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PRODUCTIVITY OF OIL-BEARING ROSES UNDER ORGANIC AND CONVENTIONAL SYSTEMS

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Abstract

Organic production and markets are expanding rapidly. A field study was carried to compare effects of different agriculture soil system on productivity of Rosa damascena Mill. and Rosa damascena x Rosa gallica. The experiment was conducted on six private arable areas with oil bearing rose in Rose valley, Southern Bulgaria. The selected study area size was 5000 m^2 from each private territory. The flowers of R. damascena were picked up in the morning (6:00-8:00 a.m.), in 3, 4 and 5 phases. The productivity was determined as essential oil content in the blossoms. Soil samples were also collected from every study area from surface horizon 0-30 cm. The samples were analyzed for several soil parameters as, organic matter content, pH values, available nitogen, phosphorus and potassium content. Statistical analysis was done with Unscrambler (Camo, Norway) software packages. The agricultural system of the oil bearing rose (Rosa damascena Mill.) grown has an effect on the essential oil content. The mean value of essential in organic production = 0.026% is statistically proven lower than conventional production = 0.038%.

Key words: *rose oil, organic system, conventional system, low input system.*

INTRODUCTION

Growing oil-bearing roses and production of rose oil is a tradition with a long history of over 300 years in Bulgaria. Bulgaria together with Turkey supply around 80-90% of the rose essential oil consumed worldwide by the perfumery and cosmetics industry (Kovacheva et al., 2010). Almost 95% of rose fields in Bulgaria are based on a single genotype of *R.* x *damascena f. trigintipetala* Dieck (the thirty petalled rose). In more recent years new hybrids based on crosses between *R.* x *damascena* and *R. gallica* showing increased resistance to diseases and good quality of the rose oil were also spreaded (Kovacheva, 2007). The Bulgarian rose oil is a key ingredient used by leading companies like Kenzo, Chanel, Dior, Fendi, Bulgari, Faberge and many others. (Kovacheva et al., 2010). Recently, the application of rose oil has been increasing. In addition to its perfuming effects, it possesses a wide range of biochemical activities, such as analgesic, hypnotic, antispasmodic, anti-inflammatory and anticonvulsant. (Kumar et al, 2013) The essential oil content of the oil-bearing rose (*Rosa damascena* Mill.) is relatively low, around 0.3-0.4 ml kg^{-1} in fresh flowers. In the scientific literature there are various methods have been examined to improve essential oil extraction efficiency and ultimately essential oil yields. For instance the investigation of Kumar et al., 2013 are connected with the effect of various agronomic interventions viz., harvesting date, harvesting conditions and storage duration of damask rose (*Rosa damascena* Mill.) flowers on essential oil content and composition in western Himalayas. Tintchev et al. (2012) demonstrated that the yield could be significally improved after treatment of raw material with pulsed electric fuelds. However, studies related to irrigation and fertilization of *Rosa damascena* are limited. Based on the results obtained of Nedkov et al. (2014) work team concluded that the additional yield (for blossom and oil) depending on the amount of irrigation depth. The debatable topic is also chemical versus organic cultivation in medicinal and aromatic plants (Malik and Ahmad, 2011). According to Nurzynska-Wierdak (2013), biofertilization, balanced mineral fertilization of medicinal plants is an important cultivation factor determining essential oil quantity and quality. *R. damascena* grows well and produces high yields on deep, aerated soils, with organic matter content and neutral soil reaction. Penkov and Kovacheva (2013) defined Chromic Luvisols as one of the most suitable for growing the oil-bearing rose with values of pH between 6.7 and 6.9). More efficient agricultural practices is a key factor for further increase of the overall rose production and reduction of the production costs. Regardless of the numerous challenges faced by organic rose growers, the increasing worldwide demand and price for organic rose oil provide a promising future for the organic rose sector in Bulgaria (Chalova et al., 2017).

The aim of our study to perform monitoring of several private oil-bearing farms in Southern Bulgaria, with the same climate and soil conditions and different agriculture systems in order to find the best actual and tested agriculture systems in oil-bearing roses cultivation producing high quantity and quality rose oil. Here are presented the initial results, with the focus on soil fertility, soil available nutrients, rose essential oil and the relationship between them.

