

GROWTH AND YIELD STIMULATION OF WINTER OILSEED RAPE (*BRASSICA NAPUS* L.) BY MG-TITANIT FERTILISER

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The effort to achieve higher yields at the required qualitative level has led to the intensive studying the problems of the rational usage of the titanium containing fertilisers by the agricultural research in the course the previous thirty years. Therefore, the objective of the experiment was to evaluate the impact of two doses of Mg-Titanit (0.2 l/ha and 0.4 l/ha) on the formation of the aboveground and underground phytomass, also on the total chlorophyll in leaves, on the titanium and nitrogen content in the seeds and straw, on the quantity and quality of winter rape yield. The doses were applied two or three times on the leaves of winter rape (BBCH 50–52, BBCH 59, BBCH 66–67). The experiment was realized on the Haplic Chernozem (48°42' N, 17°70' E – Western Slovakia) during two farming years

(2009/2010 and 2010/2011). The results showed that all three applications of Mg-Titanit in both doses stimulated the formation of aboveground and underground phytomass of winter rape. The highest growth of phytomass was detected after the second application. The application of Mg-Titanit in the growth phases BBCH 50–52 and BBCH 59 increased the contents of both chlorophylls (a and b), where the growth of chlorophyll b content was more considerable than the growth of chlorophyll a content. The third spraying by Mg-Titanit decreased the content of the total chlorophyll. The application of Mg-Titanit had the positive impact on the yield of seeds, straw and fat content in the winter oilseed rape seeds.

Key words: biostimulant, fertiliser, titanium, winter rape

Titanium ranks among ten most frequently occurring elements in the earth crust. In spite of this fact, in most plants the titanium content is low and it varies in the interval 0.1 mg/kg – 10.0 mg/kg of dry substance (Tlustoš *et al.* 2005). The reason for the low content of Ti in plants is its low bioaccessibility in both acid and alkaline soils.

In the 20th century it was detected that the titanium usage in the crop production could increase not only the chlorophyll content in the plant leaves but also the content of vitamin C, sugar and nutri-

ents in the plants of tomato, grapevine, potato, sugar beet, strawberries and kohlrabi. Titanium can increase the yield of cereals, root crops, oil plants, fruit, vegetables and technical crops, namely from 5% to 50% and decrease the content of nitrates and some heavy metals (Traetta-Mosca 1913; Pais 1983; Balík *et al.* 1989; Tichý & Tóth 1990; Carvajal *et al.* 1994; Carvajal & Alcaraz 1998). Thanks to these findings the detailed research of the titanium impact on plants started (Kužel *et al.* 2003; Alcaraz-Lopez *et al.* 2003; Tlustoš *et al.* 2005). It resulted in the

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information that it is highly assumed the foliar application of titanium to have the negative impact on crops in the soils with the deficient Mg content and the soils with less than pH 6 and content less than C_{ox} 0.7%. It was found out that the symptoms of the toxic impact of titanium on some plants could be expected in the cases when the titanium concentration in sprays was higher than 10 mg/kg, or 12.5 mg/l (Kužel *et al.* 2007). There are less scientific facts about the phytotoxic effects of the foliar application of titanium on plants than the facts about their positive impact. Therefore, the Slovak producers of the liquid fertilisers add titanium into the common microelements (Kováčik 2014).

One of the fertilisers containing titanium is Mg-Titanit, which is being used not only in Slovakia but also in the whole world. In 2013 this fertiliser was reclassified as a biostimulator. In many cases its usage is effective economically, however, its optimal application doses and the optimal application dates have not been determined yet (Dobromilská 2007).

The objective of the paper is to evaluate the impact of two doses of the fertiliser Mg-Titanit (0.2 l/ha and 0.4 l/ha), which were applied two or three times on the winter oilseed rape leaves on: dynamics of the underground and aboveground phytomass formation, the content of the total chlorophyll in leaves, the content of titanium and nitrogen in seeds and straw, quantity and quality of winter oilseed rape yield.

MATERIAL AND METHODS

The effect of the application of liquid fertiliser Mg-Titanit (MgTi) on creation of aboveground and underground phytomass dynamics, total chlorophyll content and yield parameters of winter oilseed rape was investigated in a small plot field trial (20 m² per one plot) realized on the Haplic Chernozem (48°42' N, 17°70' E – western Slovakia) during two farming years (2009/2010 and 2010/2011).

