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STUDIU PRELIMINAR PRIVIND CREȘTERILE VEGETATIVE ÎN PRIMUL AN DE LA PLANTARE LA 3 SOIURI DE DUD (*MORUS* spp.) DIN ZONA SCDP BĂNEASA

PRELIMINARY STUDY ON VEGETATIVE GROWTH DURING THE FIRST YEAR AFTER PLANTING IN THREE MULBERRY VARIETIES (*MORUS* spp.) FROM THE SCDP BĂNEASA AREA

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Abstract

This preliminary study presents findings on vegetative growth dynamics during the first year after planting in three mulberry *(Morus spp.)* cultivars: 'Kinriu', 'Kokuso21', and 'No24', within the SCDP Băneasa area located in the north part of Bucharest. The study follows the thematic plan for the implementation of the 'ASAS Strategy on Research-Development-Innovation in Fruit Growing' (2021–2027), focused on genotype evaluation and the identification of breeding parents. The main objective was to assess first-year vegetative growth, with plants trained in a bush crown shape. Statistical analysis employed descriptive methods, Pearson correlations, and ANOVA. Significant differences were observed in tree height across varieties and repetitions. In 'Kinriu' height significantly influenced average trunk diameter ($p = 0.049$) and trunk cross-sectional area (TCSA) ($p = 0.047$). In 'No24', height strongly influenced diameter and TCSA ($p = 0.008–0.009$). Although no statistically significant differences were found between cultivars for average diameter and TCSA ($p > 0.05$), 'No.24' and 'Kokuso' tended toward higher values than 'Kinriu'. Significant differences were observed for height and small diameter (d2) mm between cultivars, while average diameter remained the best predictor for TCSA. The study will continue through 2025, with additional data collection planned for autumn (new vegetative growth dynamics). Preliminary conclusions suggest that 'No.24' exhibits the most vigorous height growth and robust vegetative development, 'Kokuso' performs well in both parameters, and 'Kinriu' demonstrates the weakest growth overall.

Cuvinte cheie: dud, creșteri vegetative, sistem de cultură.
Key words: mulberries, vegetative growth, training system.

1. Introduction

Mulberries are exploited for different uses: food, beverage, sericulture, pharmaceutical industry, artisanal wood design, wood used in brandy barrel production, root systems stabilize the soil reducing erosion and landslides. There are varied species of mulberry but only some of them bear ripening fruits. The fruit tree species *Morus spp.* (mulberry) has been reintroduced into the focus of agricultural development through the Fruit Growing Law no. 348/2003, which stipulates in Article 11 that: owners or legal holders of land who wish to establish plantations of fruit trees and mulberry trees are eligible for state financial support, in accordance with applicable legislation'. Moreover, mulberry cultivation has been integrated into the Thematic Plan for the Implementation of the Gheorghe Ionescu-Sisești Academy of Agricultural and Forestry Sciences (ASAS) Strategy on Research, Development, and Innovation in Pomology for the period 2021–2027. Prior to the study, there were no notable mulberry plantations for fruit production in the area.

In 2023, the ADER 24.1.2 – Mulberry project was launched under the title: 'Research on the Productive Evaluation of the Romanian Silkworm Germplasm and the Advanced Utilization of the Sericultural Fodder Base. The project is being carried out in collaboration with the Sericultural Research Station Băneasa.

As part of this initiative, the Research Station for Fruit Growing Băneasa established a super-intensive experimental mulberry (*Morus spp.*) plantation for leaf and fruit production in the spring of 2024. The experiment was designed to assess the effects of bush-type training systems on three mulberry cultivars: 'Kinriu', 'Kokuso 21' and 'No. 24'. These cultivars were selected for their superior leaf nutritional quality, which is essential for ensuring a consistent and efficient fodder supply for *Bombyx mori* (silkworm) rearing. Additionally, they are fruit-bearing cultivars, contributing to their dual-purpose value.

2. Material and methods

The experimental plantation was established using three mulberry cultivars: 'Kinriu', 'Kokuso 21', and 'No. 24'.

