

## Assessment of the Effect of Foliar Silicone Fertilizer on Winter Wheat Cultivation

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### ABSTRACT

The aim of the conducted field experiment was efficacy assessment of foliar fertilization of Hondia winter wheat cultivar. The conducted studies concerned the wheat yield, the characteristics of grain including the macroelement content and the parameters of the obtained flour. The field experiment was conducted in the growing period of 2018/2019 in Lipnik at the Agricultural Experimental Station belonging to the West Pomeranian University of Technology in Szczecin. The experiment was conducted on light soil of good rye complex, belonging to IV b bonitation class. The factor under study in the present experiment was spraying with Polist 18 N with silicone. The effects of 4 variants were compared (without spraying, one spray – initiation of vegetation, two sprays – initiation of vegetation and shooting phase, three sprays – initiation of vegetation, shooting phase and earing phase). The experimental plant was Hondia winter wheat cultivar from DANKO Plant Breeder. Significant yield of winter wheat increase was obtained following three sprayings with Polist 18 N with silicone. The obtained results indicate the possibility of further increase in yield following the fourth spraying in the grain maturity phase. The introduction of a dose of 400 g SiO<sub>2</sub> per hectare (three sprayings) resulted in significant changes in the qualitative characteristics of winter wheat grain cultivar Hondia and flour. There was an increase in the gluten content, value of sedimentation index, quality number and dough development time. The obtained results show that the application of Polist 18 N with silicone to winter wheat is substantiated.

**Keywords:** silicone fertilization, Polist 18 N with silicone, Hondia wheat cultivar

### INTRODUCTION

Foliar fertilization is an efficient measure aimed at improving and increasing crop yield. Foliar fertilizers are characterised by a sufficiently high content and adequate combination of nutrients available for quick uptake and distribution by plants. Modern agriculture, particularly cereals cultivation, increasingly relies on foliar fertilization.

Silicon is the second most abundant element in soil, 50-70% of soil is silicon dioxide. All plants rooted in soil contain a certain amount of silicone

in their tissues. Plants require some amounts of silicone in soil, in the form of monosilicic acid, for proper functioning [Kowalska et al. 2018]. Until recently, silicone was neglected in fertilization treatments. Nowadays, it is considered to be a beneficial, and even essential, element for plants [Ma and Yamaji 2008]. The highest amount of silicone is accumulated by cereals – approx. 3%. Various authors emphasize the role of silicone in increasing the plant resistance to stress [Tuna et al. 2008, Sacala 2009]. The literature on the subject indicates that silicon supports the plant growth by stimulating the plant development and

decreasing the pathogen and pest risk, owing to the characteristics of silicone, which stimulates the formation of strong cell walls, thus increasing their durability and stiffness [Ma and Yamaii 2006, Kowalska et al. 2018, Radkowski and Radkowska 2018].

Liquid foliar fertilizer concentrate Polist 18 with silicone (N 18%, SiO<sub>2</sub> 2%, K 0.7%) accelerates plant regeneration following winter damage. The addition of Polist 18 with silicone to the working fluid results in improved hydration and, consequently, better permeability of plant epidermis (cuticle) which increases the uptake of nutrients as well as improves the activity of pesticides and foliar microelement fertilizers. It can be applied as a foliar fertilizer, as well as in pre-sowing and top dressing fertilization. The preparation is one of the fertilizers which, when applied correctly, does not cause plant burn.

The aim of the conducted field experiment was efficacy assessment of foliar fertilization of *Hondia* winter wheat cultivar. The conducted studies concerned wheat yield, the characteristics of grain including the macroelement content and the parameters of the obtained flour.