T a b l e 1

Soil agrochemical parameters before the foundation of experiments in a soil layer 0.0–0.6 m

Year	N_{min}	P	K	Ca	Mg	S	N_t	C_{ox}	pH_{KCl}
	[mg/kg]							[%]	
2009/2010	12.05	40	221	3,575	414	15.0	1,709	1.49	6.89
2010/2011	13.05	23	160	7,650	505	34.5	1,099	1.25	6.95

N_{min} – inorganic nitrogen; P, K, Ca, Mg – available phosphorous, potassium, calcium, magnesium; S – water soluble sulphur, N_t – total nitrogen, C_{ox} – total (oxidizable) carbon

T a b l e 2

Variants of experiment

Variant		Growth phase of Mg-Titanit application		
		BBCH 50–52	BBCH 59	BBCH 66–67
number	designation	dosage [l/ha]		
1	0	0	0	0
2	2 × Ti0.2	0.2	0.2	0
3	3 × Ti0.2	0.2	0.2	0.2
4	2 × Ti0.4	0.4	0.4	0
5	3 × Ti0.4	0.4	0.4	0.4

The agrochemical parameters of Haplic Chernozem taken from soil layer 0.0 m – 0.6 m are given in Table 1. The agrochemical parameters were determined by the following methods: $N_{\min} = N-NH_4^+ + N-NO_3^-$, $N-NH_4^+$ – colorimetrically by Nessler’s agent, $N-NO_3^-$ – colorimetrically by the phenol 2.4 disulphonic acid, P – colorimetrically (Mehlich III – Mehlich 1984), K and Ca – flame photometry (Mehlich III – Mehlich 1984), Mg – AAS (Mehlich III – Mehlich 1984), S – spectrometrically ICP OES (Zbiral 2002), C_{ox} – oxidometrically by Ľjurin in modification of Nikitin (Dziadowiec & Gonet 1999), N_t – by distilling (Kjeldahl – Bremner 1960), pH/KCl – potentiometrically (1.0 mol/dm³ KCl). Experiment consisted of 5 variants (var. 0; 2×Ti0.2; 3×Ti0.2; 2×Ti0.4; 3×Ti0.4). 0 – control treatment without MgTi fertiliser; 2×Ti0.2 – two applications of MgTi in the dose of 0.2 l/ha; 3×Ti0.2 – three applications of MgTi in the dose of 0.2 l/ha; 2×Ti0.4 – two applications of MgTi in the dose of 0.4 l/ha; 3×Ti0.4 – three applications of MgTi in the dose of 0.4 l/ha. The fertiliser was applied in the spring during two, or three different growth stages: BBCH 50–52, BBCH 59, BBCH 66–67 (Table 2). The plant sampling was carried out two or three weeks after spraying by the fertiliser. Growth phase (BBCH 59, BBCH 66–67, BBCH 71) in which plant samples were taken for study of aboveground phytomass creation is given in Table 3. To determine the content of the assimilation pigments (chlorophyll *a*, chlorophyll *b* and total chlorophyll) the last developed leaf of ten plants was sampled. The pigments were determined by spectrophotometric method (Lichtenhaler 1987).

The fat content in seeds was detected by Soxhlet method and nitrogen content in seeds was detected by Eastin (1978) method. To determine the Ti content in seeds was used the inductively coupled plasma atomic emission spectroscopy (ICP-AES) method (Zbiral *et al.* 2011). Obtained results were processed by mathematical and statistical method, by analysis of variance (ANOVA) and linear regression analysis using Statgraphics PC software, version 5.0.

Mg-Titanit fertiliser (stimulant) is dark brown liquid with bulk density 1.36 kg/l. It contains 8.5 g of titanium per 1 liter of fertiliser, 3% of magnesium, and 4% of sulfur. Titanium is in form of titanium ascorbate and sulfur with magnesium is in form of magnesium sulphate (MgSO₄).

