landscape, ecological and economic conditions. The authors analyzed existing methods for zoning territories and proposed an improved system of criteria for identifying agro-ecological zones. Particular attention is paid to the issues of preventing soil degradation and increasing the efficiency of land use. Based on the research, practical recommendations have been developed for organizing a system for protecting agricultural lands, taking into account their agro-ecological characteristics. The use of GIS technologies has made it possible to increase the accuracy in compiling cartographic materials and automate the process of identifying erosion-hazardous areas, which helps improve agro-ecological zoning. The application of the proposed integrated approach and an improved system of criteria makes it possible to optimize the use of agricultural lands and prevent their degradation. The results of the work can be used in the development of programs and schemes for the use and protection of land resources and land management, helping to increase fertility, determine yields, optimize crop rotations and plan agricultural activities.

Key words: agricultural land, land conservation, soil degradation, agro ecological zoning, sustainable land use, rational use of land, earth deflation

IRSTI 68.47.37 **DOI** https://doi.org/10.37884/1-2025/35

K.Kassen[1], Zh.N.Niyazbekova[1], G.A. Akhmetkanova, Zhang Fengxia[2], A. Nurlabi[1], A. Kopabayeva[1]*

[1]Kazakh National Agrarian research university, Almaty, Kazakhstan,
*kassenkuanysh12@gmail.com**, *zhannur.niyazbekova@gmail.com*,
gulnar.akhmetkanova@kaznaru.edu.kz, *nurlabi-ainur@mail.ru*, *araika-05.10@mail.ru*
[2]Shandong Yangxin Runfeng Agricultural Technology Co., Ltd., Shandong, China,
zfx2145999@126.com

EFFECT OF LOW-CONCENTRATION FERTILIZERS ON THE MORPHOLOGICAL PARAMETERS OF *ZANTHOXYLUM BUNGEANUM*

Abstract

Zanthoxylum bungeanum Maxim, also known as "Huajiao," is a plant native to China, prized for its fragrant flavor and various therapeutic properties. Nutrient insufficiency is a significant limitation to plant development, and fertilization is commonly used to overcome this challenge. However, the effects of fertilization vary depending on the amount of fertilizer applied, the years following treatment, and the nutritional condition of the forest site. In this study, the effects of different soil fertilization treatments—nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and a special compound fertilizer for pepper (HZ)—on the morphological parameters of *Z. bungeanum* were analyzed from March to August 2024. The results showed that plant height and weight significantly improved with fertilization, with low concentrations of fertilizer having the most positive effects on these growth parameters. These findings highlight the importance of optimizing fertilizer application to enhance the growth and development of *Z. bungeanum*. This research provides a foundation for further studies aimed at improving forest management and maximizing the potential of this valuable species.

Keywords: *Zanthoxylum bungeanum, fertilization, nutrient insufficiency, morphological parameters, fertilizer treatments, forest protection.*

Introduction

Zanthoxylum bungeanum Maxim, commonly known as “Huajiao,” is a valuable plant native to China, prized for its aromatic fruit and various therapeutic properties. For over two millennia, it has been cultivated for its medicinal and culinary uses, particularly in traditional Chinese medicine [1].

However, despite its importance, the growth and yield of *Z. bungeanum* can be adversely affected by nutrient deficiencies in the soil. In natural ecosystems, plants often face limitations in nutrient availability, which hinders their growth and development [2]. Therefore, adequate fertilization becomes essential to overcome these challenges and optimize plant productivity [3].

