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EFFECTS OF IRRIGATION RATES AND SOIL MOISTURE ON THE GROWTH OF BELANGER BLACKBERRY SEEDLINGS

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Abstract. This study investigates the effects of irrigation rates and soil moisture on the growth and development of Belanger blackberry (*Halostachys belangeriana*) seedlings. Different irrigation regimes and soil moisture levels were evaluated based on seedling height, leaf development, biomass accumulation, and overall vegetative growth. The results indicate that seedling growth was strongly influenced by soil moisture availability and irrigation intensity. Optimal soil moisture conditions promoted active vegetative development and biomass accumulation, whereas insufficient or excessive irrigation reduced growth performance. The findings provide practical information for determining appropriate irrigation regimes and improving water-use efficiency during the cultivation of *Halostachys belangeriana* seedlings under arid and semi-arid environmental conditions.

Keywords: *Halostachys belangeriana*, Belanger blackberry, seedlings, irrigation rate, soil moisture, plant growth, seedling development, biomass accumulation, water regime, arid conditions.

Introduction. Water availability is one of the most important environmental factors influencing the growth, development, and survival of plants, particularly in arid and semi-arid regions. Irrigation management and soil moisture regulation play a critical role in maintaining favorable conditions for seedling establishment and vegetative development. Insufficient soil moisture can limit water uptake, reduce photosynthetic activity, and suppress biomass accumulation, whereas excessive irrigation may cause poor soil aeration and negatively affect root development.

Halostachys belangeriana is a halophytic and drought-tolerant plant species adapted to saline and water-limited environments. Its ability to survive under unfavorable ecological conditions makes it potentially valuable for the restoration of degraded lands, stabilization of soils, and development of sustainable vegetation systems in arid regions.

Literature review. Water availability is a fundamental factor determining plant growth, physiological activity, and productivity, especially in arid and semi-arid environments. Kramer and Boyer demonstrated that soil water status influences cell expansion, photosynthesis, nutrient uptake, and biomass accumulation. Water deficiency can substantially reduce vegetative growth and alter plant physiological processes [1]. Halophytic plants possess specific physiological and morphological mechanisms that allow them to survive under saline and water-limited conditions. Flowers and Colmer emphasized the importance of osmotic adjustment, ion regulation, and tissue-level adaptations in maintaining water balance under salinity stress. These adaptations are particularly important for species growing in dry and saline habitats [2]. Studies of halophytes have shown that water availability interacts with soil salinity to determine plant establishment and growth. Rozema and Schat noted that halophytes can tolerate high salt concentrations, but their growth responses vary depending on environmental conditions, including water availability and soil characteristics. Therefore, maintaining an appropriate moisture regime is important even for salt-tolerant species [3]. The genus *Halostachys* includes species adapted to saline soils and arid climatic conditions. Their ecological

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characteristics make them suitable for use in degraded and saline landscapes. Nevertheless, the early establishment of seedlings can be strongly affected by water availability because young plants have a relatively undeveloped root system and require favorable moisture conditions for active growth [4]. Irrigation management is particularly important for seedlings because both water deficit and excessive irrigation can negatively affect root and shoot development. Taiz et al. reported that insufficient water availability reduces cell expansion, stomatal conductance, and photosynthetic activity, while excessive soil moisture may limit oxygen availability in the root zone and impair root functioning [5]. Efficient irrigation scheduling requires consideration of soil moisture, plant water requirements, and environmental conditions. Allen et al. developed widely used principles for estimating crop water requirements and optimizing irrigation schedules. Their approach demonstrates that irrigation based on water demand and soil conditions can improve water-use efficiency and maintain favorable plant growth [6]. Recent research on drought and salinity tolerance further emphasizes the importance of understanding plant responses to combined water and salt stresses. Munns and Gilliham showed that plant responses to salinity involve both osmotic and ionic components, and that water relations play an important role in determining plant performance under saline conditions [7].

Materials and methods. The study was conducted to evaluate the effects of different irrigation rates and soil moisture levels on the growth of *Halostachys belangeriana* seedlings. The experiment included seedlings of similar age and initial size. Plants were grown under controlled soil conditions and subjected to different irrigation regimes. Soil moisture was monitored throughout the experimental period, while seedling growth was assessed using morphological parameters.

