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P*hacelia* Honey Productivity in Relation to Locality of Cultivation

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Abstract: California bluebell - *Phacelia tanacetifolia* Benth. is a very attractive crop in the field, with deep blue flowers anda strong, pleasant aroma. With 1 ha can produce between 500 and 1200 kg of phacelia honey. Phacelia honey is from light beige to white, translucent glassy color. The experiment with phacelia variety NS Priora was carried out on the two localities, in Novi Sad (L1) and in Zaječar (L2), in an unfavorable year for production, 2019. The locality had a statistically significant effect to the tested morpho-productive and quality parameters of phacelia, $p>0.5$. Average plant height on both locality was 63 cm, average grain yield 810 kg ha^{-1} and average honey yield 750 kg ha^{-1}. The nitrogen content of grain varied from 3.35% to 3.40%, protein content varied from 20.93% to 21.25%, cellulose content varied from 4.31% to 4.40% and ash content varied from 5.70% (L1) to 5.81% (L2). Research results have shou that variety NS Priora has excellent quality components of seed and potential for grain yield and honey yield.

Keywords: *Phacelia tanacetifolia,* Grain yield, Honey yield, Locality, NS Priora.

1. Introduction

Lacy phacelia - *Phacelia tanacetifolia* Benth. belongs to the family *Boraginaceae*, subfamily *Hydrophylaceae*. There are about 200 species in the Phacelia genera, some perennial and some annual (Cazzola, 1987; Lakić *et al*., 2018). As a commercial species *Phacelia tanacetifolia* is for a long time recognized by beekeepers as a preferred foraging plant for honeybees (Teittinen, 1980) with a high potential for honey yield (Orsi and Bionoi, 1987; Stevenson, 1990; 1991; Popović *et al*., 2016; 2019). *Phacelia tanacetifolia* Benth. is a very attractive crop in the field, with deep blue colored flowers and a strong, pleasant aroma. A single flower can give up to 4.5 mg of nectar, with a sugar concentration of 28%. With 1 ha can produce between 500 and 1200 kg of phacelia honey (Popović *et al*., 2016; 2017; 2019). Phacelia honey is from light beige to white, translucent glassy color, mild and delicate aroma with a fine pleasant flavor (nice soft lemony scent and taste). Crystallization is slow and into fine crystals making the honey finely creamy, because content of fructose in it is higher than content of glucose (like acacia honey). Phacelia have a sweet and complete flower for the honey bees because it provides both pollen (for protein – needed for egg production) and nectar (for carbohydrates – needed for energy). Significant is the potential of Phacelia as bee forage, with a high potential for honey yield, a green manure, forage crop (either on its own or in a mix with peas or vetch) to provide forage and production of honey, it is host of aphid parasite, has nematicidal properties, allelochemical properties of the plant, etc. Phacelia has high energy and protein content. Phacelia honey is good for our health. Monofloral honey is more expensive than multi-floral honey, and the price strictly depends on its botanical origin

(Stanek *et al.*, 2019). Phacelia honey is a very good diuretic, has an estrogenic action, helping in fixing calcium in the bones, in women favors the emphasizing of feminine features and has strong rejuvenating effect, helpful for the treatment of sinus problems, maintains the blood cholesterol level, has disinfecting and skin care effect and helping in treating burns. Honey is the major part of Chinese medical industry.

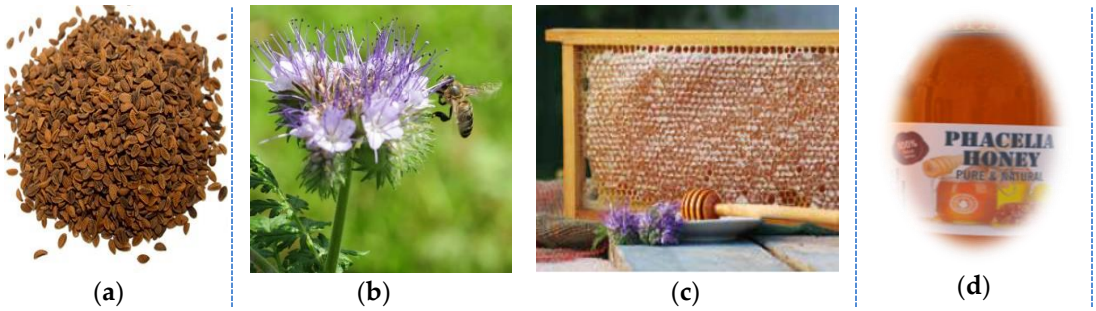


Figure 1. Lacy **p**hacelia plant: (**a**) Phacelia seed; (**b**) Phacelia flowers and been; (**c**) Phacelia honey-comb; (**d**) Phacelia honey

Besides that phacelia is honey culture, it also has great agro-technical significance: Quick for establish; improves soil structure; drought tolerant; for erosion control; nitrogen savenger; weed suppression; potential for grazing; potential in hay; attractive for pollinators. Phacelia has been used as a forage crop, either on its own (Danial and Zobelt, 1986) or in a mix with peas or vetch to provide forage and for honey production (Petkov, 1966). Phacelia has also been used as a green manure crop in Europe for a number of years (Anon., 1989). When ploughed as a green manure, it has influence on increasing content of carbon and nitrogen in soil to over 80 cm of depth (Beckmann, 1977). It was also find, that the crop have nematocidal properties, (Anon., 1989; Booker Seeds, 1990) although it is not clear is this is the case when used as a green manure or the root system was actively nematocidal. Phacelia is commonly established quickly after the harvest of the main crop, to maintain soil structure, fertility and to protect the soil surface (Mariander *et al*., 1981).