Nutrient availability in the soil is a key factor influencing plant growth. While plants require a variety of essential nutrients for proper development, the availability of these nutrients is highly dependent on soil conditions and the type of fertilizers applied [4]. Nutrient insufficiency can lead to reduced growth, affecting key morphological parameters such as plant height, biomass, and overall development [5]. To address this, various fertilization strategies, including the use of nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca) are employed to supplement soil nutrients and improve plant growth [6]. The effects of this organic fertilizer were evaluated on pepper (*Capsicum annuum* L.) growth over two seasons in sandy and mountain soils [7]. Similarly, bio-phosphorus fertilization significantly improved yield and fruit quality in orange trees (*Citrus sinensis*) [8]. Despite the extensive research on the impact of fertilizers on various crops [9] , the effects of fertilizer application on *Z. bungeanum* remain underexplored. Previous studies have primarily focused on the influence of higher fertilizer concentrations [10], leaving a gap in understanding how lower concentrations of fertilizer affect the morphological development of this plant.

Although *Z. bungeanum* has been widely cultivated for its economic and medicinal value, studies on its nutrient requirements, particularly at lower fertilizer concentrations, are still limited. Most existing research has focused on high fertilizer doses, while the impact of low-concentration fertilizers remains unclear. This study addresses this gap by evaluating the effects of low-concentration nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and a special compound fertilizer for pepper (HZ) on the morphological parameters of *Z. bungeanum*. By investigating how these fertilizers influence key growth parameters, this research provides new insights into nutrient optimization for sustainable cultivation. The findings will not only enhance fertilizer management strategies for *Z. bungeanum* but also offer a framework applicable to other crops with similar growth requirements, ultimately supporting sustainable agriculture and maximizing the plant’s economic and therapeutic potential.

Materials and methods

Experimental Site

The experiment was carried out in the tree nursery of the Northwest A & F University in China (34◦20′ N, 108◦24′ E) and spanned from March to August 2024. The area is located 520 m above sea level. The average annual temperature is 12.8 ◦C, and the average annual rainfall is 632 mm. It belongs to a warm temperate monsoon, semi-humid climate zone. The chemical properties of the soil are as follows: pH was 7.06; soil organic matter was 25.0 g/kg; available nitrogen was 53.70 mg/kg; available phosphorus was 12.1 mg/kg; available potassium (K) was 512 mg/kg; Ca was 23.2 cmol/kg; Mg was 2.3 cmol/kg; and Mn was 6.1 mg/kg.

Plant Materials

One-year-old seedlings of *Z. bungeanum* with a similar average growth in the experimental field were selected for the experiment. The average plant height of *Z. bungeanum* was 15 cm, and the average ground diameter was 2.78 mm. Seedlings were planted in spring. A total of 130 seedlings of *Z. bungeanum*. The seedlings were planted in special bags measuring 17*13 cm in size (Figure 1).

Treatment and measurement

In this study, we evaluated five types of fertilizers: nitrogen (N, applied as urea), phosphorus (P, applied as potassium dihydrogen phosphate), potassium (K, applied as potassium sulfate), calcium (Ca, applied as calcium nitrate), and HZ, a special compound fertilizer for peppers developed by the Northwest A & F University. HZ contained 72.7% active ingredients, including N (12,2%), P (14,7%), K (19,1%), Ca, (13,6%) Mg (2,4%), S (8,8%), and B (1,9%) providing both macro- and micronutrients. A total of 16 treatments, including a control group (CK) without fertilizer, were tested using a linear design, with each treatment having two replications of four seedlings, while CK had 10 seedlings. Fertilizer dosages for N, P, K, and Ca treatments were 200, 400, and 600 mL per tree, whereas for HZ, the dosages were 300, 500, and 1200 mL per tree. A stock solution was prepared by diluting raw materials with water, and the final standard solution was formulated according to treatment concentrations. Each group received a total of 4000 mL of solution, applied weekly from late April to early May, totaling six applications.

Figure 1. Potted *Z. bungeanum* seedlings. A total of 130 *Z. bungeanum* seedlings were cultivated in specialized planting bags, each measuring 17 × 13 cm.

