International Journal of Scientific Trends- (IJST)
ISSN: 2980-4299
Volume 5, Issue 5, May - 2026
Website: https://scientifictrends.org/index.php/ijst
Open Access, Peer Reviewed, Scientific Journal

Phenology of Origanum Tyttanthum Gontsch (Small-Flowered Oregano)

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Abstract
This article investigates the phenological development of the medicinal plant Origanum tyttanthum Gontsch. under introduction conditions. The study comparatively analyzed the effects of autumn and spring planting periods, as well as different planting schemes (45 × 30 cm, 60 × 30 cm, and 90 × 30 cm), on the growth and development of the plant during the first, second, and third years of vegetation. Based on phenological observations, changes in plant height, stem diameter, number and size of leaves, and the number of lateral shoots throughout the vegetation period were determined. The results demonstrated that the autumn planting period combined with the 90 × 30 cm planting scheme provided the most favorable conditions for morphological development, vegetative growth, and biomass production of Origanum tyttanthum Gontsch.

Keywords: Origanum tyttanthum Gontsch., small-flowered oregano, phenology, introduction, vegetation period, planting time, planting scheme, morphological characteristics, growth dynamics, medicinal plants, biomass, autumn planting, spring planting.

Introduction

The development of plants varies depending on planting methods and environmental conditions. Accordingly, changes occurring during different stages of development, vegetation years, and growing seasons are of considerable scientific interest. Phenology of Seed-Propagated Plants. Phenological characteristics, including the onset of vegetation, the duration and sequence of developmental stages, provide a comprehensive basis for evaluating the life cycle of the medicinal plant *Origanum tyttanthum* Gontsch. under introduction conditions. The stable and recurrent occurrence of phenological phases indicates the successful adaptation of the species to new climatic and soil conditions, whereas shifts or interruptions in these phases suggest the presence of limiting factors affecting the introduction process. Therefore, phenological observations play a crucial role in scientifically assessing the success of plant introduction.

The growth and developmental patterns of *Origanum tyttanthum* Gontsch. propagated by seeds during the first year of vegetation were analyzed based on phenological observations. The obtained results demonstrated that the morphogenetic development of the plants was directly influenced by the planting season and planting scheme.

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As noted in the previous sections of this dissertation, *Origanum tyttanthum* Gontsch. consistently showed superior performance under autumn planting conditions across all experimental variants. In particular, plants established in autumn exhibited greater plant height and stem diameter than those planted in spring, regardless of the planting scheme. This superiority can be explained by the natural stratification of seeds during the winter period, which accelerated morphogenetic processes with the onset of spring.

According to the data presented in Table 1, under autumn planting conditions, by March 25, plant height ranged from 8.8 to 13.9 cm, stem diameter from 0.26 to 0.36 cm, leaf length from 1.1 to 1.4 cm, leaf width from 0.30 to 0.35 cm, and the number of leaves ranged from 4.7 to 5.5 per plant. In contrast, under spring planting conditions, all of these parameters were considerably lower than those recorded under autumn planting.

