The influence of Fulvic Acid (AGT-50) on Spring Cereals and Sugar Beets Seed Germination and Plant Productivity

In a recent scientific study the influence of naturally occurring fulvic acids (AGT-50) on the germination of spring wheat and barley and sugar beet seeds, development of plants and their yield and quality, was investigated. The use application of AGT-50 for seed dressing reliably increased the final germination percentage and decreased the mean germination time in spring wheat, spring barley, and sugar beet. It significantly reduced the number of spring wheat sprouts damaged by *Fusarium* sp. and the number of spring barley sprouts damaged by *Fusarium* sp. and *Microdochium nivale*. AGT-50 increased the length of spring wheat and barley shoots and the air-dry weight of shoots and roots. The use of AGT-50 during plant vegetation reliably increased spring wheat grain yield and sugar beet roots yield, and improved yield quality. Combinations of AGT-50 with fungicides as a seed treatment were also investigated.

Fulvic acids, such as those found in AGT-50, make up an important part of soil organic matter. They contain macro and micro elements and amino acids. Fulvic acids improve the absorption of nutrients from the soil and act as a carrier of substances from the surface of plant organs to plant cells. Owing to their low molecular weight, fulvic acids can penetrate the pores of membranes, while also transporting nutrients, i.e. they act as natural chelates [1, 2]. Also, due to their low molecular weight, fulvic acids can remain in the soil solution even at high salt concentrations and over a wide pH range. These acids promote the growth of lateral roots and shoots, improve the quality parameters of plant yield [3-6]. The positive effects of fulvic acids are particularly manifested in drought conditions [7-10]. Seed germination and seedling growth characters are extremely important factors in determining yield. The use of fulvic acids for soaking or dressing seeds improves seed germination and decreases damage diseases of sprout often caused by fungal pathogens [11, 12]. The composition of AGT-50 used in this study includes fulvic acid 4.50%, humic acid 0.15%, 13 organic acids, 18 amino acids and over 70 micronutrients, pH 3.2–3.9 (www.AgTonik.com).

Germination Study

The germination study was carried out on spring wheat ('Quintus' variety), spring barley ('Grace' variety), and sugar beet ('Lavenda' variety). Seeds were sown in germination boxes on filter paper (for the determination of germination and damage diseases) and in soil (for the determination of shoot and root weight). 100 seeds were sown in the box.

Cereal seed treatments:

• Control sprayed with water (12.5 Liters per tonne).
• Sprayed with AGT-50 (2.5 liters AGT-50 per tonne and 10 liters water per tonne)
• Seeds coated with fungicide plus AGT-50 (2.5 liters AGT-50 per tonne and 10 liters water per tonne)
• Seeds coated with fungicide

Sugar beet seed treatments:

• Control sprayed with water (12.5 Liters per tonne).
• Sprayed with AGT-50 (2.5 liters AGT-50 per tonne and 10 liters water per tonne).

Germination was performed in a thermostat at 20 °C. Germination of spring cereals and sugar beets were counted every 2 days after sowing. Final seed germination was counted 10 days after sowing. The parameters used to compare the germination data for representation were as follows: Final Germination Percentage (FGP); Germination Rate Index (GRI); Germination Index (GI); Coefficient of Velocity of Germination (CVG); Mean Germination Time (MGT).

The final germination percentage (FGP) of spring wheat ranged from 90.3% to 95.8% (Table 1). The highest FGP was found after seed dressing with fulvic acids. This difference compared to the control was statistically significant. The highest germination index (GI) and germination rate index (GRI) were found after seeds were treated with AGT-50.

The use of fulvic acids (ATG-50 a.k.a MLG-50/Mineral Ful) for seed dressing reliably increased the final germination percentage and decreased the mean germination time in spring wheat, spring barley, and sugar beet (Table 1). It significantly reduced the number of spring wheat sprouts damaged by *Fusarium* sp. and the number of spring barley sprouts damaged by *Fusarium* sp. and *Microdochium nivale* (Figure 1).

When calculating the final seed germination, the rate of seed damage by fungal diseases was performed (Figure 1). Spring wheat seeds were not severely infected by fungal diseases; therefore, not many of those diseases were found during germination: 0.8%–3.8% of sprouts were found to be affected by *Fusarium* sp. and 1.0%–2.7% by *Microdochium nivale.* The smallest portion of diseased sprouts were found in those germination boxes in which the sown seeds were treated with fungicide and with fungicide in combination with AGT-50. The use of AGT-50 reduced the amount of *Fusarium* sp. by 52.6% compared to the control. The effect of AGT-50 on

Microdochium nivale was smaller. The number of sprouts damaged by *Microdochium nivale* decreased by 25.9% compared to the control (Figure 1).