The fertilizer solution configurations were as follows: For nitrogen (CH_4N_2O, 46% active ingredient), treatments N1, N2, and N3 were prepared with 200, 400, and 600 mL of stock solution diluted in 1400, 1200, and 1000 mL of water, respectively, resulting in pure fertilizer rates of 0.5, 1.0, and 1.5 g, with each plant receiving 167 mL of solution. Phosphorus (KH_2PO_4, 22.8%) treatments P1, P2, and P3 followed the same dilution pattern, with pure fertilizer rates of 0.5, 1.0, and 1.5 g. Similarly, potassium (K_2SO_4, 55%) treatments K1, K2, and K3 used the same concentrations and application rates. Calcium ($Ca(NO_3)_2 \cdot 4H_2O$, 17%) treatments Ca1, Ca2, and Ca3 were also prepared using the same method. HZ, the compound fertilizer (72.7% active ingredients), was applied at three levels: HZ1 (300 mL stock + 1400 mL water, 1.5 g pure fertilizer), HZ2 (500 mL stock + 1200 mL water, 2.5 g), and HZ3 (1200 mL stock + 1000 mL water, 6.0 g). The control group (CK) received no fertilizer, and each plant across all treatments received 167 mL of solution.

Seedling height and diameter were recorded on days 28, 56, 84, and 112 after soil fertilization. A tape measure was used to measure height, while diameter was assessed 1 cm above the seedling base using a calliper.

Statistical Analyses

Morphological data were statistically analyzed using SPSS software (IBM Inc., Chicago, IL, USA) and expressed as mean ± standard deviation (SD) based on two replicates. The Shapiro-Wilk test was used to assess normality, and Levene's test was applied to check the homogeneity of variance. Since both tests showed non-significant results ($p > 0.05$), the data met the assumptions for parametric analysis. To assess the impact of fertilization treatments on seedling height and diameter, a one-way analysis of variance (ANOVA) was performed, followed by Duncan's multiple range test to identify significant differences between treatments ($p < 0.05$). Significant differences at the 0.05 level are denoted by lowercase letters in tables and figures.

Results and discussion

The effect of different nutrient fertilizers on the height of seedlings

Nutrient deficiencies are often considered the primary limitation to plant development, with fertilization serving as the primary strategy to mitigate this issue. However, the effects of fertilization vary based on the fertilizer dose, the duration since application, and the nutrient status of the growth environment [11]. In the present study, three concentrations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and humic acid fertilizer (HZ) were applied to investigate the growth response of *Z. bungeanum* seedlings. While previous studies have suggested that higher fertilizer doses are generally more beneficial for tree growth [9], our findings revealed that low concentrations of fertilizer were more effective in promoting seedling growth. This may be attributed to the risk of nutrient imbalances or toxicity associated with excessive fertilization, which can exceed the plant's absorption capacity and negatively affect growth [12]. By day 28, no significant differences in seedling height were observed among the various fertilizer concentrations and treatments. However, seedlings treated with N1 and CK exhibited significantly greater heights compared to those treated with P1, K1, and Ca1. This suggests that fertilizers had limited influence on seedling height during the early growth stage, with the N1 treatment showing the most pronounced effect. At later time points (days 56, 84, and 112), seedling heights in the N1, N2, and N3 treatments were comparable but significantly higher than those in the CK treatment. Interestingly, seedling height decreased as fertilizer concentration increased, particularly in the P, K, and Ca treatments. By day 84, seedlings treated with P1, Ca1, and HZ1 exhibited height increases of 32.8%, 38.3%, and 18.8%, respectively, compared to the CK seedlings. On the final measurement day (day 112), seedlings in the P1, K1, and Ca1 treatments demonstrated significantly greater heights than those treated with higher concentrations of the same fertilizers. These treatments resulted in increases of 35.4%, 31.1%, and 30.1% in seedling height, respectively, compared to the CK treatment. This highlights that higher fertilizer concentrations had an inhibitory effect on seedling growth. For the N and HZ treatments, no significant differences in seedling height were observed among the low (1), medium (2), and high (3) concentrations on days 84 and 112. However, the heights in these treatments remained significantly higher ($p < 0.05$) than in the CK treatment. Overall, the results emphasize that low-concentration fertilizers are more effective in promoting the growth of *Z. bungeanum* seedlings, while higher concentrations may have adverse effects (Table 2, Figure 2).