Table 1 Phenological Characteristics of *Origanum tyttanthum* Gontsch. (Small-Flowered Oregano) Propagated by Seeds During the First Vegetation Year (2021)
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Planting Time	Planting Scheme	Plant Height (cm)	Stem Diameter (cm)	Leaf Length (cm)	Leaf Width (cm)	Number of Leaves
March 25						
Autumn	45x30	8,8±0,25	0,26±0,33	1,2±0,22	0,30±0,04	5,5±0,7
	60x30	11,1±0,25	0,31±0,33	1,3±0,22	0,31±0,04	5,6±0,7
	90x30	13,9±0,19	0,36±0,27	1,4±0,16	0,35±0,06	4,7±0,51
Spring	45x30	2,8±0,25	0,17±0,33	1,0±0,22	0,31±0,04	5,6±0,7
	60x30	2,9±0,25	0,20±0,33	1,4±0,22	0,31±0,04	5,6±0,7
	90x30	3,9±0,19	0,21±0,27	1,5±0,16	0,36±0,06	4,8±0,51
April 5						
Autumn	45x30	27,0±0,47	0,41±0,01	3,16±0,04	0,70±0,02	16,1±0,42
	60x30	28,2±0,47	0,43±0,01	3,18±0,04	0,72±0,02	16,5±0,42
	90x30	29,1±0,37	0,45±0,02	3,21±0,02	0,76±0,02	18,3±0,65
Spring	45x30	24,2±0,47	0,39±0,01	3,14±0,04	0,65±0,02	15,8±0,42
	60x30	25,2±0,47	0,42±0,01	3,16±0,04	0,71±0,02	16,0±0,42
	90x30	26,1±0,37	0,44±0,02	3,19±0,02	0,72±0,02	18,0±0,65
April 25						
Autumn	45x30	54,1±0,42	0,42±0,01	3,31±0,07	1,42±0,02	20,1±0,6
	60x30	59,1±0,42	0,44±0,01	3,34±0,07	1,45±0,02	20,5±0,6
	90x30	67,2±0,51	0,46±0,01	3,38±0,06	1,51±0,02	20,6±1,98
Spring	45x30	52,2±0,42	0,39±0,01	3,28±0,07	1,40±0,02	20,0±0,6
	60x30	55,1±0,42	0,43±0,01	3,33±0,07	1,43±0,02	20,1±0,6
	90x30	62,9±0,51	0,44±0,01	3,36±0,06	1,48±0,02	20,2±1,98
May 15						
Autumn	45x30	55,3±0,46	0,40±0,01	3,48±0,07	1,42±0,01	22,4±0,85
	60x30	59,7±0,46	0,45±0,01	3,51±0,07	1,55±0,01	22,7±0,85
	90x30	68,5±0,30	0,48±0,01	3,56±0,07	1,90±0,01	22,9±0,46
Spring	45x30	52,4±0,46	0,38±0,01	3,40±0,07	1,36±0,01	22,1±0,85
	60x30	56,6±0,46	0,42±0,01	3,48±0,07	1,50±0,01	22,5±0,85
	90x30	64,3±0,30	0,46±0,01	3,54±0,07	1,88±0,01	22,6±0,46

Compared with the autumn planting period, the corresponding values under spring planting were lower by 6.0–10.0 cm in plant height and 0.09–0.15 cm in stem diameter, while leaf width and the number of leaves were reduced by an average of 0.1–0.2 cm and 0.1 leaf per plant, respectively. These differences can be explained by the natural stratification of seeds during the winter period under autumn planting, which promoted earlier germination and more vigorous early growth.

According to the phenological observations recorded on April 5, plant growth became more active. Under autumn planting conditions, plant height ranged from 27.0 to 29.1 cm, whereas under spring planting it ranged from 24.2 to 26.1 cm. In the 90 × 30 cm planting scheme, leaf length reached 3.21 cm, leaf width 0.76 cm, and the number of leaves was the highest, averaging 18.3 leaves per plant. In contrast, the 45 × 30 cm and 60 × 30 cm planting schemes, characterized by narrower row spacing, exhibited lower biomorphological parameters due to increased competition among plants.

The results obtained on April 25 showed that the highest growth performance was recorded under autumn planting using the 90 × 30 cm planting scheme. Plant height reached 67.2 cm, while leaf length and leaf width measured 3.38 cm and 1.51 cm, respectively. The corresponding values under spring planting were comparatively lower, which can be attributed to the later onset of vegetative growth.

The observations made on May 15 also confirmed the continued vigorous growth of plants established in autumn under the 90 × 30 cm planting scheme. Plant height reached 68.5 cm, leaf length 3.56 cm, and leaf width 1.90 cm. Growth performance under spring planting remained relatively lower, indicating that plants established in autumn entered the vegetation period earlier and consequently exhibited more intensive growth.

Table 2 Growth Dynamics of Seed-Propagated Medicinal *Origanum tyttanthum* Gontsch. during the Second Vegetation Year

