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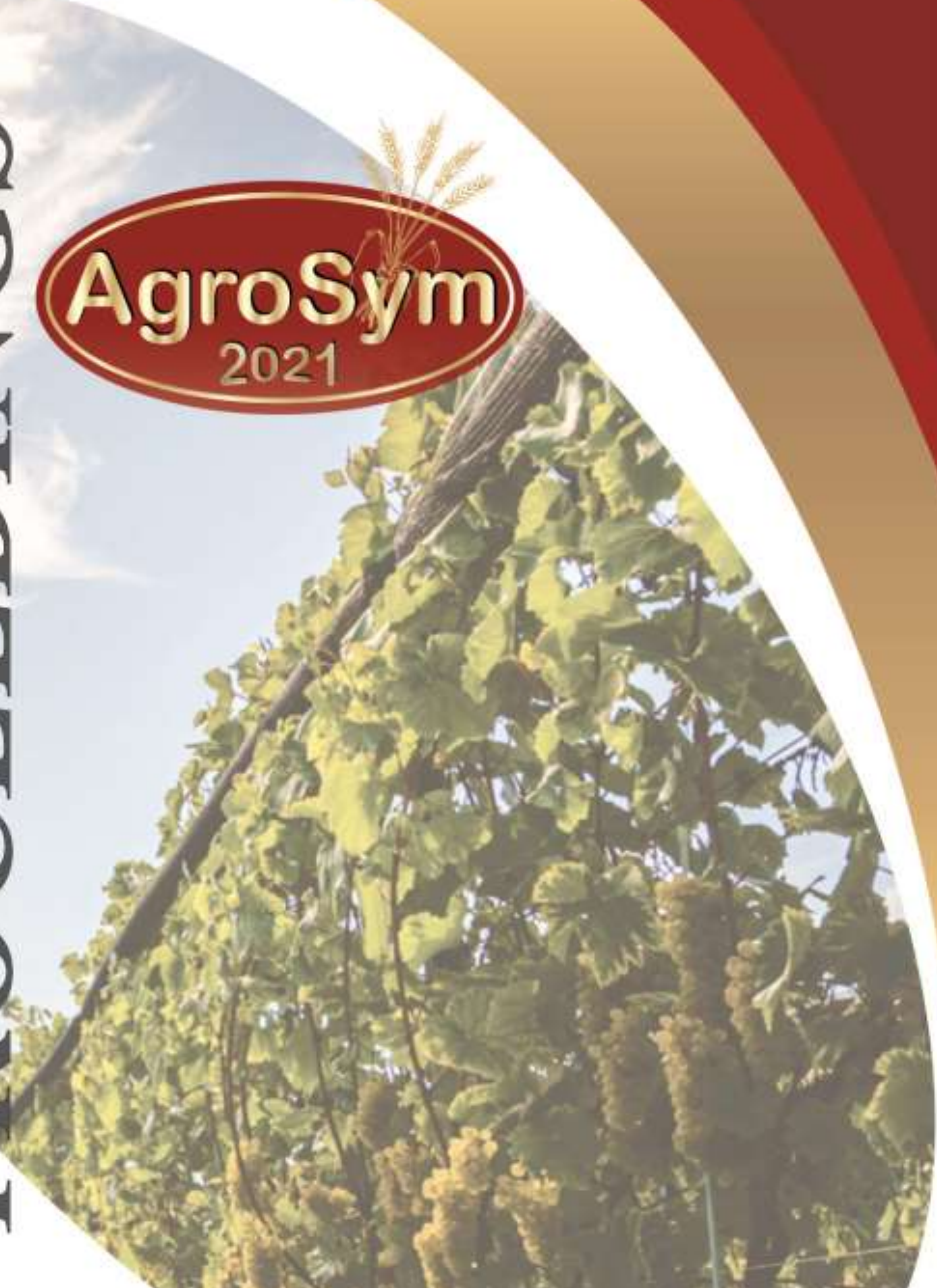

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October 7-10, 2021

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PREFACE

The Faculty of Agriculture of the University of East Sarajevo (Bosnia and Herzegovina), the Faculty of Agriculture of the University of Belgrade (Serbia) and the International Centre for Advanced Mediterranean Agronomic Studies - Mediterranean Agronomic Institute of Bari (CIHEAM-Bari, Italy) organized the XII International Scientific Symposium "Agrosym 2021" on Jahorina mountain (East Sarajevo, Bosnia and Herzegovina). This year's edition of Agrosym was organized for the first time in a hybrid format, in-person (250 participants) and virtual via ZOOM (450 participants), because of the prescribed restrictions due to the COVID-19 pandemic.

