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CULTIVATION POTENTIAL OF CHIA (*Salvia hispanica* L.) IN CLUJ COUNTY

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Abstract

Chia (Salvia hispanica) is an annual herbaceous species from the Lamiaceae family. It is a tropical short-day species, native to Mesoamerica. Chia seeds are considered a "superfood" due to nutritional characteristics. Aim of this research was to assess the cultivation potential of chia in local climate (Cluj-Napoca, Romania). The research was conducted on four Salvia hispanica accessions cultivated in the experimental field from Agro-Botanical Garden of the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca. In field conditions, growth cycle lasted between 150-170 days. According to BBCH scale were identified eight principal growth stages. Fruit development and fruit maturation were the longest. In September, seeds were harvested for analysis. The average thousand seeds mass was 1.43 g, average protein content 17.06 g/100 g and average fat content was 31.32 g/100 g. Plants developed a specific habitus and had a complete life cycle, producing fruits with viable seeds at the end of summer. Average seed germination was 92.88%. Quality of seeds was comparable with the one from literature, indicating to the potential for cultivation of chia in continental temperate conditions of Cluj county, Romania.

Key words: *food, proteins, lipids, germination, quality, phenology.*

INTRODUCTION

Salvia hispanica L. is an annual short-day herbaceous species from the family *Lamiaceae* that is native to Mesoamerica (Iannucci & Amato, 2021). The edible seeds were used as food by Mayan and Aztec in pre-Columbian times (Baginsky et al., 2016; de Falco et al., 2017). Today, chia seeds find wide utilization in food industry, as supplements or in cosmetology (Motyka et al., 2021). The nutritional value of chia seeds is given by their rich chemical composition, such as high content of polyunsaturated omega-3 fatty acids, essential amino acids, polyphenols derived from caffeic acid and vitamins (de Falco et al., 2017; Motyka et al., 2021; Rentería-Ortega et al., 2021). Aside of the nutritional benefits, chia can be considered a good candidate for the development of functional foods, and important food ingredient due to textural properties. In this regard, chia can be used in baked goods as hydrocolloid and egg substitute (Zettel & Hitzmann, 2018). Chia can also be used as food additive - thickener, as fat substitute, stabilizer and emulsifier in various food applications (Kulczyński et al., 2019; Rentería-Ortega et al., 2021). The inclusion of chia seeds in human diet could be considered an innovative therapeutic approach in the prevention and treatment of various ailments and diseases (Kulczyński et al., 2019). This is due to the fact that chia seeds demonstrated anti-inflammatory and antioxidant properties in addition to anti-diabetic, cardioprotective, anti-atherosclerotic and antihypertensive potential (Motyka et al., 2021; Motyka et al., 2022). Among non-food applications, there are results that indicate to the potential use of chia essential oil in controlling phytopathogenic bacteria and fungi (Elshafie et al., 2018). Based on these considerations, the extended uses and application possibilities of chia seeds will most likely increase the demand for this crop in the coming years (Zettel & Hitzmann, 2018).

Under favourable conditions, chia plants can grow up to one meter in height. Leaves have elongated shape, size 3-4 × 4-8 cm and serrate margins; leaves are inserted opposite. Flowers are hermaphrodite from white to purple having typical labiate morphology and reaching 3-4 mm in size. Flowers are arranged in verticillasters on inflorescence axis (Hrnčič et al., 2020; Motyka et al., 2022). The plant produces a dry indehiscent fruit of 1-2 mm in length, oval in shape and ranging in colour from white-gay to black; the white colour in seeds is a recessive trait (Motyka et al., 2022). Four nutlets are produced per flower, and act as seed units (Geneve et al., 2017). The hydrated chia seed forms a continuous and transparent capsule with an average thickness of about 0.4 mm, having a gel-like consistency and complex ultra-structure (Muñoz et al., 2012). Myxocarpy in chia might play some important ecological roles (Geneve et al., 2017). There are a series of traits selected for cultivation that distinguishes the cultivars from wild *S. hispanica* genotypes, but the most important is early flowering (Grimes et al., 2018) and the closed cups (Motyka et al., 2022). In Figure 1 it can be observed a *S. hispanica* plant alongside the characteristic speckled dark seeds.

