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A MINERAL PROFILE OF WINTER OILSEED RAPE IN CRITICAL STAGES OF GROWTH - MAGNESIUM

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Abstract

A high yield of oilseed rape can be achieved provided an adequate supply of magnesium and sulfur in critical stages of yield formation. The magnesium status in canopy was studied in the 2008, 2009 and 2010 growing seasons. A one factorial experiment consisting of six treatments, set up to verify the research hypothesis, was as follows: control (C), NP, NPK, NPK+MgS - $^{1}/_{3}$ of total planned dose applied in spring (NPKMgS1), NPK+1.0 MgS dose in autumn (NPKMgMgS2), NPK+MgS - $^{2}/_{3}$ in autumn + $^{1}/_{3}$ in spring (NPKMgS3). Plant samples were taken at three stages: rosette (BBCH 30), the onset of flowering (BBCH 61) and maturity (BBCH 89). An entire sample was partitioned in accordance with the growth stage into main plant organs: leaves, stems, straw and seeds. The yield of biomass, magnesium concentration and its content was determined in each part of the plant. The magnesium concentration in leaves at the onset of flowering can be used as the first predictor of yield. The predictive strength of the magnesium content in seeds as the final yield predictor corroborated the hypothesis of the importance of magnesium for the seed sink build-up. An analysis of relationships between the magnesium content in plant parts during the growing season and yield of seeds can be used to make an *ex-post* analysis of factors disturbing the development of yield structural components. The main cause of yield reduction in 2009 as compared to 2008 was the insufficient supply of magnesium to vegetative organs of oilseed plants since the onset of flowering. It was documented that the degree of magnesium supply to a growing silique is critical for the seed yield performance, as noted in 2008. It was also found that any disturbance in the magnesium supply to oilseed rape since the onset of flowering led to reduction in the seed density, which in turn decreased the magnesium seed sink capacity, as the study clearly demonstrated.

Key words: plant parts, Mg concentration, Mg partitioning, yield structural components.

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INTRODUCTION

Winter oilseed rape, a major oil crop in Europe, requires high dosage of nitrogen fertilizers, despite which yields produced in many European countries are much below the potential of this crop (FAOSTAT 2014, Supit et al. 2010). The main reason for the yield gap is the high sensitivity of oilseed rape to unfavorable growth conditions, both water stress and unbalanced N application. A temporary water shortage occurring in critical stages of growth leads to an insufficient use of fertilizer nitrogen, resulting in yield depression, as has been observed in Central European countries over the last two decades (Grzebisz et al. 2010*a*). In Europe, the cropping practice of oilseed rape relies on natural precipitation. Therefore, measures need to be taken to increase the efficiency of N use by plants in order to improve water and nitrogen management. Magnesium is a nutrient whose impact on the nitrogen economy of crops has been recognized very well (Grzebisz et al. 2010*b*, Grzebisz 2011). So far, the knowledge on the effect of magnesium on development of yield structural components has been most thoroughly investigated for cereals and sugar beet (Grzebisz 2013).

The whole oilseed rape growth period can be divided into three main stages, as proposed by Sylvester-Bradley et al. (2002). The first one, known as the period of crop foundation (PCF), extends from sowing to the rosette stage (BBCH 30). During this period, plants develop leaves and initials of subordinate branches. During the yield foundation period (YFP), the crop achieves the maximum photosynthetic area and final number of secondary branches. The period of yield realization (PYR), extending from the beginning of flowering up to the physiological maturity, is when structural components of seed yield develop. It is, therefore, assumed that each borderline time between the three major periods is of crucial importance for both the plant's nutritional status evaluation and yield prediction.

One of the objectives of the study was to assess the impact of magnesium nutrition on its accumulation and partitioning in oilseed canopy in the cardinal growth stages. Another, more important purpose was to evaluate the effect of the magnesium content in particular parts of the plant on the formation of its structural components as a prerequisite of yield assessment.

