THE EFFECT OF FOLIC APPLICATION OF MG-TITANIT FERTILIZER ON PHYTOMASS, CHLOROPHYLL PRODUCTION AND THE HARVEST OF WINTER WHEAT

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ABSTRACT

The effect of folic application of the liquid Mg-Titanit fertilizer on the phytomass of winter wheat was examined by means of a small-area field experiment in the chernozem typical for the cadastral area of Bučany. The experiment consisted of five variants (0; 2 x $Ti_{0.2}$; 3 x $Ti_{0.2}$;2 x $Ti_{0.4}$;3 x $Ti_{0.4}$). 0 – test variant; 2 x $Ti_{0.2}$ – double application of the fertilizer equal to 0.2 $l.ha^{-1}$; 3 x $Ti_{0.2}$ – triple application of the fertilizer equal to 0.2 $l.ha^{-1}$; 2 x $Ti_{0.4}$ – double application of the fertilizer equal to 0.4 $l.ha^{-1}$; 3 x $Ti_{0.4}$ – triple application of the fertilizer equal to 0.4 $l.ha^{-1}$. The fertilizer was applied in spring in three growth stages: the end of tillering, stem elongation, ear emergence to the beginning of flowering. The results have shown that the application of Mg-Titanit fertilizer had a positive effect on the production of aboveground as well as underground phytomass of wheat 14 days after spraying. The fertilizer enhanced the content of total chlorophyll in wheat leaves. A significant effect on the height of the crop was observed.

Key words: titan, wheat, foliar nutrition,

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INTRODUCTION

The content of titan is low in the majority of plants and usually varies between 0.1 – 10.0 mg.kg^{-1} of the dry matter (Tlustoš P. et al., 2005). In the 20th century it was discovered that its usage may increase the crops. Simultaneously it was discovered that its application caused a higher activity of certain enzymes (peroxidases, catalases and nitrate reductase) and a higher content of lypoxigenase and phosphofructokinases (Pais I. 1983; Simon L. et al., 1988; Balík J. et al. 1989). As a result of these findings, a more detailed research of the effect of titan on plants was launched (Kužel S. et al., 2003; Alcaraz-Lopez C. et al., 2003; Tlustoš P. 2005). In spite of multiple positive findings concerning the effects of titan on the phytomass of grown plants, negative finding have been recorded as well (Hara T., et al., 1976; Walace A., et al., 1977). The aim of this paper is to assess the influence of four doses of fertilizer containing titan applied in two various concentrations on the production of aboveground as well as underground phytomass, changes in chlorophyll dynamics and the production of winter wheat crops.

MATERIAL AND METHODS

The effect of the Mg-Titanit fertilizer (MGT) was examined by means of a small-area field experiment performed in 2012 in cultivated chernozem (48° 42' N, 17° 70' E). The winter wheat of the Šarlota sort was constituted as the model crops. The area of one parcel was 20 m^2. The Mg-Titanit fertilizer contained 8.5 g titan within 1 litre of fertilizer, 3% magnesium, 4% sulphur, whereas the titan was present in form of titanium ascorbate and the sulphur and magnesium in form of magnesium sulphate ($MgSO_4$). The agrochemical soil parameters are shown in Table 1 which also describes the methods of their determination.

Table 1. The agrochemical soil parameters before the commencement of the experiments

Depth (m)	$N–NH_4^+$	$N–NO_3^-$	N_{an}	P	K	Ca	Mg	S	N_t	C_{ox}	pH_{KCl}
	mg.kg^{-1}									%	
0.0 – 0.3	10.00	15.20	25.2	73.8	265	6 550	335	7.6	1 617	1.39	7.08
0.3 – 0.6	9.60	9.70	19.3	51.3	235	7 300	373	9.4	1 533	1.48	7.15
0.0 – 0.6	9.80	12.45	22.25	62.55	250	6 925	354	8.5	1 575	1.44	7.12

Nan – inorganic nitrogen; Nan = $N – NH_4^+$ + $N – NO_3^-$; $N – NH_4^+$ - colorimetrically using the Nessler agent; N – NO3- - colorimetrically using phenol 2,4-disulfonate acid; P - colorimetrically (Mehlich III - Mehlich, 1984); S - soluble sulfur, spetrometrically ICP after extraction with water in the ratio 1:5; Nt – via distillation (Kjeldahl - Bremner, 1960); pHKCL – potentiometrically in the extract of 1.0 M KCL, (Fiala et al., 1999); Cox – oxidometrically (Ťjurin, 1966)

The experiment consisted of five variants. 0 – the test variant without application of MGT fertilizer; $2xTi_{0.2}$ – double MGT spraying amounting to 0.2 l.ha^{-1}; $3xTi_{0.2}$ – triple MGT spraying amounting to 0.2 l.ha^{-1}; $2xTi_{0.4}$ – double MGT spraying amounting to 0.4 l.ha^{-1}; 3 x $Ti_{0.4}$ – triple MGT spraying amounting to 0.4 l.ha^{-1}. The fertilizer was applied in spring in two, more precisely in three growth stages (BBCH 29, BBCH 32, BBCH 55). The dates of sampling for the aims of analysis and evaluation of aboveground and underground plant phytomass dynamics as well as dynamics of changes in the total content of chlorophyll are shown in Table 2.