The 'Kokuso 21' cultivar (*Morus latifolia*) is a hybrid resulting from the crossbreeding of the 'Naganua', 'Gariin', and 'Shiso' cultivars. It is a bisexual cultivar of Japanese origin, characterized by entire (non-lobed) leaves which has adapted well to the climatic conditions from the south of Romania. In plantations of the intensive type may be produced from the first years a high quantity of leaves with a high protein content (Doliș, 2019). It can produce significant leaf biomass even in the early years, with high protein content (Doliș, 2019). The taste of the fruit is very sweet, and the fruit color is purple (FAO, 2003). For this reason, 'Kokuso 21' is the perfect choice for mixed cultivation: leaves and fruit.

The 'No. 24' cultivar (*Morus alba*) female cultivar of Bulgarian origin, known for its vigorous growth and long shoots. It has large, entire leaves and displays excellent tolerance to cold and drought conditions. Recent studies showed that this female variety could be used for fruit production under special cultivation (Petkov, 2008). It produces medium-size, white fruits with an intense sweet flavor (FAO, 2003).

The 'Kinriu' cultivar (*Morus kagayamae*) Japanese origin, also a dioecious - female cultivar, shows moderate shoot development and large, entire leaves. This plant will produce fruit with male pollinator like 'Kokuso 27' or any fruiting mulberry nearby. It is noted for its good cold tolerance and the thick, succulent, and highly nutritious quality of its leaves. An important characteristic for its use as silkworm fodder is its slow leaf wilting rate, which helps maintain leaf freshness after harvest. The cultivar is characterized by the production of large-sized, purple-colored fruits with a distinctly medium-sweet taste (FAO, 2003).

All planting material was sourced from the Scientific Center for Sericulture in Vratsa, Bulgaria**.**

2.1. Location

The experimental orchard was established in the spring of 2024 at the Băneasa Research Station for Fruit Growing, located at the following GPS coordinates: 44°30'16.9'N and 26°04'35.0'E, at a 90 high altitude. Bucharest municipality is lying in the southern part of the country, in the Vlăsia division of the Romanian Plain, at about 60 km far off the Danube River, 100 km off the Carpathian Mts. and 250 km off the Black Sea shore (Ionac et al., 2020).

The main soil types identified in the Bucharest area are reddish-brown soil and chernozem. These soils are characterized by a predominantly loam to clay-loam texture, a medium to low humus content, and a moderate to strong degree of leaching. They exhibit a moderately stable subangular blocky structure, low water permeability, and a slightly to moderately acidic pH reaction. Nutrient availability is generally moderate to good, and the natural fertility potential is considered moderate to high.

The experimental field as shown in Table 1 is characterized by a moderately acidic to neutral soil reaction, with pH values ranging from 6.85 in the 0–20 cm layer (D1) to 6.98 in the 20–40 cm layer (D2), which provides favorable conditions for nutrient availability and root activity of mulberry (*Morus*) cultivars. The total nitrogen (N) content is relatively high in the surface layer (2.05% at 0–20 cm) and decreases with depth (1.59% at 20–40 cm), reflecting the organic matter concentration near the surface, which supports vigorous early root growth and canopy development.

The soil is rich in available phosphorus (P), with a marked gradient between layers (185.31 mg/kg at 0–20 cm versus 57.71 mg/kg at 20–40 cm). This high surface P concentration promotes initial root establishment and shoots growth but suggests limited availability in deeper layers, potentially influencing deeper rooting dynamics for the cultivars.

In contrast, exchangeable potassium (K) levels are low throughout the profile, with values of 16.4 mg/kg (0–20 cm) and 11.7 mg/kg (20–40 cm), which may represent a limiting factor for optimal growth, particularly for deeper root systems of 'Kinriu', 'Kokuso 21', and 'No. 24' cultivars.

In terms of geographical distribution, reddish-brown soils are commonly found in plains, terraces, and plateau regions, typically on flat or gently sloping surfaces in areas with a moderately warm and semi-humid climate.

From an agricultural perspective, these soils are suitable for a wide range of crops, including cereals, industrial and forage crops, fruit trees, and grapevines. They offer a moderate to narrow soil moisture window favorable for field operations and exhibit good resistance to tillage-related compaction.

The total monthly rainfall recorded between 2022 and 2024 at SCDP Băneasa (Table 2) indicates a significant precipitation deficit, particularly in 2024 - the year the trees were planted. Given that the annual water requirement for optimal tree development ranges between 650 and 1500 mm, the recorded precipitation was insufficient. Due to unfavorable climatic conditions, characterized by excessively high temperatures and low precipitation levels, five irrigation events were carried out, each with an application rate of approximately 15 liters per tree. These were scheduled during critical periods: two irrigations shortly after planting in April, followed by one irrigation each in May, July, and August.