MATERIAL AND METHODS

Magnesium in the canopy of oilseed rape was studied in the 2008, 2009 and 2010 seasons. A one factorial experiment consisting of six treatments, set up to verify the reseacrh hypothesis, was as follows: (A) Control, (B) NP, (C) NPK, (D) NPK+MgS - $^{1}/_{3}$ of total planned dose applied in spring (NPKMgS1), (E) NPK+1.0 MgS dose in autumn (NPKMgMgS2), (F) NPK+MgS - $^{2}/_{3}$ in autumn + $^{1}/_{3}$ in spring (NPKMgS3), replicated four times. Soil fertility indicated by the main agrochemical characteristics was satisfactory for producing a high yield of seeds. The content of available phosphorus in the consecutive years ranged from high to very high, potassium – from high in the first two years to medium in the last one, and magnesium – from medium in the first year, high afterwards and very high in the last year. Each year, winter wheat preceded oilseed rape. The size of an individual plot was 100 m^2. The variety *Chagall* was sown in the last decade of August. Phosphorus and potassium were applied prior to sowing in doses adjusted to the soil analysis results and treatments. Magnesium and sulfur were applied to the crop in the form of magnesium sulfate on dates presented in Table 1. Nitrogen (ammonium saltpeter) was supplied in the amount of 27 kg N ha^{-1} before sowing, 102 kg N ha^{-1} before spring regrowth and the remaining dose at the end of the rosette stage.

Table 1

Arrangement of the experiment: composition, doses and schedule

Code of the treatment	Treatments	N		P	K		Mg		S	
		time and dose of applied fertilizer (kg ha^{-1})								
		A**	S***	A	A	S	A	S	A	S
AC	control	0	0	0	0	0	0	0	0	0
NP	N + P*	27	187	30.1	0	0	0	0	0	0
NPK	NPK	27	187	30.1	149.4	0	0	0	0	0
NPKMgS1	NPK + MgS1	27	187	30.1	99.6	49.8	0	5.4	0	6.0
NPKMgS2	NPK + MgS2	27	187	30.1	149.4	0	16.3	0	18.0	0
NPKMgS3	NPK + MgS3	27	187	30.1	99.6	49.8	10.8	5.4	12.0	6.0

* di-ammonium phosphate, ** autumn, *** spring

Plants for determinations of dry mater and magnesium concentration were sampled from an area of one m^2 in three consecutive stages of oilseed growth according to the BBCH scale: 30, 61 and 89. At each measurement date, the harvested plant sample was partitioned, in accordance with the stage of development, into subsamples of leaves (BBCH 30), stems and leaves (BBCH 61), pericarp (trashed silique) and seeds (BBCH 89) and then dried (65°C). Plant material for mineral element determination was mineralized at 640°C and the ash was dissolved in 33% HNO_3. The magnesium concentration was measured by flame atomic absorption spectrometry. Results are expressed on a dry matter (DM) basis. The content of a nutrient in each plant part was achieved through the multiplication of its concentration by the respective biomass of that crop part.

The data obtained experimentally were subjected to the conventional analysis of variance using Statistica 10 software. Differences between the treatments were evaluated with the Tukey's test. Results of the F test (***, **, * indicate significance at the P < 0.1%, 1%, and 5%, respectively) are given in tables and figures. Path analysis was conducted based on correlation coefficients, by taking yield of seed and/or its structural components as effects and magnesium accumulation in plant parts as independent variables. The path diagram, showing direct and indirect path coefficients, was elaborated based on the highest value of the correlation coefficient for a particular set of variables. In the second step of the diagnostic procedure, stepwise regression was performed to define an optimal set of variables for a given crop characteristic. In the computing procedure, a consecutive variable was added to multiple linear regressions in a step-by-step manner. The best regression model was chosen based on the highest *F*-value for the entire model and significance of all independent variables (Konys, Wiśniewski 1984).

Acronyms applied in the paper:
MBY - yield of the main branch (inflorescence),
SBY - yield of secondary branches,
TSY - total yield of seeds,
SMB - number of siliques per the main branch,
SSB - number of siliques per the secondary branch,
SSMB - number of seeds per silique of the main branch,
SSSB - number of seeds per silique of the secondary branch,
Mg_{RE} - magnesium content in oilseed rape at the rosette stage,
Mg_{LE} - magnesium content in leaves of oilseed rape at the onset of flowering,
Mg_{SH} - magnesium content in stems of oilseed rape at the onset of flowering,
Mg_{ST} - magnesium content in stems of oilseed rape at maturity,
Mg_{SE} - magnesium content in seeds of oilseed rape at maturity,
Mg_{c} - magnesium concentration in leaves at the onset of flowering.

