INSTITUTE OF AGRICULTURAL ECONOMICS, BELGRADE, SERBIA

SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT III

Thematic Proceedings

Belgrade, February 2023

INSTITUTE OF AGRICULTURAL ECONOMICS BELGRADE

Volgina Street no. 15, 11060 Belgrade, Serbia
Phone/Fax: +381 (0) 11 69 72 858
Phone: +381 (0) 11 69 72 848

E-mail:
office@iep.bg.ac.rs

Internet address:
www.iep.bg.ac.rs

International Scientific Conference

SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT III

THEMATIC PROCEEDINGS

February, 2023

Belgrade, Serbia

Publisher:

Institute of Agricultural Economics, Belgrade, Serbia

Editors:

Jonel Subić, Ph.D.
Predrag Vuković, Ph.D.
Jean Vasile Andrei, Ph.D.

Technical arrangement and printing:

SZR NS MALA KNJIGA +
Zetska Street no. 15,
21000 Novi Sad, Republic of Serbia,
Phone: +381 21 64 00 578

Technical preparation and typesetting:
Vladimir Sokolović

***Printing:* 200**

ISBN 978-86-6269-123-1

ISBN (e-book) 978-86-6269-124-8

Publication of Thematic Proceedings was financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

ORGANIC SOYBEAN CULTIVATION WITH A SUSTAINABLE SYSTEM

Gordana Dozet[1], *Vojin Đukić*[2], *Zlatica Mamlić*[3], *Gorica Cvijanović*[4], *Nenad Đurić*[5], *Snežana Jakšić*[6], *Marija Bajagić*[7]

Abstract

The need for certified organic agricultural products is ever greater as in the World, so in Serbia. Triennial research was conducted with five soybean varieties and foliar treatment with aqueous extract and aminoacids aimed at esstablishing examined factors' influence on soybean yield and organic soybean cultivation system sustainability. A field experiment was set in four repetitions. All three examined factors have shown significant influence on soybean yield and that such a method of soybean cultivation is sustainable. However, in dry farming, soybean grain yield height is mostly influenced by weather conditions, primarily precipitation quantity and distribution, as well as temperature height during the vegetation period, hence yield height varies from year to year.

Key words: *amino-acids, organic cultivation, yield, soybean, aqueous extracts*

1 *Gordana Dozet*, Ph.D., Full Profesor: Megatrend University Beograd, Faculty of Biofarming, M.Tita no.39, 24300 Bačka Topola, Serbia, Phone: +38124712209, e-mail:dozetg@gmail.com

2 *Vojin Đukić*, Ph.D., Scenior Scientific Associate: Institute for crops and vegetables, Maksima Gorkog no.30, 21000 Novi Sad, Serbia, Phone: +381648205751, e-mail: vojin.djukic@nsseme.com;

3 *Zlatica Mamlić*, Ph.D., Research Associate: Institute for crops and vegetables, Maksima Gorkog no.30, 21000 Novi Sad, Serbia, Phone: +381648706156, e-mail: zlaticamiladinov@gmail.com;

4 *Gorica Cvijanović*, Ph.D., Full Professor: Institute of Information Technologies, University of Kragujevac, Jovana Cvijića bb, 34000 Serbia, Phone: +38124712209, e-mail: cijagor@yahoo.com

5 *Nenad Đurić*, Ph.D., Scenior Scientific Associate. Institute for Vegetable Crops, Smederevska Palanka, Karađorđeva no.71, 11420 Smederevska Palanka, Serbia, Phone: +381628035360, e-mail: nenad.djuric@outlook.com

6 *Snežana Jakšić*, Ph.D., Research Associate: Institute for crops and vegetables, Maksima Gorkog no.30, 21000 Novi Sad, Serbia, Phone: +381648706103, e-mail: snezana.p.jaksic@gmail.com

7 *Marija Bajagić*, Ph.D., Scientific Associate: Faculty of Agriculture,Univeristy of Bijeljina, Pavlovića put, 76300 Bijeljina, Republic Srpska, Bosnia and Herzegovina, Phone: +381638858185, e-mail: marijacvijanović@yahoo.com

Introduction

Conventional agriculture methods which were used for decades led to soil and water pollution. Abuse and excessive use of pesticides and various synthetic substances have a negative impact on the environment and biodiversity (Popović et al., 2016), but on human health as well. This fact indicates that methods applied in agricultural production should be altered and suited for organic plant cultivation systems, as to achieve sustainability and enable sufficient and quality food production (Subić et al., 2010).