RESULTS AND DISCUSSION

The data presented in the Tables 4 and 5 show that the Mg-Titanit application carried out in the growth phase BBCH 50–52 stimulated the formation of the aboveground and underground phytomass of winter oilseed rape. The impact on the aboveground and underground parts was comparable. The growth of the aboveground phytomass varied in the interval from 11.5 to 28.47% and the weight gain of roots varied in the interval from 15.35 to 26.77%. A higher single dose of Mg-Titanit (0.4 l/ha) stimulated more significantly the formation of the rape phytomass than a lower dose of (0.2 l/ha) Mg-Titanit.

After the repeated, second application of Mg-Titanit the differences between the weight of phytomass, created in the variants treated by Mg-Titanit (var. 2–5), and the untreated variant (var. 1) were

T a b l e 3

Growth stages of sampling of winter oilseed rape plant and spraying stimulator Mg-Titanit

Type of treatment			
1 st Ti spray	1 st sampling and subsequent 2 nd Ti spray	2 nd sampling and subsequent 3 rd Ti spray	3 rd sampling
Growth phase			
Occurrence of the inflorescence – inflorescence BBCH 50–52	yellow bud BBCH 59	flowering BBCH 66–67	end of flowering BBCH 71

even more significant. A lower dose of Mg-Titanit (var. 2 and 3) had more positive impact on the formation of the aboveground phytomass than a higher dose (var. 4 and 5 – Table 4). On the contrary, the root formation was increased with the growth of the application dose of Mg-Titanit, similarly to the first spraying.

The third spraying did not influence statistically significantly the formation of phytomass. Its effect on the formation of the abo-

veground and underground phytomass was slightly positive, in particular, it had more positive impact on roots (cca 5.0% increase) than on the aboveground part (cca from 1.5–3.0% increase). The different conclusion was achieved by Kováčik *et al.* (2014), the third spraying by Mg-Titanit, which was used in the growth phase BBCH 55, inhibited the formation of the aboveground wheat phytomass.

T a b l e 4

The effects of the dose and the date of application of Mg-Titanit on the dynamic creation of aboveground phytomass (100% dry matter) of winter oilseed rape (mean of two years)

Variant		Sample/growth stage						
		0./ BBCH 50–52		I./ BBCH 59		II./ BBCH 66–67		III./ BBCH 71
n.	designation	weight of one plant at gram [1pl/g]		[%]	[1pl/g]	[%]	[1pl/g]	[%]
1	0	4.616	8.124	100.00	18.137	100.00	28.165 ^a	100.00
2	2 × Ti0.2	4.616	9.058	111.50	29.106	160.48	47.149 ^b	167.40
3	3 × Ti0.2	4.616	9.058	111.50	29.106	160.48	47.586 ^b	168.95
4	2 × Ti0.4	4.616	10.437	128.47	27.026	149.01	46.988 ^b	166.83
5	3 × Ti0.4	4.616	10.437	128.47	27.026	149.01	47.842 ^b	169.86
<i>LSD</i> _{0.05}							3.2025	

n. – number, 1pl/g – weight of one plant at gram, *LSD*_{0.05} – least significant difference at the level $\alpha = 0.05$ (*LSD* test), different letter behind a numerical value respond to the statistically significant difference at the level 95.0%

T a b l e 5

The effects of the dose and the date of application of Mg-Titanit on the dynamic creation of underground phytomass (100% dry matter) of winter oilseed rape (mean of two years)

Variant		Sample/growth stage						
		0./ BBCH 50 – 52		I./ BBCH 59		II./ BBCH 66 – 67		III./ BBCH 71
n.	designation	[1pl/g]		[%]	[1pl/g]	[%]	[1pl/g]	[%]
1	0	2.109	3.022	100.00	3.539	100.00	4.525 ^a	100.00
2	2 × Ti0.2	2.109	3.486	115.35	5.141	145.27	6.215 ^b	137.35
3	3 × Ti0.2	2.109	3.486	115.35	5.141	145.27	6.440 ^b	142.32
4	2 × Ti0.4	2.109	3.831	126.77	5.459	154.25	6.135 ^b	135.58
5	3 × Ti0.4	2.109	3.831	126.77	5.459	154.25	6.359 ^b	140.53
<i>LSD</i> _{0.05}							0.5520	

n. – number, 1pl/g – weight of one plant at gram, *LSD*_{0.05} – limit of significant difference at the level $\alpha = 0.05$ (*LSD* test), different letter behind a numerical value respond to the statistically significant difference at the level 95.0%

A bigger aboveground and underground phytomass was formed in the variants with three sprayings (var. 3 and 5), in comparison with the variants of two sprayings (var. 2 and 4 – Table 6).