RESULTS AND DISCUSSION

The magnesium concentration in oilseed rape showed stage dependent changes in response to fertilizing treatments and years (Table 2). The course of the weather was the dominant factor, although it presented significant variability depending on which plant part was examined. At the rosette stage (BBCH 30), a slightly higher Mg concentration occurred in 2010, the main reason being a much lower plant density (Szczepaniak 2014*a*). The effect of differentiated amounts of the applied nutrients manifested itself as an increased Mg concentration in plants fertilized with nitrogen. This trait underwent a significant change during the subsequent stages of oilseed rape growth. The magnesium concentration in leaves at the onset of flowering (BBCH 61) responded to the interaction of both factors. Consequently, it was used as a predictor of yield:

Table 2

Statistical evaluation of magnesium concentration (g kg^{-1}) in parts of oilseed rape in critical stages of growth, average for three years

Factor	Factor level	BBCH 30	BBCH 61		BBCH 89	
		LE	LE	SH	ST	SE
Fertilization treatments (FT)	control	1.79^{a}	2.75^{a}	2.30	0.99	2.70
	NP	2.27^{b}	3.02^{a}	2.40	1.04	2.86
	NPK	2.48^{b}	3.29^{ab}	2.55	1.15	2.77
	NPKMgS1	2.40^{b}	3.17^{ab}	2.28	1.03	2.91
	NPKMgS2	2.40^{b}	3.11^{ab}	2.47	0.85	2.75
	NPKMgS3	2.50^{b}	3.31^{b}	2.39	0.99	2.77
Years (Y)	2008	2.18^{b}	3.65^{c}	3.11^{c}	1.12^{b}	2.82^{b}
	2009	2.24^{c}	2.94^{b}	1.60^{a}	0.89^{a}	3.01^{b}
	2010	2.51^{a}	2.73^{a}	2.50^{b}	1.01^{ab}	2.54^{a}
F-distribution for FT		***	***	ns	ns	ns
F-distribution for Y		**	***	***	**	***
F-distribution for FT x Y		ns	***	ns	ns	ns

*,**, *** - probability level of 0.05, 0.01, 0.001, respectively; ns – non-significant, ^{a} the same letters mean absence of significant differences

$$MBY = 3.431Mg_c + 0.213 \quad \text{for } n = 18, \quad R^2 = 0.29 \quad \text{and } p < 0.05,$$
$$SBY = 11.74Mg_c - 0.913 \quad \text{for } n = 18, \quad R^2 = 0.69 \quad \text{and } p < 0.001,$$
$$TSY = 15.17Mg_c - 0.70 \quad \text{for } n = 18, \quad R^2 = 0.66 \quad \text{and } p < 0.001.$$

Thus, it can be concluded that the leaf magnesium concentration in oilseed rape at the onset of flowering allows satisfactory prediction of yield. At the same growth stage, the magnesium concentration in stems followed a slightly different course, as indicated by the lowest value in 2009. This trend continued in the subsequent oilseed rape growth stages, as documented by the results of determinations on straw samples collected at maturity. The magnesium concentration in seeds showed slight seasonal variability, decreasing in the order: 2010 < 2008 ≤ 2009. This order followed the plant density pattern (for details cf. Szczepaniak 2014*a*). These results are contrary to the data reported by Spychaj-Fabisiak et al. (2011), who showed that increasing magnesium concentrations were parallel to the plant density and frequency of magnesium foliar application.

The magnesium content in oilseed rape showed a significant response to the experimental factors throughout each season. The interactional effects were documented only for leaves at the onset of flowering and for stems at maturity (Table 3). The effect of seasons was stage-dependent. The highest Mg accumulation in leaves at the rosette stage, which was determined in 2010, was the result of the lowest plant density. This situation changed at

Table 3

Statistical evaluation of magnesium accumulation (g Mg m^{-2}) and partitioning in plant parts of oilseed rape in critical stages of growth, average for three years