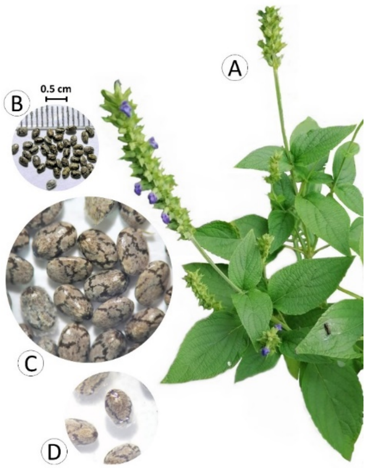

Figure 1. Characteristics of *S. hispanica*: A) chia plant, B-C) dry seeds, D) seeds swelling in water (Original)

Originating in tropical climate of southern Mexico and Guatemala (Motyka et al., 2022), the growth and development of this species is mainly influenced by day length and temperature. For successful cultivation, chia crop requires well distributed rainfall during early growth and dry conditions during seed maturation and harvest (Iannucci & Amato 2021). This plant species is not frost-tolerant, but has extended in cultivation well beyond its native range (Bochicchio et al., 2015; Grimes et al., 2018; Iannucci & Amato 2021). However, technical information about cultivation of this species remains relatively scarce (de Oliveira et al., 2019). In its natural habitats this species grows in mountain areas. In culture, thrives in acidic soils but can grow in soil with ranging pH 6.5-8.5 (Motyka et al., 2022). The optimum growth temperatures for this crop are between 16–26°C (Grimes et al., 2018).

Because this valuable plant species is a promising crop, cultivation beyond its native geographic range could be a viable possibility to cover the increasing market demands. Locally sourced chia could provide a steady flow of raw material representing an attractive option for local growers and food sector alike. However, before recommending this species for cultivation in local conditions, the agronomic suitability and feasibility of this crop must be determined.

Aim of this research was to identify the cultivation potential of chia (*S. hispanica*) in temperate conditions from Cluj county, Romania. Two objectives were defined:

- description of the plant phenology under local climatic conditions in order to determine the agronomic suitability for cultivation;
- determination of some seed characteristics after harvest, in order to find out the preliminary qualitative parameters with importance for feasibility of this crop locally.

MATERIALS AND METHODS

The experiment was conducted in the year 2020 in the Agro-Botanical Garden of the University of Agricultural Sciences and Veterinary Medicine (UASVM) from Cluj-Napoca, Romania. The Agro-Botanical Garden UASVM Cluj-Napoca is situated in temperate continental climate. The soil has loam-clay texture, pH 6.72, a low humus content (1.35%), very well supplied with macronutrients: N 0.461%, P 68 ppm, K 312 ppm (Vârban et al., 2021). Climatic conditions during the experimental interval, according to data registered by the UASVM Cluj-Napoca weather station are presented in Figure 2. Monthly average temperature was over 10°C between May and October. It can be observed that high precipitation levels were registered in June. Between June and September there were days when maximum temperature reached ≥30°C, but highest temperature was registered in the month of August of 2020. September was characterized by low precipitation levels (Figure 2).

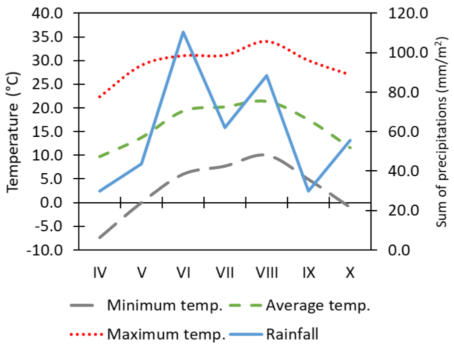

Figure 2. Climatic conditions during the experiment (April-October, 2020) in Cluj-Napoca, Romania (Original)

The biologic material was represented by dark chia seeds, obtained by Agro-Botanical Garden UASVM Cluj, from four botanical gardens, as presented in Table 1.