Honey is the major food reserve of *Apis mellifera* and the primary carbohydrate in the bee's diet; it is produced and stored in the honeycomb for consumption by the adult colony during periods with no nectar. Honey consists primarily of simple sugars, water, minerals and nitrogenous compounds. Concentrated sugars account for 95 to 99% of honey's dry matter (FAO, 1996). The majority of the sugars found in honey are fructose and glucose, which represent 85 to 95% of its total sugars, in accordance with the regulations on honey, which is comply with the world standard, Table 1. The predominance of these simple sugars, especially fructose, gives to honey most of its nutritional and physical characteristics.

Honey was discovered in India about 2000 - 3000 BC according to their holy book - Vedas. Their forest honey yields 10,000 tons each year. Honey is the major antioxidant and is also used in building up of immunity. World honey production is estimated to 1.85 million tons, in the year 2018 (FAO, 2020). According to FAO (2020) estimate, leading producers according to their production shares are China (24.70%), then follow Turkey (6.18%), Argentina (4.21), Iran (4.19%), Ukraine (3.85%), USA (3.73%), India (3.64%), Russia (3.51%), Mexico (3.47%) and Ethiopia (2.70%).The EU countries are significant producers of honey with share of 13.97% in total world production. Countries former Yugoslav participates with: 0.62% Republic of Serbia, 0.47% Croatia, 0.22% Bosnia and Herzegovina, 0.07% Slovenia and 0.03% Montenegro, Table 2.

Honey is produced in small quantities in many countries and primarily used for domestic consumption. Of the total world annual honey production about 67% is marketed in its country of production and about 23% is traded in the export market. The five biggest honey exporting countries in the world are: China, Argentina, Mexico, Germany and Brazil, accounted for more than 65% of world honey exports in 2004. Germany and the United States were the biggest honey importing countries in 2004 with more than 20% market share. Germany is by far the leading honey market in the EU. China has become the world's biggest honey consumer, significantly increasing its share of the global market from 8% in 1993 to 16% in 2004 (CAP, 2008).

As the only available natural sweetener honey was an important food for Homo sapiens from very beginning. Indeed, the relation between bees and man started as early as Stone Age (Crane, 1983). In most ancient cultures honey was used for both nutritional and medical purposes. The belief that honey is a nutrient, a drug and an ointment has been carried into our days. For a long time, in human history, it was an important carbohydrate source and the only widely available sweetener until industrial sugar production started with its replacement after 1800 (Crane, 1975).

The honey consumer establishes the quality of honey by eyes, nose and mouth. Therefore, the sensory properties of honey have a great importance. Sensory evaluation enables us to distinguish the botanical origin of honey and to identify and quantify certain defects (fermentation, impurities, of odours and flavours). Honey consists of various sugars, mainly fructose and glucose, and other substances such as organic acids, enzymes and solid particles that reach honey during its production. Honey can be of liquid or viscous consistency, partially or completely crystallized, and the color of honey can vary from light yellow to dark brown (Rulebook (2015) on the quality of honey and other bee products, Official Gazette of RS, 101/2015). The smell and taste of honey vary depending on the type of plants from which it originates. Conditions regarding the quality of honey are defined by this rulebook, Table 3. According to the regulations, there are four types of honey: Monofloral honey; Polyfloral honey; Honey-dew and Bakers honey. Monofloral honey is a product that honey bees produce from the nectar of flowers of honey plants of a certain species. Honey with the name of a certain type of honey plant should have the taste, smell and color characteristic of that plant, with the predominant number of pollen- grains of that type of plant. Monofloral honey can be labeled according to a certain plant species, if the insoluble part contains at least 45% of pollen grains of that plant species. Notwithstanding paragraph 3 of Article Rulebook on the quality of honey and other bee products (Rulebook (2015) Official Gazette of RS, 101/2015) for labeling monofloral honey with the name of certain plant species, the share of pollen grains of these plant species in insoluble honey can't be less than the share given in Table 3.Polyfloral honey (meadow, floral) is a product that honey bees produce from the nectar of flowers of different types of honey plants. Honey-dew is a product that bees produce by collecting insect excrement (Hemiptera), which feeds on juices from living parts of plants or secretions from living parts of plants. Bakers honey is honey of altered quality that is used in industry or as an ingredient in other foods that are further processed and may have an uncharacteristic taste or smell, in a state of boiling, boiled or overheated. Other bee products are classified as: 1) pollen; 2) propolis; 3) royal jelly. Pollen is a product that bees collect from the flowers of plants, form it into lumps and add their own specific substances. Propolis is a product of a mixture of natural beeswax and resinous substances that bees collect from woody plants. Royal jelly is a product of allotrophic (hipopharings) glands of young bees, milky color, thick consistency,

characteristic taste and smell, which was extracted 68 to 72 hours after transplanting larvae, with mandatory removal of larvae from an extracted royal jelly (Rulebook (2015) Ordinance on quality of honey and other bee products, Official Gazette of RS, 101/2015).

