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The Effect of Magnetic Field on Growth, Development and the Yield of Spring Wheat

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Abstract

A pot experiment carried out in a greenhouse in 1999-2000 was aimed at finding the effect of a constant magnetic field on the root system and green tops, as well as on yield of spring wheat. In all cases there was observed a slight stimulating effect of the factors examined. The growth dynamics were weakened. The plants were shorter, and so were their culms and ears. Moreover, the effect of a magnetic field on the crop of spring wheat and its structure was small.

Keywords: magnetic field, growth and development, spring wheat.

Introduction

Agricultural sciences take an interest not only in the common and valued crop-forming factors, but also in those less expensive and generally underestimated, though more pro-ecological ones, such as ionizing, laser or ultraviolet radiation, and electric and magnetic fields. From among these the least troublesome and expensive, and at the same time not dangerous to the environment, seems to be biostimulation with magnetic field. Pending the vegetation of plants there occur several complicated physical, chemical and electrochemical processes. The particles of lineral and organic substances are in most part of polar structure which, as a basic solvent in nature, determines their magnetic properties. Then it seems that the action of an external constant magnetic field may exert influence on speed and displacement direction of polarized particles of the substances [1]. In consequence it may be decisive concerning the rate and even direction of many vital processes in a plant. A moving electric charge generates a magnetic field around itself (like electron, ion or polarized particle). The organic material of live organisms has a polar structure resulting from numerous polarized chemical bonds; it may - particularly in the presence of dinoles of water molecules and dissociated mineral salts - determine its magnetic properties **[3].** Stimulation of plants with magnetic field, as a way to increase the quantity and quality of yields, has caught the interest of many scientists in all the world [2].

The most important mechanism for transportation of substances essential to life and development of plants is capillary ascent. This phenomenon occurs as a result of the charge maintained on the walls of a capillary being counterbalanced by a contrary charge accumulated in the limiting layer of solution. Formation of so-called double electric layer always occurs in heterogeneous systems as a result of the processes occurring at the phase boundary. Electric double layer is formed due to exchange of energy between both phases, selective adsorption of ions or solvation (hydration) of dipolar particles of solvent (water). The phenomenon is particularly significant when the liquid phase is aqueous solution; it exerts influence on the processes of dispersion of colloids, capillary transportation, membrane processes of exchange, and others. Capillary ascent, being the result of electrostatic interaction of charges, causes transportation of liquid along the capillary (movement of charges - ions). Around such a capillary there would be induced a magnetic field on which it might interact with an external one, thus controlling the velocity or direction of physiological processes in plants, which in turn may influence the rate of their growth and development as well as yield.

The pot experiment carried out in the greenhouse of agricultural experimental station, Agricultural Academy, Wroclaw, was aimed at finding out if there was an influence of constant magnetic field on the root system and green tops, and also on growth and yield of spring wheat.

Method and Descryotion

A strict pot experiment in four replications was carried out in the plant house of Agricultural Experimental Station, agricultural Academy, Wroclaw, in the years 1999-2000. The test plant was spring wheat of the "Igna" variety. PVC pots were filled with 9 kg medium soil of very good rye complex and then weed seeds were sown out at 25 a pot. After emergence the number of plants in each pot was reduced to 15 and around the pots (Fig. 1) there were installed four magnets of isotropic type (F10T) magnetized flat, their poles at both bases. Thus the lines of force ran vertically towards the surface, described a circle whose size depended on the value of remanence and went back to the opposite pole vertically towards the surface. So it may be assumed that in the small distance from the surface the lines of forces are mutually parallel and vertical towards the surface. The distance depends on the power of the magnet, but it is always greatest at the magnet centre, decreasing towards the circumference.

Fertilization with nitrogen at 1 g a pot was applied in two equal doses. Phosphorus and potassium were not applied because of their high content in the soil. All over the period of the experiment soil-moisture was kept at a constant level of 60% maximum capillary water capacity.

Scheme and Reserch Range

Three investigation treatments were taken into account in the experiment:

1. No exposure - without stimulation, with magnetic field (control).
2. Exposure of green tops - magnets acting on the green top of plant (four permanent magnets put around the green top over all period of its vegetation).
3. Exposure of roots - magnets acting on the root system (four magnets of permanent magnetic field put uniformly around the pot over all period of vegetation).

To catch the effect of the experimental agents on the plants there was determined the growth dynamics, and after harvest biometric measurements were made and basic yield-forming factors determined.

Results

The effects of biostimulation of spring wheat green tops in the initial stage of development were small (Tab. 1). The growth of plants got slightly weakened and from the stage of the 1st node there was observed a significant influence of that factor on diminished height of plants in further developmental stages. Much more explicit action of magnetic field was observed when it was aplied to the root system.

Biostimulation of green tops or root system of plants brought about a dimishment of their height by respectively 8 and 11% in relation to control treatment. Biostimulation significantly influenced the height of plants (Tab.2). In the case of biostimulation of green tops the length of culms got shortened by about 6% as compared with those not stimulated. Still more shortened they were (by 8.9% on average) with biostimulation of the root system. Now, the length of main and side ears appeared to depend little on the factors of the experiment.

Table 2. Length of culm and ears [cm].

