THE INFLUENCE OF HUMIC FERTILIZER ON MORPHOLOGICAL AND PHYSIOLOGICAL PROPERTIES OF MAIZE CROP, IN THE CONDITIONS OF THE MOLDAVIAN PLATEAU

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Abstract

During 2010-2012 we made a study regarding the influence of a humic fertilizer (Lignohumat) on some morphological and physiological traits of maize. Lignohumat has a high content of humic acid and microelements, acting as a growth stimulent and anti-stress agent for plants. The study was carried out in the pedo-climatic conditions of the Moldavian Plateau, (Ezareni Farm, Iași, 47°5'-47°10' N lat. 27°28'-27°33' E long.), on a 3 - 4 % slope, cambic chernozem with clay-loamy texture. The soil has a medium content of N and P and good content of K, slightly acid pH and 2.5 – 3.0 % humus content. There were applied two treatments with the humic fertilizer, one on seeds with a dose of 100 g/10 l water/t seeds and one on vegetation, on the 3-4 leaves stage, using 60 g/ha / 300 l water. We determined the average number of seeds per cob, average plant height and leaf chlorophyll content. The results of the three experimental years revealed a positive influence of the humic fertilizer on the assessed traits, the differences compared to the control being statistically assured. Compared to the control, which had an average plant height of 178.5 cm, a chlorophyll content of 47.4 CCI and cobs with 508.1 seeds, the variant treated with Lignohumate recorded higher plants (with 8 cm), with better chlorophyll content (3,5 CCI higher) and with more seeds/cob (25,1 more seeds).

Key words: lignohumate, humic fertilizer, maize, morphological properties

Aiken G. R. et al. (1985) cited by Leenheer J. A. (2002) defined humic substances as a general category of organic substances found in the natural environment, being biogenic, heterogenic, with yellow to black colour and high molecular weight.

Humic substances occur as a result of the decomposition of organic residues in soil by synthesis of the products of decay (putrefaction of dead animal and plant tissues). They are produced by organic evolution of mineral materials, and are quantified by the organic carbon increased 1.724 times. This coefficient is the average ratio of the humus mass and the mean content of carbon in humus: 100: 58% C = 1.724 *(Borlan Z., şi colab., 1994)*.

Morard P. et al. (2005) cited by Eyheraguibel B. et al. (2008) showed that the humic substances are obtained by the physical and chemical degradation of the homogenous lignocellulosic material. *Oleg Gladkov, Rodion Poloskin (2010)* presented the accelerated humification process of the lingo-sulphonates and the obtaiing of Lignohumate (humic fertilizer). This transformation process of the ligno-sulphonates in humic products is made in 1.5-2 hours in oxidant atmosphere, the whole process being supervised by a special software (*figure 1*).

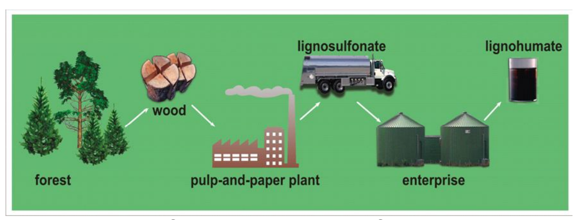

Figure 1 **Manufacturing scheme of Lignohumat (by Oleg Gladkov, Rodion Poloskin, 2010)**

The mineralization of the humic substances is higher in soils with optimum humidity and aeration, compared to soils with high content of clay (>30-35 %) and which are compacted *(Rusu M. et al. (2005), Răus L. et al. (2013).*

Eyheraguibel B. et al. (2008) showed that the humic substances do not increase the percent or the germination rate in maize seeds, but increase the root elongation, due to the water and mineral consumption of the treated plants.