In all samplings, the positive impact of the fertiliser (biostimulator) Mg-Titanit on the formation of winter oilseed rape phytomass was recorded, which corresponds with the results of several authors (Matušková 1995; Dobromilská 2007) about the impact of fertilisers containing titanium on the plant phytomass.

As there are numerous elements of the mineral plant nutrition, their effect on the chlorophyll formation is different. There is usually monitored the positive correlation between the content of nitrogen, magnesium and sulphur in a plant and the content of total chlorophyll in a plant (Marschner 2005; Tůma & Tůmová 2006). The higher chlorophyll content on a leaf surface unit was recorded also as a result of the insufficient nutrition by phosphorus (Kováčik 2014). The decrease of the chlorophyll content is

T a b l e 6

The impact of two and three applications of Mg-Titanit on the weight of winter oilseed rape phytomass in the growth phase BBCH 71, regardless the application dose

Variant		Aboveground phytomass		Underground phytomass	
number	designation	[1pl/g]	[%]	[1pl/g]	[%]
1	0	28.165	100.00	4.525	100.00
2 and 4	2Ti	47.069	167.12	6.175	136.46
3 and 5	3Ti	47.714	169.41	6.400	141.44

2Ti – two applications of Mg-Titanit, 3Ti – three applications of Mg-Titanit

T a b l e 7

Impact of trial treatments on dynamics of changes of pigment contents in leaves of winter oilseed rape (mean of two years)

Variant		Growth stage	Chlorophyll <i>a</i>	Chlorophyll <i>b</i>	Chlorophyll <i>a/b</i>	Chlorophyll <i>a + b</i>	
number	designation		[mg/m ²]			[mg/m ²]	[%]
1	0	BBCH 59	335.668 ^a	132.781 ^a	2.528	468.449 ^a	100.00
2 – 3	Ti0.2		349.496 ^a	146.293 ^b	2.389	495.789 ^b	105.84
4 – 5	Ti0.4		339.616 ^a	143.783 ^b	2.362	483.399 ^{ab}	103.19
<i>LSD</i> _{0.05}			15.364	10.474	–	18.879	–
1	0	BBCH 66 – 67	347.716 ^a	145.854 ^a	2.384	493.570 ^a	100.00
2 – 3	Ti0.2		360.477 ^b	164.003 ^b	2.198	524.480 ^b	106.26
4 – 5	Ti0.4		350.964 ^{ab}	162.935 ^b	2.154	513.899 ^b	104.12
<i>LSD</i> _{0.05}			10.404	6.884	–	11.684	–
1	0	BBCH 71	327.814 ^a	145.436 ^a	2.254	473.250 ^a	100.00
2	2 × Ti0.2		357.448 ^c	165.792 ^b	2.156	523.240 ^c	110.56
3	3 × Ti0.2		337.746 ^{ab}	158.864 ^b	2.126	496.610 ^b	104.94
4	2 × Ti0.4		347.546 ^{bc}	163.014 ^b	2.132	510.560 ^{bc}	107.88
5	3 × Ti0.4		334.974 ^{ab}	158.156 ^b	2.118	493.130 ^b	104.20
<i>LSD</i> _{0.05}			19.223	12.357	–	19.718	–

*LSD*_{0.05} – least significant difference at the level $\alpha = 0.05$ (*LSD* test), different letter behind a numerical value respond to the statistically significant difference at the level 95.0%

caused by the excessive plant nutrition by microelements and titanium (Hrubý *et al.* 2002), or growing crop in the soils with a higher content of heavy metals (Ducsay 2011), or growing crop in the polluted environment (Bergman 1992).