Table 1. Provenance of *Salvia hispanica* accessions

Botanical Garden[1]	IPEN code[2]
Jardin botanique de Besançon, France (BESN)	XX-0-CLA-1913
Jardin des Plantes Nantes, France (NTM)	XX-0-CLA-1914
"Anastasie Fătu" Botanical Garden of Iaşi, Romania (IAGB)	XX-0-IAGB-20179769G
Späth-Arboretum der Humboldt-Universität zu Berlin, Deutschland (BHU)	XX-0-BHU-2018-0262

[1]Acronymin in parentheses indicates the Garden IPEN code
[2]International Plant Exchange Network (Index Seminum, 2021)

The seeds were sown in heated greenhouse on 12 March 2020. Germination took place in 10 days. At two true leaves, the seedlings were pricked in larger pots. In the month of May (2020) seedlings were planted in the experimental field from the Agro-Botanical Garden UASVM Cluj-Napoca, Romania. Seedlings were planted at a distance of 50 cm between rows and 30 cm between plants on a row, as recommended for species from the family *Lamiaceae*, according to literature (Muntean et al., 2014; Muntean et al., 2016).

In the accordance with the objectives of the research the following determinations were conducted:

- identification of main growth stages and their duration;
- seeds characteristics after harvest: thousand seeds mass and chemical parameters (moisture, lipids, protein and ash);
- germination percentage of the seeds.

Aspect of the chia crop can be seen in Figure 3.

Figure 3. Aspect from the experimental field (Original)

Delimitation of phenophases followed the BBCH scale description (Meier, 2001), and the specific growth stages defined for chia by Pérez Brandán et al. (2019). For each accession were determined the growing degree days (GDD) and sum of rainfall, calculated according to Vârban et al. (2021) for the entire growth cycle length. Thousand seeds mass was determined according to standard procedure (Muntean et al., 2014). Germination was determined according to SR 1634/1999, using 100 seeds in four replicates. Germination was determined after 4 months from harvest (January 2021), and calculated as percentage of germinated seeds per total number of seeds placed for germination on moist blotting paper after 4, 7, 14 and 18 days (Muntean et al., 2014). Chemical characterization of seeds was conducted at the Faculty of Food Science and Technology from UASVM Cluj-Napoca. Proximate compositions were determined according to the standards (https://e-standard.eu.): moisture was determined according to SR ISO 712:1999. Nitrogen (N) content was determined by the Kjeldahl method, and crude protein was calculated using 5.7 as N conversion factor for protein of vegetable products (SR ISO 1871/2002). The lipid content was determined according to SR ISO 6492:1999 and ash (mineral content) was determined according to Romanian official methods STAS 90/1988 (Rusu et al., 2021).

RESULTS AND DISCUSSIONS

Regarding the phenology of the accessions studied in 2020, it was found that the vegetation period lasted between 150-170 days. The longest vegetation period was registered by the accession from Iași (Romania) of 170 day, while the shortest for the two accessions from France of only 150 days (from Botanical Gardens of Besançon and Nantes, respectively). The length of growth season for accession from Berlin was 155 days.
Regarding the length of the phenophases, it was observed that in all accessions the phenophase of fruit development (stage 7), fruit ripening (stage 8) and senescence (stage 9) were the predominant ones, both in number of days (Figure 4) as well as percentage from the vegetation period (Table 2).

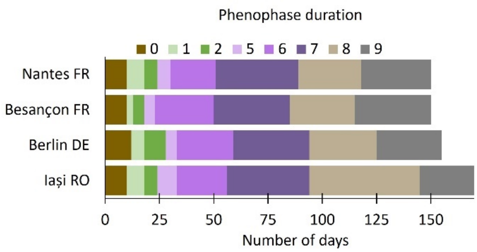

Figure 4. Phenophase duration in number of days for four accessions of *Salvia hispanica*

Seed harvesting is conducted in this phenophase. The phenophase of flowering (stage 6) was also quite long, lasting between 21-27 days (Figure 4). The share of phenophases (%) for the studied accessions are presented in Table 2. The phenophases of leaf appearance and branching of the stem were short. In the case of the accession from the Botanical Garden of Besançon, France, the phenophase of fruit development and senescence were predominant.