Table 2. The dates and growth stages of crop samples and MGT fertilizer spraying

Type of action						
sample No. 1	Ti-spraying No. 1	sample No. 2	Ti-spraying No. 1	sample No. 3	Ti-spraying No. 1	sample No. 4
Date						
27. III.	12. IV.	3. V.	3. V.	21. V.	21. V.	13. VI.
Growth stage						
end of tillering BBCH 29		end of stem elongation BBCH 32 – 37		ear emergence BBCH 55		end of flowering BBCH 67 – 69

Within 14 to 21 days after spraying the pigment content was determined using the Šesták Z. end Čatský J. method (1966). The harvest of crops was executed manually on the area of 1 m^2 from each variant and repetition 17 before proper combine harvest. The date of harvest was timed so as to ensure the ripeness of the seed without falling out of grains from the ears. Whole plants sampled in this way were then processed in the laboratory.

RESULT AND DISCUSSION

The effect of individual doses and application dates of MGT fertilizer for production of aboveground and underground phytomass of winter wheat is shown in Table 3 and 4. They reveal that in every following sampling of plant material a higher weight of leaves and roots in comparison with the previous sampling was recorded, which leads to the fact that none of the tested measures had a negative effect on phytomass production in wheat. Simultaneously a positive effect of the first folic application of MGT fertilizer during both application doses on the production of the aboveground as well as underground plant organs. Matuškovič J. (1996) came to the same conclusion stating he had achieved the highest harvest percentage growth of strawberries after the first application dose of the fertilizer containing titan. The second MGT spraying had a positive effect on phytomass production in roots after both application doses. However, a positive influence on the aboveground phytomass was observed exclusively in case of a higher application dose of MGT. After the first and the second MGT spraying a higher amount of aboveground as well as underground phytomass was produced in the variants where a higher dose of the examined fertilizer was applied (0.4 $l.ha^{-1}$). On the contrary, the experiments of Kováčik P. et al., 2011) determined that a higher amount phytomass was produced in the variants where a smaller dose of fertilizer was applied (0.2 $l.ha^{-1}$). The third spraying (var. 2 versus var. 3 a var. 4 versus var. 5) did not show any significant influence on the growth of leaves nor growth of roots.

Table 3. The effect of doses and dates of MGT fertilizer application on the dynamics of aboveground phytomass production in winter wheat

Variant		Number and date of plant sampling						
		I./27.III.	**II.**/3.V.	**III.**/21.V.	**IV.**/13.VI.	**II.**/3.V.	**III.**/21.V.	**IV.**/13.VI.
Nr.	designation	weight of one plant in grams (100 % dry mass)				%		
1	0	0.258	0.978	1.820	4.591 a	100.00	100.00	100.00
2	2 x $Ti_{0.2}$	0.258	1.015	1.670	4.391 a	103.78	91.76	95.64
3	3 x $Ti_{0.2}$	0.258	1.015	1.670	4.458 a	103.78	91.76	97.10
4	2 x $Ti_{0.4}$	0.258	1.048	2.033	6.238 b	107.16	111.70	135.87
5	3 x $Ti_{0.4}$	0.258	1.048	2.033	6.183 b	107.16	111.70	134.68
$LSD_{0.05}$					0.3421			
$LSD_{0.01}$					0.4978			

In the last, fourth sampling of plant material the statistically highest amount of aboveground as well as underground phytomass was produced in the variants where the MGT was applied in a one-time dose of 0.4 $l.ha^{-1}$, independently of whether this dose was applied two (var. 4) or three times (var. 5). The presented findings prove that double one-time application doses of MGT fertilizer (0.4 $l.ha^{-1}$) had even better influence on production of total plant phytomass than doses of half the amount (0.2 $l.ha^{-1}$), which is evident not only from Table 3 and 4, showing the effect of MGT fertilizer dose on production of aboveground as well as underground phytomass independently from the number of doses applied. The highest amount of phytomass was produced in variant 4 where two sprayings of 0.4 $l.ha^{-1}$ were applied and the highest amount of underground phytomass was produced in variant 5 where three fertilizer sprayings of 0.4 $l.ha^{-1}$ were applied. Table 5 proves that the application of MGT influenced the production of root mass more significantly than the formation of leaves. The highest ratio of aboveground phytomass and roots was observed on the unfertilized variant.

