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COMPARATIVE ANALYSIS OF HERBS PRODUCTION IN SOME PERENNIAL SPECIES OF THE GENUS *Artemisia*

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Abstract

Very few species of the genus Artemisia have been studied from an agro-phytotechnical point of view, although most of them are perennial, aromatic plants, with possible uses in medicine, human nutrition, animal feed, biofuel production, pharmaceutical or food industry, well adapted to environmental conditions, resistant to drought. The authors studied nine species of the genus: Artemisia absinthium, Artemisia abrotanum, Artemisia argyi, Artemisia austriaca, Artemisia dracunculus, Artemisia lavandulaefolia, Artemisia pontica and Artemisia vulgaris. Based on research and measurements, it has been established that there is a directly proportional relationship between plant height and grass production, with high-altitude species having the best yields. The species Artemisia lancea and Artemisia lavandulaefolia, of Asian origin, adapted well to the pedo-climatic conditions in Iasi county and had a significantly higher production than the control Artemisia absinthium.

Key words*: Artemisia, biomass, herba, plant height.*

INTRODUCTION

Genus *Artemisia* spp. from the family *Asteraceae* Bercht. & J. Presl., comprises about 500 distinct species, widespread especially in the temperate zone of the northern hemisphere and less in Africa or South America. These are usually perennial species, less annual or biennial, aromatic, growing in the form of shrubs or semi-shrubs with a height of 10-350 cm, glabrous or pubescent stems and leaves of very different shapes and colors. Some species are important for the pharmaceutical industry, the plants being used as raw material for the preparation of some medicines, and others for the food industry, animal feed or for the production of biofuels. The use of medicinal and aromatic plants, including wormwood (*Artemisia* spp.) In the prevention and treatment of certain diseases, along with allopathic medicine, is a common practice in Romania. Spontaneous species of the genus *Artemisia* (wormwood) have been used for hundreds of years in our country in food (spice, wine), animal feed (sheep, goats), folk medicine (feverfew, burns, healing, tonic, digestive, hepatoprotective, anthelmintic, diuretic, analgesic, anti-inflammatory, etc.) and veterinary medicine (insect repellent). The plants from *Artemisia* spp. Have a high ecological plasticity, meeting from the lowland area to the mountainous area, occupying both the arid and the humid area. The most used species of the genus today are *Artemisia annua*, *Artemisia absinthium* and *Artemisia vulgaris*. The main aim of the current research is to identify new spontaneous species of the genus *Artemisia* that are valuable from a phytotechnical point of view in terms of biomass (herba) production, which should be improved and then taken to culture. To date, spontaneous species of the genus *Artemisia* have been studied only from a botanical and ecological point of view and there is a possibility that some species have very valuable agrophytic properties for production.

MATERIALS AND METHODS

The researches were carried out in the field of experience of the disciplines of Phytotechnics and Medicinal Plants, it is part of the patrimony of the "Vasile Adamachi" farm, Iași Didactic Resort. The analyzes were performed in the Phytotechnics and Physiology laboratories of the Agricultural and Environmental Research

Institute Iasi, within the Iasi University of Life Science. The location is between 47^0 10 'and 47^0 15' north latitude and 27^0 30 '-27^0 35' east longitude. In the experimental area the climate has a pronounced continental character. It is largely influenced by the presence of Atlantic and Continental anticyclones. During the summer, dry weather predominates, with high temperatures, the maximum value of which can reach over 40^0C. The current trend of global warming must also warn producers of medicinal and aromatic plants. The total annual amount of precipitation ranges between 460 and 600 mm. Sometimes, in summer, torrential rains fall, and in autumn long-lasting drizzles (Table 1).

Table 1. Temperatures and precipitation recorded during the experiment period (2015-2016)