The 12th Scientific International Symposium "Agrosym 2021" made an important contribution to the agriculture practice in different fields e.g. plant production, animal husbandry, environmental protection, organic farming, forestry, and agro-economy. The Scientific Committee received 750 papers and after review, we accepted 695 papers; 159 for oral presentations and 535 for poster presentations, which addressed all the sessions of the symposium: plant production (43 oral and 167 poster presentations), plant protection and food safety (25 oral and 105 poster), environmental protection and natural resources management (24 oral and 86 poster), organic farming (6 oral and 37 poster), animal husbandry (24 oral and 69 poster), rural development and agro-economy (25 oral and 40 poster), forestry and agroforestry (12 oral and 33 poster presentations). The presented papers were submitted by about 2000 authors representing more than 80 countries worldwide.

We have had the opportunity to share new information on biotechnology, plant breeding and world markets during the COVID-19 pandemic in the plenary keynote session and many interesting research results and findings in parallel sessions. It can be pointed out that sustainable agriculture development must focus on building policies and practices at national and regional levels, with an emphasis on quality and greater diversity, followed by a demonstration of agronomic and economic viability, environmental protection and food safety, and social benefits, while fostering the convergence of rural and urban populations as well as closing the gap between producers and consumers.

AGROSYM 2021 has been a considerable undertaking from scientific, logistical and organizational points of view. Big thanks to all members of the Scientific Committee for their continued efforts and hard work, which made the symposium possible and successful. I would also like to thank my colleagues from the Organizing Committee, for all they have done to bring this event together, particularly the dean of the Faculty of Agriculture of the University of East Sarajevo, prof. Vesna Milic, as a host and chairperson, His Excellency, prof. Sinisa Berjan. Finally, I would like to thank all the authors, reviewers, session moderators and colleagues for their help in preparing and editing this book of proceedings. Special thanks also go to the organizers, partners and sponsors for their unselfish collaboration and comprehensive support.

Editor-in-Chief

Dušan Kovačević

East Sarajevo, 10 October 2021

Academician Dusan Kovacevic, Academy of Engineering Sciences of Serbia

President of the Scientific Committee of Agrosym 2021

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THE INFLUENCE OF ORGANIC FERTILIZERS ON THE SEED YIELD AND SEED QUALITY OF BUTTERNUT SQUASH (*CUCURBITA MOSCHATA*) GROWN ON DIFFERENT TYPES OF SOIL

Milan UGRINOVIĆ[1], Zdenka GIREK[1], Suzana PAVLOVIĆ[1], Slađan ADŽIĆ[1], Jelena DAMNJANOVIĆ[1], Marija GAVRILOVIĆ[1], Vladan UGRENOVIĆ[2]

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Abstract

Butternut Squash (*Cucurbita moschata*) is grown in Serbia on relatively small areas, despite its extraordinary nutritional properties that place it among the species with significant potential for the food industry. However, in the future, due to climate change, it is expected to expand its production in our country and region, primarily due to tolerance to high temperatures and drought, but also due to significant tolerance to diseases. In order to improve the technology of growing butternut squash in accordance with organic principles, a field experiment was conducted on the two soil types i.e. two different locations, with aim to investigate the effects of application of two different fertilizers on the seed yield and seed quality. Both locations are situated in the basin of the river Velika Morava, on two different types of soil (vertisol soil type and brown forest soil). At both locations, the pre-crop was corn and the applied agro-technical measures were in accordance with the principles of organic production. The average yield of Butternut Squash seeds varied from 678,1 kg/ha, as recorded on the brown forest soil, on the control treatment without fertilization to 918.75 kg/ha as recorded on the treatment with organic fertilizer NP 1 on the vertisol. Significant differences were also observed in seed germination which ranged from 84.67% in the control treatment on the brown forest soil to 98.33% as recorded in the treatment with the organic fertilizer NP2 on vertisol.

