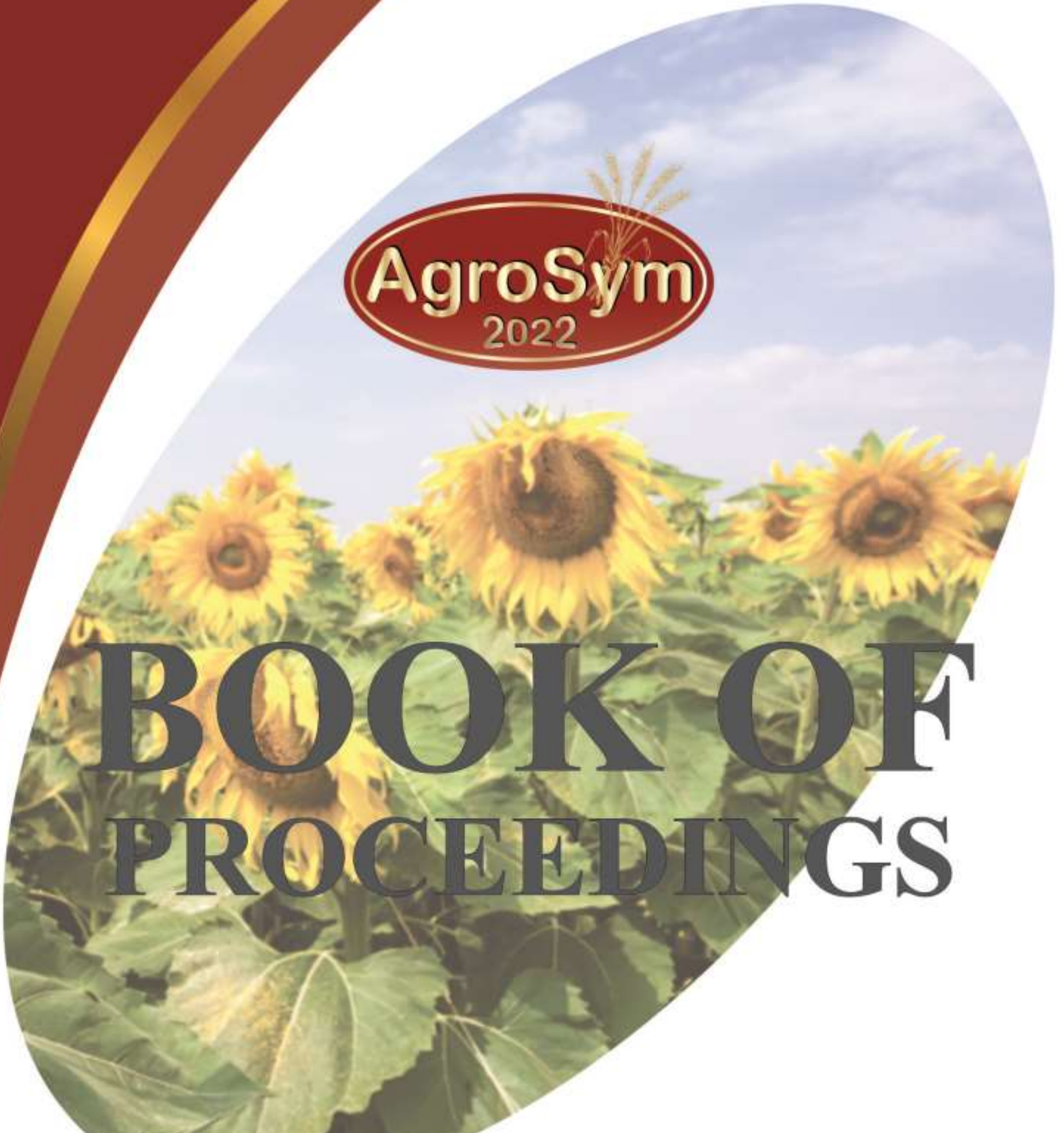

BOOK OF PROCEEDINGS

XIII International Scientific Agriculture Symposium
"AGROSYM 2022"
October 6-9, 2022

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Jahorina, October 06 - 09, 2022

