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TECHNOLOGY DESIGN FOR *SIDERITIS SCARDICA* AS A NEW CULTURE IN ROMANIA

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Abstract

The current ascending international trends to enclose in production and food sector the aromatic and medicinal plants is similar in Romania too. Due to a steadily loss of biodiversity, many endemic species, especially in the areas of origin, are endangered, among them being the species Sideritis scardica. In Romania, after 1996 it was the subject of acclimatization and breeding research. At the same time, in order to popularize and expand the species in culture, the focus of the research was directed towards the elaboration of the specific growing technology in accordance with the pedo-climatic conditions of our country. This work summarizes the research undertaken at PGRB Buzau in the period 2019-2021 on the optimal culture technology at Sideritis scardica highlighting the fact that the best results were obtained at the establishment of the culture by seedling, obtained on the experimental variant represented by 80% peat and 20% dolomite (limestone). The optimal scheme for planting in the field was of 70 cm between rows and 50 cm between plants/row and the maximum biomass production was obtained in the 3rd year of cultivation, respectively 179 kg green mass/100sqm. Studies have shown that Sideritis scardica can be successfully cultivated in Romania with a real potential for valorization: medicinal, aromatic honey, ornamental and last but not least for the revaluation of arid hollows in mountainous areas.

Key words*: genotype, breeding, acclimatization, Mursalski, seedling.*

INTRODUCTION

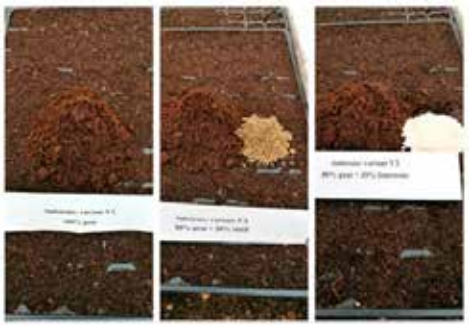
The species *Sideritis scardica* Griseb. known as an endemic plant in certain regions of the Balkan Peninsula originates in the Rhodope Mountains, at altitudes between 1000 and 2200 m.a.s.l. on sunny and steep slopes, being appreciated as one of the most valuable aromatic and medicinal plants worldwide (Shtereva et al., 2015). In Bulgaria, the important role of Sideritis scardica as traditional remedies tea and its conservation status has required its cultivation as market production (Kostadinova et al., 2008).

In Romania, it was taken into study after 2000, by the researcher Costel Vînătoru, using a variety from the mountains of Bulgaria highly appreciated for its multiple qualities: food, medicinal, aromatic, ornamental (Vînătoru, 2019). The researches undertaken were completed with obtaining the first variety of *Sideritis scardica*, patented and registered in the Official Catalogue of Cultivated Plants in Romania, under the name of Domnesc.

In the following period the research was continued at PGRB Buzau, with the aim of enriching the germplasm base and obtaining new genotypes with distinct phenotypic expression. At the same time, a special emphasis was put on the development of specific cultivation technology for the soil and climatic conditions of our country with the aim of achieving technological transfer to producers. Specialists recommend field crop as the most efficient and which favours the increase of resistance and adaptability to agro-ecological conditions (Evstatieva & Alipieva, 2011). The main objective of the present paper is to present the research undertaken in the period 2019 - 2021 on the development of specific cultivation technology.

MATERIALS AND METHODS

The research works were carried out between 2019 and 2021, at PGRB Buzau, located in the south-eastern part of Romania, in the continental climate zone. In order to establish the cultivation technology, three experimental substrate variants, containing different mixtures, were chosen for seedling production: V1 with 100% simple ground peat, partially decomposed, with microelements, pH 6, with wetting agent and fertilizer 1 g/l, extrafine structure; V2 a mixture of 80% peat and 20% sand and V3 a mixture of 80% peat and 20% dolomite (limestone).
Figure 1 shows pictures of the three substrate preparation methods.



a) b) c)

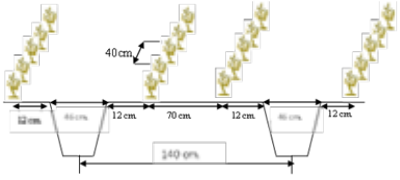
Figure 1. Three substrate variants:
a) V1 100% peat; b) V2 80% peat+20% sand;
c) V3 80% peat+20% limestone

The genetic material used in this theme comes from the germplasm collection held by PGRB, in this species, namely the Domnesc variety. Three variants were used for the establishment of the field crop: V1 by seedling, V2 by cuttings and V3 by direct sowing, as shown in Figure 2.