Keywords: *fertilizers, organic production, seed quality*.

Introduction

Butternut Squash (*Cucurbita moschata*) is an annual vegetable species belonging to the *Cucurbitaceae* family with vining growth, large and dark green leaves with bright patterns and big yellow flowers. It is grown for its specifically shaped fruits with characteristic color. In a human diet, it is appreciated for its distinctive taste, high provitamin A content and low fat content (Armesto *et al*. 2020). Thanks to these properties it has a low caloric content and it is interesting for the control of body weight, as well as cholesterol and triglyceride levels in the blood (Choi *et al*., 2007). Despite its extraordinary nutritional properties that place it among the species with significant potential for the food industry, Butternut Squash is grown on relatively small areas in Serbia, mostly like a few plants in farmers own gardens, rarely as a cash crop. However, In the future, due to climate changes, it is expected to expand its production in our country and region, primarily due to tolerance to high temperatures and drought (Ara *et al*. 2013, Shen and Yuan, 2020), but also due to significant tolerance to diseases and pests (Cavanagh *et al*., 2009; King *et al*. 2010).

The exact information about the butternut squash harvested area in the world is not available. However, the area on which the pumpkins, squash and gourds were cultivated ranged from 1.561 to 2.07 million ha in the last decade. In that period the average yields of mentioned species altogether ranged from 13.07 to 14.9 t/ha (FAOSTAT DATA 2021). According to some scientific works, the yields of butternut squash ranged from 23.03 to 78.61 for different varieties grown in the Slovak republic (Andrejiova *et al*., 2018), from 19.4 to 34.9 t/ha for different crop densities (Rangarajan *et al*. 2003), from 18.9 to 31.3 t/ha for different chemical and organic fertilizers in the agroecological conditions of Iraq (Ali *et al*., 2019), from 59.4 to 79.8 t/ha for different irrigation regimes and mulching in the agroecological conditions of northern India (Mishra, 2017). However, there is a lack of data concerning butternut squash seed yields and seed quality (Sajjan and Prasad, 2009). The Republic Statistical Office of the Republic of Serbia does not have available data on surfaces, yield and production of butternut squash in Serbia (Republic of Serbia, 2021a). According to National list of registered varieties, at the moment, only two different varieties of butternut squash are registered (Republic of Serbia, 2021b).
The two most frequent soil types in the central Serbia are the vertisol and the brown forest soil. Vertisols are soils with high silt and clay content that shrink and swell extensively upon changing soil moisture conditions (thanks to its clay content). They occur worldwide under various parent material and environmental conditions. Vertisol exhibits unique morphological charachteristic such as the presence of wedge-shaped aggregates so the shrink-swell phenomena are the dominant pedogenic processes in vertisols. That causes the changes in interparticle and intraparticle porosity when the moisture content is changing. In central Serbia, field and vegetable production is very prevalent on this type of land (Coulombe *et al*. 1996, Jelić *et al*. 2011; Dugalić and Gajić, 2012).
The brown forest soils occur in Europe, North America, Russia, China and elsewhere in the world in broadleaf forests of the temperate zone and agricultural land on which the previous forests were cleared sometime in the past. They have some good productive properties for field and vegetable crops production but in Serbia they are used more frequently for the production of fruits and vines (Dugalić and Gajić, 2012; Shishkov and Kolev, 2014).
One of the most important tasks in expanding the production of butternut squash is to provide sufficient amounts of seeds for planting and apply all knowledge that can affect production improvement. To that end, the aim of this work is to determine the optimal model of fertilizer application on these two most prevalled types of land in central Serbia.