INFLUENCE OF AQUEOUS EXTRACTS FROM BANANA PEEL AND SOYBEAN PLANTS ON SOYBEAN GRAIN YIELD

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Abstract

Foliar aqueous extract application has a positive effect on soybean yield and quality. The aim of this research wos to examine the influence of foliar application of aqueous banana peel and apical soybean plant part extracts on the yield of five soybean varieties that are of different maturity groups. This way, plant material would be used for soybean grain yield increase, and synthetic artificial fertilizer use would be avoided along with environmental polution. The results were processed via tri-factorial experiment variance analysis, and significancy of differences was tested via LSD test. Foliar application of aqueous banana peel extract increased soybean yield in a three-year experiment by 4.07% (annually from 1.33% to 6.62%), and the application of aqueous apical soybean plant part extract by 4.21% (annually from 1.21% to 6.90%). Greater yield increase was recorded during years that were unfavorable for soybean production, with the varieties Rubin (5.69% and 5.90%) and Merkur (4.34% and 4.40%) having a greater yield increase compared to other soybean varieties included in the experiment (NS Kaća 3.73% and 3.30%, NS Maximus 3.37% and 3.76%, NS Apolo 3.04% and 3.38%). The year immensely influences soybean yield, primarily depending on precipitaton distribution and quantity and temperature conditions during the vegetation period. Aqueous banana peel and apical soybean plant part extracts significantly increase soybean yield.

Key words: *aqueous extracts, foliar application, yield, varieties, soybeans.*

Introduction

Foliar applications in soybean crop during the intensive growth phase increases yield (Miladinov *et al*., 2018), especially in adverse years with a distinct drought period, but also in growing seasons with favourable conditions as well (Dozet *et al*., 2013; Dozet *et al*., 2015). Aqueous plant material extracts are being ever more used in flower and vegetable crops, but also in field crop production, both in organic and conventional cultivations (Đukić *et al*., 2021). Considering that soybean grain is being used for obtaining various products used in human consumption, it is very important for a part of total soybean production to come from an organic cultivation system, without mineral fertilizer and pesticide application (Dozet *et al*., 2019). Aqueous plant material extracts, beside macro and trace elements, also contain physiologically active substances which induce plant growth and development, often have a fungicidal and insecticidal effect, are easily

prepared at a farmstead, do not require major investments and are favourable for organic production since their use does not have a negative environmental impact.
In recent decades, climate change is being detected in the form of median daily temperature increases during vegetation and on a yearly level, along with ever greater increases in precipitation oscillations, i.e. shifts of pluvial and extremely arid years, and these conditions are highly unfavourable for soybean production (Đukić *et al.,* 2018).
Yield flacuations in certain years confirm that weather conditions during vegetation greatly affect soybean yield (Đukić *et al.,* 2018; Dozet *et al.,* 2019; Dozet *et al.,* 2022).
The aim of this paper was to investigate the effect of aqueous banana peel and apical soybean plant part extracts on soybean grain yield of five varieties which differ in vegetation period length.

Materials and methods

In a three-year experiment, the influence of foliar application of aqueous banana peel and apical soybean plant part extracts on soybean yield was investigated on five varieties of different maturity groups (NS Kaća 000 maturity group, Merkur 00 maturity group, NS Maximus 0 maturity group, NS Apolo I maturity group). The experiment was set up in the Institute of Field and Vegetable Crops’ experimental field in Rimski Šančevi, and the experimental treatments were: the control, where the amount of foliarly applied water was identical to the amount of aqueous extracts, aqueous banana peel extract and aqueous apical soybean plant part extract application. The application of aqueous plant material extracts and water on the control variant was being conducted, just 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. The experiment had four replications, and the single plot size was 10 m^2 (four soybean rows, 50 cm distance between rows and five meters of length). The aqueous extracts were made by drenching 1 kg of chopped plant material into 10 litres of rain water and, by styrring it daily, the end of fermentation was awaited, after which the aqueous extract was strained by gauze and kept in glass bottles until used. During the vegetation period, standard agronomic practices were applied in soybean production, and harvesting via small operating hold combine was conducted in the harvest maturity phase, grain mass and moisture were measured and yield per hectare with 14% moisture was calculated. The results were processed by trifactorial experiment variance analysis (Program „Statistica 10“) and difference significance was tested via LSD test.

