvestris*), forest plantation, survivability, hydrogel, growth regulators, fertilizers.

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М. Алам, И. В. Войтов, В. В. Носников
Белорусский государственный технологический университет

ПОВЫШЕНИЕ ПРИЖИВАЕМОСТИ ЛЕСНЫХ КУЛЬТУР С ПОМОЩЬЮ ГИДРОГЕЛЯ, УДОБРЕНИЙ И РЕГУЛЯТОРОВ РОСТА

Ливан сталкивается с рядом социальных и климатических стрессов, которые влияют на лесной покров и лесовосстановление. Несмотря на многочисленные действия, предпринятые правительством, сохраняется опасность возникновения засухи вследствие повышения годовых температур и уменьшения количества осадков за последние десятилетия. Существует настоятельная необходимость в разработке практических и действенных идей, которые могут помочь в восстановлении лесов. Целью данного исследования было изучение возможности использования гидрогелей, удобрений и регуляторов роста для повышения приживаемости сеянцев и усиления их роста и развития. Полученные данные показали эффективность использования раствора мочевины или аммонийного удобрения 1%-ной концентрации совместно с гидрогелем. Рассмотрено применение вместе с гидрогелем таких регуляторов роста, как Корневин, который обеспечивает наилучшие результаты при концентрации 1%, и Эпин, показавший несколько худшие результаты. В то же время при создании лесных культур обработка корневых систем регулятором роста Эпин совместно с гидрогелем повышает приживаемость сеянцев, их массу и высоту, что может быть рекомендовано для песчаных почв, в том числе и для засушливых условий. Кроме того, высокие значения приживаемости и биометрических показателей были получены при использовании сеянцев с закрытой корневой системой, которые также могут быть рекомендованы для создания лесных культур в таких условиях.

Ключевые слова: засушливые условия, сосна (*Pinus sylvestris*), лесные культуры, приживаемость, гидрогель, регуляторы роста, удобрения.

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Statement of the problem. Climate change has precipitated a myriad of environmental challenges, most notably droughts and elevated temperatures, which have deleterious consequences on the vitality and persistence of plant species. Regions undergoing a transition towards increasingly arid climates, such as the Mediterranean region, particularly Lebanon, have witnessed pronounced impacts from these challenges, resulting in a discernible decline in plant growth and survival rates. In response to this pressing issue, an array of strategies has been employed, including the utilization of containerized seedlings, hydrogel application, fertilization, and growth regulators. Nevertheless, a comprehensive investigation into the collective efficacy of this amalgamation in enhancing the survival rates of Pinus seedlings, an ecologically significant tree species in Lebanon, remains conspicuously absent. Hence, the principal objective of this study is to assess the effectiveness of employing a combination of containerized seedlings, hydrogel, fertilizers, and growth regulators on the survival rates of Pinus seedlings exposed to the harsh conditions of high temperatures and prolonged drought induced by climate change. Additionally, this research endeavors to ascertain the optimal dosages of this composite treatment for the maximization of seedling survival rates.

Introduction. Historical records indicate that Lebanon was once covered with extensive coniferous forests, constituting over 70% of its land area [1]. However, these forests have endured centuries of exploitation, dating back to 7700 BC, with various civilizations like the Phoenicians, Romans, Ottomans, and others [1–3]. The pressures of urban development, agriculture, railroad construction, firewood collection, and grazing have led to land degradation, reducing forest coverage [1, 4–7].

In recent times, Lebanese forests have faced further challenges, including climate change, the civil war, rampant bushfires, pathogens, and insect infestations [1, 8–11]. Today, forest coverage has plummeted to a mere 13% [12].

To counter this decline, the Ministry of Environment (MoE) initiated a National Reforestation Plan with the goal of increasing forest cover to 20% within 30 years, garnering support from local and international organizations [1, 11, 13].

Furthermore, a short-term capacity-building project, the “Safeguarding and Restoring Lebanon’s Woodland Resources Project” (SRLWRP), was launched in collaboration with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) [14].

