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TECHNICAL PARAMETERS OF BIOSTIMULANT SPRAYING A DETERMINANT OF BIOMETRIC TRAITS AND YIELD OF SOYBEAN SEEDS

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ABSTRACT

Spraying with various types of agrochemical substances, including biostimulants, is one of the basic agricultural treatments affecting the yield size and quality. The selected type of spraying nozzles can influence biological effectiveness of the applied substances. A 2-year field study showed which of the investigated nozzles increase the effectiveness of foliar application of a free amino acid biostimulant. The type of nozzle used for the application of biostimulants was reported to significantly influence the biometric properties and yield of soybean cultivation. It was observed that spraying nozzles, which generate finer droplets positively influence positively the biometric properties of plants and seed yield of seed than injector nozzles, which produce coarser droplets. A significant reduction of the thousand seeds mass after applying the biostimulant with standard flat fan nozzles is an exception. A 25.61% increase in soybean yield was reported after applying the biostimulant with standard flat fan nozzles and a 11.35% increase – with injector nozzles..

Introduction

The level of agricultural production considerably depends on efficient crop protection. Spraying plants with various types of agrochemical substances: pesticides, fungicides, herbicides, liquid fertilizers is one of the basic treatments affecting the size and quality of the crops yield. Recently, biostimulants have been added to the above-mentioned substances. A correct and effective application of agrochemicals in the form of spraying is related with a correct selection of technical parameters of the performed treatment (Lodwik et al., 2020). According to Węgrzyn and Parafiniuk (2019) one of the most important parameters of spraying is a suitable selection of spraying nozzles since along with the working pressure, they influence the droplets spectrum of the sprayed liquid. The spraying quality is one of the factors that determine the effectiveness of application of agrochemicals including biological effectiveness and a degree of environmental contamination in case of application of pesticides (Nuyttens et al., 2007). Presently, a phenomenon of spray drift is getting more important (Lodwik and Pietrzyk, 2017; Ozkan and Derksen 1998; Ozkan 2020). The use of injector nozzles is one of the methods to reduce the drift. The injector nozzles considerably reduce drifting but the level of coverage of sprayed plants is getting lower which may influence the effectiveness of the performed treatment (Subr et. al., 2020). Biological effectiveness of the applied substance depends, inter alia, on the plant coverage with active substance which is described with the number and drops mass per 1 cm^2 and the coverage rate of the surface expressed in percentages (Gajtkowski, 2000). Szewczyk et al., (2013) showed that for a defined volume of liquid, the smaller are the drops obtained in the spraying process, the higher is the coverage rate of the target (e.g. plant or leaves). However, too small droplets are susceptible to drifting and easily mixed with wind or air turbulences that are formed behind the moving sprayer. Coarser droplets are less susceptible to drifting but they do not help to cover appropriately plants as small droplets. Extremely coarse droplets may cause that the fluid will flow down from plants causing that active substances will not be absorbed by the plant. In case of application of biostimulants, when fluid drips down from plant to soil, it does cause its contamination but may influence the biological effectiveness of application of this type of agrochemicals.

The field studies were undertaken since there was no information concerning the impact of parameters of the sprayed liquid on the biological effectiveness of biostimulants in soya beans cultivation. The field studies were designed to find an answer to the following question: Does the application method of a free amino acids- based biostimulant with flat fan nozzles with a various structure influences biometrical properties and soya crop?

Material and methods

A field experiment was conducted in the experimental farm of the University of Life Sciences in Lublin located in Czesławice, Lubelskie Voivodeship. Abelina cultivar of soya beans was cultivated in 2020 and 2021. The experiment was conducted in the random blocks system with four iterations on 20 m^2 experimental fields. The seeds were sown on 10 May 2020 and 2021 in rows distributed every 30 cm and spaces in the row of 4.0 cm. In each growing season, plants were treated with a biostimulant Terra Sorb Complex in the form of double spraying of plants in the concentration of 0.5% and working liquid dose of 300 $l \cdot ha^{-1}$ in development stages of soya BBCH 13-15 and BBCH 61. Control combination included Soya plants sprayed with clean water. Plants were harvested after the pods had matured (BBCH 89). The plants' height, number of pods in a plant, seeds yield, and thousand seeds

mass was determined. The time limits of application of extracts were selected based on the results of previous experiments concerning the use of natural and synthetic biostimulants in soya beans cultivation (Kocira et al., 2019; Szparaga et al., 2018).