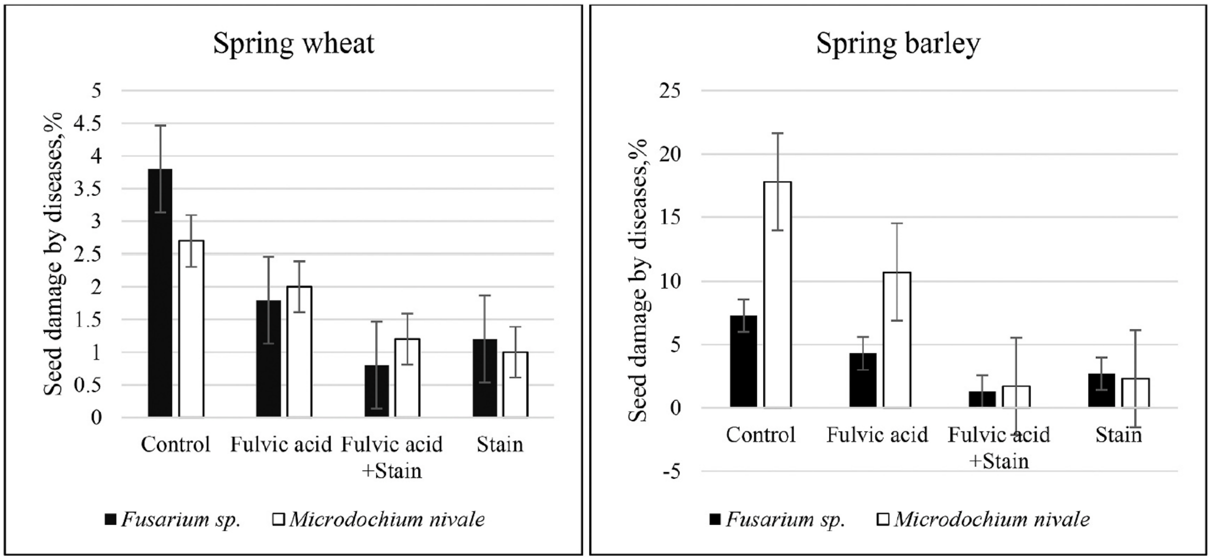
Spring barley sprouts were significantly more affected by diseases: in the control treatment 7.3% of sprouts were damaged by *Fusarium* sp. and 17.8% by *Microdochium nivale*. As in the study of spring wheat, the diseases of barley sprouts were best reduced by seed treatment with fungicide and by seed treatment with fungicide used in combination with AGT-50: *Fusarium* sp. was reduced by 63.0%–82.2% and *Microdochium nivale* by 87.1%–90.4% compared to the control. AGT-50 reduced the number of diseased sprouts by 41.1%–39.9% (Figure 1).

The treatment of sugar beet seeds with AGT-50 increased the FGP by 4.2%, GRI by 16.9%, GI by 22.0%, and CVG by 11.0%, while MGT decreased by 9.8%. Increases in FGP, GRI and GI were statistically significant (Table 1).

Table 1. The Influence of Fulvic Acid (AGT-50) on Seed Germination

Treatment	Final germination percent, %	Germination rate index	Germination index	Coefficient of velocity of germination	Mean germination time, day
Spring wheat					
Control	90.3	22.8	627.5	24.7	4.0
Fulvic acid	95.8	24.4	667.0	24.7	4.0
Fulvic acid + Stain	92.7	21.5	599.9	22.1	4.5
Stain	92.2	18.7	526.6	18.8	5.3
LSD_{05}	4.82	2.93	66.13	3.55	0.89
Spring barley					
Control	84.3	12.8	347.3	14.5	6.9
Fulvic acid	86.8	18.0	466.7	17.6	5.7
Fulvic acid + Stain	86.3	16.3	419.6	15.8	6.3
Stain	80.5	14.9	396.4	16.1	6.2
LSD_{05}	3.86	2.76	52.24	2.08	0.75
Sugar beet					
Control	87.8	16.0	430.8	16.4	6.1
Fulvic acid	91.5	18.7	525.6	18.2	5.5
LSD_{05}	3.68	2.56	93.72	1.81	0.67

Figure 1. The Influence of Fulvic Acid (AGT-50) and Chemical Stain (Fungicide) on Wheat and Barely Seeds Damaged by Fungal Diseases.



Field Study

Field experiment was carried out in spring wheat and sugar beet crops. Soil was with predominant silt loam on clay loam. The top of the carbonate horizon and the gleyicity traces were determined at the 60 cm depth. The pH value in the arable soil layer ranged from 6.4 to 6.6. Soil pH was determined in 1 N KCL extraction using a potentiometric method. The content of plant available P_2O_5 at the 0–20 cm layer was 239.0–268.0 mg kg $^{-1}$ and the content of plant-available K_2O was 183.0–194.0 mg kg^{-1}.