Honey is sold and consumed around the world. It is consumed as raw (unprocessed); as an ingredient in food, cosmetics and natural medicine; as a source of sugar for making wine or beer. Honeys have been extensively used as a topical therapeutic agent in clinical trials on abscesses, ulcers and burns (Molan, 2001; 2004). There are a lot of benefits of using it to medical treatments, including reduction of inflammation, pain reduction, reduction of odour, debridment of necrotic tissue and improvement of granulation and epithelization (Tonks *et al*, 2003). Honey has been used by humans since ancient times as both a dietary source and sweetener, and until recent times it was also highly regarded treatment for many ailments, in traditional medicine (Crane, 1999). Honey represents goods for barter, cash and export. Honey exports contribute significantly to the agricultural economy of many developing nations. Most developing countries are capable of exporting honey as long as national production exceeds local requirements (FAO, 2003). Beekeeping in our country has an ancient history and is integral part of the lifestyle of the farming communities. The major portion of honey production at ours is done using traditional bee hives which are mostly cylindrical in shape (about 1-1.5 meter in length and 30-50 cm width).

Based on the classification of plants in relation to honey yields, phacelia is classified in the sixth class, in the group of the most honey-bearing plants, and it is with the potential for yields over 500 g ha-1 of honey (Popović *et al*., 2016, 2017, 2019). According to this, phacelia is a desirable culture both in the world and in our country. Phacelia is used in our country as fodder plant, ornamental plant, medicinal plant and honey-bearing plant and sown in a regular and second sowing. The aim of this study was to determine the impact of the locality on the morpho-productive traits of phacelia variety NS Priora, quality seed and honey yield.

2. Materials and Methods

2.1. Experimental design

In this study was determine the productivity of phacelia variety NS Priora, quality seed and honey yield, produced in 2019 in two localities: L1- Novi Sad and in L2-Zajecar, Serbia. The basic plot amounted to 10 m^2 in three replications. The experiment was conducted according to a split-plot design. The standard technology for crop cultivation phacelia was applied in both localities. Autumn ploughing was carried out to a depth of 25 cm, with application of 250 kg ha^{-1} of NPK nutrients. Pre-sow plowing was done at 25 cm of depth, and nitrogen was applied once the plant was at the rosette stage. Sowing was the end of March 2019 at a depth of 2 cm. Using of 12 kg ha^{-1} of phacelia seed for sowing and density of 100 plant per m^2 is recommended. Harvest was carried out at stage of technological maturity of plants. After harvest, samples from all replications were taken for morphologically productive parameters: plant height and grain yield. The yield of honey per hectare was determined. Quality parameters were also examined. Protein content and nitrogen content, %, was determined by the *Kjeldahl* method; Oil content, %, was determined by methods of Soxhlet; Cellulose content, %, was determined by a modified method by Sharer; Ash content, %, was determined by SRPS EN ISO 2171:2012, gravimetric; was determined annealing the samples in electric muffle furnace at a temperature of 500-600 °C. The procedure lasted 3h.

2.2. Tested variety

Serbian variety NS Priora continues flowering over 8-9 weeks period (50-63 days) and have a high genetic potential of seed yields, about 1000 kg ha^{-1} in favorable years for production. Length of vegetation period NS Priora variety is 135 days. Phacelia need 50 kg N, 20 kg P and 10 kg potassium for good growth. Weed control with Fusilade forte was effective (Popović *et al*., 2016; 2017a; 2017b).

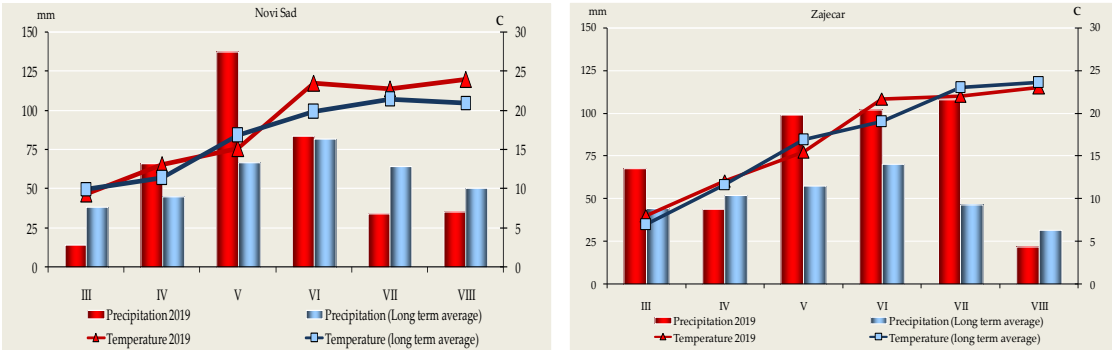
2.3. Statistical Analysis

The resulting data were analysed using mathematical and statistical analysis of variance and the obtained difference of the height was evaluated by LSD test. All of the research results are presented as tables and figures. All statistical analyses were carried out using STATISTICA software, version 13 (StatSoft Inc., Tulsa, OK, USA).