Terra Sorb Complex based on free amino acids was selected for the studies. Badania Sánchez-Hernández et al., (2013) confirm the occurrence of only levorotatory amino acids in this biostimulant. This biostimulant includes free amino acids in the amount of 20%: aliphatic amino acids (glycine, alanine, valine, leucine, isoleucine, proline), hydroxy amino acids (serine, threonine, sulphur amino acids (cysteine, methionine), aromatic amino acids (phenylalanine, tryptophan, tyrosine), acidic amino acids (aspartic acid, glutamic acid) and alkaline amino acids (histidine, arginine, lysine). Additionally, the above-mentioned biostimulator includes total nitrogen 5.5% (organic nitrogen 5%), magnesium 0.8%, boron 1.5%, iron 1%, zinc 0.1%, manganese 0.1%, molybdenum 0.001% and organic matter in 25% (Kocira et al., 2015).

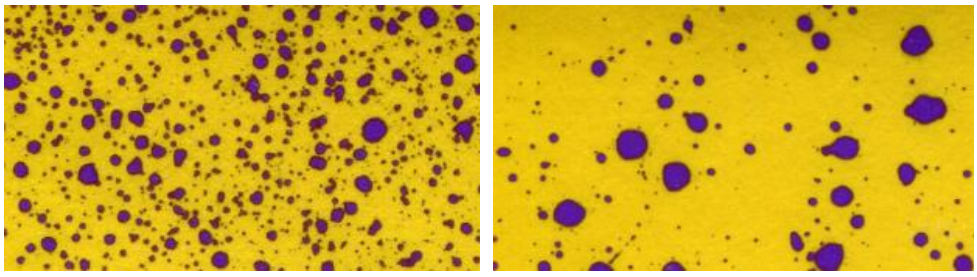
The spraying treatment was performed with a mounted field sprayer AgroMax P161. The working speed was 4.8 $km \cdot h^{-1}$ and the working pressure of spraying was 3 bar. Spraying was performed with two types of nozzles. Standard nozzle Agroplast 120 03 (AP12003) and injector nozzles Agroplast 6MSC (6MS03C). Water-sensitive paper was used to check the coverage rate of the spraying. Sensitive papers were fixed on the soya beans leaves. After treatment, water-sensitive papers were scanned, and the images were analysed using Image-Pro Plus program.

One the other hand in the laboratory, the droplets sizes was also was measured for all the nozzles with a Sympatec GmbH (Clausthal-Zellerfeld, Germany) Laser Diffraction device which uses HELOS/R system with a measuring range from R3 to R7 (0.1-8.750 μm). The studies were performed in three iterations. The sizes distributions of the droplets spectrum were determined.

The data were analysed with Statistica 13.3 (TIBCO Software Inc., Palo Alto, CA, USA). Materials were collected within two seasons (2020-2021). Regularity of data distribution was checked with Shapiro-Wilk test (Ćwiklińska et al., 2021). Significance of differences between the average values was verified with Tukey's test at the level of significance $p < 0.05$.

Results and discussion

The study of the coverage rate of plants with the sprayed fluid with biostimulant Terra Sorb Complex with water-sensitive papers showed variability in the coverage degree (fig. 1).



AP12003 6MS03C

Figure 1. Examples of water-sensitive papers after the application of biostimulants in soya beans cultivation

Spraying of the liquid with nozzles AP12003 enabled obtaining the coverage rate which was 20.94% which was more than 2.5 times higher than in case of injector nozzles 6MS03C (table 1).