A spring wheat cultivar ‘Quintus‘ was grown, the seed rate was 4.0–4.5 million ha $^{-1}$. The sowing was carried out on 10–11 April. Preceding crop – sugar beets. Spring wheat was grown according to intensive technology, N60 P60 K60 fertilizers were applied before crop sowing and N90 during vegetation. Spring wheat was harvested on 14–24 August. In addition, the AGT-50 fulvic acid preparation was used in the study fields twice during plant vegetation: spring wheat in the tillering (BBCH 29-30) rate 2.0 l ha^{-1}, and flag leaf stages (BBCH 39) rate 1.0 l ha^{-1}.

Before harvesting, cereals samples were taken from four spots of each plot within 0.25 m^2 area for determining biometric indicators.

A sugar beet cultivar ‘Lavenda’ was grown. The crop was sown on 15–20 April with a drill at a sowing density of 6–7 pelleted seeds per longitudinal meter with 45 cm interrow width. N160 P80 K150 fertilizers were applied before crop sowing. AGT-50 was applied in the stage of the 6th–8th leaves (BBCH 16-18) at a of rate 2.0 l ha^{-1}, and before the leaves cover interrows (BBCH 31-35) at a rate of 1.0 l ha^{-1}.

Application of ATG-50 increased the length of spring wheat and barley shoots and the air-dry weight of shoots and roots (Table 2). The use of AGT-50 in spring wheat crop during plant vegetation increased the number of productive stems of spring wheat by 30%, reliably increased grain yield, and improved grain quality (Table 3).

Table 2. The Influence of Fulvic Acid (AGT-50) and Chemical Stain (Fungicide) on Cereals Shoots and Roots.

Treatment	Spring wheat			Spring barley		
	Shoots height, cm	Air-dry mass of shoots, g	Air-dry mass of roots, g	Shoots height, cm	Air-dry mass of shoots, g	Air-dry mass of roots, g
Control	20.7	1.6	2.2	16.7	1.2	2.2
Fulvic acid	21.3	1.8	2.7	17.4	1.4	2.6
Fulvic acid + Stain	15.2	1.5	2.6	16.2	1.3	2.6
Stain	15.7	1.4	2.5	15.8	1.1	2.4
LSD_{05}	2.01	0.21	0.46	1.79	0.14	0.35

Spring Wheat

In the spring wheat crop, AGT-50 application reliably increased the number of productive stems (Table 3). AGT-50 had no effect on the number of grains in the head but, due to an increase in productive stems, the use of AGT-50 increased the number of grains per unit area by 37.7% compared to the reference fields. The grain yield also increased reliably. The 1000-grain weight in the fields where AGT-50 was used was lower than that in the reference ones. This effect was caused by an increase in the number of productive stems: the plants lacked nutrients when a larger quantity of grain was grown. AGT-50 field application had a positive effect on the quality of wheat grains: protein content increased by 7.1%, gluten by 8.5%, and sedimentation by 22.7% (Table 3).

Table 3. The Influence of Fulvic Acid (AGT-50) on Spring Wheat Indicators, Grain Yield and Quality.

Treatment	Number of productive stems per m^{-2}	Number of grains per ear	Number of grains per m^{-2}	Yield, %	1000 grain weight g	Crude protein, %	Gluten, %	Sedimentation, mm
Control	296.3	19.6	5808	100.0	34.04	9.8	16.5	23.3
Fulvic acid	406.0	19.7	7998	114.7	33.09	10.5	17.9	28.6
LSD_{05}	26.51	0.91		11.26	0.953	0.56	0.14	0.38

Sugar Beet

The use of fulvic acid twice during the vegetation of beet significantly increased the yield of sugar beet roots (Table 4). An increase of 7.04 t ha^{-1} of beet root vegetables was obtained in the sprayed area. There was also an increase in root size and sugar content. The use of AGT-50 in combination with pesticides used in sugar beet crops improved the action of those pesticides, so it was possible to reduce the rates used, thus reducing environmental pollution.

Table 4. The Influence of Fulvic Acid (AGT-50) on Sugar Beet Roots and Quality

Treatment	Yield t ha^{-1}	Mass of one root, kg	Sugar content %
Control	89.54	0.957	15.06
Fulvic acid	96.58	1.098	15.30
LSD_{05}	4.094	0.1424	0.321

Conclusions

The use of AGT-50 for seed dressing reliably increased the final germination percentage and decreased the mean germination time in spring wheat, spring barley, and sugar beet. It significantly reduced the number of spring wheat sprouts damaged by *Fusarium* sp. and the number of spring barley sprouts damaged by *Fusarium* sp. and *Microdochium nivale*. AGT-50 increased the length of spring wheat and barley shoots and the air-dry weight of shoots and roots.

The use of AGT-50 in spring wheat crop during plant vegetation increased the number of productive stems of spring wheat by 30%, reliably increased grain yield, and improved grain quality.

Sugar beet yield increased by 7.04 t ha^{-1} and root sugar content also increased.

The use of fulvic acids in combination with pesticides used in sugar beet crops improved the action of those pesticides, so it was possible to reduce the rates used, thus reducing environmental pollution.

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