Factor	Factor level	BBCH 30	BBCH 61		BBCH 89	
		LE	LE	SH	ST	SE
Fertilization treatments (FT)	control	0.40^{a}	0.29^{a}	0.85^{a}	0.99^{a}	0.78^{a}
	NP	0.71^{b}	0.61^{b}	1.23^{b}	1.35^{ab}	1.09^{b}
	NPK	0.74^{b}	0.66^{b}	1.23^{b}	1.70^{b}	1.22^{b}
	NPKMgS1	0.73^{b}	0.61^{b}	1.28^{b}	1.34^{ab}	1.19^{b}
	NPKMgS2	0.72^{b}	0.59^{b}	1.17^{b}	1.36^{ab}	1.24^{b}
	NPKMgS3	0.74^{b}	0.66^{b}	1.22^{b}	1.40^{ab}	1.24^{b}
Years (Y)	2008	0.59^{a}	0.52^{b}	1.34^{b}	1.78^{b}	1.34^{b}
	2009	0.66^{ab}	0.81^{c}	1.07^{a}	1.07^{a}	1.28^{b}
	2010	0.72^{b}	0.37^{a}	1.07^{a}	1.22^{a}	0.78^{a}
F-distribution for FT		*	***	**	***	***
F-distribution for Y		***	***	***	**	***
F-distribution for FT x Y		ns	***	ns	*	ns

*,**, *** probability level of 0.05, 0.01, 0.001, respectively; ns – non-significant, ^{a} the same letters mean absence of significant differences

the onset of flowering, when the maximum content of Mg was recorded in leaves in 2009, or in shoots in 2008. The latter trend continued in oilseed rape vegetative organs until maturity. The magnesium harvest index, averaged over the fertilization treatments, was year-dependent. In 2008 and 2010, it reached the level of 43% and 40%, respectively, climbing up to 55% in 2010. This rise, assuming an almost constant Mg concentration in seeds, can be explained by the level of internal crop magnesium resources. A simple balance of the nutrient in the period from the onset of flowering up to maturity showed that the net uptake of Mg by the oilseed rape canopy was 1.26 g m^{-2} in 2008 and just 0.47 g m^{-2} in 2009. Consequently, the main source of the nutrient for developing seeds was its pool accumulated in the canopy before flowering. The observed phenomenon was the consequence of magnesium management during the growth. As shown in Figure 1, the magnesium content in leaves at the onset of flowering responded to the applied fertilizers, but their effect varied from year to year. The magnesium content in plants grown on the absolute control plot was invariable in all three years, suggesting good Mg supply from soil resources. The effect of NP treatment on magnesium accumulation was nearly identical in 2008 and in 2009, implicating a significant increase compared to the control plot. No increase was observed in 2010. The effect of NPK fertilizers was documented to be the strongest in 2009, resulting in drastically higher Mg accumulation. The absence of the plants' response, in terms of their magnesium content, to fertilizers applied in 2010 suggests the presence of other, non-nutritional factors negatively affecting the

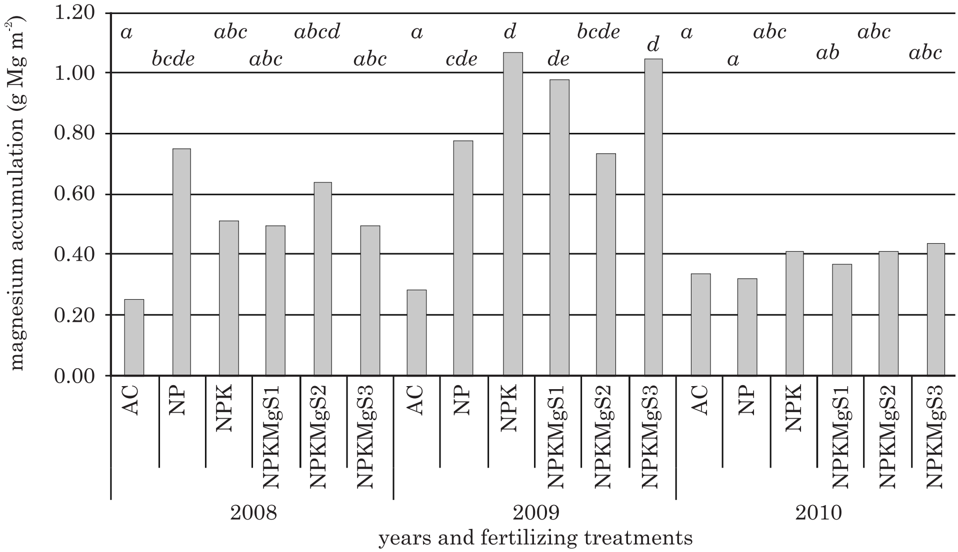

Fig. 1. Effect of differentiated fertilization in consecutive years on magnesium accumulation in leaves of oilseed rape at the onset of flowering

growth of oilseed rape plants, of which the main one was the high soil moisture during the autumn growing season, which resulted in the formation of soil crust and inferior resistance to frost during winter (Tonev 2006).