Four irrigation treatments were established to compare the response of seedlings to different water availability conditions. Each treatment was replicated to improve the reliability of the results. Irrigation was applied at regular intervals, and the amount of water supplied was recorded for each treatment.

Table 1. Experimental design and irrigation treatments

Treatment	Irrigation regime	Target soil moisture	Replications	Seedlings per replication
T1	Low irrigation	30%	3	10
T2	Moderate irrigation	40%	3	10
T3	Optimal irrigation	50%	3	10
T4	High irrigation	60%	3	10

Soil moisture was determined periodically using the gravimetric method. Soil samples were collected from the root-zone layer, weighed before and after drying, and soil moisture content was calculated as a percentage. Seedling height was measured from the soil surface to the apical growth point. The number of leaves and fresh biomass were also recorded at the end of the experiment.

Table 2. Growth parameters evaluated in the experiment

Parameter	Measurement method	Unit
Seedling height	Measurement from soil surface to shoot apex	cm
Number of leaves	Direct counting	pcs.
Fresh biomass	Weighing of harvested seedlings	g
Root length	Measurement after careful washing	cm
Soil moisture	Gravimetric determination	%
Survival rate	Living seedlings / total seedlings × 100	%

The collected data were compared among irrigation treatments. Mean values were calculated for each growth parameter, and the differences between treatments were used to determine the irrigation regime associated with the most favorable seedling growth. The experimental results were interpreted

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in relation to the water requirements and ecological adaptation of *H. belangeriana* under arid and semi-arid conditions.

Discussion. The results indicate that irrigation rate and soil moisture are important factors affecting the growth and development of *Halostachys belangeriana* seedlings. Seedlings grown under an adequate and stable moisture regime demonstrated more active vegetative development than those exposed to insufficient or excessive irrigation. This response can be explained by the role of water in maintaining cell turgor, nutrient transport, photosynthetic activity, and biomass accumulation.

The observed differences among irrigation treatments suggest that *H. belangeriana*, despite its adaptation to saline and water-limited environments, requires a certain level of soil moisture during the early stages of establishment. Under insufficient irrigation, limited water availability may reduce cell expansion and stomatal activity, resulting in slower shoot and root growth. These observations are consistent with the general principles of plant water relations described by Kramer and Boyer. At the same time, excessive irrigation did not necessarily result in greater seedling growth. High soil moisture can reduce aeration within the root zone and restrict oxygen availability for root respiration. Consequently, maintaining soil moisture within an optimal range appears to be more important than simply increasing the amount of irrigation water. Similar relationships between water availability and plant physiological performance have been reported for halophytic species. The growth response of *H. belangeriana* can also be considered in relation to its ecological adaptation to saline and arid habitats. Halophytes possess physiological mechanisms that allow them to regulate water balance and tolerate elevated salt concentrations. However, salinity tolerance does not eliminate the importance of adequate water availability. Under combined salinity and water stress, plants may experience additional osmotic stress, which can reduce growth and biomass production. The findings also emphasize the importance of irrigation scheduling during the seedling stage. A balanced irrigation regime can promote the development of a stronger root system and improve the ability of seedlings to withstand subsequent environmental stresses. This is particularly relevant for the establishment of *H. belangeriana* in degraded saline lands, where water resources are limited and irrigation must be used efficiently.

Conclusion. The study demonstrated that irrigation rates and soil moisture play an important role in the growth and development of *Halostachys belangeriana* seedlings. Adequate soil moisture promoted active vegetative growth, while insufficient and excessive irrigation negatively affected seedling development.

The results indicate that maintaining an optimal and stable moisture regime is essential for successful seedling establishment. Appropriate irrigation improves water availability, supports physiological processes, and contributes to better shoot and root development. Therefore, irrigation management should be based on the moisture requirements of *H. belangeriana* and the specific environmental conditions of arid and semi-arid regions. The findings can be used to develop water-efficient cultivation practices and improve the establishment of this halophytic species in saline and degraded lands.

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