Soybean is sorted among legumes and considered one of the oldest cultivated plant varieties in the world. During the last few decades, soybean has gained considerable significance in human nutrition and represents the greatest protein source in animal production. Soybean surfaces that are in an organic cultivation system are ever greater as in the world and Europe, so domestically. In the year 2020, organic cultivation system soybean surfaces amounted to 913,949 in the world, 272,445 in Europe and 789 ha domestically (FiBL, 2022).

Foliar soybean side dressing during the intensive growth phase increases yield (Miladinov et al., 2018), especially during unfavorable years with a distinct drought period, but also in years that are favorable for production (Dozet et al., 2015). Aqueous plant material extracts are ever more used in plant production, floriculture, vegetable growing, but also in arable farming, as organically, so conventionally (Đukić et al., 2021). Considering that soybean grain is used to obtain various products which are used in human alimentation, it is important for a part of total soybean production to be from an organic cultivation system, without applying mineral fertilizer and pesticides (Dozet et al., 2019). Aqueous plant material extracts, beside macro and trace elements, also contain physiologically active substances which boost plant gowth and development, often have fungicidal and insecticidal effects, are easily prepared within the farmstead, do not require greater investments and are suitable for organic production since their application does not have a negative impact on the environment.

In recent decades, climate change in the form of elevated mean daily temperatures in vegetation and on an annual basis were detected, along with ever greater precipitation oscillations, i.e. the shifting of pluvious and extremely arrid years, and these conditins are very unfavorable for soybean production (Đukić et al., 2018).

Aminoacids are very important for plant development and stress defense (Trovato et al., 2021). Yield oscillations in certain years confirm that weather conditions during vegetation have a great impact on soybean yield (Đukić et al., 2018; Miladinov et al., 2018; Dozet et al., 2019).

The goal of this paper is to observe the effects of aqueous nettle and common comfrey extracts, as well as the effects of aminoacids on soybean grain yield among five soybean varieties that differ in vegetation period length.

Material and work methods

In a triennial experiment, foliar aqueous nettle and common comfrey extract application's effects were observed, as well as aminoacids' on soybean yield among five different maturation varieties (Kaća 000 maturity group, Merkur 00 maturity group, Maximus 0 maturity group, Apolo I maturity group and Rubin II maturity group). The experiment was set on the Institute of Field and Vegetable Crops' experimental field in Rimski Šančevi, and the experiment variants were the control where the foliarly applied water quantity was identical to the quantity of aqueous extracts, aqueous nettle and common comfrey extraxcts application and aminoacids application with the preparation Trainer. Aqueous plant material extracts' and control variant water's application was conducted in the intensive plant growth phase, before the soybean flowering phase, with an amount of 300 litres of liquid per hectare in which the aqueous extract was diluted in a ratio of 1:15. Trainer was contemporaneously applied in a quantity of 1 litre per hectare. The experiment was set in four iterations, and the elementary plotlet size totaled 10 m^2 (four soybean rows, an inter-row distance of 50 cm and five meters of length).

Nettle (*Urtica dioica*) – used as an insecticide to protect other plants and as fertilizer. It is found in nature and plucked fom rudimentary habitats in direct proximity to spontaneously grown high trees and shrubs.

Common comfrey (*Pulmonaria officinalis*) – plucked from the same habitat as nettle. Contains iron, potassium, calcium, phosphorus and manganese, as well as a vitamin B complex. Used for producing excellent liquid organic fertilizer which enriches the soil with it's mineral compounds.