## METHODOLOGY

### The characteristics of the experiment

The field experiment was conducted in the growing period of 2018/2019 in Lipnik (53°41'N, 14°97'S), at the Agricultural Experimental Station belonging to the West Pomeranian University of Technology in Szczecin. The experiment was conducted on light soil of good rye complex, belonging to IV b bonitation class (USDA 2006). The soil was brown earth, acidic (pH<sub>KCl</sub> 5.0), originating from light loamy sand with a humus layer of a depth of 20–25 cm. The soil abundance in phosphorus and potassium is of average level and the humus content in arable layer amounts to approx. 1.60–1.70%.

The factor under study in the present experiment was spraying with Polist 18 N with silicone. The subsequent doses were 10, 5 and 5 dm<sup>3</sup> per hectare. The effects of 4 variants were compared (without spraying, one spray – initiation of vegetation, two sprays – initiation of vegetation and shooting phase, three sprays – initiation of vegetation, shooting phase and earing phase). The experimental plant was *Hondia* winter wheat

cultivar from DANKO Plant Breeder, characterised by good qualitative parameters of grain with high technological parameters. In Poland, the quality was evaluated as belonging to group A, and was entered into the National Register in 2014. The recommended seed rate is 320–350 germinating seeds per 1 m<sup>2</sup> (approx. 170–190 kg ha<sup>-1</sup>) [<https://danko.pl/odmiany/hondia/>].

The winter wheat seeding date was the third decade of September 2018. The previous crop was oat harvested at grain full maturity. Following the harvest of the previous crop, stubble disking was performed. Four weeks before the planned wheat seeding date, the cultivation practices were carried out using a tiller at the depth of approx. 22 cm. Prior to seeding, basic fertilization with Polifoska 6 in the amount of 300 kg ha<sup>-1</sup> was carried out, and the cultivation practices were conducted using a tiller at the depth of approx. 8 cm. The seeding date was September 28<sup>th</sup>, and the seeding was carried out using Haldrup seed drill, providing 340 seeds per m<sup>2</sup>. When at least three true leaves were developed, wheat was treated with a Bizon herbicide in the amount of 1 dm<sup>3</sup> ha<sup>-1</sup>. In accordance with the applicable law, three doses of nitrogen were applied in the amount of 50 kg ha<sup>-1</sup> each: the first in the spring of 2019, around March 1, to obtain canopy uniformity and wheat tillering; the second at the beginning of the shooting phase to ensure good plumpness of the grain; the third determining the quality of the grain, at the beginning of wheat earing phase [Journal of Laws of 2018, item 1339, Journal of Laws of 2018, item 1438]. Wheat was harvested using Wintersteiger plot combine on the area of 15 m<sup>2</sup>, converting the results to dt ha<sup>-1</sup>.

### Chemical analyses

Prior to the harvest, the samples of plants were taken for the purpose of the assessment of the yield components. The height of plants was identified with measuring 20 plants on each plot in full maturity phase (BBCH 89). The length of ear was determined with a sample of 20 ears selected at random. In the growing period, the chlorophyll content was determined using a photo optical method with a Minolta Spad 502 chlorophyll meter, 10 measurements for each variant. The leaf area index (LAI) was identified with the Ceptometer Accu Par, 5 measurements for each variant. The weight of 1000 grains (MTZ) was identified [PN-68/R-74017:1968]. The falling number (LO) was determined using Hagberg-Perten method,

according to ISO 3093:2010. Mass per storage volume, the so-called hectolitre mass, was calculated according to ISO 7971-3:2010.

After mineralization of the grain in the solution of sulphuric(VI) acid in combination with  $H_2O_2$ , the nitrogen content was determined using the Kjeldahl method [ISO 20483:2014-02P]. In order to determine the total macro component content, the grain samples were mineralised in the mixture of nitric(V) acid and chloric(VII) acid in proportion 1:1 [ISO 6869:2000]. After mineralisation of the samples, the phosphorus content was determined using colimetric determination [ISO 6491:2000P], whereas the contents of potassium, calcium and magnesium were determined with the use of Atomic Absorption Spectrometer (Thermo Fisher Scientific iCE 3000 Series).