MATERIALS AND METHODS

Study area and soil sampling

The study was conducted on six private oil bearing roses farms in Kazanlak (Rose) valley called, Southern Bulgaria in 2019. The Rose valley is situated in the middle of the country between the Stara Planina Mountain on the North and Sredna Gora Mountain on the South. The valley is around 90 km long and around 10 km wide. The climate is transitional continental, relatively mild with altitude between 400 and 500 m. The winters are warmer and the summers cooler, in this area the average annual temperature is around 11°C, and the annual precipitation is 540 mm. Three of oil rose private plantations are certified as organic farming and have been applied an organic agriculture system and the rest of them are characterized as conventional farming. The detailed characterization of agricultural practices of studied farms is presented in Table 1.

The study area size of every farm was 5000 m^2. The geographical coordinates of every study area was measured by GPS Garmin. Soil samples were collected from every area from surface horizon 0-30 cm using an Eijkelkamp soil sampling equipment. The soils were air-dried, ground and sieved with a particle less than 2 mm. The samples were analyzed for several soil parameters as, organic matter content by loss of ignification, pH values by potentiometric method, mineral nitrogen content using spectrophotometer JENWAY 6705 UV/VIS, available potassium and available phosphorus content by the Egner-Riem method. The concentration of available potassium was determined by AAS using Analyst 800 Atomic Absorption Spectrometer, Perkin Elmer. Visual soil assessment of soil texture and soil structure in the field was performed (Houškova, 2005).

Plant sampling and analysis

Rosa damascena Mill and *Rosa damascena* x *Rosa gallica* genotypes have been observed. In general, harvesting time and flowering stage are critical factors for obtaining high yields and quality of the oil. Harvesting takes place early in the morning, from 06.00 to no later than 11.00, to avoid temperature increase during the day, which negatively affects the yield and the quality of the rose oil. Harvesting time starts in the middle of May and continues for less than a month (Chalova, 2017). The flowers in our study are picked up in the morning (6-8 a.m.), in the most appropriate development phases (IV-V), with half to full-open petals (Staikov et al., 1975)

The essential oil content in the blossoms was determined after water distillation in Clevenger-type microapparatus. The process parameters were: sample amount 200 g; roses:water ratio = 1:4; distillation rate 3-4 ml/min; duration of the distillation process: 2.5 h. The essential oil was measured to the graduated part of the apparatus in milliliters and is calculated as a percentage by volume (v/w). For better accuracy, a relative density recalculation is made and is presented as a percentage by weight (w/w).

Table 1. The geographical data, soil type, variety and agricultural practices of the studied farms

Farm's number	Area	Soil type	Variety	Mineral fertilization	Organic fertilization	Irrigation	Soil tillage
	Conventional farming						
01	Damascena 1, Skobelevo	Fluvisols	*R. x damascena f. trigintipetala* Dieck	yes	-	yes	-
02	Damascena 2, Skobelevo	Fluvisols	*R. x damascena f. trigintipetala* Dieck	yes	-	yes	-
03	Koprinka	Luvisols	*R. x damascena f. trigintipetala* Dieck	yes	-	-	yes
	Organic farming						
04	Skobelevo	Fluvisols	*Rosa damascena x Rosa gallica*	-	yes	yes	-
05	Asen	Fluvisols	*Rosa damascena x Rosa gallica*	-	yes	yes	-
06	Yasenovo	Fluvisols	*R. x damascena f. trigintipetala* Dieck	-	yes	-	yes

Data analysis

The statistical analysis was done with Unscrambler (Camo, Norway) software packages.

RESULTS AND DISCUSSIONS

The Rose Valley represents the deluvial non-calcareous sediments. Colluvium is an assorted mixture of material with or without rock fragments consisting of pebbles, sand, silt, and clay that accumulates at the base of steep slopes. According to Revised Legend of the World Soils, the soil type in the all arable areas is Fluvisols. Fluvisols (Deluvial soils) are formed by downhill creep, where the sorting of materials comes about through gravity. Creep is the slow movement of soil masses down slopes that are usually steep.

The process takes place in response to gravity where there is pronounced water saturation (Shishkov and Kolev, 2014). In the deluvial soils, organic matter content naturally decreases over time.

The soil in the region have ochric and nondiagnostic features, typcal for fluvisols. The soils samples in the all six arable areas were characterized with acid reaction, typical for that soil. The range of values of pH (H_2O) was between 4.20 and 6.10. The distribution of values of pH in the soil among the studies areas is presented on Figure 1, both farms with organic with conventional farming cultivate soil with acid reaction. The soil organic matter (OM) content varied between low and high content with values from 0.86 to 4.03%, where mean OM, % values was 2.80 (Figure 2).