Regarding the annual temperature patterns recorded in the area, average values (Table 3) during the winter months rarely drop below 0°C for extended periods, indicating a predominantly temperate climate.

Fertilization consisted of the localized application of macro and micronutrient-based fertilizers (NPK 16:16:16) at a rate of 150 g per tree.

2.2. Experimental Design

The study was conducted in the experimental field using a randomized block design with three replications (Table 4). In terms of cultivation and training system, the seedlings were planted in a north–south orientation, with a spacing of 3.5 meters between rows and 1.5 meters between plants within rows, resulting in a planting density of approximately 1,905 trees per hectare, typical of super-intensive orchards.

The trees were trained in a bush-type form by pruning the aerial part to 20–25 cm in the first year after planting, followed by the selection and maintenance of 3–5 shoots which developed into permanent basal stems.

To assess the effects of the training systems, three replications were established for each of the three studied cultivars, with 5 trees per replication, under both bush-type training and semi-standard training. Specifically, for the 'Kinriu' cultivar, 3 replications (R1–R3) of 5 trees each were used; the same experimental structure was applied for 'Kokuso 21' and 'No. 24' cultivars.

2.3. Measurements

In September 2024, measurements were performed on selected trees using a digital caliper for stem diameter and a measuring tape for stem heigh, number of new shoots and the length of shoot traits.

2.4. Statistical Analysis

For statistical interpretation, the DATAtab Online Statistics Calculator (DATAtab e.U., Graz, Austria; URL: https://datatab.net) was used.

The overall difference (hypothesis: all means equal) among 3 varieties were tasted for significance using one way analysis of variance (ANOVA). After that the number of newly emerged shots and shoot length were counted for every cultivar.

The Descriptive Statistics module was employed to identify differences between means (Table 5). As a result, mean values and standard deviations were obtained. The metric variables considered were stem height (cm), average stem diameter (D), and TCSA (trunk cross-sectional area), all analyzed by cultivar (Table 6).

In the Correlations module, Pearson's correlation coefficient was applied to assess relationships between growth parameters, using stem height, average stem diameter as variables, newly emerged shots and shoot length. Additionally, post-hoc tests were conducted to evaluate statistical significance among groups.

Significant differences were observed between 'Kinriu' and the other two cultivars ('Kokuso 21' and 'No. 24'), with 'Kinriu' showing significantly lower values ($p < 0.001$ and $p = 0.005$, respectively). No significant difference was found between 'Kokuso 21' and 'No. 24' ($p = 0.358$).

3. Results and discussions

This preliminary study aimed to assess tree development to identify the cultivar with the most vigorous growth and highest leaf productivity. Vigorous vegetative growth ensures sufficient leaf yield to meet the optimal feeding requirements for each silkworm rearing cycle.

As a first step, tree height growth was evaluated by cultivar (Fig. 1). The results showed that the cultivar 'Kinriu' exhibited the lowest growth, followed by 'No. 24', while 'Kokuso 21' recorded the highest growth.

The ANOVA analysis (Table 7) was used to compare the mean values of 'Kinriu', 'Kokuso 21' and 'No. 24' to see if there is a statistically significant difference between them. It analyses the effect of a single independent factor, in this case 'Cultivar', on a dependent variable, in this case 'Tree height in cm'.

As shown in Table 8, the p-value of <0.001 is smaller than the common significance level of 0.05. This indicates that there is a statistically significant difference between the separate groups 'Kinriu', 'Kokuso 21' and 'No.24'. In other words, the variability between the groups of 'Cultivar' is significantly greater than the variability within them.

For pairwise comparison between groups, the Bonferroni post-hoc test was applied to identify where significant differences occurred.

According to the Bonferroni test (Table 9), the difference between 'Kokuso 21' and 'No. 24' was not statistically significant ($P = 0.508$). In contrast, the pair wise comparisons 'Kinriu'–'Kokuso 21' and 'Kinriu'–'No. 24' yielded P-values below 0.05, suggesting that these groups differ significantly based on the measured parameters.