Table 2. Effects of Fertilization on seedling height of *Zanthoxylum bungeanum*

Treatment	Height/cm			
	28d	**56d**	**84d**	**112d**
N1	12.46±1.99 a	23.23±3.14 a	41.66±1.73 a	72.73±2.02 a
N2	7.78±2.13 bc	19.34±1.83 a	39.31±3.36 a	71.29±4.38 a
N3	7.34±4.40 c	18.11±5.65 a	38.84±6.11 a	69.70±3.45 a
CK	12.01±1.13 ab	19.19±2.07 a	32.82±2.78 b	56.32±3.65 b
P1	14.24±1.77 a	26.97±3.27 a	48.87±2.55 a	87.30±2.09 a
P2	13.41±2.04 a	25.25±3.43 a	40.50±7.59 b	65.89±7.72 b
P3	10.78±3.98 a	20.54±3.15 b	36.86±4.83 bc	64.98±6.75 b
CK	12.01±1.13 a	19.19±2.07 b	32.82±2.78 c	56.32±3.65 c
K1	12.86±2.41 a	22.27±2.33 a	45.21±1.96 a	82.16±3.15 a
K2	11.25±2.29 a	21.73±3.31 a	44.18±7.02 a	78.77±8.53 ab
K3	10.98±1.76 a	20.79±2.70 a	42.09±4.49 a	74.21±5.76 b
CK	12.01±1.13 a	19.19±2.07 a	32.82±2.78 b	56.32±3.65 c
Ca1	14.03±2.90 a	27.68±2.33 a	53.22±3.02 a	80.60±4.79 a
Ca2	13.29±1.01 a	23.79±1.74 b	39.69±1.66 b	66.49±2.83 b
Ca3	12.89±1.33 a	20.30±1.98 c	37.40±6.93 bc	63.79±8.71 b
CK	12.01±1.13 a	19.19±2.07 c	32.82±2.78 c	56.32±3.65 c
HZ1	14.59±1.76 a	24.53±1.96 a	40.40±2.31 a	68.06±1.66 a
HZ2	12.04±3.59 a	23.97±2.76 a	38.90±2.39 ab	67.63±3.24 a
HZ3	11.46±1.96 a	21.20±2.85 ab	36.24±3.62 bc	65.29±3.11 a
CK	12.01±1.13 a	19.19±2.07 b	32.82±2.78 c	56.32±3.65 b