The data in the Table 7 show that in each sampling the content of pigments (chlorophyll *a*, chlorophyll *b* and subsequently total chlorophyll) was higher in the variants treated by Mg-Titanit than in the control, untreated variant. The first and partially

also the second spraying (application in the growth phases BBCH 50–52 and BBCH 59, and measurement in phases BBCH 59 and BBCH 66–67) had more significant impact on the growth of chlorophyll *b* than the growth of chlorophyll *a*. Similarly, Kováčik *et al.* (2014) monitored a higher increase of chlorophyll *b* content in the wheat leaves than chlorophyll *b* after several applications of Mg-Titanit. On the contrary, after the autumn application of the pig manure on maize and sunflower Kováčik (2014)

T a b l e 8

The impact of Mg-Titanit application on nitrogen and titanium content in winter oilseed rape seed and straw (mean of two years)

Variant		N in seeds		N in straw		Ti in seeds		Ti in straw	
n.	designation	[mg/kg]	[%]	[mg/kg]	[%]	[mg/kg]	[%]	[mg/kg]	[%]
1	0	33,347 ^a	100.00	7,840 ^b	100.00	1.34 ^a	100.00	8.40 ^a	100.00
2	2 × Ti0.2	33,587 ^{ab}	100.72	7,654 ^{ab}	97.63	1.50 ^a	111.94	10.40 ^b	123.81
3	3 × Ti0.2	33,818 ^{abc}	101.41	7,576 ^{ab}	96.63	1.77 ^b	132.09	11.32 ^c	134.76
4	2 × Ti0.4	33,944 ^{bc}	101.79	7,502 ^a	95.69	2.08 ^c	155.22	10.78 ^{bc}	128.33
5	3 × Ti0.4	34,299 ^c	102.85	7,536 ^a	96.12	2.30 ^c	171.64	10.98 ^{bc}	130.71
mean	33,799	–	7621.6	–	1.798	–	10.376	–	
<i>LSD</i> _{0.05}	531.562	–	290.241	–	0.224	–	0.724	–	

n. – number, *LSD*_{0.05} – least significant difference at the level $\alpha = 0.05$ (*LSD* test), different letter behind a numerical value respond to the statistically significant difference at the level 95.0%

T a b l e 9

The influence of application Mg-Titanit on the some yield parameters of winter oilseed rape seeds

Variant		Yield (seeds)			Seeds/straw (mean)	Oil	Yield of oil	TKW
n.	designation	2010	2011	mean		mean of two years		
		[t/ha]				[%]	[t/ha]	[%]
1	0	2.83 ^a	4.69 ^a	3.76 ^a	0.60	40.94 ^a	1.54 ^a	4.78 ^a
2	2 × Ti0.2	3.20 ^b	5.22 ^b	4.21 ^b	0.65	41.72 ^b	1.76 ^b	4.75 ^a
3	3 × Ti0.2	3.00 ^{ab}	5.87 ^c	4.44 ^b	0.70	41.90 ^b	1.86 ^b	4.73 ^a
4	2 × Ti0.4	3.20 ^b	5.23 ^b	4.21 ^b	0.67	42.15 ^b	1.77 ^b	4.72 ^a
5	3 × Ti0.4	3.06 ^{ab}	5.63 ^c	4.34 ^b	0.68	41.65 ^b	1.81 ^b	4.72 ^a
mean		3.058	5.328	4.192	0.66	41.672	1.748	4.74
<i>LSD</i> _{0.05}		0.240	0.275	0.274	–	0.669	0.218	0.0631

n. – number, *LSD*_{0.05} – least significant difference at the level $\alpha = 0.05$ (*LSD* test), different letter behind a numerical value respond to the statistically significant difference at the level 95.0%

recorded higher increase of chlorophyll *a* than chlorophyll *b* in the leaves of those crops. The author explained this fact by the significant content of nitrogen and other macroelements (magnesium, phosphorus, sulphur, potassium and calcium) in manure.

After the first and second spraying by Mg-Titanit there was the highest content of both pigments recorded in the variants 2 and 3, i. e. in the variants where the tested fertiliser was applied in the single doses at the level 0.2 l/ha. After the first spraying the content of total chlorophyll was increased by 5.84% and after the second spraying by 6.26%. In the variants 4 and 5, where Mg-Titanit was applied in the single doses of 0.4 l/ha, the contents were lower insignificantly than in the variants 2 and 3, however, they were higher than in the control variant. It is evident that from the aspect of chlorophyll formation in the leaves of winter oilseed rape that it is more suitable if the Mg-Titanit is applied in the single doses of 0.2 l/ha than in the doses of 0.4 l/ha.