Planting Season	Planting Scheme	Plant Height (cm)	Stem Diameter (cm)	Leaf Length (cm)	Leaf Width (cm)	Numberof Leaves
March 15						
Autumn	*45x30*	9,8±0,20	0,42±0,016	1,4±0,26	0,24±0,03	20,9±1,87
	60x30	10,2±0,12	0,46±0,010	1,5±0,22	0,31±0,05	21,5±1,86
	90x30	11,2±0,30	0,48±0,020	1,6±0,16	0,36±0,06	23,7±2,36
Spring	*45x30*	8,8±0,20	0,40±0,016	1,3±0,26	0,23±0,03	20,6±1,89
	60x30	10,0±0,11	0,42±0,010	1,4±0,22	0,30±0,04	21,1±1,86
	90x30	11,0±0,30	0,44±0,020	1,5±0,16	0,34±0,05	23,5±2,34
April 5						
Autumn	*45x30*	28,2±1,65	0,50±0,01	2,80±0,096	0,31±0,003	43,8±0,77
	60x30	29,3±2,11	0,46±0,016	2,86±0,056	0,32±0,007	48,9±0,69
	90x30	30,2±1,41	0,48±0,020	3,02±0,065	0,33±0,015	49,5±1,06
Spring	*45x30*	24,4±1,64	0,45±0,01	2,65±0,096	0,26±0,003	41,8±0,76
	60x30	26,2±2,12	0,45±0,016	2,76±0,056	0,28±0,007	42,9±0,67
	90x30	27,1±1,42	0,49±0,020	2,82±0,065	0,30±0,015	43,5±1,06

April 25						
Autumn	*45x30*	56,6±2,29	0,56±0,016	2,95±0,016	0,31±0,025	111,2±5,62
	60x30	59,9±2,08	0,61±0,021	3,04±0,013	0,32±0,01	112,8±2,59
	90x30	68,3±2,32	0,66±0,016	3,03±0,015	0,34±0,01	118,9±4,39
Spring	*45x30*	53,3,±2,28	0,52±0,016	2,92±0,016	0,30±0,03	110,2±5,62
	60x30	77,8,±2,08	0,53±0,021	3,04±0,013	0,31±0,01	111,8±2,59
	90x30	58,4,±2,33	0,56±0,016	3,03±0,015	0,33±0,02	116,9±4,39
May 15						
Autumn	*45x30*	66,1±0,23	0,67±0,016	2,96±0,016	0,31±0,025	234,5±16,11
	60x30	68,1±0,34	0,76±0,021	3,05±0,013	0,32±0,01	238,1±16,66
	90x30	70,2±0,26	0,95±0,016	3,04±0,015	0,35±0,01	244,5±16,53
Spring	*45x30*	57,2±0,23	0,61±0,016	2,95±0,016	0,30±0,025	217,5±16,11
	60x30	64,7±0,34	0,62±0,021	3,01±0,013	0,31±0,01	222,1±16,66
	90x30	65,9±0,26	0,67±0,016	3,02±0,015	0,34±0,01	228,5±16,53

During the second year of our study, phenological observations on the growth and development of the medicinal plant *Origanum tyttanthum* Gontsch. were continued. Analysis of the phenological data revealed that the rate of plant height increase during the second vegetation year was significantly higher than that observed in the first vegetation year after seed germination. This accelerated growth and development during the second year can be attributed to the accumulation of reserve nutrients in the rhizome.

In particular, among the different planting schemes, the best growth performance was observed under the **90 × 30 cm** planting scheme with autumn planting. According to the observations, plant height reached **11.2 cm** on **March 15**, **25.1 cm** on **April 5**, **34.3 cm** on **April 25**, and **40.2 cm** on **May 15**. Under the same planting scheme but with spring planting, the corresponding plant heights were **11.0 cm**, **24.1 cm**, **28.4 cm**, and **28.9 cm**, respectively.

Lower growth values were recorded under the other planting schemes regardless of the planting season. For example, under the **60 × 30 cm** planting scheme with autumn planting, plant height reached **9.8 cm**, **23.0 cm**, **32.0 cm**, and **36.1 cm** on the respective observation dates, which were lower than those obtained under the **90 × 30 cm** scheme. Likewise, plants established in spring exhibited reduced growth compared with those planted in autumn throughout the observation period.

The results obtained during the second year of the experiment demonstrated that the vegetation period of *Origanum tyttanthum* Gontsch. began earlier and that plant development proceeded more rapidly due to the availability of reserve nutrients accumulated in the rhizome. Differences observed in plant height, stem diameter, leaf number, and leaf size among the various planting schemes can be explained by differences in row spacing, which influenced plant competition and access to growth resources (**Table 2**).