2.4. Meteorological conditions

Compared with perennial data (period 1985-2015), the amount of precipitation in vegetation period 2019 in Novi Sad and Zaječar was higher. Precipitation in period Mart-August in 2019(392.5 mm) in Novi Sadfor 44.7 mm were higher than perennial average (347,8 mm), while the average temperature (21.6 °C) was higher for 1.5 °C than perennial average (20.1 °C), Figure. 1a.

Precipitation in Zaječar in 2019 (443 mm) were higher than the long-term average for 101.2 mm, while the average temperature was 20.5 °C, which were higher than the long-term average (20.1 °C) for 0.4 °C, Figure. 1b. April to May period was characterized by precipitation above average in locality of Novi Sad. In May, June and July, precipitation was above the multiannual average in locality of Zaječar.



(**a**) (**b**)

Figure 1. Total total precipitation (mm) and average temperature (°C) in the vegetation period, VP, 2019 and in average VP of 30 years: (**a**) in Novi Sad; (**b**) in Zaječar, Serbia.

Precipitation in July exceeded perennial values for 63 mm. The main problem was the enormous amount of precipitation that caused incidence of rot. During the ripening phase in August, the average temperatures were at the level of perennial averages in locality Zaječar. All this caused lower habitus of phacelia plants, shorter flowering length, lower honey seed yield and postponed further the phacelia harvest and reduced yields (Table 1, Figure 3a).

3. Results and Discussion

Honey plants, like a phacelia, are of great importance for beekeeping. Share of pollen grain in phacelia is 60%, Table 1.

Table 1. The smallest share of pollen-grains in the insoluble part for certain plant species

No.	Name of plant	Share of pollen, %
1.	Tame chestmnut/Pitomi kesten (*Castanea sativa* Mill.)	85
2.	**California bluebell (*Phacelia tanacetifolia* Benth.)**	**60**
3.	Rapeseed/Uljana repica (*Brassica napus* L.)	60
4.	Sunflower/Suncokret (*Helianthus annuus* L.)	40
5.	Alfalfa/Lucerka (*Medicago sativa* L.)	30
6.	Linden/Lipa (*Tilia* spp.)	25 (10)*
7.	Acacia / Bagrem (*Robinia pseudoacacia* L.)	20
8.	Mint/Menta (*Mentha* spp.)	20
9.	Heaths/Vres (*Calluna vulgaris* L.)	20
10.	Coastal heath/Primorski vres (*Satureja montana* L.)	20
11.	Taraxacum/Maslačak (*Taraxacum officinale* Weber)	20
12.	Rosemary/Ruzmarin (*Rosmarinus officinalis* L.)	20
13.	Sage/Žalfija (*Salvia officinalis* L.)	15 (10)*
14.	Strawberry tree/Planika (*Arbutus unedo* L.)	10
15.	Agrumi (*Citrus* spp.)	10 (5)*
16.	Lavender/Lavanda (*Lavandula* spp.)	10 (5)*

[1] Source: Rulebook on the quality of honey and other bee products, Official Gazette of RS, 101/2015

* With characteristic sensory properties of honey for a certain type of plants (smell, taste, color)

Republic of Serbia are significant producers of honey with share of 0.62% in total world production, Table 2.

Table 2. Honey production in Word in 2018[1]

Honey production	t	Share, %	Honey production	t	Share, %
Word	1.850.868	100.00	Romania	29.162	1.58
Asia	855.835	46.24	Hungary	27.936	1.51
Europe	426.380	23.04	Poland	23.472	1.27
America	355.835	19.23	Greece	21.400	1.16
Africa	200.700	10.84	Germany	20.333	1.10
Oceania	32.310	1.74	France	17.489	0.94
China	457.205	24.70	Serbia	11.427	0.62
EU	258.610	13.97	Bulgaria	10.338	0.56
Turkey	114.113	6.18	Portugal	10.030	0.54
Argentina	79.468	4.29	Italy	9.500	0.51
Iran	77.567	4.19	Czechia	8.992	0.49
Ukraine	71.279	3.85	Croatia	8.727	0.47

USA	69.104	3.73	Pakistan	4.289	0.23
India	67.442	3.64	Slovakia	4.112	0.22
Russian Federation	65.006	3.51	Switzerland	4.005	0.22
Mexico	64.253	3.47	Austria	4.000	0.22
Ethiopia	50.000	2.70	Bosnia &Herzegovina	3.992	0.22
Brazil	42.346	0.23	Albania	3.937	0.21
Canada	39.116	0.21	Sweden	3.400	0.18
Spain	36.394	1.97	Finland	2.606	0.14
Australia	11.300	0.60	Denmark	1.500	0.08
Portugal	10.030	0.54	Slovenia	1.360	0.07
Israel	3.600	0.19	Norway	1.350	0.07
Japan	2.886	0.16	Montenegro	500	0.03

[1]Source: FAO, 2020;

Honey is a sweet and viscous fluid produced by honeybee from the nectar of flowers. Nectar is a fine, sticky, sweet liquid that is changed (ripened) by the honey bee to a stable, dense and high-energy food. According to Codex Alimentarius Commission Standardization: "Honey is the natural sweet substance produced by honey-bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects which suck it from the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in the honeycomb to ripen till mature" (CAC, 2001).