Each row in the Table 10 presents the Pearson correlation coefficient (r) and corresponding p-value between tree height and trunk cross-sectional area (TCSA), computed for each cultivar × repetition combination. Notable examples include 'No 24' in R1, where a strong and statistically significant positive correlation was observed ($r \approx 0.96$, $p \approx 0.009$), suggesting that taller trees consistently exhibited larger

TCSA values. Conversely, cells with pale or bluish shades reflect weaker or negative relationships, such as 'Kokuso21' in R2 (r ≈ –0.65), though this was not statistically significant (*p* ≈ 0.23).

Cultivar 'No 24' exhibited the most consistent pattern of positive correlation between tree height and TCSA, with a statistically significant result observed in repetition R1 (*p* ≈ 0.009). In contrast, 'Kinriu' showed a very strong and significant correlation in repetition R3 (r ≈ 0.88, *p* ≈ 0.047), but no meaningful relationship was detected in R2. Meanwhile, 'Kokuso 21' did not display a consistent trend, as the correlations across its repetitions were generally weak or statistically non-significant.

Although 'Kinriu' recorded the lowest average tree height and TCSA among the tested cultivars, a strong and statistically significant positive correlation between height and TCSA was observed in repetition R3 (r ≈ 0.88, *p* ≈ 0.047). This suggests that within this cultivar, despite overall limited vegetative development, taller individuals tended to have thicker trunks, indicating a consistent internal allocation of growth resources. However, this relationship was not evident in the other repetitions (R1 and R2), highlighting potential sensitivity to environmental or local site conditions.

In contrast, 'No 24' demonstrated both superior vegetative growth (higher mean height and TCSA) and a more consistent correlation pattern, with a highly significant relationship in R1 (*p* ≈ 0.009). 'Kokuso 21' showed intermediate performance, with relatively high average values but inconsistent and statistically non-significant correlations between height and TCSA.

Given these results, 'No 24' appears to be the most vigorous and reliable cultivar in terms of first-year vegetative growth and trunk development, making it a more suitable choice than 'Kinriu' for initial establishment under the tested conditions. 'Kokuso 21' may also be a viable alternative, though with less predictable growth dynamics.

4. Conclusions

This preliminary evaluation of first-year vegetative growth in three mulberry cultivars 'Kinriu', 'Kokuso 21', and 'No. 24' - under the bush-type training system revealed significant differences in adaptability and vigor under the pedoclimatic conditions of SCDP Băneasa.

Among the three cultivars, 'Kinriu' consistently recorded the lowest values for key growth parameters, including tree height, shoot length, and TCSA. Despite a strong and statistically significant correlation between height and TCSA observed in one repetition (R3), the overall vegetative performance of 'Kinriu' was weak, suggesting limited adaptability to the environmental and soil conditions of the site. The cultivar's inconsistent growth across replications also points to a higher sensitivity to micro-environmental variation.

In contrast, 'No. 24' exhibited the most vigorous and uniform vegetative development, with high average values for height and TCSA, and a strong, significant correlation between these parameters in repetition R1 (r ≈ 0.96, *p* ≈ 0.009). These results highlight its potential for consistent and robust early establishment, making 'No. 24' the most suitable cultivar for cultivation in this location.

'Kokuso 21' showed intermediate performance, with relatively high vegetative values but inconsistent correlation patterns between height and trunk development. Although it may not match the vigor of 'No. 24', it still represents a viable alternative due to its balanced shoot and trunk growth.

In summary, for first-year establishment in super-intensive plantations under the studied conditions, 'No. 24' is the most promising cultivar, followed by 'Kokuso 21'. 'Kinriu', while valuable for its leaf quality and cold tolerance, may require further adaptation strategies or alternative site conditions to perform optimally.

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Status of Mulberry (*Morus spp.*) Genetic Resources in the World, FAO,Rome April, 2003, Chart 8 Table 8.
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Tables and figures

Table 1. Soil chemical properties of the experimental plot at two depth intervals (0–20 cm and 20–40 cm)

Indicator	D1 (0-20 cm)	D2 (20-40 cm)
pH	6.85	6.98
N total %	2.05	1.59
P mg/kg	185.31	57.71
K mg/kg	16.4	11.7

Tabel 2. Total monthly values of rainfall (mm) registered at Băneasa station, 2022-2024 years

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
2022	6	6	17	76	52	33	25	31	53	9	48	24	**380 mm**
2023	86	4	18	0	34	32	56	5	3	12	58	24	**332 mm**
2024	50	5	55	45	31	98	67	22	76	6	46	88	**589 mm**

Source: OGIMET (2022-2024)

Table 3: Mean annual temperature (^{0}C) for Băneasa region.