The magnesium content in stems at the onset of flowering was not differentiated by the interaction of fertilizers and seasons, despite the significant impact of both factors. It became an important yield forming factor during plant maturation, as evidenced by its content in straw (Table 3). In general, the magnesium content in vegetative organs during flowering and seed filling, averaged over the fertilization treatments, increased by 33% in 2008 and by 12% in 2010, while no such increase was noted in 2009. A detailed analysis showed a strong impact of the fertilization treatments, which was not year-dependent (Figure 2). In 2008, the magnesium content in stems of control plants was double the one noted in the other years. The effect of the applied fertilizers was year-specific. In 2008, the amount of magnesium in stems was the highest in the NPKMgS2 treatment, while in the others years it peaked in the NPK treatment. The absence of any increase in the magnesium content in stems notcied in 2009, accompanied by a much higher harvest index, suggests some depletion of its soil reserves. This hypothesis is supported by the fact that magnesium is only moderately remobilized from its vegetative pools during plant maturation, thus being highly responsive to foliar application in late stages of seed-crop growth (Grzebisz 2013).

Path- and stepwise analyses were performed to evaluate the importance of magnesium accumulation and partitioning in oilseed rape organs during the growth on the yield of seeds. The correlation and path coefficients sho-

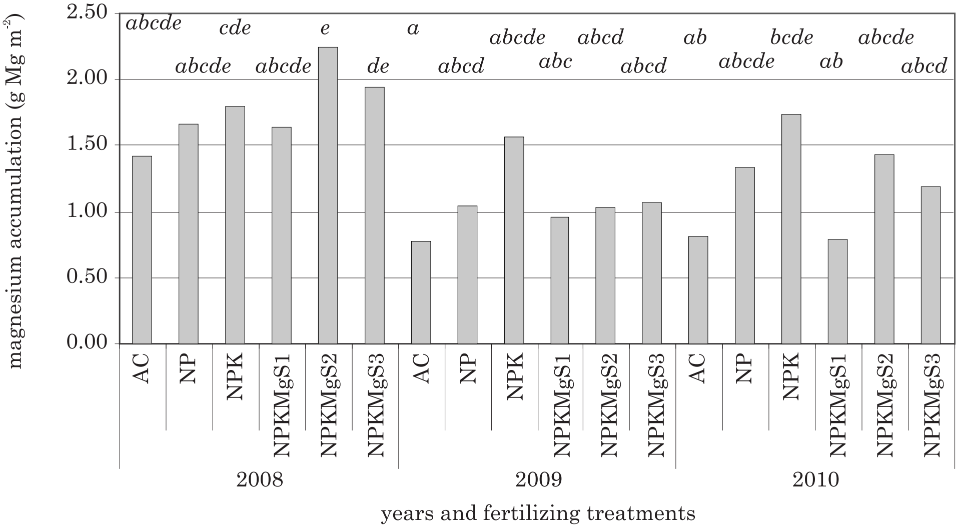

Fig. 2. Effect of differentiated fertilization in consecutive years on magnesium accumulation in stems of oilseed rape at physiological maturity

wed that yield produced by the main inflorescence depended the most on magnesium accumulation in seeds, on condition that no factor disturbed its accumulation during plant maturation. The predictive importance of this plant organ was only slightly modified by the Mg content in stems (Figure 3*a*). The dominant effect of magnesium content in seeds was fully corroborated by the stepwise regression models. The accuracy of prediction improved when Mg_{SH} had been introduced into the model:

$MBY = 0.91Mg_{SE} + 0.247$ for $n = 18$, $R^2 = 0.79$ and $p < 0.00000$,
$MBY = -0.283Mg_{SH} + 1.11Mg_{SE} + 0.41$ for $n = 18$, $R^2 = 0.89$ and $p < 0.00000$.