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Figure 1. ***Origanum tyttanthum*** **Gontsch. Plants Grown under Autumn and Spring Planting Conditions during the First Vegetation Year**

The results of our field experiments also demonstrated that both the planting season and row spacing significantly affected stem diameter. In particular, during the second vegetation year, plants established in autumn under the **90 × 30 cm** planting scheme exhibited larger stem diameters than those planted in spring. Furthermore, narrower row spacing in the **60 × 30 cm** and **45 × 30 cm** planting schemes resulted in increased plant density, which reduced stem diameter due to stronger interplant competition.

During the second vegetation year, changes in both the number and size of leaves were also recorded. Analysis of the results showed that, under the **90 × 30 cm** planting scheme with autumn planting, the average number of leaves per plant reached **23.7** on **March 15**, **49.5** on **April 5**, **118.9** on **April 25**, and **244.5** on **May 15**. Under the same planting scheme but with spring planting, the corresponding values were **23.5**, **43.5**, **116.9**, and **228.5** leaves per plant, respectively. Leaf width differed among planting schemes and planting seasons between **March 15** and **April 5**. However, by **April 25** and **May 15**, these differences had become much less pronounced. This can be explained by the increase in the number of stems during the vegetation period. Although stem proliferation had little effect on the total number of leaves, it negatively influenced leaf expansion. Consequently, by the end of the virginal growth stage, differences in leaf width among the planting schemes became minimal. This phenomenon resulted from increased branching and reduced spacing between plant clumps. As plant density increased, the lateral expansion of leaves gradually decreased due to intensified competition for available resources.

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Figure 2. Mature Growth Stage of *Origanum tyttanthum* Gontsch.

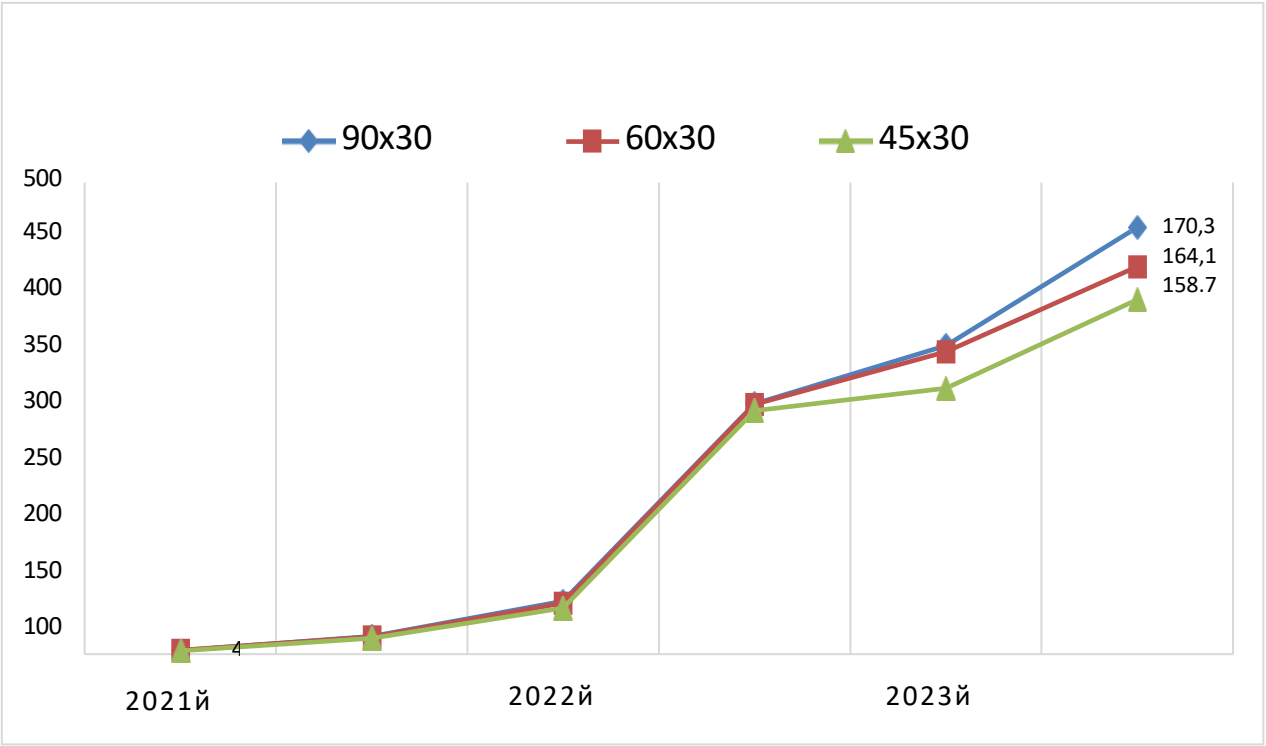

Figure 3. Dynamics of the Increase in the Number of Lateral Shoots of Seed-Propagated *Origanum tyttanthum* Gontsch. during Successive Vegetation Years