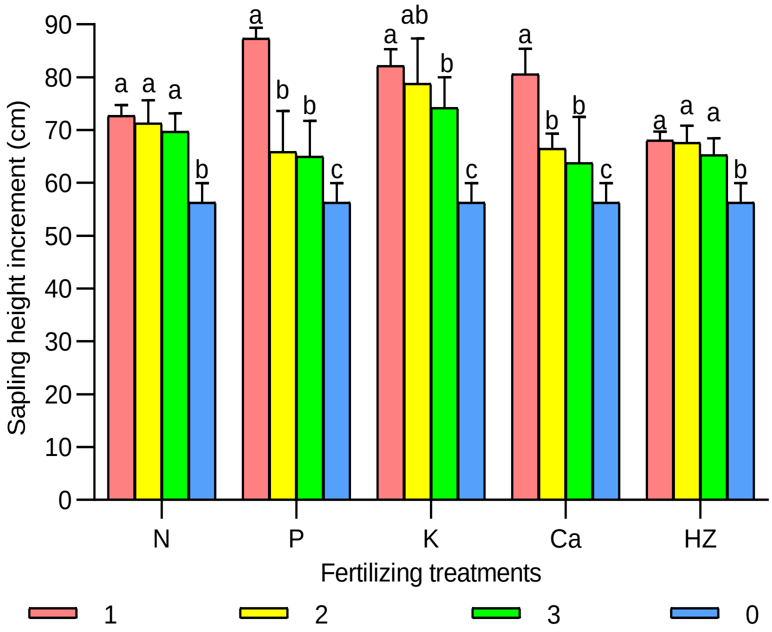

Figure 2. The figure illustrates the increment in seedling height (cm) of *Z. bungeanum* measured on day 112 following fertilization. A total of 16 treatments, including a control group (CK) without fertilizer, were tested using a linear design. Each treatment had two replications of four seedlings, while CK had 10 seedlings. Data represent the mean ± standard error. Different letters indicate significant differences among treatments with the same fertilizer, as determined by Duncan's multiple range test ($p < 0.05$). For N, P, K, and Ca treatments, the numbers indicate fertilizer application rates: 0 corresponds to 0.0 g, 1 to 0.5 g, 2 to 1.0 g, and 3 to 1.5 g. For HZ treatment, the numbers represent: 0 as 0.0 g, 1 as 1.5 g, 2 as 2.5 g, and 3 as 6.0 g.

The effect of different nutrient fertilizers on the diameter of seedlings

The effects of different nutrient fertilizers on seedling diameter of *Z. bungeanum* were assessed, focusing on treatments with NPK, Ca, and HZ. Each of these nutrients plays a crucial role in plant growth and development [13], and their influence was observed across different treatment conditions. The N1 treatment led to significant increases in seedling diameter starting from day 28, with consistent growth observed through subsequent measurements. N is often a limiting nutrient in intensive agricultural systems, and the application of nitrogenous fertilizers is essential for promoting high crop yields [14]. Similarly, P1 treatment resulted in a significant increase in seedling diameter beginning at day 56 and continuing throughout the study. By day 112, the seedlings treated with P1 exhibited a diameter 25.1% larger than the CK. The largest diameter was observed in P1-treated seedlings, which were 25.1% larger than those in CK0 by the 112th day. Phosphorus use efficiency is typically low (15-20%) in crops, and its application through fertilizers significantly enhances plant growth and development [14].

Inorganic phosphate (Pi), sourced mainly from mined rock phosphate, is a critical nutrient, but its depletion can limit plant growth, resulting in stunted development, reduced leaf number, and impaired photosynthetic capacity[15, 16]. K is crucial for key metabolic processes, plant growth, and stress responses, accounting for up to 10% of a plant's dry weight [17]. In this study, the potassium treatment did not show significant differences in seedling diameter among the various concentrations from days 28 to 84. However, by day 112, seedlings under the K1 treatment exhibited significantly larger diameters compared to other potassium treatments, suggesting that a lower concentration of potassium may be particularly beneficial for seedling growth during the final stages of development. The seedlings treated with Ca1 showed consistently higher diameters across all measurement points, from day 28 to day 112. The positive effect of calcium on seedling growth was evident throughout the experiment. HZ1 treatment also resulted in significant increases in seedling diameter, starting from day 28 and continuing through the entire study. These results suggest that both Ca1 and HZ1 play important roles in enhancing seedling growth, likely by improving nutrient availability and stimulating physiological processes (Table 3, Figure 3).