Table 2. Phenophase duration (%) from growing season of four *Salvia hispanica* accessions

Principal growth stage according to BBCH scale	Besançon FR (BESN)	Nantes FR (NTM)	Iași RO (IAGB)	Berlin DE (BHU)
0. Germination	6.7	6.7	5.9	7.7
1. Leaf appearance	2.0	5.3	4.7	3.9
2. Shoot appearance	3.3	4.0	3.5	6.5
5. Inflorescence growth	3.3	4.0	5.3	3.2
6. Flowering	18.0	14.0	13.5	16.8
7. Fruit development	23.3	25.3	22.4	22.6
8. Ripening	20.0	19.3	30.0	20.0
9. Senescence	23.3	21.3	14.7	19.4
GDD	2383.7	2697.9	2630.9	2670.8
Rainfall (mm)	328.92	341.86	333.48	341.10

In the case of accession from Nantes, France, the predominant phenophase was represented by fruit development (25.33%). The accession from Iași (Romania) had the longest vegetation period, while the longest phenophase was the fruit ripening, which represented 30% of the vegetation period. The shortest phenophase duration was registered for the accession of Besançon, the appearance of leaves (stage 1). There was also considerable overlapping between phenophases, particularly between vegetative and reproductive growth stages (Figure 5).

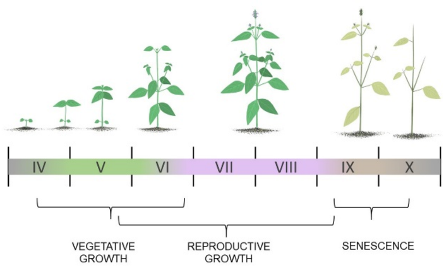

Figure 5. Growth stages of chia in Cluj county

The formation and ripening of the fruit began during last part of August, followed by senescence, which took place during September and October. In all accessions, growth cycle ended in October. Senescence process was gradual, lasting >30 days except for the accession from Iași, with a senescence of 25 days. The fruits were harvested in September. During the entire growth season, the growing degree days ranged between 2383.7-2697.9°C while sum of rainfall accumulated ranged between 328.92-341.86 mm/m^2 (Table 2). In summary, in conditions from Cluj county (2020), the chia plants completed their phenological cycle, reaching physiological maturity and forming fruits. Images with vegetative and reproductive growth stages of chia are presented in in Figure 6. There were three vegetative stages (that includes germination, leaf and shoot appearance) (Figure 6 A-E) and four reproductive growth stages represented by inflorescence growth, flowering, fruit development and ripening (Figure 6 F-J).

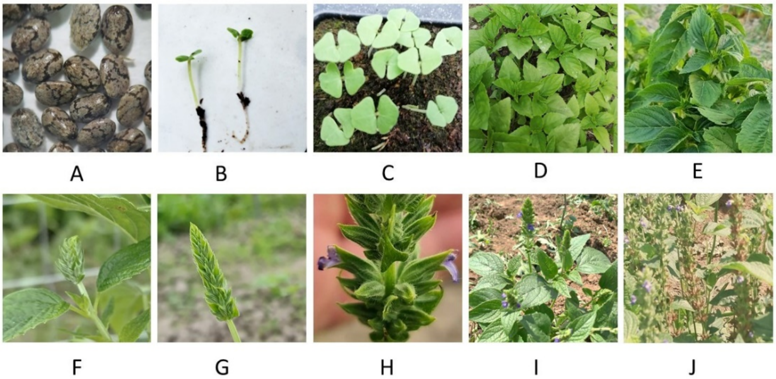

Figure 6. Examples of phenological stages of chia in Cluj county according to BBCH scale: A) dry seed, principal growth stage 0; B-C) cotyledons unfolded, principal growth stage 1; D) appearance of true leaf pairs, principal growth stage 1; E) shoot appearance, principal growth stage 2; F-G) inflorescence growth, principal growth stage 5; H-I) flowering, principal growth stage 6; J) fruit development, principal growth stage 7 (original)

The results for thousand seeds mass (TSM) are found in Table 3. The mass of 1000 seeds of *S. hispanica* registered values between 1.39 and 1.48 g. The thousand seeds mass registered significantly higher values for accession from Iași compared to the accession from Berlin and Besançon. Regarding the germination percentage, on average it increased from 82.31% after four days to 90.06% after 14 days but mean value varied by accession (Table 4).