Material and Methods

The field experiments were performed at two locations with different soil types, the first one near Jagodina town on the vertisol soil type (44°01′55.23″ N 21°15′18.55″ E, 108.0 m above sea level) and the second one in Žabari municipality in Serbia on the brown forest soil (44°37′38.56″ N 21°11′21.08″ E, 222 m above sea level). The basic chemical properties of different soil types were shown in Table 1.

Table 1. Soil chemical properties at the two experimental locations

Location	pH H_2O (KCl)	$CaCO_3$ (%)	Humus (%)	Total N (%)	P (ppm)[1]	K (ppm)[1]
Žabari	6.61 (5.15)	0.0	2.30	0.115	196.3	283.0
Jagodina	7.32 (5.59)	0.0	2.92	0.15	195.8	361.4

[1-] Available P an K

The previous crop was field corn and the harvest residues were chopped and plough into the soil. A mineral fertilizer (100 kg/ha, N-46%, UREA) was added. However, at the Žabari location about a half of harvested residues were colected and removed from the experimental field. At the late autumn, additional amount of mineral fertilizer (200 kg/ha N:P - 11:52) was applied and the soil is further tilled using disc harrow.
At the mid April, examined fertilizers (8.0 t/ha of organic fertilizer NP 1 – dried chicken manure with N, P and K content of approximately 4, 4, and 4 percent; 15 t/ha of organic fertilizer NP2 – with declared N, P and K content of approximately 4, 7, and 8 percent, respectively) were applied on the marked experimental plots and incorporated in to the surface soil layer using two wheel tractor with rotary tiller. Up to 4 seeds were sown manualy on the marked places (1.5m distance betveen rows and 0.6 distance betveen plants in the row) on the April the 18th (Žabari) and April the 19th (Jagodina).
There were 9 elementary plots randomly distributed on the Žabari location and also in another location the same (Jagodina). The size of elementary plot was 6.0 x 4.2 m, consisted of 4 rows each. The surface area of each elementary plot was 25.2 m^2.
After shoot emerging, excessive plants were removed and the space betveen the rows were cultivated several times in order to supress the apearance of weeds. Weed control within rows was performed manually. All measures applied except the mineral fertilization (farmyard of acceptable quality and allowed mineral fertilizers were not available) were in accordance to the Law on Organic Production and the accompanying regulations (Republic of Serbia 2021c).
Data on climate parameters for the nearest meteorogical station (Veliko Gradište) were provided through the internet portal of the Republic Hydrometeorological Service of Serbia (RHSS 2021). However, due to the specifically modified weather conditions at the Žabari experimental field site, during some summer and autumn months, precipitation was measured with the help of a round vessel with a graded scale, and the results are shown in parentheses (Table 2).

Table 2. Temperature (T) and precipitation (P) parameters for Butternut squash crop at two locations during the trial (2020), with long-term averages

Months	Žabari				Jagodina			
	2020		1981-2010		2020		1981-2010	
	T ^oC	P (mm)*	T ^oC	P (mm)	T ^oC	P (mm)	T ^oC	P (mm)
Apr	12,2	2	11,8	55.9	12.3	23.1	11.4	52.9
May	15,8	93	17	73.6	16	81.1	16.2	78.7
Jun	20,4	89,6 (78)	19,9	87.6	20.2	68.5	19	87.5
Jul	22	110,6 (89)	21,9	67.7	22.4	54.5	20.4	60.7
Aug	23	62 (43)	21,5	56.7	22.9	86.7	20.1	43.4
Sep	19,5	30,3 (37)	16,8	50.3	19.4	49.1	16.4	47.7
Oct	12,9	101,8 (86)	11,7	41.2	13.1	83.1	11.1	37.8
Nov	6,4	15,7 (12)	6	47.3	6.4	17.3	5.9	52.9
Av/Sum	16.5	505(440)	15.8	480.3	16.6	463.4	15.06	461.6

*- values within parentesis are related to the seasonal precipitation corection for the Žabari experimental site.