Aqueous extracts are made by drenching one kilogram of shreded plant material in 10 litres of rain water and, by stirring daily, the end of fermentation was awaited, after which the aqueous extract was strained through a gauze and kept in glass bottles upon application. During the vegetation period, standard agrotechnical soybean production measures were applied, and during the harvest maturity phase, small operating hold combine harvesting was conducted, grain mass and moisture were neasured and yield per hectare with 14% moisture was calculated. Results were processed via trifactorial experiment variance analysis (program „Statistica 10“), and difference significance was tetsed via LSD test. Research results are exhibited in table form.

Meteorological conditions

The years in which this paper’s research was conducted varied by meteorological parameters (Table 1).

Table 1. *Weather conditions in the study years.*

Month	Mean monthly temperature (°C)				Precipitation (lm^{-2})			
	2018	2019	2020	*Average*	2018	2019	2020	*Average*
IV	17.4	14.1	12.9	11.8	50.0	54.0	11.1	47.6
V	20.5	15.0	16.1	17.0	64.0	85.0	47.3	67.6
VI	21.7	22.6	20.7	20.1	164.0	64.0	161.9	88.6
VII	22.1	22.8	22.4	21.8	83.0	22.0	77.3	66.7
VIII	24,3	24.7	23,2	21.4	51.0	80.0	137.5	58.1
IX	19.5	19.2	19.1	17.0	27.2	54.0	31.4	47.8
Average, Total	20.9	19.7	19.1	18.2	439.2	359.0	466.5	376.4

Average temperatures during the vegetation period for the years 2018 (20.9°C), 2019 (19.7°C) and 2020 (19.1°C) were higher compared to the perennial average (18.2°C).

Temperatures in the year 2018 were high in the first part of vegetation (april and may 5.6°C and 3.5°C above the perennial average) and in august (2.9°C above average). In the year 2019, april temperatures exceeded the perennial average by 2.3°C, may temperatures were lower by 2.0°C, and in the time of flowering ang pod formation (june) and grain filling (august) temperatures were 2.5°C and 3.3°C above the perennial average, respectively.

In the year 2020, lower temperatures were recorded during the intensive plant growth period, may temperatures were lower than the perennial average by 0.9°C, while april temperatures were higher by 1.1°C, june and july temperatures by 2.1°C compared to the perennial average. The greatest influence temperatures had on soybean yield was during the periods of flowering, pod forming and grain filling (Đukić et al., 2018). Very high temperatures in june and july along with precipitation deficiency do not favor soybean production (Dozet et al., 2021).

Average precipitation quantity in the soybean vegetation period in 2018 was higher by 62.8 lm^{-2}, and in 2020 by 90.1 lm^{-2} compared to the perennial average (376.4 lm^{-2}), while in 2019 there was less precipitation by 17.4 lm^{-2} compared to the perennial values. Precipitation deficiency in 2019 was pronounced in june, july and the first half of august, which, along with high temperatures, led to compulsory plant maturation and significant soybean yield decrease (Đukić et al., 2018). In 2018, precipitatio deficits occured in august and september, but the distribution was more favorable compared to the year 2020.

Research results and discussion

Observing soybean yield by certain years (Table 2), it can be noticed that the yield achieved in the year 2018 (5.085 $kgha^{-1}$) was statistically very significantly higher compared to 2019 (3.966 $kgha^{-1}$) and the year 2020 (3.793 $kgha^{-1}$). The lowest yield was recorded in 2020 and, compared to this value, soybean yield in 2018 was increased by 34.08% and in 2019 by 4.57%.

By observing soybean yield by variety it can be noticed that the greatest recorded yield was that of variety Rubin (4.847 $kgha^{-1}$), a statistically very significantly higher value compared to varieties Kaća (3.546 $kgha^{-1}$), Merkur (4.166 $kgha^{-1}$), Maximus (4.371 $kgha^{-1}$) and Apolo (4.476 $kgha^{-1}$). Statistically very significantly higher recorded yield was that of soybean varieties Apolo, Maximus and Merkur in comparison with the soybean variety Kaća. Compared to the variety Kaća, which has the shortest vegetation period and achieved the lowest grain yield per surface unit, variety Merkur's grain yield increased by 17.47%, variety Maximus's by 23.25%, variety Apolo's by 26.22% and variety Rubin's by 36.68%.