Grain milling was carried out with a 6 roller laboratory mill by the Research Institute for Baking Industry in Bydgoszcz. The obtained flour was sifted with a laboratory sifter of adequate aperture size (265  $\mu\text{m}$  – farinographic assessment, 230  $\mu\text{m}$  – gluten content, 150  $\mu\text{m}$  – sedimentation index). The analysis of the baking value of grain was conducted on the samples with two replicates. The flour sedimentation value by the Zeleny method was determined according to ISO 5529:2010E, using the apparatus consisting of the measurement panel and a shaker SWD type – 89 Sadkiewicz. The analysis of the farinographic characteristics of flour and dough from Hondia winter wheat cultivar was conducted with Farinograph Brabender apparatus using the head of type 50, according to ISO 5530-1: 2015-01. The following parameters were determined: water absorption, dough development and stability time, and dough softening after 10 min. The gluten content was identified according to ISO 21415-2:2015 with a Gluten Index Perten device. For this purpose, a sample of flour

was sifted with a sifter of 230  $\mu\text{m}$  in aperture size and supplemented with 2% brine. Next, the resulting gluten was weighted, the result was multiplied by 10; then total gluten mass was identified and expressed as a percentage.

### Statistical analysis

The results were statistically developed using analysis of variance in one-factor random blocks design. Confidence half-intervals were calculated with Tukey's multiple test, the adopted significance level was  $p=0.05$  [Hill et al. 2006]. The statistical analysis of the results was conducted with Statistica 10.0 software.

## RESULTS AND DISCUSSION

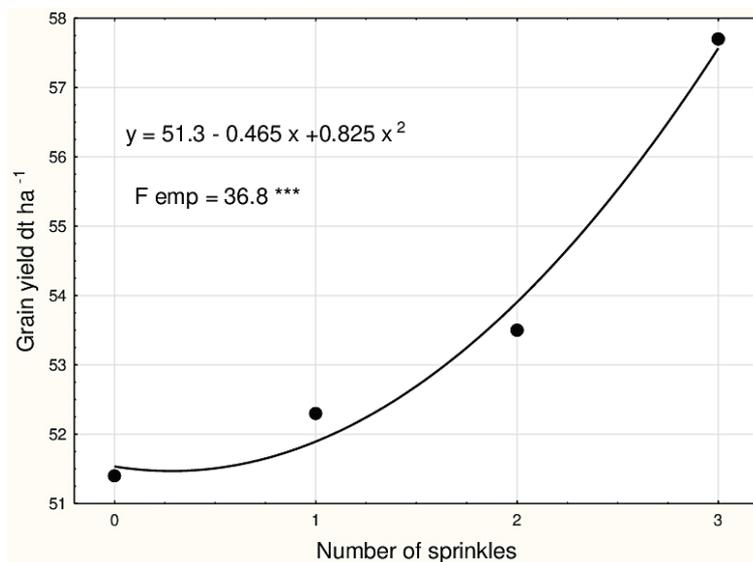
### Yield and elements of grain yield structure of winter wheat and physiological indices

In comparison with the control, a significant increase in yield was found following the application of three sprays with Polist 18 N with silicon, amounting to 12.2% yield increase. The course of the regression line markedly shows the possibility of further increase in yield following spraying in the milk or dough stage of grain (Table 1, Fig. 1). Numerous studies confirm the findings that fertilization with silicone has a beneficial effect on wheat growth and yield [Ahmad et al. 2007, Abro et al. 2009, Hellal et al. 2012, Laane 2017]. However, the literature on the subject also contains contrary information on the lack of the effect of foliar silicone fertilization on yield and quality of grains [Segalin et al. 2013].