Climate change, modern agriculture, impact of pesticides and other factors have reduced different types of nectar and pollen in world which affected the diet of the bees. Honey is produced in small quantities in our country and primarily used for domestic consumption. Honey production is in accordance with the regulations on honey, which is comply with the world standard, Table 3.

Table 3. Comparison of test results of different honeys with the world standard.

Parameters	Serbian honey standards[1]	Ethiopian honey standards*	World honey standards*
Moisture content (% by mass)	<20.0	17.5-21.0	18-23.0
Mineral content (% by mass)	0.1-0.5	<0.6	0.25-1.0
Total reducing sugars (% by mass)	>60.0	>65.0	60-70.0
Sucrose (% by mass)	<5.0	<5.0	<10.0
Acidity meq/kg	<50.0	<40.0	<50.0
HMF mg/kg	<40.0	<40.0	<80.0

[1] Source: Rulebook on the quality of honey and other bee products, Official Gazette of RS, 101/2015

* Source: Nuru Adgaba (1999) FAO, Agricultural Services Bulletin 68 in MoARD (2007)

The composition of honey is rather variable and primarily depends on the floral source; however, certain external factors also play a role, such as seasonal and environmental factors and processing. Honey contains at least 181 substances (Chow, 2002); it is a supersaturated solution of sugars, mainly composed of fructose (38%) and glucose (31%), containing also minerals, proteins, free amino acids, enzymes and vitamins (Perez, 2002; Terab *et al*., 2003). A wide range of minor constituents is also present in honey, many of which are known to have antioxidant properties. These include phenolic acids and flavonoids (Martos, 2000; Tomas-Barberan *et al*., 2001; Dimitrova *et al*., 2007), certain enzymes (glucose oxidase, catalase) (Molan and Betts, 2014) and aminoacids (Pérez *et al*., 2007), Table 4.

Table 4. Average composition in honey (data in g/100 g)

No.	Component	Average (%)*
1.	Water	17.2
2.	Fructose	38.19
3.	Glucose	31.28
4.	Sucrose	1.31
5.	Disaccharides, calculated as maltose	7.31
6.	Higher sugars	1.5
7.	Free acid as gluconic	0.43
8.	Lactone as gluconolactone	0.14
9.	Total acid as gluconic	0.57
10.	Ash	0.169
11.	Nitrogen	0.041
12.	Minerals	0.2
13.	Amino acids, proteins	0.3
14.	pH value	3.9

* **Source:** Chow, 2020; Perez, 2002; Terab *et al*., 2003; Martos, 2003; Tomas-Barberan *et al*., 2001; Dimitrova *et al*., 2007; Molan and Betts, 2014; Pérez *et al*., 2007.

3.1. Lacy phacelia quality and productivity parameter

Based on the analysis of variance, it can be concluded that are highly significant differences at grain yield regard the locality of investigation (Fexp=28.59*). Highly significant differences are also for protein content (Fexp = 31.50*), honey yield and plant height regard the locality of investigation (Fexp=52.83** and 55.68**), Table 5.

Table 5. Analysis of variance for tested parameters

Effect	SS	Deg.of Freed.	MS	F	p
Nitrogen content					
Intercept	68.3437	1	68.3437	10935.00	0.00000
Locality	0.0037	1	0.0037	0.60	0.4818
Error	0.0250	4	0.0062		
Protein content					
Intercept	2668.72	1	2668.729	524995.80	0.00000
Locality	0.160	1	0.160	31.50*	0.00495
Error	0.020	4	0.005		
Cellulose content					
Intercept	113.535	1	113.535	11353.50	0.00000
Locality	0.0150	1	0.0150	1.50	0.28786
Error	0.400	4	0.0100		
Ash content					
Intercept	198.720	1	198.720	22973.43	0.00000
Locality	0.0182	1	0.0182	2.10	0.22104
Error	0.0346	4	0.0086		
Plant height					
Intercept	23940.10	1	23940.17	6529.14	0.00000
Locality	204.17	1	204.17	55.68**	0.00172
Error	14.67	4	3.67		
Seed (Grain) yield					
Intercept	3943083	1	3943083	7721.44	0.00000
Locality	14603	1	14603	28.595*	0.00589
Error	2043	4	2043		
Honey yield					
Intercept	3241350	1	3241356	5556.600	0.00000
Locality	30817	1	30817	52.825**	0.00190
Error	2333	4	583		

3.1.1. Nitrogen content

Average nitrogen content at both localities was 3.37%, and varied from 3.40% (L2) to 3.35% (L1). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At the locality L2, higher values for NC were achieved by 1.49% in relation to the locality L1, Table 6, Fig. 2b.

