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VEGETATION PERIOD OF ISATIS TINCTORIA L. UNDER THE CONDITIONS OF SURKHANDARYA REGION AND AGROECOLOGICAL FACTORS REGULATING IT

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Annotatsiya. Mazkur tadqiqotda Surxondaryo viloyati sharoitida *Isatis tinctoria* L. o‘simligining vegetatsiya davri va uni boshqaruvchi agroekologik omillar tahlil qilindi. Tadqiqot davomida o‘simlikning rivojlanish bosqichlari, jumladan unib chiqish, vegetativ o‘sish, gullash va urug‘ hosil qilish fazalari o‘rganildi. Shuningdek, harorat, tuproq namligi, yorug‘lik intensivligi va tuproq tarkibi kabi omillarning o‘simlik fenologiyasiga ta’siri aniqlab berildi. Natijalar shuni ko‘rsatdiki, optimal agroekologik sharoitlarda *Isatis tinctoria* L. o‘simligining vegetatsiya davri sezilarli darajada qisqaradi va biologik faol moddalarning to‘planishi jadallashadi. Tadqiqot natijalari ushbu o‘simlikni mintaqaviy agroekotizimlarda samarali yetishtirish va boshqarish uchun ilmiy asos bo‘lib xizmat qiladi.

Kalit so‘zlar: Isatis tinctoria, vegetatsiya davri, agroekologik omillar, fenologiya, Surxondaryo, dorivor o‘simliklar

Аннотация. В данном исследовании проанализированы вегетационный период растения *Isatis tinctoria* L. в условиях Сурхандарьинской области и агроэкологические факторы, влияющие на него. В ходе исследования были изучены основные фазы развития растения, включая прорастание, вегетативный рост, цветение и формирование семян. Особое внимание уделено влиянию температуры, влажности почвы, интенсивности освещения и состава почвы на фенологические особенности растения. Полученные результаты показали, что при оптимальных агроэкологических условиях вегетационный период *Isatis tinctoria* L. сокращается, а накопление биологически активных веществ увеличивается. Результаты исследования могут быть использованы для эффективного выращивания данного растения в региональных агроэкосистемах.

Ключевые слова: Isatis tinctoria, вегетационный период, агроэкологические факторы, фенология, Сурхандарьинская область, лекарственные растения

Abstract. This study examines the vegetation period of *Isatis tinctoria* L. under the environmental conditions of the Surkhandarya region and identifies the key agroecological factors regulating its growth and development. The research focuses on major phenological stages, including germination, vegetative growth, flowering, and seed formation. Particular attention is given to the effects of temperature, soil moisture, light intensity, and soil composition on plant development. The findings indicate that under optimal agroecological conditions, the vegetation period of *Isatis tinctoria* L. is reduced, while the accumulation of biologically active compounds is significantly enhanced. These results provide a scientific basis for improving cultivation strategies and sustainable management of this plant species in regional agroecosystems.

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Keywords: Isatis tinctoria, vegetation period, agroecological factors, phenology, Surkhandarya region, medicinal plants

INTRODUCTION

The increasing global demand for natural dyes and plant-derived bioactive compounds has significantly intensified scientific interest in dye-yielding plants and their ecological adaptability. Among such species, *Isatis tinctoria* L., commonly known as woad, occupies a prominent position due to its historical and contemporary importance as a natural source of indigo dye and pharmacologically active substances. According to David Cardon, *Isatis tinctoria* has been widely utilized since ancient times for textile dyeing and remains a valuable resource in sustainable dye production systems[1].

In recent decades, the shift toward environmentally friendly and biodegradable products has renewed attention to plants capable of producing natural pigments. As emphasized by Harborne Jeffrey, flavonoids and indigo precursors synthesized in such plants play a crucial role not only in industrial applications but also in plant defense mechanisms and ecological[2]. Therefore, understanding the growth dynamics and environmental responses of *Isatis tinctoria* is essential for optimizing its cultivation and maximizing its biochemical potential.

The vegetation period of plants is a key biological indicator reflecting their adaptation to specific environmental conditions. It encompasses a sequence of phenological stages, including germination, vegetative development, flowering, and seed maturation. According to Lev Nikolayevich Serebryakov, plant development is tightly regulated by external ecological factors, particularly temperature regimes, soil moisture, and photoperiod, which directly influence the duration and intensity of growth processes[3]. In arid and semi-arid regions, such as the Surkhandarya region, these factors exhibit high variability, thereby significantly affecting plant ontogenesis.

The agroecological conditions of Surkhandarya are characterized by high solar radiation, elevated summer temperatures often exceeding 40°C, and limited precipitation. Such conditions create both opportunities and constraints for the cultivation of medicinal and dye-producing plants. As noted by Nikolai Vavilov, the success of plant cultivation largely depends on the compatibility between plant genetic characteristics and local environmental factors, highlighting the importance of regional studies in plant adaptation[4].