Results and discussion

Meteorological parameters for the three year experiments are shown on Table 1. Average temperatures during the vegetation period for the year 2018 (20.9 °C), the year 2019 (19.7 °C) and 2020 (19.1 °C) were higher compared to the perennial average (18.2 °C).
Temperatures in 2018 were high in the first part of plant growth (April and May 5.6 °C and 3.5 °C above the perennial average, respectively) and in August (2.9 °C above average). In 2019, April temperatures were higher than the perennial average by 2.3 °C, May temperatures lower by 2.0 °C, and in the time of blossoming and legume formation (June) and in the time of grain filling (August), temperatures were higher than the perennial average by 2.5 °C and 3.3 °C, respectively.

In 2020, lower temperatures during the intensive plant growth period were recorded, May temperatures were lower than the perennial average by 0.9 °C, while the April temperatures were higher by 1.1 °C, June and July temperatures were higher by 0.6 °C, August temperatures higher by 1.8 °C and September temperatures higher by 2.1 °C compared to the perennial average. The greatest influence that temperature has on soybean yield is during the periods of flowering, pod formation and grain filling (Đukić *et al.*, 2018). Very high temperatures in June and July along with precipitation insufficiency do not favour soybean production (Dozet *et al.*, 2021).

Table 1. Weather conditions in the study years

Month	Mean monthly temperature (°C)				Precipitation (lm^{-2})			
	2018	2019	2020	Long- term average	2018	2019	2020	Long- term 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

The average amount of precipitation during the soybean vegetation period of 2018 was higher by 62.8 lm^{-2}, and in 2020 by 90.1 lm^{-2} in comparison 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. The precipitation insufficiency in 2019 was expressed in June, July and the first half of August, which, along with high temperatures, led to compulsory plant maturation and significant soybean yield reduction (Đukić *et al.*, 2018). In 2018, precipitation insufficiency occured in August and September, but the distribution was more favourable compared to 2020.

Observing soybean yield by certain years (Table 2), it is noticeable that the achieved yield in 2018 (5.085,1 $kgha^{-1}$) was significantly higher compared to 2019 (3.965,8 $kgha^{-1}$) and 2020 (3.792,6 $kgha^{-1}$). 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%.

Observing soybean yield by varieties, it is noticed that the highest yield was recorded in relation to the variety Rubin (4.847,0 $kgha^{-1}$), a statistically significant higher value compared to the varieties NS Kaća (3.546,2 $kgha^{-1}$), Merkur (4.165,8 $kgha^{-1}$), NS Maximus (4.370,8 $kgha^{-1}$) and NS Apolo (4.476,1 $kgha^{-1}$). Significantly higher yield was recorded among soybean varieties NS Apolo, NS Maximus and Merkur in comparison to the variety NS Kaća. Compared to the variety NS Kaća, which has the shortest vegetation period, and which achieved the lowest grain yield per surface unit, the variety Merkur’s grain yield was increased 17.47%, the variety NS Maximus’ by 23.25%, the variety NS Apolo’s by 26.22% and the variety Rubin’s by 36.68%.

Observing soybean yields by foliar application treatments, it is noticed that the highest yield was recorded at the treatment with a foliar aqueous apical soybean plant part extract application (4.341,7 $kgha^{-1}$), significantly higher value compared to the control (4.166,1 $kgha^{-1}$), while the yield achieved with the aqueous banana peel extract application (4.335,7 $kgha^{-1}$) was also significantly higher compared to the control. In comparison to the control, soybean yield was increased via aqueous banana peel extract application by 4.07%, and via aqueous apical soybean plant part extract application by 4.21%.

Observing the same year and different soybean varieties, it is noticed that in 2018 the highest yield was achieved with the soybean variety Rubin (5.851,7 $kgha^{-1}$), which was highly significant compared to the soybean varieties NS Kaća (3.891,0 $kgha^{-1}$), Merkur (4.802,3 $kgha^{-1}$), NS Maximus (5.415,7 $kgha^{-1}$) and NS Apolo (5.465,0 $kgha^{-1}$).