Table 4. The effect of doses and dates of MGT fertilizer application on the root formation dynamic in winter wheat.

Variant		Number and date of plant sampling						
		I./27.III.	**II.**/3.V.	**III.**/21.V.	**IV.**/13.VI.	**II.**/3.V.	**III.**/21.V.	**IV.**/13.VI.
No.	designation	weight of one plant in grams (100 % dry mass)				%		
1	0	0.0576	0.201	0.217	0.430 a	100.00	100.00	100.00
2	2 x $Ti_{0.2}$	0.0576	0.217	0.279	0.521 b	107.96	128.57	121.16
3	3 x $Ti_{0.2}$	0.0576	0.217	0.279	0.444 ab	107.96	128.57	103.26
4	2 x $Ti_{0.4}$	0.0576	0.249	0.408	0.655 c	123.88	188.02	152.33
5	3 x $Ti_{0.4}$	0.0576	0.249	0.408	0.697 c	123.88	188.02	162.09
$LSD_{0.05}$					0.0862			
$LSD_{0.01}$					0.1254			

The positive effect of MGT fertilizer on the aboveground phytomass recorded during the experiment resulted not only from the effect of titanium but also of magnesium contained in the fertilizer. Both elements significantly influenced the content of total chlorophyll in the plant's leaves (Richter R. et al., 2004; Tůma J. and Tůmová L., 2006) and subsequently positively influenced the photosynthesis intensity (Marschner H., 2005). The application of a fertilizer containing titanium and magnesium increased the content of total chlorophyll (chlorophyll *a* + chlorophyll *b*) with the highest increase recorded on 13th June, i. e. after the third spraying. On one hand, these findings correspond with the discoveries of Kováčik P. and Vician M. (2012) recording a positive effect of titanium fertilizer on the content of chlorophyll in the wheat's leaves. On the other hand, the abovementioned authors observed a higher increase of total chlorophyll after the second spraying. From the aspect of positive effect of the examined fertilizer on total chlorophyll content, such increase after every spraying showed in an increase in chlorophyll *b* and after the first and third spraying also in an increase of chlorophyll *a* (tab. 6).

The effect of experiment variants on the amount of wheat grain crops was particularly significant. The harvest of straw was remarkably influenced as well.

Table 5. The effect of MGT fertilizer application on the dynamics of changes of the relationship between aboveground and underground phytomass in winter wheat

Sampling/Date	Variant	Aboveground phytomass	Underground phytomass	Aboveground to underground phytomass ratio
		g.plant^{-1}		
II./3. V. 2012	1	0.978	0.201	4.87
	2 – 3	1.015	0.217	4.68
	4 – 5	1.048	0.249	4.21
III./21.V. 2012	1	1.820	0.217	8.39
	2 – 3	1.670	0.279	5.99
	4 – 5	2.033	0.408	4.98
IV./13. VI. 2012	1	4.591	0.430	10.68
	2	4.391	0.521	8.43
	3	4.458	0.444	10.04
	4	6.238	0.655	9.52
	5	6.183	0.697	8.87
	2 to 5	5.381	0.579	9.29

Table 6. The effect of experiment variants on dynamics of changes in pigment contents in wheat leaves

Variant No.	Variant Designation	Date	Chlorophyll *a*	Chlorophyll *b*	Chlorophyll *a+b*	Carotenoids
			mg.l^{-1}			
1	0Ti	3. 5. 2012	9.368 a	5.857 a	15.225 a	2.246 a
2 – 3	$Ti_{0.2}$		9.562 a	6.127 a	15.689 a	2.314 a
4 – 5	$Ti_{0.4}$		9.952 a	6.402 a	16.354 a	2.420 b
$LSD_{0.05}$			0.8801	0.9333	1.6609	0.0760
$LSD_{0.01}$			1.3335	1.4141	2.5165	0.1151
1	0Ti	21. 5. 2012	10.414 a	6.593 a	17.007 ab	2.662 b
2 – 3	$Ti_{0.2}$		10.353 a	7.018 b	17.371 b	2.636 ab
4 – 5	$Ti_{0.4}$		10.206 a	6.724 a	16.929 a	2.628 a
$LSD_{0.05}$			0.2447	0.1883	0.4255	0.0325
$LSD_{0.01}$			0.3707	0.2853	0.6447	0.0493
1	0Ti	13. 6. 2012	8.567 a	4.620 a	13.186 a	2.342 a
2	$2xTi_{0.2}$		9.158 abc	5.421 ab	14.579 ab	2.358 a
3	$3xTi_{0.2}$		8.907 ab	5.138 ab	14.045 ab	2.348 a
4	$2xTi_{0.4}$		9.505 bc	5.877 bc	15.381 bc	2.281 a
5	$3xTi_{0.4}$		9.643 c	6.640 c	16.283 c	2.210 a
$LSD_{0.05}$			0.7173	0.9010	1.5698	0.1642
$LSD_{0.01}$			1.0436	1.3109	2.2840	0.2389