Excess of magnesium in stems of oilseed rape plant at the onset of flowering or in straw at maturity affected negatively the yield of seeds from the main branch. The yield produced by secondary branches can be best predicted by the magnesium content in seeds, which exerted the highest direct effect (Figure 3*b*). The dominance of Mg_{SE} as a yield predictor was confirmed by the developed regression models:

$SBY = 2.047Mg_{SE} + 0.42$ for $n = 18$, $R^2 = 0.80$ and $p < 0.00000$,
$SBY = 0.64Mg_{ST} + 1.61Mg_{SE} + 0.048$ for $n = 18$, $R^2 = 0.91$ and $p < 0.00000$.

The total yield produced by oilseed rape, as revealed by the applied statistical procedures, was predicted the best by the magnesium content in seeds (Figure 3*c*). The practical usefulness of Mg_{SE} as the dominant yield predictor was entirely corroborated by the developed regression model:

$TSY = 2.959Mg_{SE} + 0.67$ for $n = 18$, $R^2 = 0.95$ and $p < 0.00000$.

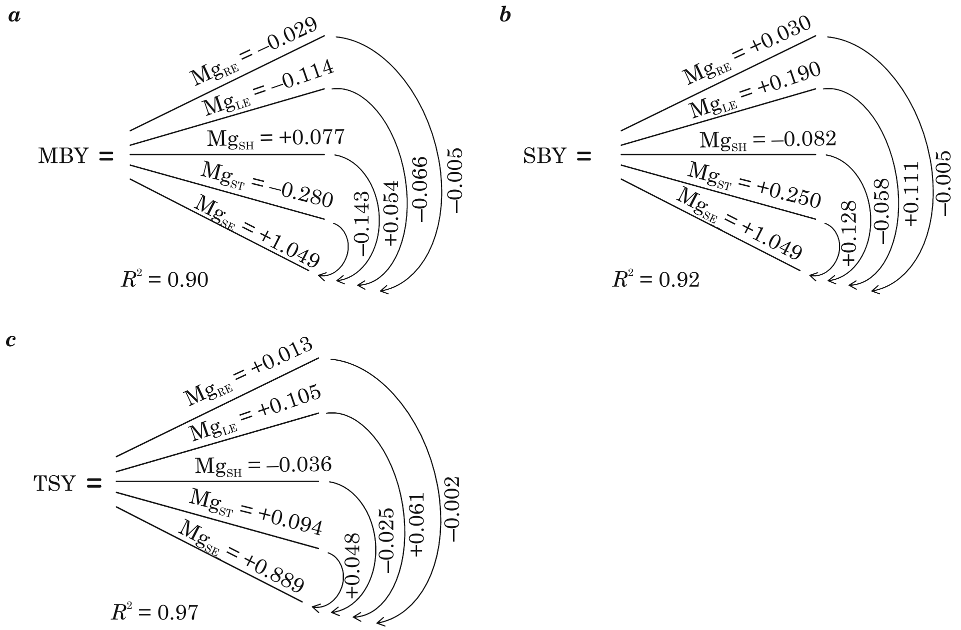

Fig. 3. Path diagram: The arrangement of magnesium characters impacting both directly and indirectly yield of oilseed rape produced by: *a* – the main inflorescence, *b* – secondary branches, *c* – whole plant

The models presented above clearly support the nutrient-seed sink hypothesis presented by Szczepaniak (2014a) for nitrogen. However, for the magnesium content in seeds, its prediction accuracy based on the direct impact was very high, irrespective of the plant part. The magnesium content in seeds as a predictive variable showed the strongest direct effect for each of the studied types of yield, which was at the same time compatible with the lowest sum of indirect effects (Table 4). For the nitrogen content in seeds, it was relatively low for the yield from secondary branches Szczepaniak (2014*a*). For comparison, the content of potassium in plant organs demonstrated a relatively weak effect on yield components of oilseed rape, irrespectly of good

Table 4

Components of path analysis of the impact of Mg characteristics on oilseed rape yield, n = 18

Yield type/ Mg variable	MBY		SBY		TSY	
	DI*	INDs**	DI	INDs	DI	INDs
Mg_{RE}	-0.029	0.110	0.030	0.194	0.013	0.180
Mg_{LE}	-0.114	0.463	0.190	0.544	0.105	0.565
Mg_{SH}	0.077	0.671	-0.82	0.605	-0.036	0.683
Mg_{ST}	-0.280	0.463	0.250	0.486	0.094	0.522
Mg_{SE}	1.049	-0.160	0.711	0.186	0.889	0.086