Specification/Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Year 2015													
Average temperatures	-3.2	-0.6	5.3	10.5	16.9	21.1	23.8	23.0	19.2	9.4	6.4	2.0	9.3
Multiannual average	-3.5	-1.8	3.1	10.2	16.0	19.5	21.2	20.5	15.9	10.0	4.1	-0.8	9.5
Deviation	-0.3	1.2	2.2	0.3	0.9	1.6	2.6	2.5	3.3	-0.6	2.3	1.2	-0.2
Recorded rainfall, mm	18.8	8.8	56.1	32.4	7.7	51.1	22.8	40.8	19.8	66.4	104.2	10.2	439.1
Multiannual environments	29.7	26.9	28.4	43.9	55.9	82.6	69.3	56.0	45.3	32.5	37.0	29.7	537.2
Deviation + -	-10.9	-18.1	27.7	-1.5	-48.2	-31.5	-46.5	-15.2	-25.5	33.9	67.2	-19.5	-98.1
Year 2016													
Average temperatures	-2.5	5,.	6.5	13.3	15.3	20.9	22.6	21.4	18.3	8.2	4.0	0.4	11.1
Multiannual average	-3.5	-1.8	3.1	10.2	16.0	19.5	21.2	20.5	15.9	10.0	4.1	-0.8	9.5
Deviation	-1.5	3.5	3.4	3.0	-0.7	1.4	1.4	0.9	2.4	-1.8	-0.1	-0.4	1.6
Recorded rainfall, mm	80.0	28.8	33.8	76.2	70.4	142.4	24.0	53.4	10.2	212.0	69.8	20.6	821.6
Multiannual environments	29.7	26.9	28.4	43.9	55.9	82.6	69.3	56.0	45.3	34.5	37.0	29.7	537.2
Deviation + -	50.3	1.9	5.4	32.3	14.5	59.8	-45.3	2.6	-35.0	179.5	32.8	9.1	284.4

The experiment was placed on a cambic chernozem soil, also known as leached chernozem, with the subtype of mesocalcaric cambic chernozem. In order to achieve the established objectives. The experiment was placed on a cambic chernozem soil, also known as leached chernozem, with the subtype of mesocalcaric cambic chernozem. In order to achieve the objectives, the experiment focused on the comparative cultures of the nine species of *Artemisia*: *Artemisia absinthium, Artemisia abrotanum, Artemisia vulgaris, Artemisia dracunculus, Artemisia austriaca, Artemisia pontica, Artemisia lancea, Artemisia lavandulaefolia, Artemisia argyi*. The experience was one-factor. The sowing was carried out in plots of 9 sqm/variant, in randomized blocks, with two repetitions for each *Artemisia* species. The distances between rows and between plants in a row were different depending on the requirements of each species. The experiment was stationary, the plants being perennial, and the determinations were made every year, on plants taken at random from the area delimited for each species and marked. The experimental groups were established in 2014 through the vegetative organs of each species, and in the following years observations were made and samples were taken. To determine the dynamics of plant growth, the plant material was used on the entire surface of each plot. on which the phenological observations were made, the stage of vegetation, the general appearance, the state of vegetation, the presence of weeds, attacks of diseases and pests. for all measurements during the growing season, from the beginning of late March to early April, at intervals of seven days, and 10 days, respectively, until the time of flowering of the latest species. The determinations consisted of measuring the height of the plants, counting the branches and leaves. Biometric measurements on plant growth and

development were performed in 2015 and 2016, when the plants of the nine species were two and three years old, respectively. At the end of these measurements, the green biomass production was calculated and a comparative analysis of the grass production for the nine *Artemisia* species was performed, taking as a control the *Artemisia absinthium* species.

RESULTS AND DISCUSSIONS

In March 2015, observations were made regarding the on set of vegetation in each species, an aspect genetically determined by the territorial origin of the analyzed species, given that the temperature and humidity were the same for all species (Table 2).

Table 2. Planting time for *Artemisia* spp.

Species name	Origin	Start date in vegetation
Artemisia absinthium L.	Eurasia and North Africa and widely naturalized in Canada and the northern United States	12-16.03.2015
Artemisia abrotanum L.	Central and south-eastern Europe, the Mediterranean region	04-06.03.2015
Artemisia argyi H. Lev. & Vaniot	East Asia (China, Korea, Mongolia), East Russia	15-16.03.2015
Artemisia austriaca L.	Kazakhstan, Kyrgyzstan, Russia, Tajikistan; SW Asia (Iran), C, E and SW Europe	05-07.03.2015
Artemisia dracunculus L.	Southeast Russia, Central and Northern Asia	25.03-05.04.2015
Artemisia lavandulaefolia DC.	China, Japan, Russia, Mongolia	16-18.03.2015
Artemisia lancea Vaniot	East Asia (Korea, China, Taiwan, East Russia, Japan and India)	29.03-03.04.2015
Artemisia pontica L.	Southeast Europe	18-22.03.2015
Artemisia vulgaris L.	Native to Europe, Asia, North Africa and Alaska, it is native to North America	10-20.03.2015

The fastest start in vegetation was highlighted in the species *Artemisia abrotanum* and *Artemisia austriaca*, and the slowest start in vegetation was in the species *Artemisia dracunculus* and *Artemisia lancea*. This aspect is extremely important in practice, in establishing the time of sowing/planting in order to make the most of the water supply in the soil in early spring, especially in dry regions. In the two years of research, the nine species of the genus *Artemisia* studied had an average stem height of 169.08 cm. However, there are large differences between species compared to this average value of the species, as can be seen in Table 3.