a) b) c)

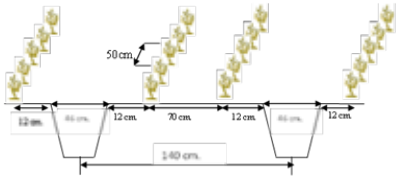
Figure 2. Material used to establish the culture of *Sideritis scardica*:
a) V1 seedling; b) V2 cuttings; c) V3 seeds

Land preparation was done in autumn, by clearing the land of plant debris followed by deep autumn ploughing at a depth of 30 cm, and in spring the soil was tilled with a disc harrow, equipped with a levelling frame, after which the land was shaped using the L445 tractor in aggregate with MMS 2.8 with a width of 1400, 94cm at the crown, a 46cm ridge and 70cm between rows.
Regarding the schemes for establishing the culture, three variants with different densities were used as can be seen in Figure 3, images a), b), c):
V1 - 70 cm between rows and 40 cm between plants /row (Figure 3a);



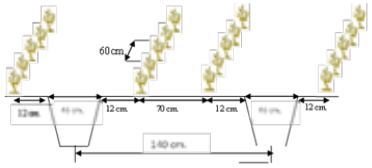
a)

V2: 70 cm between rows and 50 cm between plants / row (figure 3 b);



b)

V3: 70cm between rows and 60 cm between plants / row (Figure 3 c):



c)

d)

Figure 3. Crop establishment schemes with different plant/row densities:
a) V1 at 40cm; b) V2 at 50cm; c) V3 at 60cm;
d) third year of *Sideritis* crop

In the first year, in 2019, the crops were established by the three methods: V1 by seedlings, V2 by cuttings and V3 by direct sowing. Sowing was carried out, for all three variants, in the first decade of March, in heated protected areas (greenhouse), when the average daily temperature was 15-16°C. The three pre-prepared substrates: 100% peat, 80% peat + 20% sand, 80% peat + 20% dolomite, were used to fill the 33 x 53 cm and 70 cells/tray cellular pallets.
Schematically, the three methods are shown in Table 1.

Table 1. Schematic representation of culture establishment methods and distances

Method name	Method of establishing culture	Distance between rows	Distance between plants per row		
			V1	V2	V3
V1	seedling	70cm	40cm	50cm	60cm
V2	cuttings	70cm	40cm	50cm	60cm
V3	directly sown	70cm	40cm	50cm	60cm

The three substrate variants called V1, V2 and V3 and configured differently, 100% peat for V1, 80% peat and 20% sand for V2 and 80% peat and 20% dolomite for the V3 variant can be found in the table 2 below:

Table 2. Configuration of the three substrate variants

Crt. No.	Substrate type	Peat	Sand	Limestone
1.	V1	100%		
2.	V2	80	20%	
3.	V3	80%		20%

The maintenance works were the usual ones, namely: filling the gaps after planting, weed control by two manual and three mechanical hoeing and supplying the crop with water on time, in critical phenophases using a watering norm of 200-250 m^3/ha.
Irrigation works require special attention due to pubescence leaves because can adhere to the soil surface and rot easily.
If the plant is grown on unmulched land or without rocks, the rain can lead to sticking the hairs of the leaves with the soil, a phenomenon that depreciates the foliar mass and can even lead to compromising the crop. In the picture below you can see two plants, one partially and totally destroyed due to excess water:

a) b)

Figure 4. Two plants of *Sideritis scardica* destroyed due to excess water: a) partially; b) totally

In case of hoeing is very important not to bring soil close to the stem.
During the vegetation period, biometric and qualitative measurements were carried out; the values from the measurements were processed by statistical calculation using SPSS software, performing analysis of variance by ANOVA test followed by DUNCAN test with 95% confidence interval and p-value < 0.05%. Temperatures and precipitation were also monitored during the study period, 2019-2021 and processed to obtain monthly average values and plotted.

RESULTS AND DISCUSSIONS

The natural growing conditions for *Sideritis scardica* do not target high demands, the species prefers rocky soils with sandy-clay composition, pH between 6.9-8 and a low nutrient content. The Buzaului area, where the experiment was carried out, is a lowland area, characterized by a continental climate, with hot and dry summers and low rainfall. The soil is luto-sandy alluvial with good drainage. Charts 1 and 2 represent the main climatic factors with monthly average values; measurements were carried out in the interval 2019-2021, temperature being recorded and expressed in degrees Celsius and precipitation in mm. In chart 1, regarding the evolution of precipitation, a slight upward trend is observed, 2019 being the year with the lowest monthly average of 34.58mm and 2021 the year with a maximum of 49.58mm.