In our study, the third vegetation year of *Origanum tyttanthum* Gontsch. was characterized by a marked increase in the number of stems per plant. As shown in Table 3, under the typical gray soil conditions of the Pastdargom district, plants established in autumn using the 90 × 30 cm planting scheme exhibited a steady increase in stem number from the beginning of the third vegetation

year. The average number of stems per plant reached 138.2 in March, 158.2 in April, 169.3 in the third decade of April, and 170.4 in May.

Similarly, plants established in spring under the same 90 × 30 cm planting scheme also showed a gradual increase in the number of lateral shoots throughout the growing season. The average number of lateral shoots per plant was 132.2 in March, 148.2 in April, 159.3 in the third decade of April, and 160.3 in May. These results indicate that although both planting periods promoted continuous vegetative development, autumn planting provided more favorable conditions for stem formation and branching during the third vegetation year.

Table 3 Phenological Characteristics of Seed-Propagated Medicinal *Origanum tyttanthum* Gontsch. during the Third Vegetation Year (2021–2023)

Planting Time	Planting Scheme	Stem Length (cm)	Stem Diameter (cm)	Number of Lateral Shoots (No.)
March 15				
Autumn	*45x30*	9,8±0,20	0,42±0,016	121,5±16,12
	60x30	10,2±0,12	0,46±0,010	124,7±16,54
	90x30	11,2±0,30	0,48±0,020	138,2±16,61
Spring	*45x30*	8,8±0,20	0,40±0,016	115,5±16,12
	60x30	10,0±0,11	0,42±0,010	120,7±16,52
	90x30	11,0±0,30	0,44±0,020	132,2±16,67
April 5				
Autumn	*45x30*	28,2±1,65	0,50±0,01	145,1±16,11
	60x30	29,3±2,11	0,46±0,016	149,3±16,53
	90x30	30,2±1,41	0,48±0,020	158,2±16,66
Spring	*45x30*	24,4±1,64	0,45±0,01	133,5±16,11
	60x30	26,2±2,12	0,45±0,016	134,7±16,53
	90x30	27,1±1,42	0,49±0,020	148,2±16,66
April 25				
Autumn	*45x30*	56,6±2,29	0,56±0,016	157,9±18,54
	60x30	59,9±2,08	0,61±0,021	163,1±16,32
	90x30	68,3±2,32	0,66±0,016	169,3±16,11
Spring	*45x30*	53,3,±2,28	0,52±0,016	147,9±18,54
	60x30	77,8,±2,08	0,53±0,021	149,1±16,32
	90x30	58,4,±2,33	0,56±0,016	159,3±16,11
May 15				
Autumn	*45x30*	66,1±0,23	0,67±0,016	158,7±18,56
	60x30	68,1±0,34	0,76±0,021	164,1±16,31
	90x30	70,2±0,26	0,95±0,016	170,4±16,14
Spring	*45x30*	57,2±0,23	0,61±0,016	148,8±18,56
	60x30	64,7±0,34	0,62±0,021	149,7±16,33
	90x30	65,9±0,26	0,67±0,016	160,3±16,10

The plant growth dynamics recorded in 2023 (Table 3) demonstrated that the morphological characteristics of the medicinal plant *Origanum tyttanthum* Gontsch. varied depending on the planting season, planting scheme, and growing period. During the third vegetation year, a

comparative evaluation of autumn and spring planting was conducted to determine the most effective planting period and spacing at each stage of plant development.