Out of the analysed elements related to the grain yield structure of winter wheat, statistically

**Table 1.** Yield and elements of grain yield structure of winter wheat and physiological indices

Characteristic	Unit	Number of sprays with Polist 18 N with silicone				Mean	NIR <sub>0,05</sub>
		0	1	2	3		
Yield	dt·ha <sup>-1</sup>	51.4	52.3	53.5	57.7	53.7	2.05
Number of plants	Item·m <sup>-2</sup>	330.0	332.0	334.0	334.0	332.5	n.s.
Number of ears	Item·m <sup>-2</sup>	410.1	460.1	466.4	470.7	451.8	58.47
Number of grains	item	31.0	27.9	28.0	29.8	29.1	n.s.
MTZ	g	40.9	41.0	41.1	41.2	41.0	n.s.
Ear length	cm	9.58	9.29	9.73	9.74	9.58	0.44
Plant height	cm	86.8	84.9	86.6	87.4	86.4	n.s.
LAI	m <sup>2</sup> ·m <sup>-2</sup>	1.08	1.39	1.45	1.57	1.37	0.06
SPAD	–	38.8	40.0	43.3	44.2	41.6	1.82



**Figure 1.** Relationship between yield ( $y$ ) and the number of wheat plant spraying ( $x$ )

confirmed differences were found only with respect to the number of ears per area unit. In comparison with the control, a significantly higher, i.e. by 15%, number of ears was found following three sprays with Polist 18 N with silicone (Table 1).

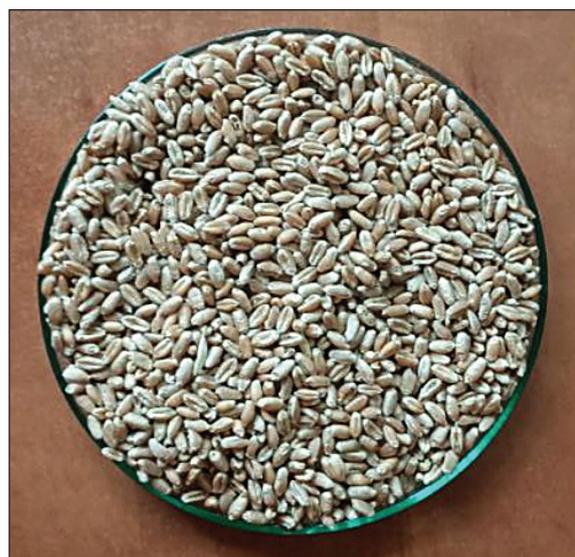
The weight of 1000 grains indicates grain plumpness and storage capacity of grain. The study by IUNG states that Hondia wheat cultivar is characterised by high MTZ value, amounting to 41.9 g [Jończyk 2018]. In comparison with the results of the present analysis, the mean MTZ was very similar, i.e. 41.0 g. The applied spraying with Polist 18 N with silicone did not result in changes of the parameters characteristic for yield structure, such as: the number of ears, the number of plants, the number of grains, plant height, the length of ear and MTZ – no changes were observed (Table 1, Fig. 2). Conversely, the study by Kowalska et al. [2018] using the ZumSil fertilizer demonstrates an increase in values regarding the emergent crop density, the height of plants and ear density.

Significant differences were reported with respect to leaf area index (LAI) and leaf greenness index (SPAD). The analysis of LAI shows that each subsequent dose of fertilizer resulted in a significant increase of the said parameter (maximum 45%). The changes in SPAD values were similar; however, the maximum increase was only 14% (Table 1).

Foliar fertilization in the form of sprays with Polist 18 N resulted in the changes of the nitrogen and phosphorus content in winter wheat grain (Table 2). A significantly higher amount of nitrogen was identified in the grain collected from

the objects subjected to two and three sprayings. Only with two sprayings, the increase in the phosphorus content in wheat grain was significant, approx. 30% (Table 2). In this case, the content of phosphorus was 5.06 g P kg<sup>-1</sup>.