Table 3. The maximum stems height of *Artemisia* spp.

Species of the	Stem height (cm)			Difference from species average		The difference from the control	
Artemisia spp.	2015	2016	Average	cm	%	cm	%
Artemisia absinthium	196.00	206.70	201.30	32.22	19.56	-	100,00
Artemisia dracunculus	144.70	145.30	145.00	-18.08	-10.75	-56.30	-27.96
Artemisia abrotanum	151.70	150.30	151.00	-18.08	-10.69	-50.30	-24.99
Artemisia austriaca	73.00	72.70	72.70	-96.38	-57.00	-128.60	-63.88
Artemisia lancea	238.70	237.70	238.20	69.12	40.88	36.90	18.33
Artemisia argyi	100.70	189.00	189.90	20.82	12.31	-11.50	-5.71
Artemisia lavandulaefolia	242.00	239.30	240.60	71.52	42.30	39.30	19.52
Artemisia pontica	102.30	93.00	97.60	-71.48	-42.28	-103.70	-51.50
Artemisia vulgaris	188.00	183.00	185.50	16.42	9.71	-15.80	-7.85
Average			169.08				

Some species have been placed above the average height, such as *Artemisia absinthium*, *Artemisia lancea, Artemisia argyi, Artemisia lavandulaefolia* and *Artemisia vulgaris*. The most significant positive difference from the species average was recorded in *Artemisia lavandulaefolia* (71.52 cm, respectively 42.30%), and in *Artemisia lancea*, which exceeded the average by 69.12 cm (40.88). These are followed by *Artemisia absinthium*

(32.22 cm and 19.56%), *Artemisia argyi* (20.82 cm and 12.31%) and *Artemisia vulgaris* (16.42 cm and 9.71%). The other four species had a smaller size than the average species, with *Artemisia austriaca* (-96.38 cm and -57% respectively), *Artemisia pontica*, with -71.48 cm (-42.28%) and *Artemisia abrotanum* with -18.08 (-10.69%) less than the average height of all species. Taking as a witness the species *Artemisia absinthium*, considered the most important and at the same time cultivated, we can see that only 3 species exceed it in height of the respective stem, *Artemisia lancea* (by 18.33%), and *Artemisia lavandulaefolia* (by 19.52%), the other species being smaller. These include *Artemisia austriaca* (-63.83%), *Artemisia pontica* (-51.5%,) and to a lesser extent *Artemisia abrotanum* (-24.99%). grass at the optimum time of harvest for each species. 10 plants from each variant were chosen at random, on which the biometric measurements were made, and these were harvested in their entirety, weighed and the average plant production was determined. After counting the plants in each variant, depending on the size of the area, the density of the plants at harvest and the production per unit area and per hectare were calculated (Table 4).

Table 4. Plant density and herba production at harvest (average 2015-2016)

Artemisia spp.	Plant density, thou pl.	Biomass, g/pl	Herba yield, t/ha	Biomass, kg/m^2
Artemisia absinthium	37.0	516.0	19.10	1.91
Artemisia abrotanum	28.0	643.0	18.00	1.80
Artemisia argyi	31.0	600.0	18.60	1.86
Artemisia austriaca	64.0	170.0	10.90	1.09
Artemisia dracunculus	37.0	392.0	14.50	1.45
Artemisia lavandulaefolia	34.0	748.0	25.40	2.54
Artemisia lancea	28.0	936.0	26.20	2.62
Artemisia pontica	34.0	328.0	11.10	1.11
Artemisia vulgaris	36.0	517.0	18.60	1.93
Average value	36.3	538.8	19.6	1.96

Being perennial crops, the density is the same in the two years of experience, and the differences in the average weight of the plants in the two climatic years were insignificant, so that the production situation will be presented as the average value of the two years. Analyzing the plant density, we find an average of 36 thousand pl/ha for all nine species, well correlated with the size of the plants (height). Only three species had above average density; *Artemisia austriaca* (64 thousand pl./ha, almost double the average value), with the lowest production per plant (170 g) and *Artemisia absinthium* with 37 thousand pl./ha, slightly above average, and *Artemisia dracunculus* - equal to the species *Artemisia absinthium*. Most species recorded values of density below the average of nine (between 31-34 thousand pl./ha), but with the lowest values are *Artemisia abrotanum* and *Artemisia lancea* (28 thousand pl./ha). They also recorded the highest yields per plant (936 g for *Artemisia lancea* and 643 g for *Artemisia abrotanum*). Only *Artemisia lavandulaefolia* had a high density (34 thousand pl./ha) and a high weight per plant (748 g), second after Artemisia lancea. *Artemisia absinthium* and *Artemisia dracunculus* species, at the same density (37 thousand pl./ha) they recorded different weights on the plant (516 g and 392 g/pl., respectively), because in *Artemisia dracunculus* the height is lower. We can also notice the species *Artemisia argyi* which gave a good production per plant (600 g) at a density of 31 thousand pl/ha.