* direct effect, ** sum of indirect effects

values of the correlation coefficients potassium, except total yield, for which K_{ST} proved to be the best variable (Szczepaniak 2014*b*). In conclusion, the magnesium content in seeds is the foremost oilseed rape attribute that can be applied with high accuracy for *ex-post* yield evaluation. The dominant role of magnesium arises from its impact on all basic processes responsible for carbohydrates, proteins and oil transformations in a growing seed, as a key component of ATP (Gerendás, Fűhrs 2013).

The harvested yield of oilseed rape is a function of the performance of yield forming components (Diepenbrock 2000, Grzebisz et al. 2010*c*). The study by Szczepaniak (2014a) fully supported this conclusion. The impact of the magnesium content in oilseed rape organs throughout the season was component-specific. The number of siliques developed by the main inflorescence was significantly predicted by the magnesium content in seeds and in the rosette (Figure 4*a*). The highest direct effect of the Mg content in seeds and, simultaneously, the lowest indirect effects of other variables were observed (Table 5). This finding was entirely corroborated by the developed stepwise regression models:

$SMB = 19.03Mg_{SE} + 24.82$ for $n = 18$, $R^2 = 0.65$ and $p < 0.00005$,

$SMB = -19.96Mg_{RE} + 20.47Mg_{SE} + 36.31$ for $n = 18$, $R^2 = 0.80$ and $p < 0.00001$.

Table 5

Components of path analysis of the impact of Mg characteristics on oilseed rape yield structural components, $n = 18$

Yield component /Mg variable	SMB		SSMB		SSB		SSSB	
	DI*	INDs**	DI	INDs	DI	INDs	DI	INDs
Mg_{RE}	-0.503	0.245	0.729	-0.367	0.313	0.095	-0.164	0.057
Mg_{LE}	-0.110	0.506	0.679	-0.519	-0.444	0.136	0.856	-0.312
Mg_{SH}	0.312	0.106	-1.336	0.947	0.468	0.076	-0.689	0.365
Mg_{ST}	0.414	0.110	-0.752	0.777	0.202	-0.167	0.051	0.521
Mg_{SE}	0.516	0.290	0.478	-0.818	0.205	0.222	0.060	0.014

* direct effect, ** sum of indirect effects

These two statistical procedures showed that an excessively high content of magnesium in leaves of oilseed rape in early stages of the growth caused a reduction in the number of siliques developed by the main branch. As shown in Figure 4a, any deficiency of magnesium in stems leads to worse silique performance.

Assessed by the path analysis, the impact of the magnesium content in oilseed rape organs on the number of seeds per silique of the main inflorescence was the highest for its content in shoots at the onset of flowering (Figure 3*b*). The negative signs of both the path and correlation coefficients mean that excess of Mg in shoots leads to lower seed density. The detailed analysis of the developed model showed a positive *albeit* indirect impact of