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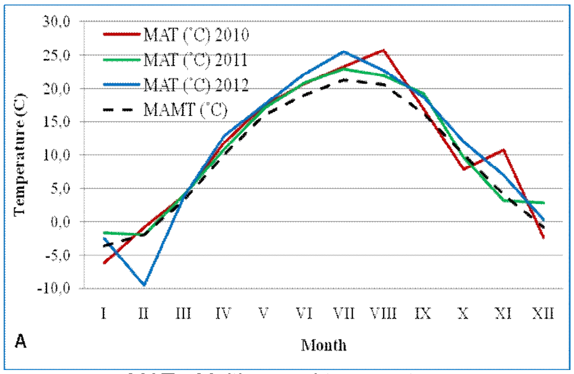
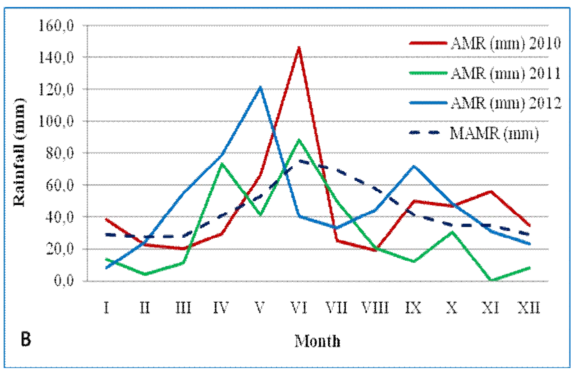
MATERIAL AND METHOD

The study was carried out in the pedo-climatic conditions of the Moldavian Plateau, at the Ezareni Farm, which belongs to UASVM Iaşi. The terrain has a slope of 3-4 %, the soil being a cambic chernozem, with medium to good fertility (medium content of nitrogen and phosphor and good content of potassium), with 2.5 – 3.0% humus and low acid pH. In *figure 2* are represented the climatic conditions for the analyzed period of time.



MAT - Multi-annual temperature
MAMT - Multi-annual mean temperature



AMR - Average monthly rainfall
MAMR - Multi-annual mean rainfall

Figure 2 **Characterization of climatic factors for 2010-2012** ***(A – air temperature, B – rainfall)***

The crop technology was specific for maize, with a fertilization of 60 kg/ha a.s. P_2O_5 + 40 kg/ha a.s N before seedbed preparation and 20 kg/ha a.s. N on vegetation at the first mechanical hoeing.

The seedbed was prepared in the sowing day, with the combinatory, and the sowing was carried out with SPC4-FS + U650, using the PR38A24 hybrid from Pioneer.

The sowing was carried out when the soil temperature has reached 10 °C, with heating perspectives, at 8-10 cm depth and 70 cm between rows, with a recommended density of 65000 plants/ha. During the vegetation period, were made one mechanical and two manual hoeings.

Along with the agro-technical measures, there was made a chemical treatment with Dual Gold 960 EC (1,0 l/ha), against the annual monocot and some dicot (*Setaria sp., Echinochloa sp., Digitaria sp., Amaranthus sp., Chenopodium sp., Hibiscus sp.*) and after emergence was applied Dicopur D (1,0 l/ha).

There was made a seed treatment with 100 g Lignohumate in 10 l water / t seeds. On vegetation, was made a foliar treatment, in the 4 leaves stage, with 60 g/ha / 300 l water.

It has been determined the average number of seeds per cob, the average plant height and the chlorophyll content. For the determination of *average plant height* there were made measurements approximately 30 days after sowing, in two vegetation phenophases (early and late July) and at harvesting.

The leaf chlorophyll content was measured using the CCM 200 plus device from *Opti-Science* (*figure 3*).

Figure 3 **Device for determining the chlorophyll content of leaves (http://www.envcoglobal.com)**

It is a device used for measurements in the field and does the precise, reliable and easy determination of the leaf chlorophyll content. It can store up to 4000 measurements, made with a detector with two photo-diodes and absorbance detector.

The determinations were carried out approximately 30 days after sowing, in early and late July, at the upper third, the middle and the lower third of the plants, for a clearer highlight of the Lignohumate influence on the plant development. The data was stored on the internal memory, and after being downloaded on the PC, it was processed using ANOVA and the F test.

RESULTS AND DISCUSSION

Determination of the average number of grains per cob

The average number of grains per cob was influenced by the Lignohumate treatments, the differences between the treated variant and the control being statistically significant in 2010 and 2011 and unassured in 2012. The lowest difference from 2012 (20 grains/cob) was determined by the climatic conditions which have not favor the fertilizer absorption, due to the long periods of hydric stress (*table 1*).