Table3. Effects of Fertilization on seedling diameter of *Zanthoxylum bungeanum*

Treatment	Diameter/mm			
	28d	**56d**	**84d**	**112d**
N1	3.40±0.16 a	3.85±0.14 a	5.21±0.11 a	7.05±0.25 a
N2	2.64±0.26 bc	3.19±0.30 b	4.85±0.34 a	6.84±0.24 a
N3	2.39±0.88 c	3.13±0.49 b	4.72±0.57 a	6.73±0.31 a
CK	3.20±0.10 ab	3.63±0.15 a	5.02±0.30 a	6.02±0.47 b
P1	3.13±0.20 a	4.01±0.30 a	5.77±0.27 a	8.04±0.34 a
P2	3.11±0.28 a	3.58±0.26 b	4.88±0.43 b	6.26±0.47 b
P3	2.96±0.22 a	3.43±0.19 b	4.86±0.35 b	6.22±0.70 b
CK	3.20±0.10 a	3.63±0.15 b	5.02±0.30 b	6.02±0.47 b
K1	3.15±0.31 a	3.64±0.26 a	5.47±0.32 a	7.66±0.26 a
K2	3.12±0.40 a	3.61±0.46 a	5.35±0.58 a	7.13±0.78 ab
K3	2.85±0.12 a	3.55±0.21 a	5.05±0.63 a	6.68±1.03 bc
CK	3.20±0.10 a	3.63±0.15 a	5.02±0.30 a	6.02±0.47 c
Ca1	3.51±0.26 a	4.20±0.24 a	6.30±0.26 a	7.85±0.30 a
Ca2	2.87±0.17 c	3.56±0.11 b	4.92±0.26 b	6.43±0.47 b
Ca3	2.99±0.15 bc	3.50±0.12 b	4.90±0.29 b	6.37±0.67 b
CK	3.20±0.10 b	3.63±0.15 b	5.02±0.30 b	6.02±0.47 b
HZ1	3.38±0.11 a	3.82±0.13 a	5.46±0.20 a	7.02±0.29 a
HZ2	3.05±0.31 b	3.55±0.40 a	5.13±0.51 a	6.98±0.54 a
HZ3	3.02±0.25 b	3.53±0.21 a	5.06±0.17 a	6.87±0.28 a
CK	3.20±0.10 ab	3.63±0.15 a	5.02±0.30 a	6.02±0.47 b

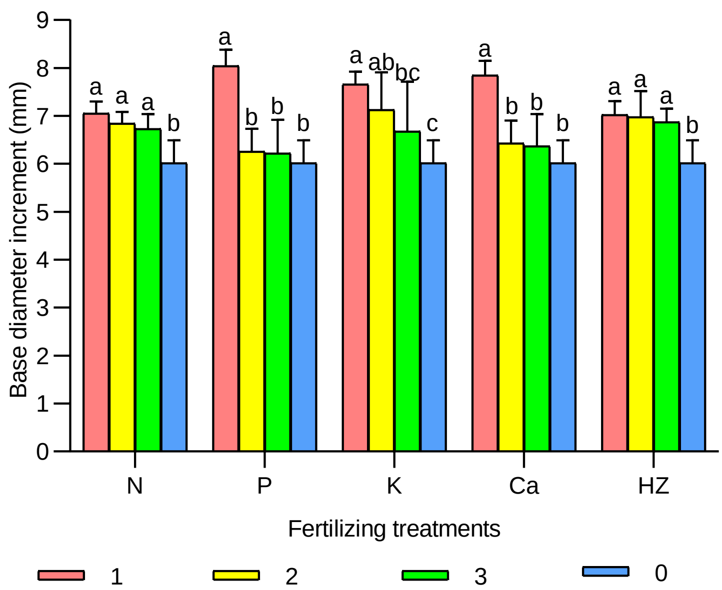

Figure 3. Seedling diameter (mm) of *Z. bungeanum* at day 112 after fertilization. A total of 16 treatments, including a control group (CK) without fertilizer, were tested using a linear design. Each treatment had two replications of four seedlings, while CK had 10 seedlings. Data represent the mean ± standard error. Different letters indicate significant differences among treatments with the same fertilizer, as determined by Duncan's multiple range test ($p < 0.05$). For N, P, K, and Ca treatments, the numbers denote fertilizer application rates: 0 corresponds to 0.0 g, 1 to 0.5 g, 2 to 1.0 g, and 3 to 1.5 g. For HZ treatment, the numbers represent: 0 as 0.0 g, 1 as 1.5 g, 2 as 2.5 g, and 3 as 6.0 g.