Table 3. Thousand seeds mass (TSM) of *Salvia hispanica*

Provenance	Mean TSM	±SD	±SE	Duncan test
Besançon FR, (BESN)	1.40	0.054	0.019	a
Nantes FR, (NTM)	1.44	0.052	0.018	ab
Iași RO, (IAGB)	1.48	0.046	0.016	b
Berlin DE, (BHU)	1.39	0.064	0.023	a

[1]SD - standard deviation; SE - standard error; differences between means followed by same letters are not significant

Table 4. Germination (%) of *Salvia hispanica* seeds (Mean ± SD)

Provenance	After 4 days	After 7 days	After 14 days	After 18 days
Besançon FR, (BESN)	85.50 ± 2.65 b	86.00 ± 2.45 bc	91.75 ± 4.65 b	94.00 ± 2.16 a
Nantes FR, (NTM)	80.50 ± 2.38 ab	81.75 ± 2.22 ab	84.25 ± 3.69 a	90.25 ± 1.71 a
Iași RO, (IAGB)	86.25 ± 1.71 b	87.25 ± 1.71 c	92.00 ± 3.56 b	94.25 ± 2.22 a
Berlin DE, (BHU)	77.00 ± 5.48 a	80.25 ± 3.30 a	92.25 ± 3.59 b	93.00 ± 4.08 a
Average	82.31 ± 4.94	83.81 ± 3.73	90.06 ± 4.92	92.88 ± 2.92

[1]SD - standard deviation; differences between means followed by same letters are not significant (Duncan test)

Statistical analysis revealed that accessions from Iași and Besançon registered significantly higher germination percentage after four days compared to the accession from Berlin. After four and seven days, the accession from Berlin presented the lowest germination among the accessions studied, but after 14 days presented the highest germination. After 18 days, all four accessions registered a germination >90%. At this point there were no more significant differences between mean germination percentage among accessions (Table 4). Seed quality is particularly important for this species, considering that it is found in relationship with the nutritional values. The highest fat content was identified in the accession from Besançon followed by the accession from Iași. Similar protein content was identified for the accessions from Nantes and Iași. Compared with data from literature can be observed that seeds moisture situates within middle range (Tables 5, 6). Fat content of seeds obtained in conditions from Cluj county is similar with the one reported for chia crops from Brazil (da Silva et al., 2017), Bolivia (Ayerza, 2016) and Chile (da Silva Marineli et al., 2014). The protein content of seeds was lowest in this study for accessions Besançon and Berlin (Table 5), and these levels are lower (<15%) than those from literature, where roughly the reported range is 18-25% (Table 6).

Table 5. Chemical characteristics of *Salvia hispanica* seeds (Mean) in Cluj county

Provenance	Humidity (g/100 g)	Lipids g/100 g dry substance	Proteins g/100 g	Ash (total mineral substances) g/100 g
Besançon FR, (BESN)	6.33	32.20	15.56	5.30
Nantes FR, (NTM)	6.88	30.22	18.35	5.20
Iași RO, (IAGB)	6.30	32.10	18.35	5.30
Berlin DE, (BHU)	6.48	30.74	15.96	5.10

Table 6. Characteristics of *Salvia hispanica* seeds according to literature

Country of source material	Moisture (%)	Lipids (%)	Proteins (%)	Ash (%)	Source
Mexico – Jalisco	5.80	18.30	18.80	4.70	Rodríguez et al., 2021
Mexico	6.82	35.13	24.11	-	Grancieri et al., 2019
Brazil – Rio Grande do Sul	7.14	32.16	18.18	4.56	da Silva et al., 2017
Brazil – Mato Grosso	5.62	30.17	19.72	5.07	da Silva et al., 2017
Ecuador	5.71	16.06	19.78	4.82	Carrillo et al., 2018
Ecuador	-	33.30	18.90	-	Ayerza, 2016
Bolivia	-	31.80	23.90	-	Ayerza, 2016
Chile	5.82	30.22	25.32	4.07	da Silva Marineli et al., 2014