3.1.2. Phacelia protein content

Average protein content at both localities was 21.09% and varied from 21.25% (L2) to 20.93% (L1). The locality had a statistically significant influence on the obtained values of the examined parameter. At the locality L2, higher values for PC were achieved by 1.52% in relation to the locality L1, Table 6, Fig. 2a. Phacelia has been found to have high energy and protein content, but some questions were raised about possible allelochemical properties of the plant (Danial and Zobelt, 1986).

Table 6. Lacy phacelia quality parameters

Level of Factor		No	Mean	Std. Dev.	Std. Err.	-95,00%	+95,00%
Nitrogen content, NC, %							
Total	L1 and L2	6	3.375	0.075	0.031	3.295	3.455
Locality–L1	Novi Sad	3	3.350	0.050	0.029	3.226	3.474
Locality-L2	Zaječar	3	3.400	0.100	0.057	3.151	3.648
Protein content, PC, %							
Total	L1 and L2	6	21.090	0.189	0.077	20.890	21.290
Locality-L1	Novi Sad	3	20.927	0.087	0.051	20.709	21.144
Locality-L2	Zaječar	3	21.253	0.050	0.029	21.128	21.378
Cellulose content, CC, %							
Total	L1 and L2	6	4.350	0.105	0.043	4.239	4.460
Locality-L1	Novi Sad	3	4.300	0.100	0.057	4.051	4.548
Locality-L2	Zaječar	3	4.400	0.100	0.058	4.152	4.649
Ash content, AC, %							
Total	L1 and L2	6	5.755	0.103	0.042	5.647	5.863
Locality-L1	Novi Sad	3	5.700	0.100	0.058	5.452	5.948
Locality-L2	Zaječar	3	5.810	0.085	0.049	5.598	6.022

[1]

Parameter	LSD	Locality	NC	PC*	CC	AC
	0.5		0.179	0.161	0.227	0.211
	0.1		0.297	0.268	0.376	0.350

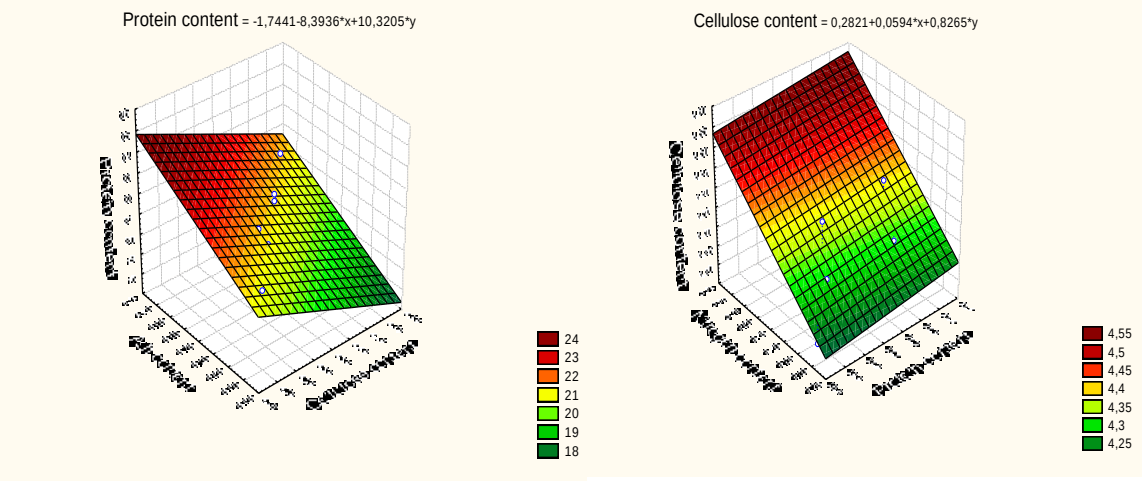
3.1.3. Phacelia cellulose content

Average cellulose content at both localities was 4.35% and varied from 4.30% (L1) to 4.40% (L2). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At locality L2, values higher for CC by 0.10% were achieved compared to locality L1, Table 6, Figure 2b.

3.1.4. Phacelia ash content

Average ash content in both localities was 5.76 and varied from 5.70% (L1) to 5.81% (L2). The locality did not have a statistically significant influence on the obtained values of the examined parameter. At the locality L2, the values higher by CC by 0.11% were realized in relation to the locality L1, Table 6, Figure 2b.

Phacelia tanacetifolia, used as a honey-crop and cover-crop species in arable agricultural systems. These results have implications both from an ecological perspective and in terms of the prescription of plants to remediate or condition soil structure in managed systems (Bacq-Labreuil et. al., 2019). In agricultural systems, the use of cover crops is increasing (Storr *et al*., 2019) in order to increase the sequestration of carbon (Scott *et al*., 2017), soil macro-porosity (Abdollahi *et al*. 2014; Cercioglu *et al*., 2018) and decrease soil erosion (Storr *et al*., 2019). Furthermore, cover crops have an impact on the biota of the soil, increasing microbial diversity and richness (Fernandez *et al*., 2016) and the abundance of saprophytic and mycorrhizal fungi (Finney *et al*., 2017).