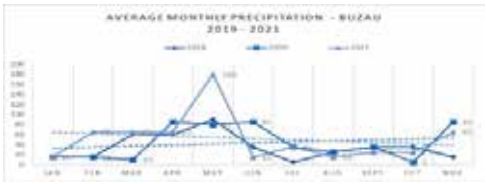


Chart 1. Evolution of average monthly precipitation in the period 2019-2021

Chart 2, on temperature evolution, shows a downward trend, from a monthly average of 12.92°C in 2019 to a monthly average of 11.25°C in 2021. It is worth mentioning that in the June-September flowering period, the monthly averages were identical in 2019 and 2020, i.e. 22.5°C, and in 2021 a monthly average of 20.4°C was recorded in the same period (June-September).

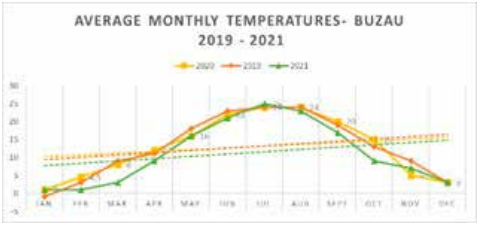


Chart 2. Evolution of monthly average temperatures in the period 2019 – 2021

Throughout the growing season, from sowing, crop establishment to harvest, phenological, biometric and laboratory observations were carried out during all years of study. In terms of seedling production it was found that the best substrate variant is V3, composed of 80% peat and 20% dolomite (limestone). Tables 3 and 4 show phenological observations and biometric measurements of the seedlings obtained from the three substrate variants at the time of planting, i.e. at about 60 days after sowing. Thus, the height of the seedling had a minimum value of 2.41cm in the substrate V1, with 100% peat, and a maximum value of 3.53cm in substrate V3, containing 80% peat and 20% limestone (table 3). Similarly the range of the coefficient of variation is narrow, between 4.08% and 4.62%, with differences in the height of the plants within normal limits. In terms of the number of leaves of the seedlings at the time of planting the calculated average was 5.66 for the 100%turf variant, V1 and equal to 7.66 for the other two variants, V2 and V3. The coefficient of variation (CV) ranged from 9.72% in the case of V2 to 13.15% in the case of V1. The standard deviations (SD) for PH (plant height) were 0.1 for V1, 0.1 for V2 and 0.2 for V3; for NL (number of leaves) the standard deviations (SD) obtained were: 1 for V1, 0.7 for V2 and 0.7 for V3 (Table 3).

Table 3. Seedling growth dynamics of *Sideritis sc.* as a function of substrate: plant height and number of leaves

Substrat type	Plant height (cm)		Number of leaves	
	Mean±SD	CV%	Mean±SD	CV%
V1	2.41±0.1^{c}	4.84%	5.66±1^{b}	13.15%
V2	2.96±0.1^{b}	4.08%	7.66±0.7^{a}	9.72%
V3	3.53±0.2^{a}	4.62%	7.66±0.7^{a}	11.11%

*Letters represent Duncan test results with 95% confidence interval and $p < 0.05\%$.

Regarding leaf length, the lowest average was recorded for substrate V1, 2.18 cm and the maximum was 3.61cm for substrate V3, with a composition of 80% sand and 20% limestone (Table 4).

Table 4. Seedling growth dynamics of *Sideritis sc.* as a function of substrate: length and width leaf

Substrat type	Leaf length (cm)		Leaf width (cm)	
	Mean±SD	CV%	Mean±SD	CV%
V1	2.18±0.08^{c}	3.45%	0.91±0.15^{b}	16.06%
V2	3.35±0.13^{b}	3.76%	1.2±0.09^{a}	7.45%
V3	3.61±0.11^{a}	2.95%	1.3±0.08^{a}	6.12%

*Letters represent Duncan test results with 95% confidence interval and $p < 0.05\%$.

The coefficient of variation (CV) ranged from 2.95% to 3.76%.

Measurements taken to determine leaf width had minimum mean values in V1, namely 0.91cm and 1.3 in the substrate of V3.

The coefficient of variation (CV) ranged from 6.12% to 16.06% (Table 4).