The current study aimed at increasing the survival rate of forest plantations through the combined use of hydrogel, fertilizers and growth regulators, also to test the effectiveness of using containerized seedlings. The study was undertaken using both lab methods and field methods. Two lab methods were conducted, one assessing the comparative impact of fertilizers Urea (N – 46%), Ammonium Sulfate (N – 21%), and Organic liquid humic fertilizer “Biovermtechno” (N – 1.2%) on hydrogel’s water-absorption capacity, the second assessing the comparative impact of Cornevin (indolylbutyric acid, 5 g/kg) and Epin (24-epibrassinolide, 0.025 g/l) on water-absorption capacity. “GidroSorb”, which is a spatially cross-linked polymer of acrylic acid based on a potassium salt, was used as a hydrogel. Next, the field study was conducted to assess the combined impact of alternated combination of Urea, growth regulators, and containerized seedlings on both survivability and Root:Shoot growth rates.

Results and discussion. The aim of the experiment was to assess how the hydrogel absorption capacity using different percentages of fertilizers Urea, Ammonia and organic fertilizer would be affected. The experiment was conducted using tea bags containing 0.5 g of hydrogel and submerging them in different concentrations of urea, ammonia, and organic fertilizer to see the effect of the hydrogel water retention capacity. The tea bag plus the hydrogel weighed around 0.55–0.6 g, and the calculations were made inclusive of the weight of the tea bag containing the hydrogel and the water absorbed.

Fig. 1 below shows that the level of water absorption was higher when using Urea, with maximum absorption occurring at a concentration of 1% of Urea.

Additionally, it needs to be noted that there was no difference between urea and ammonia’s impact on the EC; though there was an increase in the EC with increased concentrations of both. The EC with organic factor was not measurable due to high readings. Also, the same can be inferred from the following Fig. 1 above which depicts the readings using testing of distilled water EC when adding different percent of urea and ammonia.

The results derived from organic fertilizer were considerably disparate. The organic fertilizer’s EC reached values so high that they were beyond the scope of measurable parameters. This could arise from the diverse composition inherent to organic fertilizers, which could be constituted of various solutes in significant quantities [14]. Consequently, when dissolved, these solutes might amplify the EC values disproportionately.

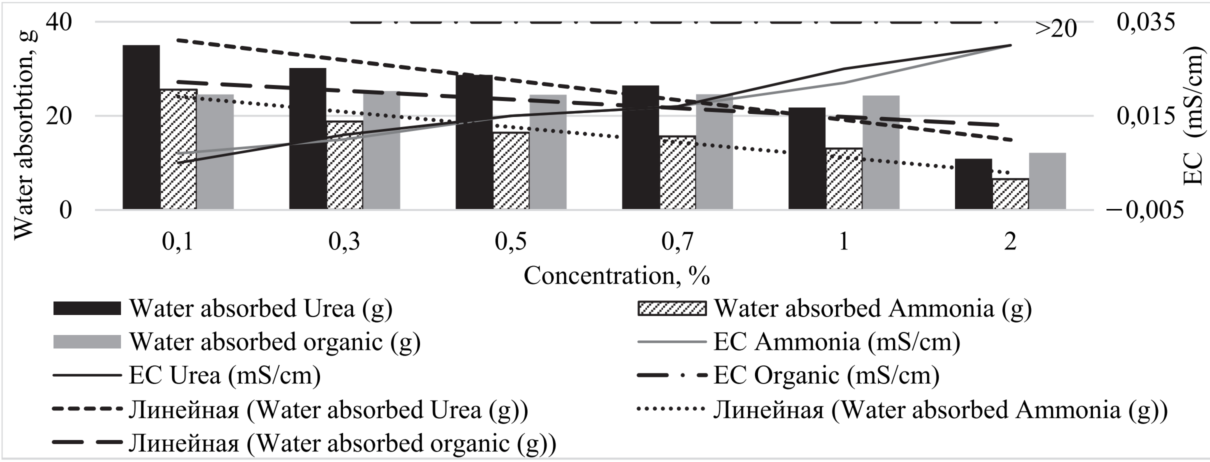

Fig. 1. Effect different percentage of Urea, Ammonia and Organic Fertilizers on Hydrogel's water retention capacity and the water's electrical conductivity (EC)