For the other two accessions (Nantes, Iași), the protein content although situates within lower range compared to literature data (Table 6), resembles the levels registered by some chia crops from Mexico - Jalisco (Rodríguez et al., 2021), Brazil - Rio Grande do Sul (da Silva et al., 2017) and Ecuador (Ayerza, 2016). The ash content of the seeds from this study is similar with the one reported for chia from Brazil - Mato Grosso (da Silva et al., 2017), however most sources from literature report a level of ash <5% for chia (Table 6). In large part, nutritional and health benefits of chia seeds are due to their lipid fraction (polyunsaturated fatty acids, chiefly α-linolenic acid) besides other constituents (Rentería-Ortega et al., 2021). Other non-food applications are also linked to the lipid fraction of chia seeds; for example, lipids from chia seeds can be used to obtain nanoemulsions and nanoliposomes with pharmaceutical applications (Motyka et al., 2022). Regarding the protein content, seeds obtained in Cluj county presented low levels. However, this is not the chief attribute that seeds are used for, but they do represent an important nutritional parameter. According to literature, the most important storage protein found in chia seeds is globulin, that constitutes up to 52% of the total protein content, followed by albumins (17%), glutelins (14%), and prolamins (12%) alongside a few other with lower abundance (Motyka et al., 2022).

Although the chia plants completed their phenological cycle in conditions from Cluj county, viability of the seeds is important because it can ensure seed production for establishing the crop, locally. There were no significant differences between accessions after 18 days, since all four accessions reached a germination percentage >90%. A study conducted on chia seeds in Brazil testing different germination temperatures (25-30 °C), reported a germination percentage after 4 days of 19-57% and after seven days between 72-88% (de Oliveira et al., 2019). The germination percentage obtained in this study is higher compared to this cited study after four days, but values after seven days are comparable. Another study from Brazil reported a mean germination of 96% after 14 days (at 25 °C), but under lower temperature conditions (at 18 °C), the germination percentage decreased to 67% (Possenti et al., 2016). Based on research of chia seed germination under different stressors, was proposed the characteristic pectinaceous mucilage formed around hydrated chia seeds enhances germination, and in addition could potentially provide an ecological advantage in arid or semiarid conditions, in salinized soil or with irregular soil moisture (Geneve et al., 2017). Interestingly, germination of the seeds might enhance nutraceutical potential of chia, with potential application in the design of novel foods (Beltrán-Orozco et al., 2020). Several applications of chia are associated with the mucilaginous layer of hydrated seeds. The viscoelastic properties and solubility are given by its chemical composition. Analysis revealed that this mucilage is a polymer consisting mainly of sugars (xylose, glucose, arabinose and galactose) and a considerable amount of uronic acids (Rentería-Ortega et al., 2021).

Life cycle of chia crop starts with germination, since these plants are propagated by seed. After germination, the plant enters the seedling stage. This stage is critical, and recognized as highly important for the establishment of the crop (Iannucci & Amato 2021). From seedling stage until physiologic maturity the chia plants undergo a succession of vegetative and reproductive phenophases until approaching the end of their life cycle once with senescence onset. A study conducted across a climatic gradient in Chile suggests that chia might have a quantitative-type sensitivity to day length (Baginsky et al., 2016), and this can be explained based on their origin. However, due to breeding efforts, were obtained genotypes with early flowering, that no longer limit the chia cultivation to latitudes lower than 25 degrees near the equator. Instead such genotypes due to earlier flowering in summer when day length is longer than 12 h, allows the time for maturation before frost, very advantageous for the cultivation in temperate climates (Grimes et al., 2018). Considering that chia plants are cultivated for seeds, relationships as well as conditioning factors between reproductive growth stages and yields are the most important.

A study conducted in Australia, indicated that the critical period for grain yield of chia starts from 550 degree-days before flowering (Diez et al., 2021). In Chile, highest yields were associated with latitudes with longer day lengths. It was determined a required day length threshold of 11.8 h for the beginning of flowering of chia plants. The study indicated that when plants were exposed to shorter days, the flower initiation was more precocious, but in the case of inadequate day length chia plants began to flower when they accumulated 600-700 ºC day degrees, calculated with the base >10 °C (Baginsky et al., 2016).