(**a**) (**b**)

Figure 2. Lacy phacelia quality parameters; (**a**) Linear 3D Surface Plot for protein content, ash content and cellulose content (**b**) Linear 3D Surface Plot for cellulose, nitrogen content and protein content.

3.1.5. Phacelia plant height

Average plant height in both localities was 63.17 cm, and varied from 57.33 cm (L2) to 69.00 cm (L1). The locality had a statistically significant influence on the obtained values of the examined parameter.

At the locality L1-Novi Sad, significantly higher values were achieved for the height of plants, i.e. higher 16.91% in relation to the locality L2 - Zaječar, Table 7, Figure 3a.

Phacelia tanacetifolia is an annual herb that grows erect to a maximum height near 100 centimeters with none to a few branches. The wild form is glandular and coated in short stiff hairs. The dense and hairy inflorescence is a one-sided curving or coiling cyme of bell-shaped flowers in shades of blue and lavender (https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=37579).

3.1.6. Phacelia seed yield

The locality had a statistically significant influence on the yield of phacelia seeds. At the locality L1-Novi Sad, a significantly higher seed yield was achieved in relation to the locality L2-Zajecar. Average seed yield on both localities was 810.67 kg ha^{-1} and varied from 761.33 kg ha^{-1} (L2) to 860.00 kg ha^{-1} (L1). Locality L1 had higher seed yields by 11.47% compared to locality L2, Table 7, Figure 3a.

Phacelia seed traits depend on many factors: genotype, the moisture content in physiologically mature seeds at harvest time, the technological maturation of seed, seed infection by pathogens, the presence of pests etc. Seed characteristics are changed and due to different agro-ecological conditions (Popović *et al*., 2016; 2017; 2018; Lakić *et al*., 2018).

Cazzola (1987) reported potential phacelia seed yields of 1000- 1500 kg ha^{-1}, which would possibly be attainable if could be harvested all seed and if losses through uneven maturity and/or shattering minimize.

3.1.7. Phacelia honey yield

Honey-bearing crop was attractive to bees. About 3 hives per hectare should be provided if there is no bee source nearby (Glamočlija *et al*., 2015).

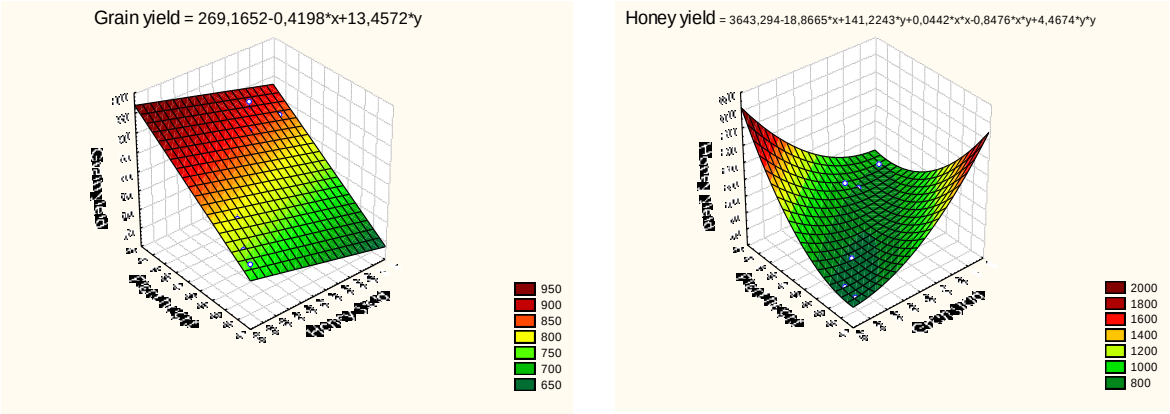
The phacelia plants in both localities were highly attractive to bees. Phacelia bloomed for 57 days at locality L1, four days longer than at the locality L2 (53 days).

Table 7. Lacy phacelia productivity parameters, Novi Sad and Zaječar, 2019

Level of Factor		No	Mean	Std. Dev.	Std. Err.	-95,00%	+95,00%
Plant height, PH cm							
Total	L1 and L2	6	63.167	6.616	2.701	56.224	70.109
Locality	Novi Sad	3	69.000	1.000	0.577	66.515	71.484
Locality	Zaječar	3	57.333	2.516	1.453	51.081	63.584
Seed yield, SY, kg ha^{-1}							
Total	L1 and L2	6	810.667	57.698	23.555	750.116	871.217
Locality	Novi Sad	3	860.000	26.457	15.275	794.276	925.724
Locality	Zaječar	3	761.333	17.925	10.349	716.803	805.863
Honey yield, HY, kg ha^{-1}							
Total	L1 and L2	6	735.000	81.425	33.242	649.549	820.450
Locality	Novi Sad	3	806.667	30.551	17.638	730.775	882.558
Locality	Zaječar	3	663.333	15.275	8.819	625.387	701.279

Parameter	LSD	Locality	PH	SY	HY
	0.5		4.342	51.220	54.743
	0.1		7.201	84.949	90.791

The locality had a statistically significant effect on phacelia honey yield. At the locality L1-Novi Sad, a significantly higher honey yield was achieved compared to the locality L2-Zaječar. Average honey yield in both localities was 735.00 kg ha^{-1} and varied from 663.33 kg ha^{-1} (L2) to 806.67 kg ha^{-1} (L1). At locality L1, the values for honey yield were higher by 17.77% compared to locality L2, Table 7, Figure 3b.