The hectolitre weight is an increasingly important qualitative parameter of cereal grain. The higher the coefficient value, the better the quality of grain. The values of the said parameter over 76 kg/hl<sup>-1</sup> for wheat grain indicate its high plumpness and uniformity. The grain of Hondia wheat grain cultivar Hondia is characterised by hectolitre weight higher than 76 kg/hl<sup>-1</sup>. Falling number is a characteristic determining the storage



**Figure 2.** Photography of winter wheat grain cultivar Hondia

**Table 2.** The effect of spraying with Polist 18 N with silicone on the chemical composition of wheat grain

Element	Unit	Number of sprays with Polist 18 N with silicone				NIR <sub>0.05</sub>
		0	1	2	3	
Nitrogen	g·kg <sup>-1</sup>	27.3	27.7	28.7	30.1	0.83
Phosphorus		3.91	4.09	5.06	4.22	0.529
Potassium		4.52	4.47	4.24	4.36	n.s.
Magnesium	mg·kg <sup>-1</sup>	933	924	936	903	n.s.
Calcium		268	271	227	249	n.s.

viability and technological suitability of grain [Knapowski et al. 2015]. In the present study, the falling number of winter wheat ranged from 397 to 428, which indicates its high suitability for food purposes. The application of Polist 18 N with silicone in the form of spraying showed no effect on the changes in the hectolitre weight and the falling number of wheat grain.

The gluten content is an important index of both technological quality as well as nutritional value of wheat. The gluten content determined in Hondia winter wheat grain cultivar, amounted to 40.3%, on average. Only the application of three sprayings resulted in a significant 11% increase of the gluten content in grain. Gluten weakening, gluten index and water absorption of flour showed no changes due to the application of Polist 18 N with silicone (Table 3).

Mean value of the sedimentation index of Hondia wheat cultivar grown in the present experiment was 23.1 cm<sup>3</sup> and was higher than the threshold value i.e., 20 cm<sup>3</sup> [Podolska and Sułek 2003]. Similarly to the gluten content, three sprayings with Polist 18 N with silicone caused a significant increase in the sedimentation index,

dough development time and the quality number by 24%. The results obtained in the present experiment show that only the introduction of a dose of 400 g SiO<sub>2</sub> per hectare resulted in the qualitative changes of wheat grain and flour.

Foliar fertilization with Polist 18 N with silicone showed no significant modifications of the three parameters of flour: water absorption, dough stability and dough softening jB (Table 3).

## CONCLUSIONS

Significant yield increase was obtained following three sprayings with Polist 18 N with silicone. The obtained results indicate the possibility of further increasing the yield following the fourth spraying in the grain maturity phase.

The introduction of a dose of 400 g SiO<sub>2</sub> per hectare (three sprayings) resulted in significant changes in the qualitative characteristics of the grain and flour of Hondia winter wheat. There was an increase in the gluten content, value of sedimentation index, quality number and dough development time.

**Table 3.** The effect of the application of Polist 18 N with silicone on qualitative characteristics of wheat grain and flour

Characteristic	Unit	Number of spraying with Polist 18 N with silicone				NIR <sub>0.05</sub>
		0	1	2	3	
Hectolitre weight	kg·hl <sup>-1</sup>	76.5	76.2	77.4	76.4	n.s.
Falling number	s	406	415	428	397	n.s.
Gluten content	%	38.3	40.4	40.1	42.6	2.21
Gluten weakening	mm	1.75	1.5	1.5	2.75	n.s.
Gluten index	%	50.9	48.0	52.1	50.6	n.s.
Sedimentation index	cm <sup>3</sup>	20.8	23.6	22.1	25.8	2.81
Water absorption of flour	%	57.8	58.7	58.3	58.0	r.n.
Dough development time	min	2.86	3.0	3.4	3.55	0.641
Dough stability	min	4.80	5.1	5.4	5.96	1.32
Dough softening jB	-	88.9	87.0	80.5	82.0	n.s.
Quality number	-	59.8	62.8	66.0	73.5	6.82

The obtained results show that the application of Polist 18 N with silicone to winter wheat is substantiated.

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