This experiment sheds light on the relationship between hydrogel absorption capacities and various fertilizer concentrations. While urea and ammonia both optimize at a 0.1% concentration, organic fertilizers require a thrice-fold increase to achieve peak absorption. The substantial increase in EC with rising concentrations of the fertilizers accentuates the ionic interactions at play, with organic fertilizers rendering highly augmented EC values.

These insights not only underscore the versatility of hydrogels but also hint at the potential avenues for enhancing their efficacy in tandem with specific fertilizers in forestry applications.

The next lab experiment aimed to understand the potential of using growth regulators along with 1.7% of hydrogel on the water absorption capacity of hydrogel. Growth regulators have been used in previous studies focused on determining their impact on diverse plants [15] and vegetation growth [14]; however, most of the studies have focused on actual plants' growth or embryogenesis, rather than determining the impact on hydrogels' capacity to absorb moisture and hence have a more potent impact on the entire reforestation effort in a region.

The experiment was conducted using tea bags containing 0.5 g of hydrogel and submerging them in different concentrations of Epin and Cornevin to see the effect of the hydrogel water retention capacity. The tea bag plus the hydrogel weighed around 0.55–0.6 g, and the calculations were made inclusive of the weight of the tea bag containing the hydrogel and the water absorbed.

A one-way ANOVA was conducted with resulted in obtaining a DfB of 1 and DfW of 8, and an F-value of 5.727. The p-value was 0.043. The p-value (0.0255) is less than 0.05, it can be said that there are statistically significant differences between the groups being compared.

The differences in the impact of different percentages of EPIN and Cornevin on the absorption of water with 0.5 g of the hydrogel are depicted in the following Fig. 2.

It can be inferred from the above figure that Cornevin gives better results than Epin consistently, however, the best results are obtained with 1% of Cornevin.

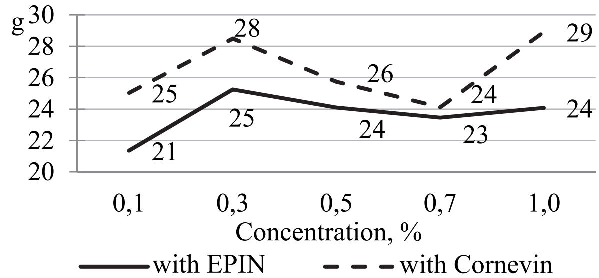

Fig. 2. Water Absorption with 0.5 g Hydrogel and Different percentage of Epin and Cornevin

Next, a field experiment was done Field Experiment in Negoleroe Forest which is known for its sandy soil, where both solid and solution Hydrogel been used with Epin to see their effect of on Seedlings. In addition containerized seedling were compared to bare roots ones.

Root:shoot (R:S) experimentation has been used to determine the plant's sustainability during environmental constraints [16]. The ratio has been found to vary based on several factors like availability of nutrients. Previous studies have used R:S biomass measurement after treating the seedlings with diverse nutrients to gauge the impact of those nutrients, with the underlying aim of measuring the impact of R:S mass on absorption and distribution of nutrients. The current study used a similar experiment, but measured the growth and diameter rather than mass.

The experiment was conducted over a period of 6 months, where the seedlings were treated in different ways:

a) with dry hydrogel;
b) with Hydrogel Solution;
c) with EPIN and Hydrogel;
d) without any input (control group);
e) bare seedlings;
f) containerized seedlings.

Dry hydrogel in an amount of 0.25–0.30 g was placed into the landing slot. The root systems of seedlings were dipped in a hydrogel solution.