The Butternut Squash fruits were harvested during the late october of 2020. Samples per each treatment replication were taken (inner rows were used for sampling in order to avoid border effects). Collected fruits were weight on the field using hand scale (the data not shown) and the seeds were taken out from each fruit. The seed yields (natural seeds without processing) were measured using the technical scale after few days of drying in the tin layers in the ventilation barn. For each seed sample (three repetitions) the percentage of germination was determined in the acredited seed laboratory. The calculated percentage of germination data were transformed by arcsine √(x/100) prior to analysis. Two way ANOVA and further LSD-testing were performed using Statistika 7 software package for Microsoft Windows.

Results and Discussion

Conventional farming agricultural production, without farmyard application, have been practiced at both experimental sites and strong anthropogenic factor with long-term rotation of corn, wheat and meadow/clover was present. The experiment was transition to organic agricultural practice. Chemical analysis of the examined soils from Žabari and Jagodina experimental sites indicate similar values of basic parameters with smaller differences in pH values, humus and potassium content (Table 1.). On the other side, there were differences concerning temperature conditions and precipitations (Table 2.). Despite the fact that the year was with enough rainfall, severe spring drought in the pre-sowing period and after sowing on the Žabari experimental site, slowed down the germination and emerging of butternut squash plants which later affected the crop homogeneity and possibly the results of this trial. Also the precipitation schedules during the vegetation period were diverse on the both localities. However, the examined effects of locality and applied fertilizers significantly affected butternut squash seed yields and germination rate (Table 3.).

Table 3. Mean squares (MS) from ANOVA for the butternut squash seed yield and the percentage of germination on two examined localities and different treatments (Fertilizers).

Effect	d.f.	Seed Yield	Percentage of germination
Locality (L)	1	35529**	29.4*
Fertilizers (F)	2	39366**	59.1**
L / F	2	89	112.4**
Error	12	357.41	3.61

*,** – significant at the 0.05 and 0.01 levels of probability, respectively

Table 4. Butternut squash seed yields (t/ha) and the percentage of germination on two examined localities and different treatments (Fertilizers)

Locality	Fertilizers	Seed yield (t/ha)	Germination (%)
Žabari	Control	678.10	84.67
	NP1	786.50	98.33
	NP2	834.07	96.00
Jagodina	Control	762.23	96.67
	NP1	884.27	93.33
	NP2	918.73	96.67
	$lsd_{0.05}$	19.42	1.95
	$lsd_{0.01}$	27.22	2.74

During the experiment, the average butternut squash seed yield on both sites was 810.65 kg/ha, but on vertisol (Jagodina), higher average yields were achieved compare to brown forest soil (Municipality of Žabari). The highest butternut squash seed yield was achieved at the locality of Jagodina when NP2 fertilizer has been applied (918.73 kg/ha) and the lowest (678.1 kg/ha) on the control treatment on the Žabari experimental site (Table 4.).

According to results of Sajjan and Prasad (2009), *Cucurbita moschata* seed yields can be doubled using fertilizers and plant growth stimulators. The fruit yields achieved are significantly below the yields reported by Mishra (2017) and significantly below the highest yields reported by Andrejiova *et al*. (2018) (the data not shown). Knowing the approximate share of seeds in butternut squash fruit yields, our results varied in accordance with results of Rangarajan *et al*. (2003) and Ali *et al*., (2019), but were higher compare to some other research (Sajjan and Prasad, 2009).

The percentage of germination is one of the key parameters concerning seed quality. The *Cucurbita moschata* percentage of germination is usually above 90% (Valdez-Melara *et al*., 2009) and all treatments were in that range except control treatment in Žabari, probably due to presence of some fruits with sturdy and immature seeds.

Conclusions

Yields that were significantly below genetic potential indicate that agroecological conditions were not optimal despite sufficient amounts of precipitation. Based on the results of the experiment, a better choice for butternut squash seed production is vertisol. In order to enable high seed yields as well as sustainable organic production and production according to principles of organic butternut squash cultivation during the conversion period it is necessary to use high doses of organic fertilizers. The NP2 fertilizer is recommended, regardless of the type of soil on which the production is organized.

When it comes to the basic seed quality parameter, the percentage of germination, it is not possible to give definitive instructions on this issue, because despite statistically significant differences between treatments, logical conclusions cannot be made and further investigation is needed.

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