Table 2. *Average soybean grain yield (kgha^{-1})*

Year A	Variety B	Miror variant, C			Average AxB	Average A
		Control	Trainer	A.e*		
2018	Kaća	3.867	3.918	3.888	3.891	5.085
	Merkur	4.729	4.832	4.846	4.802	
	Maximus	5.385	5.437	5.425	5.416	
	Apolo	5.437	5.477	5.481	5.465	
	Rubin	5.794	5.884	5.877	5.852	
	Prosek AxC	5.042	5.110	5.103		
2019	Kaća	3.169	3.342	3.316	3.275	3.966
	Merkur	3.724	3.961	3.953	3.879	
	Maximus	3.869	4.024	4.107	4.000	
	Apolo	4.218	4.308	4.320.	4.282	
	Rubin	4.155	4.506	4.515	4.392	
	Prosek AxC	3.827	4.028	4.042		
2020	Kaća	3.359	3.523	3.534	3.472	3.793
	Merkur	3.689	3.876	3.882	3.816	
	Maximus	3.554	3.779	3.757	3.697	
	Apolo	3.492	3.762	3.790	3.681	
	Rubin	4.051	4.407	4.434	4.297	
	Prosek AxC	3.629	3.869	3.879	Average B	
Average BxC	Kaća	3.456	3.594	3.579	3.546	
	Merkur	4.047	4.223	4.227	4.166	
	Maximus	4.269	4.413	4.430	4.371	
	Apolo	4.382	4.516	4.530	4.476	
	Rubin	4.667	4.932	4.942	4.847	
Average C		4.166	4.336	4.342		
Average 2018-2020					4.281	
*Ae- Aqueous extracts						

LSD	A	B	C	AxB	AxC	BxC	AxBxC
5%	317	302	174	411	100	177	445
1%	211	216	117	291	71	122	317

By observing soybean yields by foliar application treatments it is noticable that the greatest recorded yield was that of the variant with foliar aqueous nettle and common comfrey extracts application (4.342 kgha^{-1}), a statistically very significantly higher value compared to the control variant (4.166 kgha^{-1}), while the yield achieved by the variant with aminoacids application, i.e. Trainer (4.336 kgha^{-1}), was statistically significantly higher compared to the control.

Compared to the experiment's control variant, soybean yield was increased via aminoacids application by 4.07%, and via aqueous nettle and common comfrey application by 4.21%.

By observing the same year and different soybean varieties, it is noted that in the year 2018 the greatest yield was achieved by soybean variety Rubin (5.852 $kgha^{-1}$), which is a statistically very significantly higher yield compared to the varieties Kaća (3.891 $kgha^{-1}$), Merkur (4.802 $kgha^{-1}$), Maximus (5.416 $kgha^{-1}$) and Apolo (5.465 $kgha^{-1}$). A statistically very significantly higher recorded yield was that of varieties Apolo and Maximus compared to the variety Merkur, as well as that of varieties Apolo, Maximus and Merkur compared to the variety Kaća. Compared to the soybean variety Kaća, variety Merkur's yield was increased by 23.42%, variety NS Maximus's by 39.19%, variety Apolo's by 40.45% and variety Rubin's by 50.39%.

In the year 2019, the highest yield was achieved by the soybean variety Rubin (4.392 $kgha^{-1}$), which is a statistically very significantly higher yield compared to the soybean varieties Kaća (3.275 $kgha^{-1}$), Merkur (3.879 $kgha^{-1}$) and Maximus (4.000 $kgha^{-1}$). A statistically very significantly higher recorded yield was that of soybean varieties Merkur, Maximus and Apolo (4.282 $kgha^{-1}$) compared to the variety Kaća, while a statistically significant higher recorded yield was that of soybean variety Apolo compared to the variety Merkur. Compared to the soybean variety Kaća, variety Merkur's yield was increased by 18.42%, variety Maximus's by 22.11%, variety Apolo's by 30.72% and variety Rubin's by 34.08%.