Table 1

The influence of Lignohumat on the average number of grains per cob in maize

Year	Variant	Grains per cob		Difference (no grains)	Significance
		Number of grains	% compared to control		
2010	V_1 – Control (untreated)	540.3	100.0	0.0	Control
	V_2 – Lignohumate*	564.6	104.5	24.3	x
	LSD 5% = 15.8 grains	LSD 1% = 24.8 grains		LSD 0.1% = 42.3 grains	
2011	V_1 – Control (untreated)	536.0	100.0	0.0	Control
	V_2 – Lignohumate*	567.0	105.8	31.0	xx
	LSD 5% = 15.4 grains	LSD 1% = 24.1 grains		LSD 0.1% = 41.1 grains	
2012	V_1 – Control (untreated)	447.9	100.0	0.0	Control
	V_2 – Lignohumate*	467.9	104.5	20.0	
	LSD 5% = 23.2 grains	LSD 1% = 36.4 grains		LSD 0.1% = 61.9 grains	
Average 2010-2012	V_1 – Control (untreated)	508.1	100.0	0.0	Control
	V_2 – Lignohumate*	533.2	104.9	25.1	xxx
	LSD 5% = 3.6 grains	LSD 1% = 5.7 grains		LSD 0.1% = 9.6 grains	

* Lignohumate treatment - 100 g/10 l water/t seeds + 60 g/ha / 300 l water in the 3-4 leaves stage.

The statistical analysis of the mean values for the three experimental years shows a strong influence of the Lignohumate treatments on the average number of seeds per cob. Thus, the number of seeds per cob for the treated variant was 25.1 higher compared to the control, which had 508.1 seeds/cob (*table 1*).

The average number of seeds/cob had higher values for the treated variant compared to the control, especially in the years with relative uniform repartition of rainfall.

Determination of the average plant height

The average plant height was positively influenced by the Lignohumate treatments, being favored by the climatic conditions. The differences between the treated variant and the control were statistically significant in each vegetation stage, with values of 4.5 cm after the plant emergence, 7.4 cm in early July, 9.8 cm in late July and 10.2 cm at harvesting. The control plants had 45.3 cm after emergence, 203.6 cm in early July, 233.0 cm in late July and 232.2 cm at harvesting (*table 2*).

Table 2

The influence of Lignohumat on the average plant height in maize crop – mean values 2010-2012

Vegetation stage	Variant	Plant height		Difference (cm)	Significance
		cm	% compared to control		
Emergence (29.05-05.06)	V_1 – Control (untreated)	45.3	100.0	0.0	Control
	V_2 – Lignohumate*	49.8	110.0	4.5	xx
	LSD 5% = 2.1 cm	LSD 1% = 3.4 cm		LSD 0.1% = 5.7 cm	
Vegetation (01.07-05.07)	V_1 – Control (untreated)	203.6	100.0	0.0	Control
	V_2 – Lignohumate*	211.0	103.6	7.4	xxx
	LSD 5% = 2.5 cm	LSD 1% = 3.9 cm		LSD 0.1% = 6.6 cm	
Vegetation (29.07-31.07)	V_1 – Control (untreated)	233.0	100.0	0.0	Control
	V_2 – Lignohumate*	242.8	104.2	9.8	xx
	LSD 5% = 4.1 cm	LSD 1% = 6.4 cm		LSD 0.1% = 10.9 cm	
Harvest (07.09-27.09)	V_1 – Control (untreated)	232.2	100.0	0.0	Control
	V_2 – Lignohumate*	242.5	104.4	10.2	xxx
	LSD 5% = 2.5 cm	LSD 1% = 3.9 cm		LSD 0.1% = 6.6 cm	

* Lignohumate treatment - 100 g/10 l water/t seeds + 60 g/ha / 300 l water in the 3-4 leaves stage.

The data analysis from *table 2* highlights that the differences between the treated variant and the control were higher at emergence, when the plants were 10.0 % higher than the control. The positive effect of the Lignohumate treatments was slightly decreased in the other vegetation stages, when the plant height was 3.6 % in early July, 4.2 % in late July and 4.4 % higher at harvesting *(table 2)*. This aspect shows that for maize, it is very important the way it starts the vegetation, the advance taken in the first stages regarding the height being cumulated during the whole period of life, for the treated variant.

Approximately 30 days sowing there were recorded the highest differences between the treated variant and the control, because the seed treatments are superior to the foliar ones in vegetation.

The statistical analysis of the mean values for the three experimental years shows a significant influence of the Lignohumate treatments on the average plant height in maize. It reached 186.5 cm for the fertilized variant and 178.5 cm for the untreated control (*table 3*).