Year	J	F	M	A	M	J	J	A	S	O	N	D
2024	0.4	7.5	8.3	14.3	15.9	24.7	26.2	25.4	19.4	11.9	4	3.5

Source: OGIMET (2024)

Table 4. Experimental design

Cultivar	Replicates			Total
	Replicate 1 (R1)	Replicate 2 (R2)	Replicate 3 (R3)	
'Kinriu'	5	5	5	15
'No. 24'	5	5	5	15
'Kokuso 21'	5	5	5	15
Total	15	15	15	15

Table 5. Descriptive statistics for growth parameters by cultivar (mean ± standard deviation, n = 15)

Parameter	Cultivar	Frequency	Mean	Std. Deviation
Stem height (cm)	**'Kinriu'**	15	68.2	11.69
	'Kokuso 21'	15	92.87	11.72
	'No. 24'	15	85.4	19.18
Newly emerged shots (nr.)	**'Kinriu'**	15	2.03	0.23
	'Kokuso 21'	15	2.03	0.3
	'No. 24'	15	1.8	0.25
Shoot lenght (cm)	**'Kinriu'**	15	39.61	12.77
	'Kokuso 21'	15	64.88	11.07
	'No. 24'	15	58.29	16.42
Average stem diameter (mm)	**'Kinriu'**	15	13.75	2.56
	'Kokuso 21'	15	13.79	1.7
	'No. 24'	15	12.13	2.11

Table 6. Difference of metric variables considered between the groups.

Cultivar	Stem height (cm)	Average stem diameter (cm)	Newly emerged shots (number)	Shoot length (cm)
Kinriu	68.2	13.75	2.03	39.61
Kokuso 21	**92.87**	**13.79**	2.03	**64.88**
No. 24	85.4	12.13	1.8	58.29

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Table 7. One-way ANOVA

	Sum of Squares	df	Mean Square	F	p
Variety	4800.18	2	2400.09	11.22	<.001
Residual	8983.73	42	213.9		
Total	13783.91	44			

Table 8. Pairwise comparisons of mean shoot length between mulberry cultivars using t-tests.

Pair wise	Mean difference	Std. Error	t	p
Kinriu-Kokuso 21	-12.5	2.51	-4.98	<0.001
Kinriu-No. 24	-8.51	2.51	-3.39	0.005
Kokuso 21-No. 24	3.99	2.51	1.59	0.358

Table 9. Pairwise Comparison of Mulberry Varieties Using the Bonferroni Test

Pair wise	Mean diff.	Std. Error	t	p
Kinriu-Kokuso 21	-24.67	5.34	-4.62	<0.001
Kinriu-No. 24	-17.2	5.34	-3.22	0.007
Kokuso 21-No. 24	7.47	5.34	1.4	0.508

Table 10. Correlation coefficients between tree height and trunk cross-sectional area (TCSA) for each variety × repetition

Variety	Repetition	r	p-value
Kinriu	R1	0.768584	0.128897
Kinriu	R2	0.001752	0.99777
Kinriu	R3	0.883546	0.046863
Kokuso 21	R1	-0.04294	0.94535
Kokuso 21	R2	-0.6534	0.231788
Kokuso 21	R3	0.740404	0.152441
No. 24	R1	0.961655	0.008962
No. 24	R2	0.390983	0.515176
No. 24	R3	0.672639	0.213455

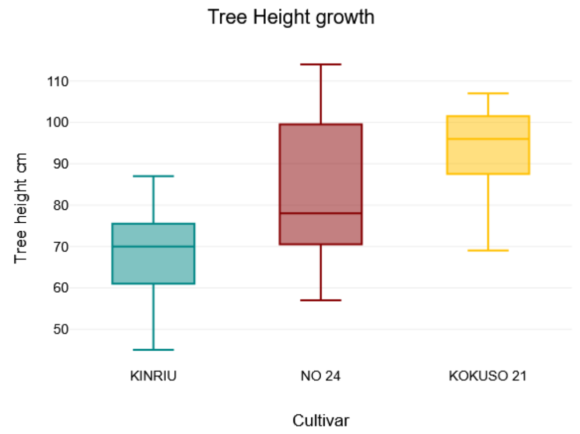

Fig. 1. Graphical illustration of tree height development across cultivars