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

Year (A)	Variety (B)	Treatments (C)			Average (AxB)	Average (A)
		Control	*AE - Banana peel	*AE - Soybean plants		
2018	NS Kaća	3.867	3.918	3.888	3.891,0	5.085,1
	Merkur	4.729	4.832	4.846	4.802,3	
	NS Maximus	5.385	5.437	5.425	5.415,7	
	NS Apolo	5.437	5.477	5.481	5.465,0	
	Rubin	5.794	5.884	5.877	5.851,7	
	Average (AxC)	5.042,4	5.109,6	5.103,4		
2019	NS Kaća	3.169	3.342	3.316	3.275,7	3.965,8
	Merkur	3.724	3.961	3.953	3.879,3	
	NS Maximus	3.869	4.024	4.107	4.000,0	
	NS Apolo	4.218	4.308	4.320	4.282,0	
	Rubin	4.155	4.506	4.515	4.392,0	
	Average (AxC)	3.827,0	4.028,2	4.042,2		
2020	NS Kaća	3.359	3.523	3.534	3.472,0	3.792,6
	Merkur	3.689	3.876	3.882	3.815,7	
	NS Maximus	3.554	3.779	3.757	3.696,7	
	NS Apolo	3.492	3.762	3.790	3.681,3	
	Rubin	4.051	4.407	4.434	4.297,3	
	Average (AxC)	3.629,0	3.869,4	3.879,4	Average (B)	
Average (BxC)	NS Kaća	3.465,0	3.594,3	3.579,3	3.546,2	
	Merkur	4.047,3	4.223,0	4.227,0	4.165,8	
	NS Maximus	4.269,3	4.413,3	4.429,7	4.370,8	
	NS Apolo	4.382,3	4.515,7	4.530,3	4.476,1	
	Rubin	4.666,7	4.932,3	4.942,0	4.847,0	
Average (C)		4.166,1	4.335,7	4.341,7		
Average 2019-2020					4.281,2	
*AE – aqueous extracts						

LSD	A	B	C	AxB	AxC	BxC	AxBxC
1%	316.9	32.0	173.5	410.6	100.3	178.6	444.8
5%	210.8	216.1	116.5	291.2	70.9	121.5	317.3