In the year 2020, the highest yield was achieved by soybean variety Rubin (4.297 $kgha^{-1}$), which is a statistically very significantly higher yield compared to the varieties Kaća (3.472,0 $kgha^{-1}$), Merkur (3.815,7 $kgha^{-1}$), NS Maximus (3.696,7 $kgha^{-1}$) and Apolo (3.68 $kgha^{-1}$). A statistically significant higher recorded yield was also that of soybean variety Merkur compared to the variety Kaća. Compared to the soybean variety Kaća, variety Merkur's yield was increased by 9.90%, variety Maximus's by 6.47%, variety Apolo's by 6.03% and variety Rubin's by 23.77%.

By observing the same year, yet different foliar application treatments, it is noted that the 2018 yield varied from 5.042 $kgha^{-1}$ (control variant) to 5.110 $kgha^{-1}$ (variant with foliar Trainer application), yet there were no statistically significant differences between treatments. The yield was increased by 1.33% by applying Trainer, and 1.21% by applying aqueous nettle and common comfrey extract. In the year 2019, statistically very significant higher recorded yields were those where aqueous nettle and common comfrey extracts (4.042 $kgha^{-1}$) and aminoacids (Trainer) (4.028 $kgha^{-1}$) were applied compared to the experiment's control variant (3.827 $kgha^{-1}$). By applying aqueous nettle and common comfrey extracts, the yield was increased by 5.26%, and Trainer by 5.62%. In the year 2020 as well, statistically very significant higher recorded soybean yields were those where aqueous nettle and common comfrey extract (3.879 $kgha^{-1}$) and Trainer (3.869 $kgha^{-1}$) were applied compared to the experiment's control variant (3.629 $kgha^{-1}$). Trainer (aminoacids) application increased the yield by 6.625, and aqueous nettle and common comfrey extract application by 6.90%.

By observing soybean yields of the same varieties, yet different treatments, it is noted that variety Kaća's yield was statistically significantly higher with the Trainer application treatment (3.594 $kgha^{-1}$) compared to the control (3.465 $kgha^{-1}$). Aqueous nettle and common comfrey extract application increased the yield by 3.73%, and Trainer application by 3.30%. Variety Merkur's recorded yield was statistically very significantly higher when aqueous nettle and common comfrey extract was applied (4.227 $kgha^{-1}$) and statistically significantly higher when Trainer (4.223 $kgha^{-1}$) was applied compared to the experiment's control variant (4.047 $kgha^{-1}$). Triner application increased the yield by 4.34% and aqueous nettle and common comfrey extract application by 4.40%. The variety Maximus achieved a statistically significant higher yield when aqueous nettle and common comfrey extract (4.430 $kgha^{-1}$) and Trainer (4.413 $kgha^{-1}$) were applied compared to the control (4.269 $kgha^{-1}$). By applying aqueous nettle and common comfrey extract, the yield was increased by 3.37% and 3.76% by applying Trainer. The soybean variety Apolo's statistically significant high recorded yields were those of variants where aqueous nettle and common comfrey extract (4.530 $kgha^{-1}$) and Trainer (4.516 $kgha^{-1}$) were applied compared to the control (4.382 $kgha^{-1}$). Aqueous nettle and common comfrey extract application increased the yield by 3.04% and aminoacids (Trainer) application by 3.38%. Soybean variety Rubin's variants with aqueous nettle and common comfrey extract application (4.942 $kgha^{-1}$) and Trainer (4.932 $kgha^{-1}$) had a statistically very significant higher recorded yield compared to that of the experiment's control variant (4.667 $kgha^{-1}$). By applying Trainer, the yield was increased by 5.69% and 5.90% by applying aqueous nettle and common comfrey extract.