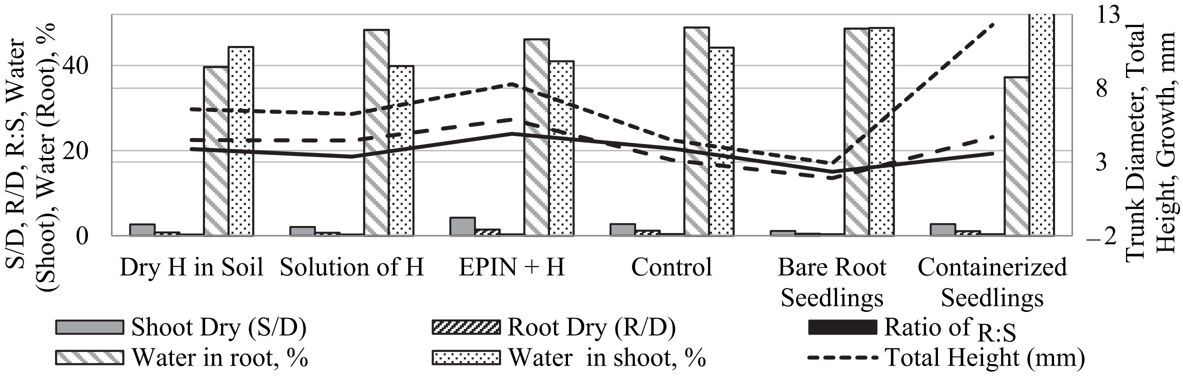

Fig. 3. Findings from Field Experiment in Negoreloe Forest

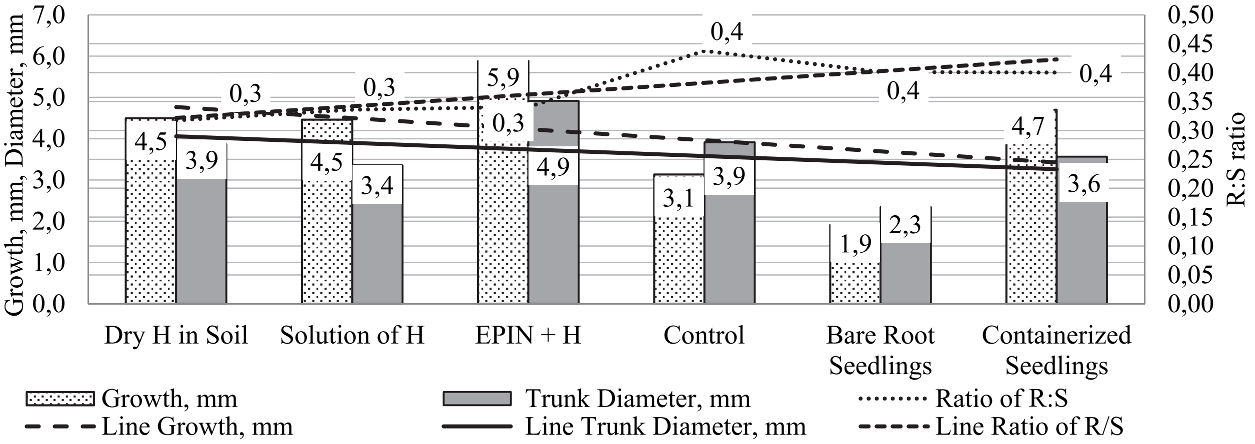

Fig. 4. Ratio R:S and Growth in Negoreloe Forest

The initial height was measured at the inset of the experiment. The measurements were again taken at the end of 6 months, and their growth was noted along with the diameter. Further, measurements included shoot (dry and wet respectively), root (dry and wet respectively). Next, calculations were based on Ratio of Dry root on Dry shoot and percentage of water in root and percentage of water in shoot. The following Fig. 3 shows the findings from the experiment graphically.

Mašková T., Herben T. had found that the R:S ratio was inversely related with nutrient absorption, and this relationship was more marked for large sized seedlings [16]. A similar interpretation can be made for the current findings, where the R:S shows an inverse relationship with the growth.