Compared to the soybean variety NS Kaća, the variety Merkur’s yield was increased by 23.42%, the variety NS Maximus’ by 39.19%, the variety NS Apolo’s by 40.45% and the variety Rubin’s by 50.39%.
In 2019, the highest yield was achieved by the variety Rubin (4.392,0 $kgha^{-1}$), which was statistically higher yield compared to the soybean varieties NS Kaća (3.275,7 $kgha^{-1}$), Merkur (3.879,3 $kgha^{-1}$) and NS Maximus (4.000,0 $kgha^{-1}$). Statistically very significantly higher yield was also recorded among the soybean varieties Merkur, NS Maximus and NS Apolo (4.282,0 $kgha^{-1}$) compared to the variety NS Kaća, while a statistically significantly higher yield was achieved by the variety NS Apolo compared to the variety Merkur. In comparison to the soybean variety NS Kaća, the yield was increased for the variety Merkur by 18.42%. the variety NS Maximus by 22.11%, the variety NS Apolo by 30.72% and the variety Rubin by 34.08%.
In 2020, the highest yield was achieved by the variety Rubin (4.297,3 $kgha^{-1}$), which is statistically very significantly higher compared to the soybean varieties NS Kaća (3.472,0 $kgha^{-1}$), Merkur (3.815,7 $kgha^{-1}$), NS Maximus (3.696,7 $kgha^{-1}$) i NS Apolo (3.681,3 $kgha^{-1}$). A statistically significantly higher yield was achieved by the soybean variety Merkur in comparisn to the variety NS Kaća. Compared to the soybean variety NS Kaća, the variety Merkur’s yield was increased by 9.90%, the variety NS Maximus’ by 6.47%, the variety NS Apolo’s by 6.03% and the variety Rubin’s by 2.77%.
By observing the same year but different foliar application treatments, it is noticed that soybean yield in 2018 varied from 5.042,4 $kgha^{-1}$ (control variant) to 5.109,6 $kgha^{-1}$ (aqueous banana peel extract application variant), although there was no statistically significant difference between certain treatments. By applying aqueous banana peel extract, the yield was increased by 1.33%, and 1.21% by applying aqueous apical soybean plant part extract. In 2019, statistically very significantly higher soybean yields were recorded when applying aqueous apical soybean plant part extract (4.042,2 $kgha^{-1}$) and aqueous banana peel extract (4.028,2 $kgha^{-1}$) in comparison to the experiment’s control (3.827,0 $kgha^{-1}$). By applying aqueous banana peel extract, the yield was increased by 5.26% and 5.62% by applying aqueous apical soybean plant part extract. In 2020 as well, a statistically significantly higher soybean yield was recorded when applying aqueous apical soybean plant part extract (3.879,4 $kgha^{-1}$) and applying aqueous banana peel extract (3.869,4 $kgha^{-1}$) in comparison to the experiment’s control variant (3.629,0 $kgha^{-1}$). By applying the aqueous banana peel extract, the yield was increased by 6.62% and 6,90% by applying aqueous apical soybean plant part extract. Whilst observing soybean yields of the same varieties, and of different treatments, it is noticed that the variety NS Kaća’s yield was statistically significantly higher among the variant with aqueous banana peel extract application (3.594,3 $kgha^{-1}$) in comparison to the control variant (3.465,0 $kgha^{-1}$). Aqueous banana peel extract application increased the yield by 3.37%, whilst aqueous apical soybean plant part extract increased the yield by 3.30%. Among the variety Merkur, a statistically very significantly higher yield was recorded when aqueous apical soybean plant part extract was applied (4.227,0 $kgha^{-1}$) and a statistically significantly higher yield when aqueous banana peel extract was applied (4.223,0 $kgha^{-1}$) compared to the experiment’s control variant (4.047,3 $kgha^{-1}$). By applying the aqueous bananana peel extract, the yield was increased by 4.34%, and 4.40% by aplying aqueous apical soybean plant extract. The variety NS Maximus achieved a statistically significantly higher yield by applying aqueous soybean plant part extract (4.429,7 $kgha^{-1}$) and aqueous banana peel extract (4.413,3 $kgha^{-1}$) in comparison to the control (4.269,3 $kgha^{-1}$). By applying aqueous banana peel extract, the yield was increased by 3.37% and 3.37% by applying aqueous apical soybean plant part extract. The soybean variety NS Apolo was recorded to give statistically

significantly higher yields when the aqueous apical soybean plant part extract (4.530,3 $kgha^{-1}$) and aqueous banana peel extract (4.515,7 $kgha^{-1}$) were applied, in comparison to the control (4.382,3 $kgha^{-1}$). Applying aqueous banana peel extract increases the yield by 3.04% and 3.38% by applying aqueous apical soybean plant part extract. The Rubin soybean variety's variants recorded a statistically very significantly higher yield when applying the aqueous apical soybean plant part extract (4.942,0 $kgha^{-1}$) and aqueous banana peel extract (4.932,3 $kgha^{-1}$), in comparison to the experiment's control varient (4.666,7 $kgha^{-1}$). By applying the aqueous banana peel extract, the yield has increased by 5.69% and 5.90% by applying aqueous apical soybean plant part extract.

Conclusion

The year very significantly affects soybean yield, primarily depending on quantity, precipitation distribution and temperature conditions during the vegetation period. Soybean varieties with a longer vegetation period have a greater yield potential than varieties with a shorter vegetation period. Aqueous banana peel and apical soybean plant part extracts significantly increase soybean yield.

Acknowledgment

The realisation of this research was financed by the Republic of Serbia's means, and on the grounds of the Ministry of Education, Science and Technological Advancement's decision on financing scientific research in the year 2022, number: 451-03-68/2022-14 of 17.01.2022.

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