Table 1.
Droplets size parameters and coverage rate of the spray deposit produce by the tested nozzles AP12003 and 6MS03C of plants

Parameters	AP12003	6MS03C
Minimum size of drops, (μm)	43.0	43.0
Maximum size of drops, (μm)	1423.0	2891.0
Averag size of drops (μm)	969.0	1358.0
Number of droplets (per $cm^{2)}$)	131.1	80.4
Coverage rate, (%)	20.94	7.76

The investigation of drop spectrum showed differences between the nozzles selected for the research. Nozzles AP12003 were characterized with a bigger number of drops with a size from 0 to 250 μm. Nozzles 6MS03C generated more drops with the size of 250 to 700 μm (table 2). AP12003 is characterized by a Volume Median Diameter (VMD) of 139.27 μm that classifies this nozzle type (according to ASABE S 572.1 standard) as producing fine drops. VMD of or injector nozzles 6MS03C reach 366.94 μm that classifies them as producing coarse drops.

Table 2.
Distribution of the spraying spectra according the droplets size (average % ± SD) for nozzles AP12003 and 6MS03C at 3 bar spraying pressure.

Ranges of the fraction size (μm)	Distribution of the spraying spectra according the droplets size (average % ± SD) and VMD (average diameter ± SD)	
	AP12003	6MS03C
0-100	33.90±0.18	8.66±0.27
100-150	30.34±0.15	9.94±0.16
150-200	18.09±0.19	9.46±0.04
200-250	9.13±0.20	7.96±0.07
250-300	4.20±0.07	7.10±0.03
300-350	2.05±0.05	7.05±0.11
350-400	1.18±0.05	7.23±0.16
400-450	0.60±0.05	7.21±0.14
450-500	0.36±0.06	7.16±0.13
500-600	0.13±0.11	12.37±0.29
600-700	–	8.44±0.29
700-3500	–	7.45±0.30

Application of Terra Sorb Complex biostimulant in Abelina soya beans cultivar enables to significantly increase the height of plant by 26.21% on average when applied with Agroplast 120 03 standard flat fan nozzles and by 15.09% with Agroplast 6MSC injector nozzles with regard to the control combination (figure 2). Kocira (2019) also reported the growth

of soya beans when applying Terra Sorb Complex in two various concentrations with the use of standard flat fan nozzles. The growth of a bean stalk after application of the biostimulant which included amino acids was also observed by Colla et al., (2014), stating that the use of protein hydrolysate stimulates the growth of the stalk acting similarly to gibberellins.

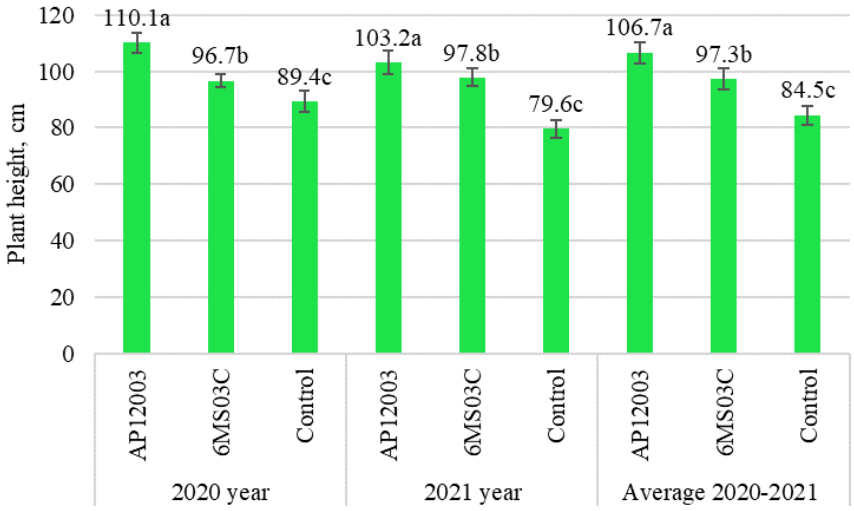


Figure 2. The effect of biostimulant application of two types of nozzles (Standard flat fan nozzle AP12003 and Injector flat fan nozzle 6MS03C) on the height of soya beans plants

Foliar application of Terra Sorb Complex enabled a significant increase of the number of pods on a plant regardless the type of used sprayers (figure 3). No significant difference between the application of biostimulant with standard flat fan nozzles (AP12003) and application with injector flat fan nozzles (6MS03C) was reported. However, Alheidary et al., (2020) showed that effectiveness of the foliar fertilization of maize with zinc and iron depends on the type of spraying nozzles.