Table 7. The effect of changeable sources on quantitative crop parameters of winter wheat

Source of variability	Degrees of freedom	Grain	Straw
		F – calculated	
Variant	4	17.235^{++}	4.48^{+}
Repetition	3	2.644	0.457
Residue	12		
Total	19		

In comparison with a larger amount, the application of a smaller amount of MGT (var. 2 and 3) influenced the crop of grain in a different way. A smaller amount, whether applied two or three times, had an insignificant to a slightly negative effect. On contrary, a larger amount (var. 4 and 5) had a conclusively significant and positive effect. Similar influences of experiment variants were observed on the growth of straw, although they were statistically inconclusive considering the test variant (Table 8). The disparities in straw harvest between the variants fertilized by a smaller MGT application amount were of a high significance. The totally highest grain and straw harvest was achieved within variant 4 where the MGT amounting to two times 0.4 l.ha^{-1} was applied twice during the vegetation period of rape. This variant brought forth a grain harvest higher by 12.6 % compared to the test variant. The same results were produced by Kováčik P. and Vician M. (2012) as they stated that the largest grain harvest was achieved in the variant which was MGT-sprayed twice by a total amount of 0.8 l.ha^{-1}.

Table 8.The effect of MGT fertilizer application on grain and straw crops of winter wheat (2012)

Variant No.	Variant designation	Grain t.ha^{-1}	Grain %	Straw t.ha^{-1}	Straw %	Straw/ grain	Grain/ straw
1	0	4.33 a	100.00	5.13 ab	100.00	1.185	0.844
2	2 x $Ti_{0.2}$	4.22 a	97.46	4.94 a	96.30	1.171	0.854
3	3 x $Ti_{0.2}$	4.22 a	97.46	4.91 a	96.30	1.163	0.859
4	2 x $Ti_{0.4}$	4.89 b	112.63	5.56 b	108.38	1.144	0.881
5	3 x $Ti_{0.4}$	4.73 b	109.24	5.55 b	108.19	1.173	0.852
$LSD_{0.05}$		0.231		0.464			
$LSD_{0.01}$		0.323		0.651			

The application of MGT had a more beneficial effect on growth of grain in comparison with straw independently from the amount and number of sprayings. The straw-grain ratio was thus decreased (Table 8). Evaluation of the effect of MGT amount (0.2 and 0.4 l.ha^{-}1) on grain crops independently from the number of applications shows that when intending to enhance the wheat grain growth it is more suitable to apply a higher amount of MGT rather than a lower one. The grain crop achieved in variants 4 and 5 (Table 8) fully corresponds with the effect of MGT fertilizer application on the production of aboveground and underground phytomass in wheat and the content of total chlorophyll in the wheat leaves. Considering the number of sprayings (independently from the MGT application amount) it is more suitable for the growth of crops to apply only two sprayings.

CONCLUSIONS

None of the foliar applications of MGT fertilizer caused burning of the wheat leaves nor other phenomena damaging aboveground and underground phytomass. The first application of MGT fertilizer increased the growth of aboveground and underground organs of wheat plant in all experiment variants. The weight of roots increased after every spraying, i.e. within every sampling in comparison with the test variant independently from the amount of MGT. The examined fertilizer positively affected the content of total chlorophyll. This increase was observed especially in form of a chlorophyll *b* increase and after the first and third spraying also in form of a chlorophyll *a* increase. The most significant and beneficial effects of MGT fertilizer on the content of total chlorophyll were observed in the growth stage BBCH 67 – 69. The amount of 0.4 $l.ha^{-1}$ Mg-Titanit applied two and three times in the growth stages BBCH 29, BBCH 32 – 37 and BBCH 55 highly conclusively and positively influenced wheat grain and straw crops. The application of MGT proved to be more beneficial for the growth of grain rather than straw independently from the amount and number of sprayings.The grain crop achieved in variants where an amount of 0.4 $l.ha^{-1}$ (two and three times during the vegetation period) was applied fully corresponds with the effect of MGT fertilizer amount on the production of aboveground and underground phytomass in wheat and the content of total chlorophyll in wheat leaves.

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