The average weight of a plant in the nine species reached 534.7 g, and the average biomass was 1.96 g/sqm, depending on both density and average value per plant, as well as biomass production (herba) per hectare (19.60 t). The species *Artemisia vulgaris* had a density close to *Artemisia absithium* and having similar dimensions, both the grass production and the other parameters were close. Comparative analysis of the production of species per hectare is presented in Table 5, both in relation to the average of the species and to the control - *Artemisia absinthium* and expressed in absolute and relative values, as averages over the two years.

Tabel 5. Comparative analysis of herba production in *Artemisia* spp. (average 2015-2016)

Artemisia spp.	*Herba production, t/ha*	Differences from the average		Differences from the *A. absinthium*	
		t/ha	%	t/ha	%
Artemisia absinthium	37.0	516.0	19.10	1.91	0.00
Artemisia abrotanum	28.0	643.0	18.00	1.80	-5.76
Artemisia argyi	31.0	600.0	18.60	1.86	-2.62
Artemisia austriaca	64.0	170.0	10.90	1.09	-42.93
Artemisia dracunculus	37.0	392.0	14.50	1.45	-24.10
Artemisia lavandulaefolia	34.0	748.0	25.40	2.54	32.98
Artemisia lancea	28.0	936.0	26.20	2.62	37.17
Artemisia pontica	34.0	328.0	11.10	1.11	-41.36
Artemisia vulgaris	36.0	517.0	18.60	1.93	-2.61
Average value	36.3	538.8	19.60	1.96	

At a first analysis we can see the big difference between the *Artemisia* species in terms of grass production, from 10.9 t/ha for *Artemisia austriaca*, to 26.2 t/ha for *Artemisia lancea*. Productions above the average of the species gave their majority, but the species *Artemisia lancea* can be noticed, with 8 t/ha more, (by 47.3% higher than the average), *Artemisia lavandulaefolia* with 7.62 t/ha more (with 42.8% higher than average). The species *Artemisia absinthum*, the most cultivated in our country, achieved 19.1 t/ha, with 1.32 t/ha more than the average of the species (7.42%). The species *Artemisia argyi* and *Artemisia abrotanum* exceeded the average of the species by 0.50 t/ha and 0.10 t/ha, respectively - that is -2.76 and -0.55%, respectively. The species *Artemisia austriaca* and *Artemisia pontica* were well below the average of the species, with 7.20 and 6.90 t/ha respectively minus, i.e. 39.8 and 38.12%. The comparison with the control *Artemisia absinthium* showed, on the one hand, the good production of this species, compared to six other species classified under it, which gave yields with 0.5-8.2 t/ha lower (-2.62% to -42.9%), the smallest difference, with an almost equal production, recording *Artemisia argyi*, and the largest, *Artemisia austriaca* with more than 8 t/ha minus (-42.9%), followed by *Artemisia pontica* (-41.6%). However, there are two species that are much more productive than *Artemisia absinthium*, namely *Artemisia lancea* and *Artemisia lavandulaefolia*, which exceeded it by 7.1 t/ha and 6.3 t/ha, respectively (37.2% and 33%). The higher biomass production can also be explained by the higher size of the plants of the species *Artemisia lancea* and *Artemisia lavandulaefolia* in compared to the control *Artemisia absinthium*. They quickly adjusted to the much more favorable conditions in Iasi and reacted positively, especially to the fertility of the soil. From this it can be deduced that they may be of interest to be cultivated, even more than *Artemisia vulgaris* or *Artemisia absinthium* which are cultivated in Romania.

CONCLUSIONS

Research has shown that *Artemisia lancea* and *Artemisia lavandulaefolia* have a significantly higher production than the control *Artemisia absinthium*. This is mainly due to the direct correlation between plant height and grass production, high-altitude species (*Artemisia lancea* and *Artemisia lavandulaefolia*), with the best production. The current results require new research on the content of active substances useful for the pharmaceutical or food industry and then the development of cultivation technology of the two species *Artemisia lancea* and *Artemisia lavandulaefolia* under the local climate and soil conditions in Romania.

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