The performed experiment showed that application of the biostimulant influences the reduction of the one thousand seed mass (figure 4). Similar effects were obtained by Boghdady et al., (2016) when they applied seaweed extract in chickpea cultivation. Reduction of the one thousand seed mass is caused by the increase of the number of pods on a plant. A significant reduction of one thousand seed mass by 2% towards the control combination was reported in case of application of biostimulant with a standard flat fan nozzle (AP12003). The use of injector nozzle 6MS03C did not significantly affect this parameter.

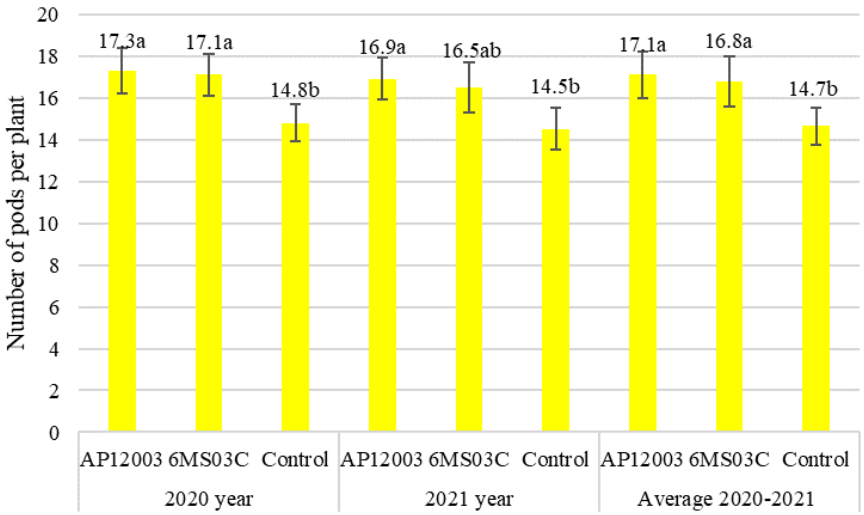


Figure 3. The effect of biostimulant application with two types of nozzles (Standard flat fan nozzle AP12003 and Injector flat fan nozzle 6MS03C) on the number of of soya beans plants

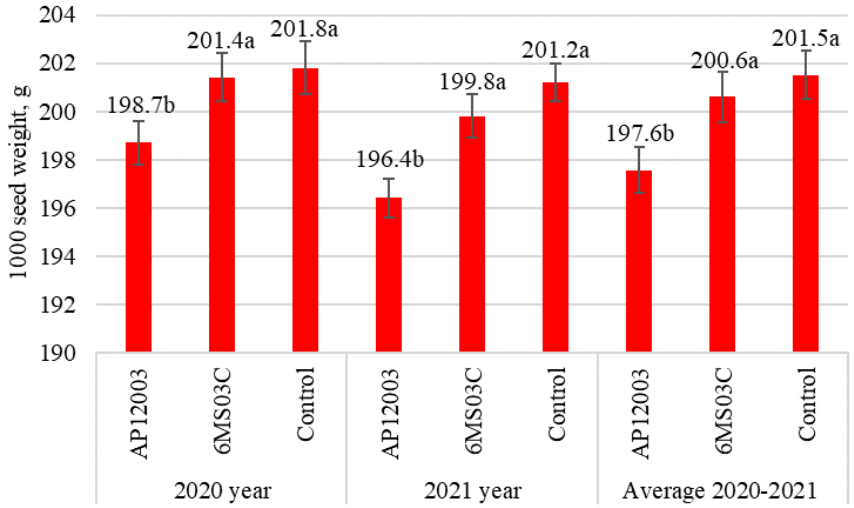


Figure 4. The effect of biostimulant application of two types of nozzles (Standard flat fan nozzle AP12003 and Injector flat fan nozzle 6MS03C) on the 1000 seed weight of soya beans plants

Application of the biostimulant based on amino acids with the use of two various types of nozzles caused an average increase of yield by 25.61% when applied with nozzles AP12003 and by 12.81% when applied with nozzles 6MS03C. Moreover, a significant difference in the obtained yield was reported after the application of a biostimulant with various nozzles (Fig. 5). The highest yield was obtained with the use of nozzles AP12003, and it was significantly higher by 11.35% than the yield obtained after application of the biostimulant with nozzles 6MS03C. The impact of the nozzles type on the plants yield was also reported by Alheidary et al., (2020) investigating foliar fertilization of maïze with 3 types of nozzles.