Regarding leaf size the standard deviations (SD) varied as follows: for length the standard deviations were: 0.08 for V1, from observations made on the seedlings at the time of planting: plant height, number of leaves, leaf dimensions (length and width), 0.13 for V2 and 0.11 for V3; for width standard deviations were calculated: 0.15 for V1, 0.09 for V2 and 0.08 for V3 (Table 4).

For a better understanding of the results obtained, the three substrate variants are represented in different colours and segmented by type of quantitave characteristics (Chart 3).

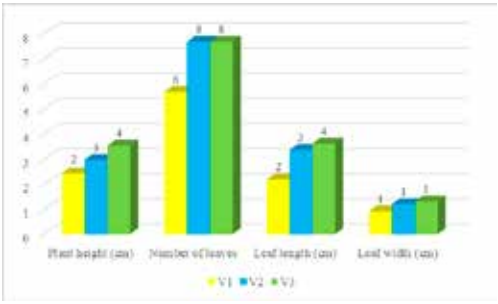


Chart 3. Graphical representation of quantitative characteristics according to substrate type

Regarding the establishment of the crop in the field using seedling, cuttings and seed, it was found that V1, respectively the seedling method is the best and safest way to establish the crop of this species in Romania. One important recommendation is that seedling should not be inserted deeper into the soil than the level of nutrient cube (Figure 5).

Figure 5. Seedling in a nutrient cube

The culture was established on all three expression variants around 1st of May. The percentage of survive in V1 was over 95%, in V2 42% and in V3 by direct sowing only 14% of the seeds germinated. In case of irrigation, excess moisture should be avoided, as the plant may wither.

It was also found that in this variant, V3, the plants had a great competitive opposition with weeds, which required additional hand weeding and transplanting work in the remaining gaps due to uneven sprouting. It should be specified that, although a carefully selected seed with a germination percentage of over 92% was used, the crop had chaotic densities within it, most probably due to the small size of the seed: length 2.23 mm, width 1.45mm (MMB = 1.308 g).

Regarding the establishment of crops using different densities between plants per row, it was found that V2 is the optimal variant of establishing the crop in terms of plant density per row ensuring a higher yield than the other variants, while it also makes good use of the land and can easily perform maintenance work.

The measurements were carried out at the time of harvesting the flower stems. The values obtained were the basis for calculating mean values (M), standard deviations (SD) and coefficients of variation (SD) using statistical formulas. In terms of the number of stems, the values fall within normal growth and development trends. In 2019 (table 5) were recorded at the V1 variant, an average value of 32 rods, 38 rods at V2 and 34 rods at V3. Regarding vegetative mass in 2019 the mean for V1 was 137.99g, for V2 was 184.82g and 157.16g for V3. Coefficient of variations (CV) ranged from minimum average value 1.63% at V2 to a maximum average value 3.27% at V3.

Table 5. Mean values of quantitative characteristics of the vegetative mass of a *Sideritis sc.* bush depending on the type of substrate used - 2019

Year	2019					
Crop variant	Rod number		Rod weight (g)		Vegetative mass (g)	
	Mean ±SD	CV%	Mean ±SD	CV%	Mean ±SD	CV%
V1	32± 0.70^{c}	2.19%	4.31± 0.01^{c}	0.23%	137.99± 3.53^{c}	2.56%
V2	38± 0.70^{a}	1.84%	4.86± 0.02^{a}	0.41%	184.82± 3.01^{a}	1.63%
V3	34±1^{b}	2.94%	4.62± 0.01^{b}	0.22%	157.16± 5.14^{b}	3.27%

In 2020 (Table 6), the values recorded were higher, namely: an average value of rod number was 130.4 at V1, 147.2 rod number at V2 and 140.1 average value of rod number for V3.

Table 6. Mean values of quantitative characteristics of the vegetative mass of a *Sideritis sc.* Bush depending on the type of substrate used - 2020

Year	2020					
Crop variant	Rod number		Rod weight (g)		Vegetative mass (g)	
	Mean ±SD	CV%	Mean ±SD	CV%	Mean ±SD	CV%
V1	130.4± 0.89^{c}	0.68%	5.75± 0.03^{b}	0.52%	750.06± 7.77^{c}	1.04%
V2	147.2± 0.83^{a}	0.56%	5.86± 0.03^{a}	0.51%	862.9± 8.85^{a}	1.03%
V3	140± 1.00^{b}	0.71%	5.75± 0.06^{b}	0.52%	805.86± 12.23^{b}	1.52%

The main quantitative characteristic monitored, was the average value of the vegetative mass of a *Sideritis sc*. bush and the determinations carried out recorded in 2020 an average weight from minimum value 750.06g from V1 to 862.9g maximum value at V2.
In 2021 (Table 7), the values recorded were the highest, namely: an average value of rod number was 179.8 at V1, 211.2 rod number at V2 and 188.2 average value of rod number for V3. The vegetative mass of a *Sideritis sc*. bush and the determinations carried out recorded in 2021 presented an average weight from minimum value 1166.16g from V1 to 1418.35g maximum value at V2.