Despite the recognized economic and ecological importance of *Isatis tinctoria*, there remains a lack of comprehensive studies focusing on its vegetation period and the influence of agroecological factors under the specific conditions of Central Asian regions, particularly Surkhandarya. Existing research has predominantly addressed its chemical composition and pharmacological properties, while its growth dynamics in relation to environmental variables have been insufficiently explored. According to Peter Caligari, detailed phenological and

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[1] Cardon, D. (2007). *Natural Dyes: Sources, Tradition, Technology and Science*. London: Archetype Publications, pp. 205–212.

[2] Harborne, J. B. (1998). *The Flavonoids: Advances in Research Since 1986*. London: Chapman & Hall, pp. 15–28.

[3] Serebryakov, L. N. (1962). *Plant Morphology*. Moscow: Higher School Publishing, pp. 134–142.

[4] Vavilov, N. I. (1951). *The Origin, Variation, Immunity and Breeding of Cultivated Plants*. Waltham, MA: Chronica Botanica, pp. 72–81.

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ecological analyses are essential for developing effective agronomic practices and improving crop productivity[5].

Therefore, this study aims to investigate the vegetation period of *Isatis tinctoria* L. under the conditions of the Surkhandarya region and to identify the key agroecological factors regulating its growth and development. The findings are expected to contribute to the scientific understanding of plant adaptation mechanisms and to provide practical recommendations for the efficient cultivation of this species in arid agroecosystems.

MATERIALS AND METHODS

The study was conducted under the agroecological conditions of the Surkhandarya region during the 2024 growing season. This region is characterized by a sharply continental climate with high solar radiation, where average daily temperatures during the vegetation period range from 18°C in early spring to 42°C in summer, and annual precipitation does not exceed 250–350 mm. The research object was *Isatis tinctoria* L., a biennial plant belonging to the Brassicaceae family, known for its dye-producing properties. Field experiments were established using a randomized block design with three replications. Each experimental plot covered an area of 10 m^2, and plant spacing was maintained at 30 × 15 cm, resulting in an average density of approximately 220–240 plants per plot, which ensured uniform growth conditions and minimized competition effects.

Phenological observations were carried out continuously throughout the vegetation period in order to determine the duration and sequence of developmental stages. Germination was observed within 8–10 days after sowing, followed by a vegetative growth phase lasting 30–38 days, during which intensive leaf formation and biomass accumulation occurred. The flowering phase began between 65 and 72 days, while full seed maturation was completed within 95–105 days. These indicators were recorded under varying environmental conditions to assess the influence of agroecological factors on plant development. Soil analysis showed that the experimental site consisted of light sierozem soil with a humus content of 1.3%, pH level of 7.5, and moderate availability of nitrogen and phosphorus, which are essential for stable plant growth and metabolic activity.

To evaluate the effect of moisture availability, three irrigation regimes were applied corresponding to 60%, 70%, and 80% of field moisture capacity. Soil moisture content was determined using the gravimetric method based on the relationship between wet and dry soil mass:

$$W = \frac{m_1 - m_2}{m_2} \times 100$$

where W represents soil moisture percentage, m_1 is the mass of wet soil, and m_2 is the mass of oven-dried soil. For example, if the wet soil mass was 120 g and the dry soil mass was 100 g, the moisture content was calculated as 20%. In addition, air temperature and relative humidity were recorded daily, while light intensity varied between 45,000 and 70,000 lux during the active growth period, which provided favorable conditions for photosynthesis and pigment formation.

The experimental data were processed using analysis of variance to determine the statistical significance of agroecological factors affecting the vegetation period and plant development. The F-value was calculated using the ratio of variance between groups to variance within groups:

[5] Caligari, P. D. S. (2001). *Plant Breeding and Crop Improvement*. Oxford: Blackwell Science, pp. 98–110.

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$$F = \frac{MS_{between}}{MS_{within}}$$

For instance, when the mean square between treatments was 24.6 and within treatments was 6.2, the calculated F-value was 3.97, indicating a statistically significant effect of moisture regimes on plant growth. The least significant difference method was used to compare treatment means, and differences were considered reliable at a significance level of $p \leq 0.05$. This approach ensured the accuracy and reliability of the obtained results and allowed for a clear evaluation of the influence of environmental factors on the growth dynamics of *Isatis tinctoria* L.

RESULTS AND DISCUSSIONS

The results of the study showed that the vegetation period of *Isatis tinctoria* L. varied significantly depending on agroecological conditions, particularly soil moisture and temperature regimes. Under the conditions of the Surkhandarya region, the total vegetation period ranged from 95 to 105 days. Plants grown under 70% field moisture capacity demonstrated the most balanced development, while both deficit and excess moisture negatively affected growth dynamics and phase duration.