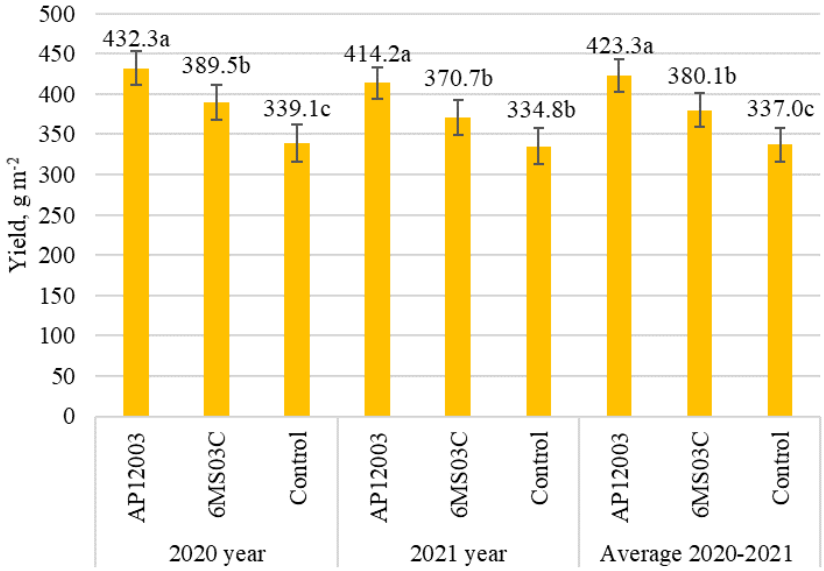


Figure 5. Effect of application of a biostimulant with two types of nozzles (Standard flat fan nozzle AP12003 and Injector flat fan nozzle 6MS03C) on the yield of soya beans plants

Conclusions

The field studies performed in two growing seasons (2020 and 2021) enabled conclusion that the type of nozzles used for the application of a biostimulant based on free amino acids has a significant impact in soya beans cultivation. It was observed that nozzles, which generate finer droplets (Standard flat fan nozzle), influence positively the biometrical properties of plants and yield of soya bean than the ones that generate coarser droplets (Injector flat fan nozzle). Application of the biostimulant with standard flat fan nozzles led to increase the yield of soya beans by more than 25.61%. The use of the injector nozzles also allowed increasing the yield but only by 11.35%.

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PARAMETRY TECHNICZNE OPRYSKU BIOSTYMULATOREM CZYNNIKIEM DETERMINUJĄCYM CECHY BIOMETRYCZNE I PLON NASION SOI

Streszczenie. Jednym z podstawowych zabiegów wpływających na wielkość i jakość uzyskiwanych plonów jest opryskiwanie roślin różnego rodzaju agrochemikaliami, w tym biostymulatorami. Dobór dysz rolniczych może wpływać na efektywność biologiczną stosowanych substancji. Przeprowadzone dwuletnie badania polowe pozwoliły stwierdzić, które z badanych dysz wpływają na efektywniejsze aplikowanie dolistne biostymulatora opartego na wolnych aminokwasach. Stwierdzono istotny wpływ rodzaju stosowanych dysz do aplikacji biostymulatora w uprawie soi na cechy biometryczne i plon soi. Zaobserwowano, że dysze wytwarzające więcej mniejszych kropel korzystniej wpłynęły na cechy biometryczne roślin i plon nasion niż dysze inżektorowe. Wyjątkiem jest istotne zmniejszenie masy tysiąca nasion po aplikacji biostymulatora za pomocą standardowych dysz płaskostrumieniowych. Stwierdzono wzrost plonowania soi o 25,61% po aplikacji biostymulatora dyszami standardowymi płaskostrumieniowymi i o 11,35% dyszami inżektorowymi.

Słowa kluczowe: dysze rolnicze, oprysk, wolne aminokwasy, cechy biometryczne, stopień pokrycia