Conclusion

The year very significantly affects soybean yield, primarily depending on the amount and distribution of precipitation and temperature conditions during vegetation. Soybean varieties with a longer vegetational period have a greater yield potential compared to varieties with a shorter vegetation period. Aqueous nettle and comfrey extracts, as well as foliar application of aminoacids, significantly increase soybean yield. The examined soybean cultivation method is sustainable.

Acknowledgments

Financial support by Serbian Ministry of Education and Science agreement number 451-03-68/2022 since 17.01.2022. for this work is gratefully acknowledged.

Literature

1. Dozet G., Đukić V., Cvijanović M., Đurić, N.,Kostadinović Lj., Jakšić S., Cvijanović G. (2015): *Influence of organic and conventional methods of growing on qualitative properties of soybean*. Book of Proceedings from Sixth International Scientific Agricultural Symposium "Agrosym 2015", October 15-18, Jahorina, Bosnia and Herzegovina, 407-412.
2. Dozet G., Đukić V., Miladinov Z., Đurić N., Ugrenović V., Cvijanović V., Jakšić S, (2019): *Prinos soje u organskoj proizvodnji*. Zbornik naučnih radova Instituta PKB Agroekonomik, Vol. 25, br. 1-2, 173-180. Beograd, Srbija.
3. Dozet G., Đukić V., Cvijanović G., Đurić N., Cvijanović V., Miladinović J., Marinković J. (2021): *Uticaj folijarnog đubrenja na prinos soje*. Zbornik radova Nacionalnog naučno-stručnog skupa sa međunarodnim učešćem „Biotehnologija i savremeni pristup u gajenju i oplemenjivanju bilja" 15. decembar 2021. Smederevska Palanka, 301-308.
4. Đukić V., Miladinov Z., Balešević-Tubić S., Miladinović J., Đorđević V., Valan D., Petrović K. (2018): Kritični momenti u proizvodnji soje, Zbornik referata 52. Savetovanja agronoma i poljoprivrednika Srbije (SAPS), Zlatibor, 21-27. Januar 2018. Institut za ratarstvo i povrtarstvo, Novi Sad, 34-44.

5. Đukić, V., Miladinović, J., Mamlić, Z., Dozet, G., Cvijanović, G., Kandelinskaja, O., Miljaković, D. (2021): *Uticaj vodenog ekstrakta banane i koprive sa gavezom na prinos soje*. Zbornik radova Nacionalnog naučno-stručnog skupa sa međunarodnim učešćem „Biotehnologija i savremeni pristup u gajenju i oplemenjivanju bilja" 15. decembar 2021. Smederevska Palanka, 285-292.

6. FiBL (2022): Data on organic area in worldwide. https://statistics.fibl.org/world/area-world.html (20.09.2022.)

7. Miladinov Z., Đukić V., Ćeran M., Valan D., Dozet G., Tatić M., Ranđelović P. (2018): *Uticaj folijarne prihrane na sadržaj proteina i ulja u zrnu soje*, Zbornik radova 59. Savetovanje industrije ulja: „Proizvodnja i prerada uljarica", 17-22. Jun 2018, Herceg Novi, Crna Gora, 73-78.

8. Popović A., Golijan J., Babić V., Kravić N., Sečanski M., Delić N. (2016): *Organic farming as a factor for biodiversity conservation.* International scientific conference on Ecological crisis: Technogenesis and climate change. April 21-23, 2016 Belgrade, Serbia, pp. 61

9. Subić J., Bekić B., Jeločnik M. (2010): *Značaj organske poljoprivrede u zaštiti okoline i savremenoj proizvodnji hrane*. Škola biznisa, 3: 50-56.

10. Trovato Maurizio, Funkc Dietmar, Giuseppe Farlam, Sakiko Okumoto and Rachel Amir (2021): *Editorial: Amino Acids in Plants:Regulation and Functions in Development and Stress Dense*. Frontiers in Plant Science, Vol.12, No.772810, 1-5.