Additionally, a comparison is made of the growth characteristics and quality indicators of seedlings and are presented below (see Fig. 4 below). Other studies have conducted similar experi ments, but by varying the management of seedlings in different nurseries [17] or different soil types or seed types [16]. The current study provides a better comparative analysis as the only variations made were in terms of the additives that were given to the seedlings during the measurement, all other factors being common to them.

The Fig. 4 shows that higher the ratio R:S the lower the growth and diameter (hence nutrient absorption effectiveness). Fig. 3 also shows that EPIN + H yields the maximum growth as well as diameter for the seedlings under the field conditions in Negoreloe Forest. Further, the following Fig. 5 shows that the mortality rate, too, is the lowest for EPIN + H and for the containerized seedling where the difference is significantly relevant compared with the bear root seedlings.

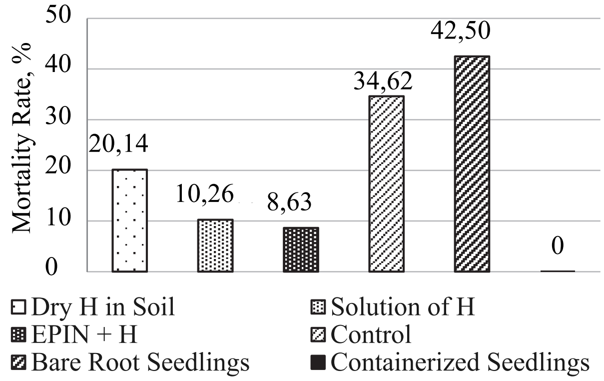

Fig. 5. Seedling Mortality Rate in Negoreloe Forest

Conclusion. In conclusion, the findings have elaborated on the effectiveness of using a 1% concentration of urea or ammonia for the most effective hydrogel moisture retention, and least impact on water absorption with urea and ammonia concentra tion increase and can be applied in soil, especially sandy soil and arid conditions. The study also found that Cornevin gives better results than EPIN consistently, however, the best results are obtained with 1% of Cornevin. However, both growth regulators can be used in the creation of forest plantations. It can also be concluded that treatment of root systems with the growth regulator Epin together with a hydrogel increases the survivability rate of the seedlings, and containerized seedlings reflected a low non significant mortality rate compared to the high mortality rate of bear roots seedlings, and such approaches can be recommended for conditions similar to Negoreloe Forest, e. g. for sandy soils in arid conditions.

Preserving the water supply in the root layer and providing the necessary supply of nutrients can be a key factor for increasing the survival rate of forest plantations created in difficult environmental conditions. The use of growth regulators can also improve survival rate by increasing resistance to adverse weather conditions and stimulating the development of underground and above-ground parts of planted plants.

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Information about the authors

Alam Michel – PhD student, the Department of Forest Plantations and Soil Science. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: michelalalam@gmail.com

Voitau Ihar Vitalievich – DSc (Engineering), Professor, Rector. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: voitov@belstu.by

Nosnikov Vadim Valer'evich − PhD (Agriculture), Associate Professor, Assistant Professor, Department of Forest Plantations and Soil Science. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: nosnikov@belstu.by

Информация об авторах

Алам Мишель – аспирант кафедры лесных культур и почвоведения. Белорусский государственный технологический университет (220006, г. Минск, ул. Свердлова, 13а, Республика Беларусь). E-mail: michelalalam@gmail.com

Войтов Игорь Витальевич – доктор технических наук, профессор, ректор. Белорусский государственный технологический университет (220006, г. Минск, ул. Свердлова, 13а, Республика Беларусь). E-mail: voitov@belstu.by

Носников Вадим Валерьевич − кандидат сельскохозяйственных наук, доцент, доцент кафедры лесных культур и почвоведения. Белорусский государственный технологический университет (220006, г. Минск, ул. Свердлова, 13а, Республика Беларусь). E-mail: nosnikov@belstu.by

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