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Ecophysiological indicators of growing some woody plants under irrigated conditions

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ABSTRACT

Agrochemicals, such as pesticides and fertilizers, are used in farming to promote plant growth and protection. While originally intended to increase yields, they have been found to have adverse effects on soil and water quality. The use of chemical inputs in agriculture significantly impacts plants and food chains. However, the ecological risks of these chemicals to the environment are often neglected. The objective of this study is to evaluate the ecophysiological indicators of juniper and apple trees under irrigated conditions. In this regard, juniper and apple trees were grown in the laboratory environment and agrochemical analysis was conducted on the soil of the test site. Since the relation of soil and water and their interaction with plant ecophysiological traits are major drivers of plant growth, these tests were conducted to obtain information that affects growing these species in the region of Almaty, Kazakhstan.

Keywords: Ecophysiological indicators, Juniper tree, Apple tree, Agrochemical analysis.
Article type: Short Communication.

INTRODUCTION

Woody plants are of great economic, cultural, and ecological significance, and efforts are needed to prevent the loss of woody species and the associated ecosystem services they provide (Sun *et al*. 2022). In general, trees and shrubs play a vital role as important sources of our daily needs. They also serve as life-savers by capturing CO_2, thereby reducing the atmospheric carbon load. The process of photosynthesis allows trees to use CO_2 and store carbon in their wood and biomass as a source of energy (Vinod *et al*. 2019). However, various factors such as adverse climatic conditions, illegal logging, human activities, and the constant emission of greenhouse gases contribute to increasing global warming. This, in turn, affects the growth of trees and shrubs in different regions of the world. Therefore, there is a significant need to study the ecophysiology of tree species at this juncture (Maiti *et al*. 2016). Ecophysiology refers to the study of plant growth in terms of various parameters such as leaf traits, xylem water potential, plant height, basal diameter, and crown architecture. These parameters are influenced by physiological traits and environmental conditions in the ecosystem. The ecophysiological study also involves various functional, physiological, biochemical, and biophysical aspects of woody trees for plant productivity. It is important to determine the variability of physiological functions among tree species and their adaptation to environmental conditions such as soil and water quality especially for countries with arid climate including Kazakhstan (Issayeva *et al*. 2022). Therefore, a clear understanding of different facets of ecophysiology will help scientists efficiently manage and protect trees in ecosystems. Soil-water relations, as well as their interaction with plant morphological and ecophysiological features, serve as significant drivers of plant growth, species

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distribution, and community organization in ecosystems (Tyree *et al*. 2003; Westoby & Wright 2006; Cipriotii *et al*. 2008; Heneghan *et al*. 2008; Golos *et al*. 2016). Therefore, studying the morphological and ecophysiological indicators can help to identify plant traits which will result in prompting restoration success (Lloret *et al*. 2004; Westoby & Wright 2006; Lewandrowski *et al*. 2016). Early seedling phases of plant growth are the most susceptible to environmental stressors such as low volume soil water, with seedling death rates of 90% estimated during the first season of drought following emergence. (Chambers 2000; Tyree *et al*. 2003; James *et al*. 2011; Standish *et al*. 2012; James *et al*. 2013; Benigno *et al*. 2014; Larson *et al*. 2015). Plant species that produce fewer viable recruits have been projected to disappear with drier circumstances in future climatic scenarios (Lloret *et al*. 2004). As a result, seedling establishment is essential to restoration because it affects the degree of success of revegetation and species recruitment. It is known that small, fragile, and underdeveloped shoot tissue restricts physiological responses to drought, and a shallow root system restricts plant access to soil water, leading to the increased seedling mortality. These factors combine to make seedlings vulnerable to environmental pressures (Tyree *et al*. 2003). Because seedlings are physically small, they are also exposed to greater temporal and spatial variation in accessible soil water when compared to grown plants that can reach soil water stored in deeper soil layers via their extensive root system (Tyree *et al*. 2003; Bochet 2015). We must apply ecophysiological indicators to increase seedling survival and advance our knowledge of seedling sensitivity to environmental pressures (Perring & Hovenden 2012). Assessing ecophysiological responses such as stomatal conductance, leaf water potential, and soil composition will help us understand the implications of water as a driver for plant development in restoration settings (Lloret *et al*. 2004). The study was carried out based on the project "Conducting scientific and industrial research to improve the ecology and health of the population of Almaty on the basis of the Koldi agrobiostation". The aim of the study was to evaluate the ecophysiological indicators of woody plants under irrigated conditions. Apple and juniper trees were chosen as research objects belonging to long-lived plants, especially the juniper because its leaves function all year round. In addition, it is found in various landscaped areas and is widely used for urban greening of parks, squares, and forest parks in different countries throughout the world (Mussina *et al*. 2018).

MATERIALS AND METHODS

Experiment site

The research was conducted at the Koldi agrobiological station located at the Kazakh National Women's Teacher Training University in Almaty, Kazakhstan. The Koldi agrobiological station (Agrobiostation) provided facilities and expertise for agricultural research. In the current study, apple and juniper trees were grown using pre-seeded seedlings in a controlled laboratory environment. We monitored and documented the growth, development, and characteristics of these trees throughout the study period.

Collecting soil samples for analysis

At the next step, soil samples were collected from the agrobiostation site to evaluate their composition. The samples were taken according to GOST 17.4.4.02-2017 “Nature conservation. Soils. Methods of sampling and preparation of samples for chemical, bacteriological, helminthological analysis". Inspection of the soil composition of the Agrobiostations test site was conducted at the Testing Laboratory of LLP "Kazakh Scientific Research Institute of Soil Science and Agrochemistry named after U.U. Uspanova."