Table 7. Mean values of quantitative characteristics of the vegetative mass of a *Sideritis sc.* bush depending on the type of substrate used - 2021

Year	2021					
Crop variant	Rod number		Rod weight (g)		Vegetative mass (g)	
	Mean ±SD	CV %	Mean ±SD	CV %	Mean ±SD	CV%
V1	179.8± 0.83^{c}	0.46 %	6.486± 0.17^{b}	2.62%	1166.16± 30.30^{c}	2.60%
V2	211.2± 0.83^{a}	0.39 %	6.716± 0.13^{a}	1.94%	1418.35± 24.66^{a}	1.74%
V3	188.2± 1.09^{b}	0.58 %	6.418± 0.07^{b}	1.09%	1207.81± 9.66^{b}	0.80%

It should be mentioned that *Sideritis scardica* is a valuable honey plant, which blooms in stages between May 15 and June 15. If the inflorescences are harvested early in May, in favorable weather conditions (late frosts), a second flowering occurs starting with September, which lasts until the arrival of frost.

Figure 6. *Sideritis sc.* first year crop

In the image above is a sequence from a culture of *Sideritis sc.* established by the V1 method, shaped land, first year of crop, weak development with reduced number of rods (Figure 6).

Figure 7. *Sideritis sc*.: the second year crop

In the second year after the establishment of the crop the plant shows both vertical and horizontal growth, increasing the number of stems and therefore the vegetative mass (Figure 7).

Figure 8. *Sideritis sc*.: the third year crop

In the third year the plant reaches a vegetative maximum (Figure 8).
The graph below (Chart 4) shows the influence of the composition of the substrate used for the establishment of the crop on the main quantitative characteristic, i.e. the vegetative mass of a *Sideritis sc.* bush in the third year after the establishment of the crop, when the phenotypic characteristics are at their maximum.

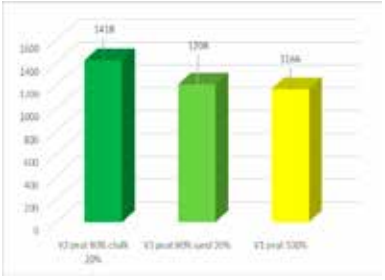


Chart 4. Influence of V2 substrate on the vegetative mass of *Sideritis sc.*

As far as green mass vs. dry mass is concerned, it was found that there are no significant

differences. The dry mass decreases by skip up to 38% of the green mass; the percentage is variable depending on the time of harvesting: the more the crop is at an advanced stage of ripening, the lower the percentage of dehydration; the explanation is that the green plant has a low water content (Figure 9).

Figure 9. Green plant vs. dried plant of *Sideritis sc.*

It has been found that *Sideritis sc.* is highly appreciated as a honey plant, providing pollen and nectar for a long period of time, starting from the end of June, second year, until frost.
It is worth mentioning that the flower has a very pleasant lemon-yellow colour and the aroma is a mix of menthol and citrus. The specific and particular aroma of mountain tea (*Sideritis scardica* Griseb.) is perhaps the most important reason for its widespread use by peoples.
In the picture below (Figure 10), *Sideritica sc.,* flowers:

Figure 10. *Sideritica sc.* flowers and bees

After harvesting, the flowering stems are dried in specially designed areas, away from sunlight and draughts; the stems are tied in bunches that weigh about 400g in green (Figure 11):

Figure 11. Drying and storage of *Sideritis sc.*

CONCLUSIONS

It has been found that the *Sideritis* species can be grown successfully in Romania, except in very hot, arid areas. Regarding the best method of establishing the crop is by seedling using a nutrient mixture of peat and dolomite (limestone). The optimum planting distance in the field is recommended to be 70 cm between rows and 50 cm between plants/row. The maximum production potential of the *Sideritis scardica* crop is achieved in the third year after establishment. The study did not detect any diseases and/or pests that would cause significant damage to the crop, which is why the crop can be grown successfully under organic conditions in the soil and climate conditions of Romania.

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