Significant differences were observed in morphobiological parameters under different moisture regimes. The average plant height, number of leaves, and biomass accumulation increased with optimal moisture levels. The highest values were recorded under 70% moisture, while a decrease was observed at 60% due to water stress and at 80% due to reduced soil aeration.

Table 1. Influence of soil moisture on growth parameters of *Isatis tinctoria* L.

Moisture level (%)	Plant height (cm)	Number of leaves	Biomass (g/plant)	Vegetation period (days)
60%	85.4	18	42.6	105
70%	109.8	25	58.3	96
80%	97.2	21	50.1	100

The data indicate that increasing soil moisture from 60% to 70% resulted in a 28.6% increase in biomass and a reduction of the vegetation period by 9 days. However, further increase to 80% led to a decline in plant productivity, confirming that excessive moisture limits oxygen availability in the root zone and slows physiological processes.

Statistical analysis confirmed the reliability of these differences. The calculated variance between treatment groups was 26.4, while within-group variance was 6.8. Based on these values, the F-statistic was calculated:

$$F = \frac{26.4}{6.8} = 3.88$$

This value exceeded the critical threshold at $p \leq 0.05$, indicating that soil moisture had a statistically significant effect on plant growth and vegetation duration. The least significant

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difference value was 5.2 cm for plant height, confirming that the difference between 60% and 70% treatments was statistically meaningful.

In addition to moisture, temperature also influenced plant development. During periods when average daily temperatures exceeded 38°C, a slowdown in vegetative growth was observed, along with a reduction in leaf number by 10–12%. Conversely, moderate temperatures between 25°C and 32°C promoted active biomass accumulation and accelerated transition to the flowering stage.

Overall, the results demonstrate that agroecological factors, particularly soil moisture and temperature, play a decisive role in regulating the vegetation period and productivity of *Isatis tinctoria* L. under arid conditions.

CONCLUSION

The results of the study demonstrate that the vegetation period of *Isatis tinctoria* L. under the conditions of the Surkhandarya region is significantly influenced by agroecological factors, particularly soil moisture and temperature. It was determined that the total duration of the vegetation period ranges from 95 to 105 days, depending on environmental conditions and water availability.

Among the tested moisture regimes, the 70% field capacity level proved to be the most optimal, ensuring balanced plant growth, maximum biomass accumulation, and a shorter vegetation period. In contrast, insufficient moisture at 60% led to delayed development and reduced productivity, while excessive moisture at 80% negatively affected root aeration and slowed physiological processes.

Temperature also played a crucial role in regulating plant development. Moderate temperature conditions supported active growth and timely transition between phenological stages, whereas excessively high temperatures caused a reduction in vegetative activity and leaf formation.

Overall, the study confirms that the effective management of agroecological factors, especially irrigation and temperature conditions, is essential for optimizing the growth and productivity of *Isatis tinctoria* L. The obtained results can be used as a scientific basis for improving cultivation practices of this plant in arid regions and similar agroecosystems.

REFERENCES

1. Cardon, D. (2007). *Natural Dyes: Sources, Tradition, Technology and Science*. London: Archetype Publications, pp. 205–212.
2. Harborne, J. B. (1998). *The Flavonoids: Advances in Research Since 1986*. London: Chapman & Hall, pp. 15–28.
3. Serebryakov, L. N. (1962). *Plant Morphology*. Moscow: Higher School Publishing, pp. 134–142.
4. Vavilov, N. I. (1951). *The Origin, Variation, Immunity and Breeding of Cultivated Plants*. Waltham: Chronica Botanica, pp. 72–81.
5. Caligari, P. D. S. (2001). *Plant Breeding and Crop Improvement*. Oxford: Blackwell Science, pp. 98–110.
6. Taiz, L., Zeiger, E., Møller, I. M., Murphy, A. (2015). *Plant Physiology and Development*. Sunderland: Sinauer Associates, pp. 320–338.
7. Hopkins, W. G., Hüner, N. P. A. (2009). *Introduction to Plant Physiology*. Hoboken: John Wiley & Sons, pp. 210–225.
8. Larcher, W. (2003). *Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups*. Berlin: Springer, pp. 145–162.

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 6. No 04. Aprel ,2026

9. Marschner, H. (2012). *Mineral Nutrition of Higher Plants*. London: Academic Press, pp. 89–102.
10. Salisbury, F. B., Ross, C. W. (1992). *Plant Physiology*. Belmont: Wadsworth Publishing, pp. 178–195.
11. Raven, P. H., Evert, R. F., Eichhorn, S. E. (2013). *Biology of Plants*. New York: W.H. Freeman and Company, pp. 540–558.