In temperate continental conditions from Cluj county, the life cycle of chia ended between September and October, lasting between 150-170 days. Similarly, in conditions from southwestern Germany, plants reached the harvest maturity between 15 September and 7 November, after 127-170 days from sowing (Grimes et al., 2018). However, this duration can be considered long compared to the ones reported in the geographical regions proximal to the centre of origin for this species. In Chile, chia crops reached maturity and completed the phenological cycle at 84-110 days after sowing (Baginsky et al., 2016). Also, the mean growing cycle length of chia ranged from 113 days in Bolivia to 110 days in Ecuador (Ayerza, 2016), therefore shorter than the one obtained in this study. Regarding the growing degree days accumulated in conditions from Cluj county, in the experimental year (2020) all accessions accumulated >2000 °C GDD, with

the base of calculation >10 °C. These values are higher compared to data from literature, but in this case were calculated for the entire life cycle until the end of stage 9 (senescence). Plants reached physiologic maturity in September, therefore a month earlier. In conditions from southwestern Germany, chia accumulated 910.2-1143.9°C growing degree days until the end of their growth cycle (Grimes et al., 2018). In Chile, growing degree days accumulated varied with latitudinal gradient, ranging between 927.7-1393.0 °C for those that reached maturity and completed their phenological cycle (Baginsky et al., 2016).
Regarding yields, under favourable conditions for this crop, there was reported yield of >2900 kg/ha in Chile (Baginsky et al., 2016). In Australia chia yields ranged between 1418 to 2148 kg/ha (Diez et al., 2021). In climatic conditions from Germany, yields reached as high as 1290 kg/ha (Grimes et al., 2018). Because productivity of this crop is related to feasibility and the prospects for successful cultivation, these are the next aspects to be assessed. Based on this study, it was demonstrated that chia plants can complete their life cycle, reaching physiological maturity and producing viable seeds in local conditions of Cluj county, Romania. This preliminary study indicates that interested growers could obtain seeds of comparable dietary quality with the ones obtained from crops in regions and countries of high favourability for this crop. In addition, based on the germination study it was determined that seeds obtained were viable reaching a germination percentage of >90%. Therefore, the preliminary screening concerning the possibility of cultivation of chia locally, established that this might be a promising crop. The results are justifying further studies and prompting the next steps into defying in more detail the cultivation potential. Following the results of this study, the first three necessary requirements were met, such as: plants completed their life cycle reaching physiologic maturity, seed produced had acceptable chemical properties and seeds were viable. In the prospects of cultivation this indicates that not only seeds of acceptable quality could be obtained locally, but growers could also have locally produced seeds for starting their crops. However, there still remain key aspects and further details that have to be studied and defined, and these should be subject for further research.

CONCLUSIONS

Salvia hispanica known as chia, is a species native to the tropical and sub-tropical region of Mexico and Central America that experiences increasing demand due to nutritional and textural properties of their seeds with wide applications in food industry.
This research reports on the potential cultivation of this species in the temperate continental conditions from Cluj county, Romania. Four accessions of *S. hispanica* were studied in order to determine the suitability for cultivation based on phenology in local conditions and some seeds characteristics after harvest.
Based on BBCH were identified eight growth stages between April and October 2020: germination, leaf appearance, shoot appearance, inflorescence growth, flowering, fruit development, ripening, senescence. The principal growth stages 3 and 4 were omitted because are not characteristic of this species. Plants had a complete life cycle lasting 150-170 days and produced fruits with viable seeds at the end of summer (average germination of 92.88%). At harvest, the average thousand seeds mass was 1.43 g, average protein content 17.06 g/100 g and average fat content 31.32 g/100 g. Quality of seeds obtained in continental temperate conditions of Cluj county, Romania, was comparable with the one obtained in native range of this species, indicating to the potential for cultivation of chia in the local climate. High temperatures during the summer registered from last few years in Cluj county could be favourable for fruit development and ripening of chia.

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