Treatment	Culm lenght		Ears lenght	
	main	side	main	side
No exsposure	76.3	67.2	8.6	7.4
Exsposure of green tops	71.5	61.5	8.8	7.2
Exsposure of roots	68.2	59.2	8.6	6.8
$LSD_{0.05}$	3.9	4.0	r.n.	0.4

r.n. - not significant difference

The effect of biostimulation on green tops yielded a 4% increase, while with biostimulation of the root system it decreased by 8.5% (Tab. 3). However, statistical analysis did not confirm a significant difference in the yields of grain and straw from a pot.

Table 1. Height of plants [cm].

Treatment	Tillering	Shooting	I node	II node	Heading	Flowering
No exposure	23.2	39.3	43.9	54.4	57.0	71.4
Exposure of green tops	22.8	38.9	45.7	54.3	52.2	64.5
Exposure of roots	20.7	34.0	44.8	54.0	47.1	58.8
$LSD_{0.05}$	1.0	1.6	0.7	r.n.	1.9	3.1

r.n. - no significant difference

The effect of stimulation by a magnetic field on the shape of grain was small (Tab. 4). In relation to control treatment, the exposure of green tops and root systems brought about increased quantity of coarse grain (2.75 mm) by 10.6 and 6.3%, respectively, while that of fine grain decreased.

Table 3. Grain and straw yield from a pot [g].

Treatment	Yield		
	grain	straw	total
No exposure	46.6	45.2	91.8
Exposure of green tops	48.5	47.1	95.6
Exposure of roots	42.6	46.1	92.3
$LSD_{0.05}$	r.n.	r.n.	r.n.

r.n. - no significant difference

Correlation Coefficients

In order to better describe the effect of stimulation of roots and aboveground plant parts with magnetic field on examined traits, correlation coefficients between influence of magnetic field and a single trait are presented. The coefficients point to a significant correlation between the factors applied and the factors examined. As for the height of plants, significance of correlation was found in almost all the developmental stages of the plants examined (Tab. 5). The very high value of the coefficients should be emphasized, testifying to the interdependence between the factor applied and the value of the feature examined. Correlation between the lengths of culms and ears was clearly weak (Tab. 6). In the case of culms and nain ears the coefficients were in most cases high, too. Generally, growing of plants was not correlated with experimental factors. The mass of ears and of their grain as

Table 4. Grain fractions [%].

Treatment	Mesh diameter [mm]					
	> 3.0	3.0 – 2.75	2.75 – 2.50	2.50 – 2.30	2.30 – 1.7	< 1.7
No exposure	16.1	30.9	24.7	18.5	7.8	2.0
Exposure of green tops	19.6	32.8	22.7	15.8	7.3	1.8
Exposure of roots	16.5	33.7	24.5	16.4	6.9	2.0

Table 5. Correlation coefficients for height of plants.

Treatment	Height of plants [cm]					
	Tillering	Shooting	I node	II node	Heading	Flowering
Exposure of roots	**0.88**	**0.81**	**0.86**	**0.90**	**0.98**	**0.89**
Exposure of green tops	**0.81**	**0.95**	**0.91**	**0.95**	**0.97**	**0.92**

* Coefficient values printed in bold type are correlated Table 6.

Table 6. Correlation coefficients for length of culms and ears.

Treatment	Ear length			Number of culms			Tillering	
	culms main	ears main	culms side	main	side	barren	full	effective
Exposure of roots	0.19	**0.80**	–0.11	0.53	**0.77**	0.33	0.57	0.05
Exposure of green tops	0.52	**0.73**	0.20	**0.82**	**0.82**	0.15	0.75	0.59

* Coefficient values printed in bold type are correlated

Table 7. Correlation coefficients for the number and mass of ears and grain from a pot.

Treatment	Mass of ears			Mass		
	main	side	total	grain	straw	total
Exposure of roots	0.24	**0.85**	**0.93**	**0.90**	**0.94**	**0.95**
Exposure of green tops	0.49	**0.96**	**0.97**	**0.98**	**0.89**	**0.98**

* Coefficient values printed in bold type are correlated

well as total mass of ears and grain were significantly correlated, with the experimental factors in all the treatments examined (Tab. 7). Presented correlation coefficients indicate that magnetic field affected plant traits in different ways.

Discussion

The results of three-year investigation into the influence of constant magnetic field on the dynamics of growth, development and yield of spring wheat showed that in general it was not favourable to development and yield of the plant. In most cases wheat plants subjected to biostimulation grew slowly, their growth dynamics having been low particularly in the initial period of vegetation. Different results were obtained by Pittman [12] and Savastin [13]. Contrary to the statements of Lebiediev et al. [7] as well as Pittman et al. [11] the differences did not get blurred with time. They were coming up to successive developmental stages more slowly than plants not subjected to exposure. Mature plants of spring wheat had significantly shorter culms and ears, though their yield was only slightly worse. In literature one can come across results confirming [5, 6] and denying dependence [7]. It should be stressed that comparison of data presented in accessible literature is very difficult because of very different parameters of field intensity applied by the authors. They often differ by several or even several hundred times, thus being uncomparable. So it would seem right to assume so called magnetic exposure dose, as recommended by Pietruszewski [10], which includes time as energy of magnetic field. Only some data found in literature may allow calculating its value by itself. In most cases lack of some experimental parameters renders such calculations impossible and so the results cannot be compared.

Conclusions

1. The effect of magnetic field marked itself in almost all stages of growth and development of spring wheat. The plants were smaller in the initial developmental stages as well as during flowering and harvest. Moreover, its influence on the elements of crop structure and yield of spring wheat was less.

2. Statistical analysis proved in general a significant correlation between the experimental factors applied and the features examined.

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