According to the observations made on March 15, plants established during the autumn planting season reached heights of 9.8 ± 0.20 cm, 10.2 ± 0.12 cm, and 11.2 ± 0.30 cm under the 45 × 30 cm, 60 × 30 cm, and 90 × 30 cm planting schemes, respectively. Stem diameter ranged from 0.42 to 0.48 cm, while the number of lateral shoots varied between 121.5 and 138.2 per plant. Under spring planting conditions, plant height measured 8.8 ± 0.20 cm, 10.0 ± 0.11 cm, and 11.0 ± 0.30 cm for the respective planting schemes. Among all treatments, the 90 × 30 cm planting scheme consistently produced the greatest stem diameter and the highest number of lateral shoots under both autumn and spring planting conditions, indicating that this spacing provided the most favorable environment for plant growth.

The phenological observations recorded on April 5 showed that, under autumn planting, plant height reached 28.2 ± 1.65 cm, 29.3 ± 2.11 cm, and 30.2 ± 1.41 cm in the 45 × 30 cm, 60 × 30 cm, and 90 × 30 cm planting schemes, respectively. Stem diameter ranged from 0.46 to 0.50 cm, while the number of lateral shoots increased to 145.1–158.2 per plant. Under spring planting, plant height was 24.4 ± 1.64 cm, 26.2 ± 2.12 cm, and 27.1 ± 1.42 cm, respectively. At this stage, plants established in autumn exhibited superior growth compared with those planted in spring. In particular, the 90 × 30 cm planting scheme produced the greatest stem diameter and the highest number of lateral shoots, confirming autumn planting combined with 90 × 30 cm spacing as the most effective cultivation practice.

The observations obtained on April 25 further demonstrated the superiority of autumn planting. Plant height reached 56.6 ± 2.29 cm, 59.9 ± 2.08 cm, and 68.3 ± 2.32 cm under the 45 × 30 cm, 60 × 30 cm, and 90 × 30 cm planting schemes, respectively. Stem diameter ranged from 0.56 to 0.66 cm, while the number of lateral shoots increased to 157.9–169.3 per plant. Under spring planting, plant height measured 53.3 ± 2.28 cm, 77.8 ± 2.08 cm, and 58.4 ± 2.33 cm in the corresponding planting schemes. Although the 60 × 30 cm planting scheme under spring conditions produced relatively greater plant height and stem diameter, the number of lateral shoots remained lower than that observed in plants established in autumn under the 90 × 30 cm planting scheme, indicating that autumn planting with wider spacing provided more favorable conditions for vegetative development.

According to the observations recorded on May 15, plants of *Origanum tyttanthum* Gontsch. established during the autumn planting season reached heights of 66.1 ± 0.23 cm, 68.1 ± 0.34 cm, and 70.2 ± 0.26 cm under the 45 × 30 cm, 60 × 30 cm, and 90 × 30 cm planting schemes, respectively. Stem diameter ranged from 0.67 to 0.95 cm, while the number of lateral shoots reached 158.7–170.4 per plant, representing the highest values recorded for all measured parameters. In contrast, plants established during the spring planting season attained heights of 57.2 ± 0.23 cm, 64.7 ± 0.34 cm, and 65.9 ± 0.26 cm under the corresponding planting schemes. These results confirmed that autumn planting combined with the 90 × 30 cm planting scheme provided the most favorable conditions for plant growth and development, as both growth dynamics and morphological characteristics were superior to those observed under spring planting.

The results also demonstrated that, as the vegetation years progressed, *Origanum tyttanthum* Gontsch. exhibited continuous vegetative development. At the beginning of each new growing

season, plants showed an increase in size as early as March, accompanied by a greater number of leaves in the basal part of the plant. Furthermore, from the third vegetation year onward, a substantial increase in the number of lateral shoots was observed.

Continuous monitoring of these parameters indicated a progressive increase in the amount of harvestable raw plant material produced by each individual plant. Seed-propagated *Origanum tyttanthum* Gontsch. remained productive for up to 10 years, with the number of lateral branches increasing annually throughout successive vegetation periods, thereby enhancing overall biomass productivity.

Conclusion

The results of the present study indicate that, under introduction conditions, autumn planting combined with a 90 × 30 cm planting scheme provides the most favorable conditions for the growth and development of *Origanum tyttanthum* Gontsch. Autumn planting promotes natural seed stratification during winter, resulting in earlier germination and more vigorous vegetative growth, while wider row spacing improves the efficient utilization of environmental resources and creates optimal conditions for plant development and biomass accumulation.

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