The third spraying by Mg-Titanit (BBCH 66–67, measurement BBCH 71) caused the decrease of the total chlorophyll content, which corresponds with some the data of Kováčik (2014). He claim that in 65% cases there is the negative impact of spraying by Mg-Titanit on the contents of the total chlorophylls in the wheat leaves if the spraying is carried out before the wheat ear formation. He recorded the growth of the total chlorophyll content in 35%.

After three sprayings by Mg-Titanit (BBCH 50–52, BBCH 59, BBCH 66–67) there was monitored the decrease of ratio between the chlorophyll *a* and chlorophyll *b*. This ratio between the chlorophyll *a* and *b* was also diminished in the following days of the growing season. It seemed that the older plant was – the less the ratio was. However, in the period BBCH 50 to 67 the rape phytomass grows fast which results in analysing still (relatively) younger leaves. Therefore, the obtained data are not in contrast with the data given by Ebbs and Uchil (2008). They claim that in the process of the plant senescence there the transformation from chlorophyll *b* to chlorophyll *a* occurs and also there is the increased ratio of chlorophyll *a* to chlorophyll *b*.

The nitrogen content in the rape seeds was increased with the growth of the total application dose of Mg-Titanit (Table 8). The total doses of Mg-Titanit 0.4 and 0.6 l/ha (var. 2 and 3) increased the nitrogen

content insignificantly and the doses 0.8 and 1.2 l/ha increased the content significantly (var. 4 and 5).

The impact of Mg-Titanit on straw was different. In all the variants treated by Mg-Titanit there was the nitrogen content lower in comparison with the control, unfertilised variant. The lowest content was evident in the variants of the highest total application dose of Mg-Titanit (var. 4 and 5). These facts show that Mg-Titanit had impact on the redistribution of nitrogen between the vegetative and generative aboveground phytomass in favour of the generative phytomass.

The data related to the titanium content in plants are rare (Lopez-Moreno *et al.* 1996; Tlustoš *et al.* 2005). In the submitted experiment the titanium content in the rape seeds varied in the interval from 1.34 to 2.3 mg/kg and in straw from 8.4 to 11.32 mg/kg on average in the course of two years, which corresponds with the data achieved by the above mentioned authors (Table 8). The quantity of titanium in the rape seed was increased proportionally with the growing application dose of the fertiliser or with the growing nitrogen content in the rape seed. The highest content was found out in the variant 5 where 1.2 l/ha of Mg-Titanit was applied totally.

The titanium content in the rape straw was higher in all variants fertilised by Mg-Titanit comparing to the unfertilised variant. Unlike seeds the titanium content in straw did not increase proportionally with a higher dose of Mg-Titanit. The highest quantity of titanium was present in the variants where Mg-Titanit was applied three times (var. 3 and 5). The correlation coefficient *r* at the level of 0.690⁺⁺ detected between the titanium content in straw and rape seed proved the well-known fact that the increased nutrition by any element results in the increased content of the particular element, however disproportionally, in all organs.

In the rape straw there was 5.77 times more titanium than in the seeds (10.376 : 1.798), which corresponds with the data presented by Ercoli *et al.* (2008). They claim there is 4 times less titanium in seeds than in stalks and 7 times less than in maize leaves.

The Table 9 shows that the rape yield was determined by the cultivating year. In the first year the average yield of rape seed was 3.06 t/ha and in the second year 5.33 t/ha, which means the difference of

74%. In spite of the significant impact of the cultivating year on the rape seed yield it is obvious that in both years the lowest seed yield was recorded as significant statistically in the variant where Mg-Titanit was not used (var.1). In the first year of the experiment significantly higher yields were achieved in the variants where Mg-Titanit was applied twice (var. 2 and 4). In this year there was extraordinary humidity (163.8 mm) during the third application of Mg-Titanit (in May) which probably decreased the effect of the third application. On the contrary, in the second year of the experiment the highest yields were achieved in the variants where Mg-Titanit was used three times. In this year in May there was the normal precipitation (51.8 mm), which allowed a better usage of the third dose of Mg-Titanit.