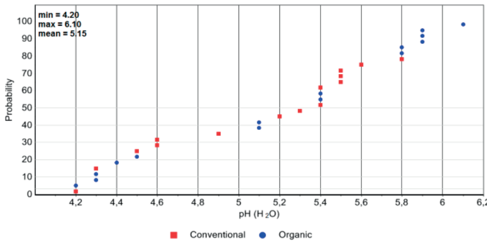

Figure 1. Normal probability distribution of pH (H_2O) values in soils samples of organic and conventional farming

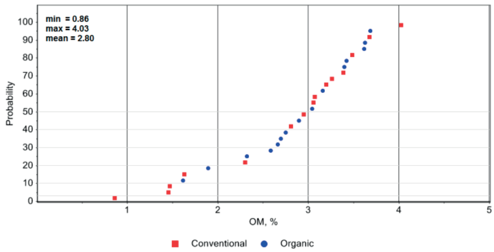

Figure 2. Normal probability distribution of organic matter content in soils samples of organic and conventional farming

The samples with the lowest organic matter was found in farm 04 with conventional farming. It was not found statistically significant of OM, % values in the soils with organic and conventional farming. It was found statistically significant of values of mineral nitrogen, $p<0.05$ between soil samples taken from organic farms and the rest - conventional farms. The all studies areas were characterized with high mineral nitrogen and potassium content, as soils belonged to conventional farming were shown higher total mineral nitrogen content (N, mg/kg) than areas with organic farming. That difference is shown in Figure 3, which graphically illustrated the visible difference between the two studied agricultural systems, with mean values = 57.61 mg/kg at conventional farming versus 50.38 mg/kg at organic farming. The values of available potassium varied between 20.69 and 31.96 mg/100 g, with mean values = 27.7 mg/100 g at conventional farming to 22.37 mg/100 g at organic farming. The values of available phosphorus varied between 5.95 and 12.30 mg/100 g, as the lowest values was found in Farm 06 - organic farming. The highest values soil nutrients content were obtained in samples taken from the all tree farms with conventional farming (Figure 4).

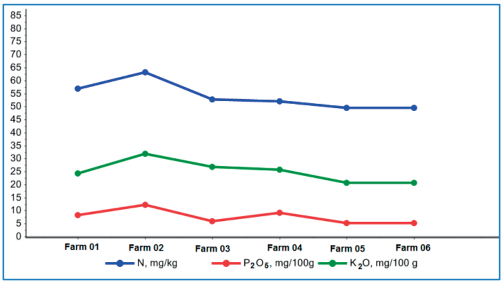

Figure 3. Statistical data of N mg/kg, P_2O_5 mg/100 g and K_2O mg/100 g values in soils samples of organic and conventional farming

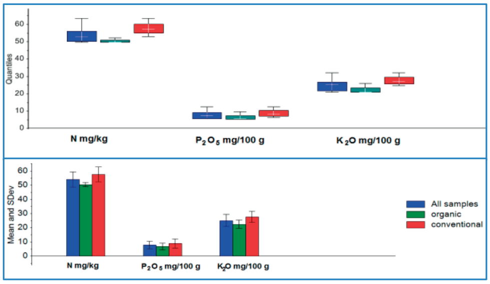

Figure 4. Distribution of available nitrogen, phosphorus and potassium content in soils of all studied farms

The reasons of that are several, as an annual mineral fertilization, the built-in drip irrigation system supply the plant with water and one important fact was mulching as an alternative technique for weed management in the same farms. In the farm 01, 02 conventional farming and 04 and 05 have been not applied soil tillage, but mulching as an alternative technique has been applied for weed management in that farms. Therefore the Farm 01 and Farm 02 could be classified as farms with a low input farming systems, as a kind of conventional farming. According to Parr et al. (1990) "the definition of Low Input Farming Systems (LIFS) seek to optimise the management and use of internal production inputs (i.e., on-farm resources) and to minimise the use of production inputs (i.e., off-farm resources), such as purchased fertilizers and pesticides, wherever and whenever feasible and practicable, to lower production costs, to avoid pollution of surface and groundwater, to reduce pesticide residues in food, to reduce a farmer's overall risk, and to increase both short- and long- term farm profitability".

Such kind of conservation agriculture is a way to increase soil fertility, reduce soil erosion, increase organic matter and improve water buffer capacity. Conservation agriculture refers to several practices which permit management of the soil. Crop residues are left in place as soil cover instead of ploughing them into the ground. Therefore that both farms not belonged to typical conventional agricultural systems, but take place between typical conventional and organic farming.

The obtained values of rose essential oil, % in all studied farms with organic and conventional farming are presented in Table 2.