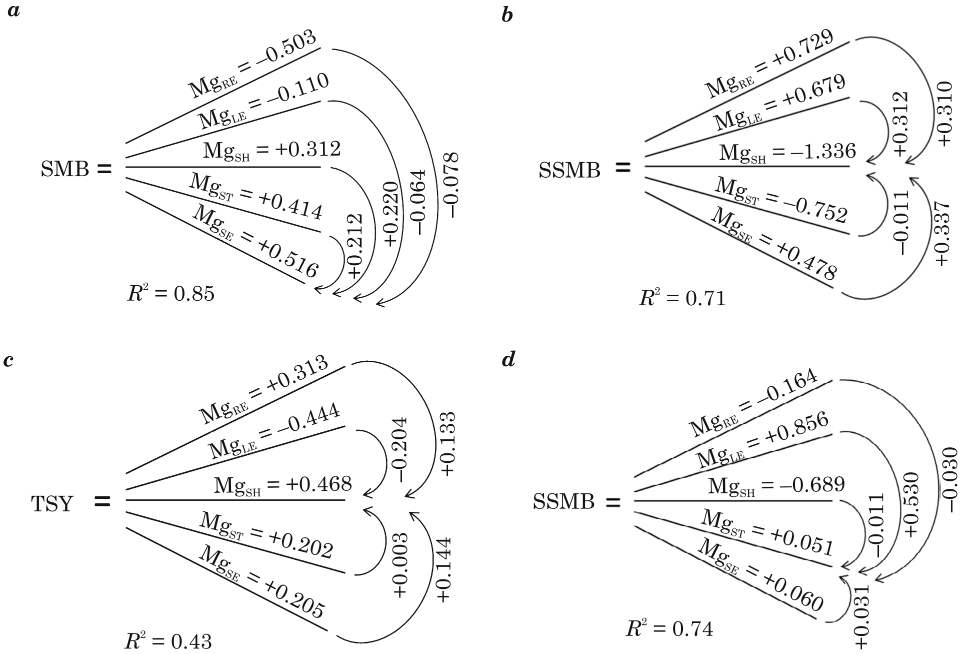

Fig. 4. Path diagram: The arrangement of magnesium characters impacting structural components of yield: *a* – number of siliques per the main inflorescence, *b* – number of seeds per silique of the main inflorescence, *c* – number of siliques per the secondary branch, *d* – number of seeds per silique of the secondary branch

the magnesium content in other plant parts (Table 4). The dominating effect of Mg_{SH} was verfied by the stepwise regression:

$$SSMB = 14.87Mg_{RE} - 8.7Mg_{SH} + 9.59 \quad \text{for } n = 18,\ R^2 = 0.49 \text{ and } p < 0.006.$$

The number of siliques developed by secondary branches was affected by all the measured yield structural characteristics, although their impact was relatively weak, as indicated by the correlation and path coefficients (Figure 4*c*, Table 4). This model was fully corroborated by the stepwise regression:

$$SSB = 70.08Mg_{ST} + 117.9 \quad \text{for } n = 18,\ R^2 = 0.30 \text{ and } p < 0.02.$$

The number of seeds per silique of the secondary branch showed the highest dependency on the magnesium content in stems as a limiting factor (Figure 4*d*). The direct path coefficients were much higher for its content in other parts of oilseed rape, especially at the onset of flowering. In fact, the highest direct and indirect effects were noted for the magnesium content in leaves. However, the predictive value of the correlation coefficient found for $Mg_{SH,}$ was shaped by the other variables (Table 5). The predictive usability of Mg_{ST} was verified by the stepwise regression model:

$$SSSB = 5.45Mg_{ST} + 3.0 \quad \text{for } n = 18,\ R^2 = 0.33 \text{ and } p < 0.013.$$

The importance of magnesium content in stems as the key predictor of yield structural component development results from its management by oilseed rape canopy in the period extending from the onset of flowering up to crop physiological maturity. Any excess of magnesium in stems led to reduction in seed density of the main inflorescence. Magnesium shortage in oilseed rape during silique and seed formation was the key factor that affected seed density. There are several causes of an insufficient supply of magnesium to developing seeds. In the current study, the optimum supply conditions occurred only in 2008, when the Mg content in both vegetative plant parts and in seeds increased substantially since the onset of flowering. In the second year, the delivery of magnesium to seeds reached the same level as in 2008. However, the yield of seeds decreased. The main reason was a much lower seed density due to the limited supply of magnesium to vegetative plant parts since the onset of flowering. It can be therefore concluded that oilseed rape is sensitive to magnesium supply during silique and seed development. Any conditions limiting its supply from the plant and/or from a soil resource results in a smaller seed density, which in turn decreases the physiological seed sink for magnesium. Concluding, oilseed rape for an optimum yield development requires prophylactic supply of magnesium fertilizer just before flowering, mainly because of low amounts of free Mg ions and limited hydrolysis of metabolically bound Mg (Gerendás, Fűhrs 2013).

CONCLUSION

The study showed that the magnesium concentration in leaves of oilseed rape at the onset of flowering can be used as the earliest predictor of yield of seeds, irrespectively of the growth conditions. The highest accuracy of yield prediction based on magnesium content in seeds implicates the key importance of this nutrient for yield development. Insufficient supply of magnesium to oilseed plant during seed formation leads to smaller seed density, which in decreases the size of the seed sink. The main, plant-specific factor responsible for seed density is the magnesium management by oilseed rape plants before the onset of flowering. This crop requires an additional supply of magnesium to support pod and seed formation.

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