(**a**) (**b**)

Figure 3. Phacelia productivity parameters: (**a**) Linear 3D Surface plot for grain yield, plant height and honey yield; (**b**) Quadratic 3D Surface plot for honey yield, plant height and grain yield.

Kumova and Korkmaz (2013) states that the flower densities of phacelia plant were 176.33 pcs/m^2 at the beginning of flowering, 6538.67 pcs/m^2 at the most dense period of flowering, and 508.33 pcs/m^2 at decreasing period of flowering. It was also determined that phacelia plant takes place within 4th class nectary plants with its 14.45 kg/h nectar potential by excreting averagely 0.66 mg/flower/day of nectar. Also, it was found that the dry matter content of its nectar was 15.90%. It was revealed that phacelia plant excretes 0.56 mg/flower pollen daily, and it provides 12.26 kg/ha productivity in terms of pollen productivity. It was expressed that the phacelia plant provides enough pollen and nectar source during its flowering period.

The application of HPLC and HPTLC methods allowed the complete differentiation of *Phacelia tanacetifolia* honey samples in context of content of other plants pollen. Thus, honeys containing more than 45% pollen from *Phacelia tanacetifolia* appear to exert more similarities in their respective chromatograms, while the chromatograms of two samples (Ph1 and Ph9), which derived from honey containing majority of pollen from other plants, differed significantly (Stanek *et al*., 2019).

Botanical origin of honey is important because it has influence on unique color, flavor, and pharmacological properties of honey. Depending on its botanical origin honey is classified, in broad terms, as either polyfloral or monofloral. On the world market, monofloral varieties of honey, produced from the nectar of a single plant species typically have a higher value. Monofloral honeys account for a sizeable portion of Europe‘s premium honey market (FAO, 1996). In contrasts to sugar, honey has a higher nutritional value, possessing more calories than other foods (1 lb or 0.454 kg of honey has the value of 1,380 calorie value, 1g of honey is equal to 303 caloric value) (Earo, 2000). One of the most obvious physical characteristics of honey is colour. Colors of honey form a continuous range from very pale yellow through amber to a darkish red to black and this can be helpful in the identification of floral source of the original nectar of differing honeys. The variations are entirely due to the plant source of the honey, although heat may modify the color of honey

by darkening action (Atrouse *et al*., 2004). Honey also has a range of viscosity that can be altered depending on the temperature at which is measured. The colour and consistency of honey is not only affected by the source of flower from which the nectar was collected but is also affected by factors such as weather and climatic change. The flavor and aroma of honey vary even more than the color. There seems to be a characteristic "honey flavor," but infinite types of flavor variations can be observed. These variations depend upon the floral source. Light-colored honey is mild in flavor and adarker honey has more pronounced flavor. Exceptions to the rule sometimes endow a light honey with very definite specific flavors. Since flavor and aroma judgments are personal and considering the tremendous variety of honey is available, everyone should be able to get a favorite honey (Crane, 1975). Honey quality control is also important to protect honey from contamination and fraudings. Honey is mainly falsified with table sugar and the collectors are the major practitioners of this act.

Its greatest medicinal potential is its application as topical agent to wounds and skin infections. Honey has anti-inflammatory, immune boosting property, and exhibits broad spectrum antibacterial activity, which are attributed both to physical factors: acidity and osmolarity, and chemical factors: hydrogen peroxide, volatiles, beeswax, nectar, pollen and propolis. Its antioxidant activity is attributed to: glucose oxidase, catalase, ascorbic acid, flavonoids, phenolic acids, carotenoid derivatives, organic acids, Maillard reaction products, amino acids, and proteins. Honey prevents and treats gastrointestinal disorders such as peptic ulcers, gastritis and gastroenteritis. It also poses prebiotic effects and promotes health of gastrointestinal tract (Abeshu and Geleta, 2016).

5. Conclusions

- Beekeeping is a long-standing cultural agricultural practice at ours.
- Beekeeping has low start-up cost, requires little land and labor, it is accessible to many rural community. Ranges of applications of what emerging from apiculture development are enormous and it is considered a major tool in combating against insecurity for food.
- Climatic change, with frequent droughts or heavy rainfall (and floods), have been noted in our country and in the world in the last few years.
- Bees survive in drought-threatened areas and supply the vulnerable communities with nutrition, honey, and a source of income
- The cultivation locality has a great influence on phacelia productivity and honey yield.
- Phacelia, as the most honey-bearing crop, has an advantage here, because growing phacelia provides profitable beekeeping in divergent years.

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