The rose essential oil, % values varied between 0.260 and 0.460% in all six farms. The rose essential oil productivity in conventional farming is statistically proven higher than organic production with values of 0.038% versus 0.026%, respectively. The data show that there is no statistically proven difference in oil production in the organic cultivation of different types of roses. The agricultural system of cultivation of the oil bearing rose (*Rosa damascena* Mill.) has an effect on the essential oil content (Figure 5).

The farms 01 and 02, characterized with low input system, with mulch system - without soil tillage and irrigation obtained significant higher oil productivity than others farms. The mean values of rose essential oil in the both farms are between 0.043 and 0.046% in compare to others. Tabaei-Aghdaei et al. (2007) reported that the essential oil content of *Damask Rose* from 28 provinces in Iran varied between 0.034 and 0.051%. According to Kovacheva et al., 2010 the essential oil content of cultivated *Rosa damascena* Mill. in the territory of Bulgaria is between 0.045 and 0.054%. It is not clear which kind of cultivation in that report the data belonged to - organic, conventional or both agricultural system for cultivation.

Table 2. Statistical data of rose essential oil, % values in studied farms with organic and conventional farming

Farm's number	Area	Rose essential oil, % (v/w)	Rose essential oil,% (w/w)	Rose essential oil, % average
		Conventional farming		
01	Damascena 1	0.0533	0.0430	0.043±0.005
02	Damascena 2	0.0533	0.046	0.046±0.008
03	Koprinka	0.02833	0.0260	0.026±0.004
	min			0.0260
	max			0.0460
	mean			0.0383*
	SD			0.0091
		Organic farming		
04	Skobelevo	0.0283	0.0247	0.025±0.002
05	Asen	0.0367	0.0313	0.031±0.002
06	Yasenovo	0.0250	0.0220	0.022±0.000
	min			0.0220
	max			0.310
	mean			0.0260*
	SD			0.0039

*statistically significant (p<0.05)

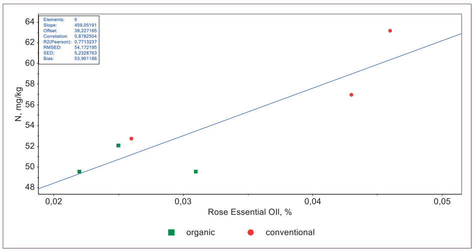

Figure 5. Statistical data of rose essential oil,% values between organic and conventional farming

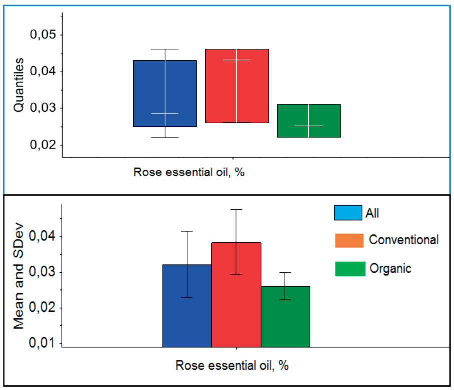

Figure 6. Scatter plots of correlation between mineral N, mg/kg and rose essential oil, %

The data obtained in our study confirmed the results of Ucar et al. (2017) that oil yields were significantly affected by irrigation water amounts, nitrogen levels, and irrigation water amounts × nitrogen levels interaction. Figure 6 graphically illustrated the correlation between soil mineral nitrogen and rose essential oil % productivity, with high Pearson's correlation coefficients, r = 0.88.

The nutrition plays a key role in the growth and development of all crop plants. In the case of medicinal plants that synthesize essential oils, nutrients can effectively increase oil yield and quality. According to Nurzyska-Wierdak (2013) nitrogen, one of essential minerals, is used by plants to build many organic compounds: amino acids, proteins, enzymes, and nucleic acids.

Amino acids and enzymes play a key role in the biosynthesis of numerous compounds which are essential oil constituents.

A second important nutrient for plants is potassium, which usually occurs in the plant at quite a high concentration, in particular in the meristematic tissues and in the phloem. For instance rosemary oil yield is significantly dependent on N and K application. (Nurzyska-Wierdak, 2013)

CONCLUSIONS

The agricultural system of the oil bearing rose (*Rosa damascena* Mill.) grown has an effect on the essential oil productivity. The mean value of essential in organic production = 0.026% is statistically proven lower than conventional production = 0.038%. The conventional farming has different shades and should not be placed under a common denominator, and to take into account every conservation agriculture practice which increase soil fertility, reduce soil erosion, with a higher productivity as a results of all of that. It was found that there are private oil-bearing farms in Southern Bulgaria, characterized as farms with low input systems applied good agriculture practices in oil-bearing roses cultivation producing high quantity rose oil and keeping soil fertility, simultaneously.

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