On average the differences between the variants fertilised by Mg-Titanit were insignificant in both years of the experiment. However, the highest yields were achieved in the variants 3 and 5, i. e. in the variants where Mg-Titanit was used three times.

The utilization of Mg-Titanit determined more significantly the yield of rape seed than the yield of rape straw. This fact is the consequence of the changes of proportions between the seed weight and rape weight (Table 9). The least ratio was in the control, unfertilised by Mg-Titanit variant. The application not only had the positive impact on the quantity of seed and straw yield but it also had the positive impact on the fat content in the rape seeds. Apart from the last variant, the growth of the application dose of Mg-Titanit increased the fat content. In all variants fertilised by Mg-Titanit there was the fat content higher significantly in comparison with the control variant. The highest fat content was

achieved in the regressing succession in the variants where totally 0.8 l/ha, 0.6 l/ha, 0.4 l/ha and 1.2 l/ha of Mg-Titanit were applied. The differences in the fat content between the variants fertilised by Mg-Titanit were insignificant. Similarly, the differences in the fat production between the variants fertilised by Mg-Titanit were insignificant. The lowest fat production per hectare was detected in the control variant 1.

The fertilising by Mg-Titanit did not have impact on the thousand kernel weight (TKW) significantly. TKW was decreased along with the growth of the application dose of Mg-Titanit. The decrease varied in the interval from 0.63% to 1.26%, which is the insignificant drop.

The recorded information from the experiment which is related to the present positive impact of the fertiliser Mg-Titanit on the quantity and quality of yield (fat content) ranks among the group of the data occurring only with the probability of 15%. In other cases (85%) the fertilisers stimulating the phytomass growth decrease the fat content in seeds (Kováčik 2014).

The growers' successfulness is determined significantly by their ability to utilize the newest knowledge from all fields of the crop production, including crop nutrition. In order to optimize the crop nutrition the experts look for the dependence between a plant height, stalk thickness or the chlorophyll contents detected in the particular growth phases, and the quantity and quality of the cultivated crops (Kováčik *et al.* 2011; Kováčik 2014). The data presented in the Table 10 show that there is the highly evidential correlation coefficient between the quantity of rape

T a b l e 10

The correlation coefficient r expressing the correlation between winter oilseed rape seed yield and phytomass or the content of the total chlorophyll in the growth phase BBCH 71

Parameter		r	P – value	Symbol
Dependent	Independent			
Seed yield	Weight of aboveground phytomass	0.8994	< 0.001	++
	Weight of underground phytomass	0.8902	< 0.001	++
	Total chlorophyll	0.5176	0.048	+

P values lower than 0.05 indicates conclusiveness and smaller than 0.01 indicates strong conclusiveness

seed yield and the underground and aboveground phytomass formed in the growth phase BBCH 71. There the correlation coefficient between the rape seed yield and the chlorophyll content was only evidentiary, i.e. at the threshold of the conclusive evidence. These facts refer to the fact that it is possible to use the information about the formed aboveground or underground phytomass or the chlorophyll content for the purpose of the winter oilseed rape yield prediction. There the precision of prediction will be probably higher if the information about the formed phytomass is used as the information about the total chlorophyll content in the leaves in the growth phase BBCH 71.

CONCLUSION

All three applications of Mg-Titanit in both single application doses (0.2 l/ha and 0.4 l/ha) carried out in the growth phases BBCH 50–52, BBCH 59, and BBCH 66–67 stimulated the formation of the aboveground and underground phytomass of winter oilseed rape. The first and second application of Mg-Titanit increased the contents of both chlorophylls (*a* and *b*). The third spraying by Mg-Titanit decreased the content of the total chlorophyll. The nitrogen and titanium contents in the rape seed were increased along with the growth of the total application dose of Mg-Titanit. The used of Mg-Titanit had the positive impact on the quantity of seed and straw yield as well as the fat content in seeds of rape. The highest seed yields and the highest fat production per hectare were achieved in the variants where Mg-Titanit was used three times. In order to assess the quantity of winter rape yield in the growth phase BBCH 71 it is more suitable to evaluate weight of the formed phytomass (aboveground or underground) than the chlorophyll content in the lastly developed rape leaf.

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