Table 3

The average height plant in maize crop – mean values on years and growing stages

Variant	Plant height		Difference (cm)	Significance
	cm	% compared to control		
V_1 – Control (untreated)	178.5	100.00	0.0	Control
V_2 – Lignohumate*	186.5	104.48	8.0	xxx
LSD 5% = 0.8 cm	LSD 1% = 1.2 cm		LSD 0.1% = 2.1 cm	

* Lignohumate treatment - 100 g/10 l water/t seeds + 60 g/ha / 300 l water in the 3-4 leaves stage.

Determination of the leaf chlorophyll content

The leaf chlorophyll content was influenced by the Lignohumate treatments, and the highest differences between the treated variant and the control were recorded in the years with emphasized hydric stress.

The statistical analysis of the mean values for the three experimental years shows a distinct significant difference between the treated variant and the control. The treated plants had an average chlorophyll content of 50.9 CCI, 3.5 CCI higher than the control (*table 4*).

Table 4

The influence of Lignohumat on the chlorophyll content of maize leaves (mean values per plant)

Year	Variant	Chlorophyll		Difference (CCI)	Significance
		CCI	% compared to control		
Average 2010-2012	V_1 – Control (untreated)	47.4	100.00	0.0	Control
	V_2 – Lignohumate*	50.9	107.38	3.5	xx
	LSD 5% = 1.8 CCI	LSD 1% = 2.9 CCI		LSD 0.1% = 4.9 CCI	

* Lignohumate treatment - 100 g/10 l water/t seeds + 60 g/ha / 300 l water in the 3-4 leaves stage.

The leaf chlorophyll content depended also on the plant level at which it was measured, being lower in the upper third.

The climatic conditions have directly influenced the chlorophyll content. In relative normaly years, like 2010 and 2011, the differences between the treated variant and the control ranged between 2.1-1.8 CCI in the upper third of the plant, 4.5-4.0 CCI in the middle and 2.8-2.4 CCI in the lower one. In the less favorable conditions of 2012, the differences were 4.3 CCI in the upper third of the plant, 4.4 CCI in the middle and 5.5 CCI in the lower one (*figure 4*).

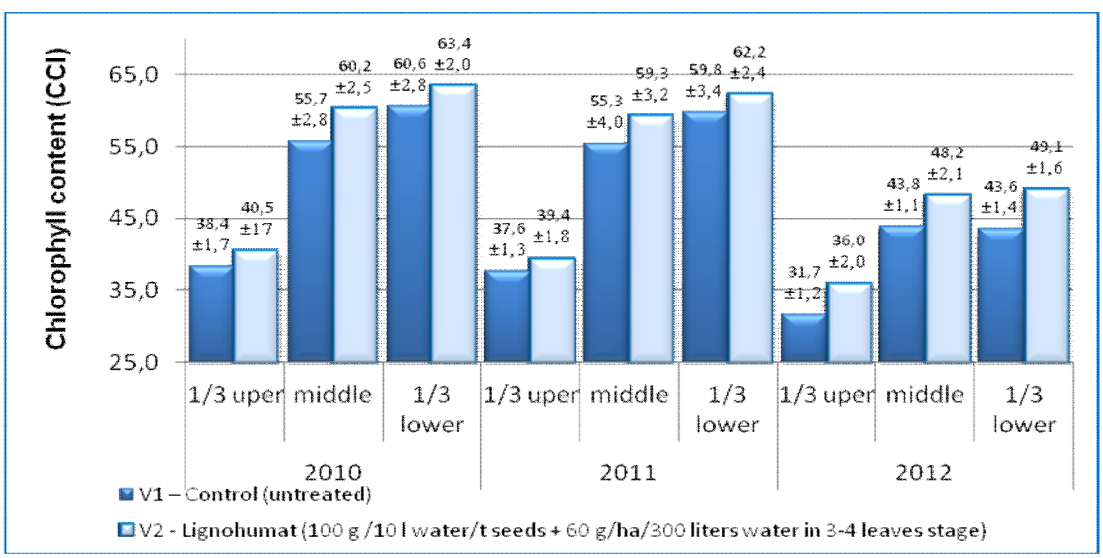


Figure 4 **The chlorophyll content of maize leaves (mean values on growing stages)**

The results of the three experimental years highlight the way in which the Lignohumate reduces the negative effects of stress in plants, contributing to their growth and normal development.

CONCLUSIONS

The humic fertilizer had a positive influence on the number of seeds per cob, average plant height and leaf chlorophyll content. Thus, we can say that it has perspectives of being successfully used in the classical maize crop technology.

The perspective of this humic fertilizer is to be tested also for other crops, eventually on an unconventional soil tillage.

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