Measurements and analysis types

The measuring instruments employed in the current study are summarized in Table 1. In addition, analysis types are listed in Table 2.

Table 1. Measuring instruments information.

No.	Device type	Factory number	Verification certificate no.	Validity
1	Specord 210 Plus	223F1426/1199	No. VA-11-19-0557 From 06/09/2022	06/09/2023
2	Inomer laboratory type I-160 MI	0451	No. VA09-19-2439 From 6/27/2022	6/27/ 2023

3	Flame photometer Type FLAPHO-4	779792/b/n	No. VA-11-19-0558 From 06/09/2022	06/09/2023
4	Electronic scales AR 2140	1227250240	No. VA-02-02-2882 From 07/28/2022	07/28/2023
5	Electronic scales ScoutProSPS202 F	7132211897	No. VA-02-02-2887 From 07/28/2022	07/28/2023

Table 2. Types and methods of analysis.

No.	Type of analysis	Method
1	Total humus (%)	ST RK 3477-2019, Tyurin
2	Easily hydrolyzable nitrogen (mg kg^{-1})	Tyurin-Kononova
3	Mobile phosphorus (P_2O_5; mg kg^{-1})	GOST-26205-91
4	Mobile potassium (K_2O_5; mg kg^{-1})	GOST-2643-85
5	pH (aqueous)	GOST-26423-85
6	Water extract	GOST-26423-85-26428-85

RESULTS AND DISCUSSION

The aim of this study was to evaluate the ecophysiological indicators associated with growing apple and juniper woody plants within a controlled environment and under irrigated conditions. For this purpose, apple and juniper trees were grown in the test site. Subsequently, the soil samples were collected and agrochemical analyses were conducted to investigate soil composition. The results of agrochemical soil analyses are presented in Table 3. Agrochemicals are chemicals, including pesticides and fertilizers, used in farming to enhance plant growth and protection (Leong *et al*. 2020). Although originally used to increase yields, they have been reported to have negative effects on soil and water quality (Pan *et al*. 2018; Corcoran *et al*. 2020). The use of chemical inputs in agriculture has a clear impact on plants and food chains. However, the ecological risks of these chemicals to the environment are often neglected by the public or dismissed by those who argue that the growing human population must be fed at any cost.

Table 3. Agrochemical indicators.

No.	Water extract in %/m, EQ, on absolutely dry soil								
	Total salts, %	Alkalinity		CL^+	SO_4^+	Ca^+	Mg^+	Na^+	K^+
		Total in HCO_3	From normal carbonates to CO_3						
1	0.066	0.034	0.001	0.000	0.016	0.006	0.006	0.001	0.003
2	1.83	0.56	0.03	0.000	0.34	0.30	0.49	0.04	0.07

As can be observed in Table 3, total salts in sample number 2 are higher than in 1. For the juniper tree exposed to high levels of Cl^- (Chlorine) toxicity can occur and lead to leaf burn, yellowing, and wilting. For apple trees, chlorine tolerance is better. However, excessive chlorine can reduce nutrient uptake and cause leaf damage. In the case of SO_4^+ for juniper trees, sulfate ions have little effect on the causticizing equilibrium but for apple trees high sulfate levels may impact growth and yield. Sulfate toxicity can lead to succulence in roots and stunted growth. Ca^+ is essential for cell wall structure, and growth, so that, adequate calcium promotes healthy junipers. In apple trees, it is also crucial for fruit development and cell division, such that, deficiency leads to blossom end rot in apples. Mg^+ ion is vital for chlorophyll synthesis for juniper trees but deficiency causes yellowing between veins (interveinal chlorosis). For apple trees, Mg^+ ion is essential for photosynthesis and enzyme activation, hence,

deficiency affects fruit quality and yield. For juniper trees high Na^+ interferes with potassium and calcium nutrition. Na^+ stress depresses photosynthesis and growth. For apple trees, Na^+ levels should be moderate. Excessive Na^+ affects nutrient balance and stomatal regulation. In the case of juniper trees, K^+ is essential for water regulation and enzyme activation. Its deficiency leads to poor growth and weak branches. Finally, for apple trees, K^+ is critical for fruit development, quality, and disease resistance. K^+ deficiency affects fruit size and sugar content. The alkalinity of sample number 2 is higher than in 1. Alkalinity can impact both juniper and apple trees. Junipers generally prefer acidic to neutral soils. High alkalinity levels can be challenging for junipers. In alkaline soils, junipers may exhibit yellowing of leaves (chlorosis), reduced growth due to impaired nutrient uptake, and leaf drop in severe cases. Apple trees are more adaptable to a wider pH range. They can tolerate slightly alkaline soils but thrive in slightly acidic to neutral pH. Alkaline soils can affect apple trees by reducing nutrient availability (some essential nutrients become less accessible to the tree), iron chlorosis which makes leaves turn yellow due to insufficient iron uptake, and poor fruit quality. According the agrochemical analysis results and the behavior of both species at different conditions, it seems that soil sample number 2 is more suitable for growing apple trees, while soil sample 1 is more suitable for growing juniper ones.

CONCLUSIONS

It was established that the ecophysiological indicators of two different species of juniper and apple trees differ depending on the environmental conditions. As a result of the conducted research based on agrochemical analysis of the different soil samples, it can be stated that apple trees are more compatible with the environmental conditions of the region under investigation.

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