In summary, our findings indicate that lower fertilizer concentrations were more effective in promoting the growth of *Z. bungeanum* seedlings. Among the treatments, N1 and P1 had the most significant effects on seedling growth, followed by K1, Ca1 and HZ1. The role of individual nutrients is well-documented in various plant species. For example, nitrogen (N) is essential for vegetative growth and chlorophyll synthesis, as seen in wheat (*Triticum aestivum*), where nitrogen deficiency results in stunted growth and chlorosis [18]. Phosphorus (P) is critical for root development and seedling establishment in maize (*Zea mays*) [19]. Potassium (K) supports plant root growth and development [20], while calcium (Ca) plays a key role in cell wall integrity and signal transduction, as demonstrated in tomato (*Solanum lycopersicum*) [21]. These findings emphasize the importance of balanced nutrient management, with lower fertilizer concentrations proving more beneficial for optimal seedling growth and development.

Conclusion

This study examined the effects of N, P, K, Ca, (0.5g, 1.0g, 1.5g), and HZ (1.5g, 2.5g, 6.0g) under different concentration of fertilizers on *Zanthoxylum bungeanum* seedlings. Low fertilizer concentrations significantly promoted seedling height and diameter, suggesting that minimal nutrient levels support optimal growth. In contrast, higher concentrations, despite initial benefits, led to growth inhibition, likely due to nutrient toxicity. These findings suggest that precise fertilizer management can enhance seedling cultivation, reducing costs and environmental risks. Future studies should investigate long-term soil health impacts, microbial responses, and field applications to refine fertilization strategies.

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Қ.Қасен[1]*, Ж.Н.Ниязбекова[1], Г.А.Ахметканова[1], Чжан Фэнся[2], А.Е.Нурлаби[1], А.А.Копабаева[1]

[1]Қазақ ұлттық аграрлық зерттеу университеті, Алматы, Қазақстан,
kasen.kuanysh@gmail.com, zhannur.niyazbekova@gmail.com,*
gulnar.akhmetkanova@kaznaru.edu.kz, nurlabi-ainur@mail.ru, araika-05.10@mail.ru
[2]ЖШС Шандунг Янсинь Рунфэн ауыл шаруашылығы технологиялары, Шандунг. Қытай, zfx2145999@126.com

ZANTHOXYLUM BUNGEANUM ӨСІМДІГІНІҢ МОРФОЛОГИЯЛЫҚ ПАРАМЕТРЛЕРІНЕ ТӨМЕН КОНЦЕНТРАЦИЯЛЫ ТЫҢАЙТҚЫШТАРДЫҢ ӘСЕРІ

Аңдатпа

Zanthoxylum bungeanum Maxim, Қытайда "Хуадзяо" деген атпен белгілі өсімдік, хош иісті дәмі мен емдік қасиеттері үшін жоғары бағаланады. Өсімдіктердің дамуына қоректік заттардың жетіспеушілігі үлкен кедергі болып табылады, және бұл мәселені шешу үшін көбінесе тыңайтқыштар қолданылады. Алайда, тыңайтқыштардың әсері олардың мөлшеріне, қолдану уақытынан кейінгі жылдарға және орман топырағының қоректік жағдайына байланысты өзгеріп отырады. Бұл зерттеуде топырақ тыңайтқыштарының әртүрлі түрлерінің — азот (N), фосфор (P), калий (K), кальций (Ca) және бұрышқа арналған арнайы тыңайтқыштың (HZ) — *Z. bungeanum* өсімдігінің морфологиялық параметрлеріне әсері 2024 жылдың мамыр айынан тамыз айына дейін талданды. Нәтижелер көрсеткендей, тыңайтқыштарды қолдану өсімдіктің биіктігі мен салмағын едәуір жақсартты, ал төмен концентрациядағы тыңайтқыштар өсімдік параметрлеріне ең жақсы әсер етті. Бұл нәтижелер тыңайтқыштарды қолдануды оңтайландырудың *Z. bungeanum* өсімін және дамуын жақсартудағы маңыздылығын көрсетеді. Зерттеу бұл құнды түрдің мүмкіндіктерін барынша арттыру және орманды басқаруды жетілдіру бойынша қосымша жұмыстарға негіз болады.

Кілт сөздер: Zanthoxylum bungeanum, тыңайтқыштар, қоректік заттардың жетіспеушілігі,, морфологиялық параметрлер, тыңайтқыш өңдеулері, орманды қорғау.

К.Касен*[1], Ж.Н.Ниязбекова[1], Г.А.Ахметканова[1], Чжан Фэнся[2], А.Е.Нурлаби[1], А.А.Копабаева[1]

[1]Казахский национальный аграрный исследовательский университет, город Алматы, Казахстан, kasen.kuanysh@gmail.com, zhannur.niyazbekova@gmail.com, gulnar.akhmetkanova@kaznaru.edu.kz, nurlabi-ainur@mail.ru, araika-05.10@mail.ru*

[2]ТОО Шандунг Янсинь Рунфэнг Аграрные Технологии, Шандунг. Китай, zfx2145999@126.com

ВЛИЯНИЕ НИЗКОКОНЦЕНТРИРОВАННЫХ УДОБРЕНИЙ НА МОРФОЛОГИЧЕСКИЕ ПАРАМЕТРЫ *ZANTHOXYLUM BUNGEANUM*

Аннотация

Zanthoxylum bungeanum Maxim, известный как "Хуадзяо", — это растение, родом из Китая, ценящееся за свой ароматный вкус и лечебные свойства. Одним из главных факторов, ограничивающих его рост, является дефицит питательных веществ, и удобрение является основным способом решения этой проблемы. Однако эффекты от удобрения могут варьироваться в зависимости от таких факторов, как концентрация удобрений, время с момента применения и общие условия питания почвы. В этом исследовании был проанализирован эффект различных почвенных удобрений — азота (N), фосфора (P), калия (K), кальция (Ca) и специального комплексного удобрения для перца (HZ) — на морфологические параметры *Z. Bungeanum* в период с мая по август 2024 года. Результаты показали, что высота и диаметр растений значительно улучшились при использовании удобрений, при этом низкие концентрации удобрений оказали наиболее положительное влияние на ростовые параметры. Эти результаты подчеркивают важность оптимизации применения удобрений для улучшения роста и развития *Z. bungeanum*. Исследование создает основу для дальнейших работ, направленных на улучшение управления лесами и максимизацию потенциала этого ценного вида.

Ключевые слова: Zanthoxylum bungeanum, удобрение, нехватка питательных веществ, морфологические параметры, обработки удобрениями, защита леса.

МРНТИ 68.47.75 **DOI** https://doi.org/10.37884/1-2025/36

М.К. Кулшигашова, А.Д. Утебекова, Ж.Б.Адилбаева*

Казахский национальный аграрный исследовательский университет, Алматы, Казахстан, moldir060691@gmail.com, arunia190482@mail.ru , Zhanera78@mail.ru*

МИРОВОЙ ОПЫТ ДЕПОНИРОВАНИЯ УГЛЕРОДА В ЛЕСНЫХ ЭКОСИСТЕМАХ В УСЛОВИЯХ ИЗМЕНЕНИЯ КЛИМАТА

Аннотация

Леса играют ключевую роль в борьбе с глобальным потеплением, ведь они являются крупнейшим наземным резервуаром углерода. В них аккумулируются более половины углерода планеты и обеспечивают около 80% его обмена между наземными экосистемами и атмосферой. Наиболее эффективный способ сохранения углерода в лесах – это уменьшение масштабов вырубки и защита лесных массивов. И в этом немаловажное значение имеет создание и сохранение лесоохранных зон. В регулировании мирового стока углерода важное место занимает грамотная лесная политика каждого государства, имеющего лесные площади. В связи с этим очень важно изучение опыта зарубежных стран по сохранению пулов углерода в лесах, учитывая специфику законодательства, методы ведения лесного хозяйства и права собственности на лесные ресурсы. В этой статье рассматривается мировой опыт депонирования углерода в лесных экосистемах, с акцентом на Европу, СНГ и Северную