FOLIA OECOLOGICA – vol. 39, no. 1 (2012). ISSN 1336-5266

Influence of nitrogen and phosphorus content in soil on yield of selected rapeseed varieties

Zuzana Tatarková[1], Ľubica Malovcová[2], Zoltán Bedrna[1], Elena Masarovičová[1]

[1]Department of Soil Sciences, Faculty of Natural Sciences, Comenius University, Mlynská dolina, SK-842 15 Bratislava, Slovak Republic,
e-mail. tatarkova@fns.uniba.sk
[2]Plant Production Research Centre, Bratislavská cesta 122, SK-921 068 Piešťany, Slovak Republic

Tatarková, Z., Malovcová, Ľ., Bedrna, Z. Masarovičová, E. 2012. Influence of nitrogen and phosphorus content in soil on yield of selected rapeseed varieties. *Folia oecol.*, 39: 88–93.

There was conducted an experiment to determine the impact of nitrogen and phosphorus content in soil on yield and seed production of selected rapeseed varieties. Field survey was executed on plots of the Plant Production Research Centre – Plant Production Research Institute in Borovce near Piešťany. Soil samples were taken in spring, before the growing season. In homogenized soil samples were determined contents of phosphorus and inorganic-, nitrate- and ammonium nitrogen. The experiment plot was evaluated in terms of basic nutrients content. For examined rapeseed varieties, yield and seed production were determined. The highest sensitive response to the applied fertilization and N, P soil content in spring and consequently the highest yield and seed production has observed in the varieties Labrador (yield 4.68 t ha^{-1}, seed production 2.46 dkg $plant^{-1}$), Decade (yield 4.45 t ha^{-1}, seed production 2.66 dkg $plant^{-1}$), Verona (yield 4.10 t ha^{-1}, seed production 2.28 dkg $plant^{-1}$) and Champlain (yield 4.08 t ha^{-1}, seed production 2.46 dkg $plan^{-1}$). The most unfavourable results of yield and seed production were reached by the varieties Viking (yield 2.99 t ha^{-1}, seed production 1.36 dkg $plant^{-1}$) and Baldur (yield 2.88 t ha^{-1}, seed production 1.43 dkg $plant^{-1}$).

Key words
nitrogen and phosphorus nutrition, rapeseed varieties, seed production, yield

Introduction

Rapeseed (*Brassica napus* L. subsp. *napus*) is a demanding crop regarding soil, climatic conditions and agronomic methods used (Surovčík, 2000). The plant does well in regions with medium strong winters and long growing seasons, and requires loam-sandy to loam soil with neutral to weakly alkaline soil reaction (pH 6–7.2) and sufficient humus reserves. Therefore to achieve sufficiently high yield of oilseed and to prevent spread of pests, it is necessary to respect the rules of crop rotation, which means that oilseed can be cultivated on the same plot after passing a period of 4 to 5 years (in detail see Tatarková et al., 2010). Bokor (2011) recommend for crop rotation a minimum period of 8 years. Rapeseed is categorized among the most demanding crops in terms of nutrient demands. For the production of 1 ton seed and the corresponding amount of straw, the rapeseed plant takes an average of 50 kg nitrogen, 11 kg phosphorus, 50 kg potassium, 35 kg calcium, 6 kg magnesium, 18 kg sulphur, 0.3 kg boron (Varga et al., 2007). Additional fertilization with organic fertilizers, which is important for the maintenance of soil fertility, can be assured by plowing under straw and applying manure after harvesting the winter crop.

In general, nitrogen as the most important nutrient has an influence to growth of plants and their yield. The most important for plants is the nitrogen in nitrate (NO_3^-) and ammonium (NH_4^+) forms which plants take mostly from soil nitrate nitrogen. However, at very high concentration of nitrate nitrogen amount in soil, the intake of ammonium nitrogen by plants is limited.

According to Bielek (1998) plants usually uptake nitrogen from soil prior to uptake of nitrogen from fertilizers because fertilizer nitrogen shortly after application is not available to plants and only after remineralisation of the nitrogen compound is usable by plants. Surplus of nitrogen causes intensive plant growth and delay of flowering, deficiency of nitrogen exhibits with leaf yellowing.

Phosphorus is the basic plant nutrient that exists in a soil naturally in very little amount. Plants are taking it in form of organic phosphates, total intake of phosphorus depends on the amount and form of nitrogen in soil and on the soil reaction. If nitrate forms do dominate then the intake of phosphorus is blocked. Phosphor influences the root growing, flowering and protects plant during wintering. Too high contents of phosphorus in soil have a negative affect because of block boron intake, which is very important element for plant flowering. It is possible to fertilize the soil with phosphorus to the reserve for 3–4 years (Baier, 1962).

Considering the aspect of usability, rapeseed belongs to the crops that have an important position not only in food industry but also in chemical industry. Rapeseed also dominates in the production of biofuel pure rapeseed oil and FAME over ten years. FAME (fatty acid methyl ester) is component in diesel fuel. The rising demand for rapeseed is leading to pressure on the agriculture to produce sufficient rapeseed plants for both mentioned sectors of industry.

The aim of this work was the assessment of influence of nitrogen and phosphorus content in soil on the yield and seed production of selected rapeseed varieties.

Methods

For the experiment were used plots of Plant Production Research Centre – Plant Production Research Institute in Borovce near Piešťany (Slovakia). The locality Borovce is situated on the Podunajská downs on the right side of river Váh in altitude of 160 m above sea level. The year average air temperature is 9.2 °C, year average precipitation is 545 mm. In locality occur Chermozems on the loess with soil reaction 5.5–7.2 and humus content of 1.8–2%. According to soil portal www.podnemapy.sk in Borovce are fertile soils with production index IP-81-90 which are very suitable condition for rapeseed cultivation. The locality belongs to the maize production region.

The adaptation of soil for field experiment is as follows: after the harvest of preceeding crop, it was realized stubble incorporation with disc harrow, the soil was ploughed, rolled and fertilized with NPK in rate 15 : 15 : 15 with an amount of 200 kg ha^{-1}. Trifluex 48EC in amount of 2 l ha^{-1} against weed has been used. After sowing, the preparation "Butisan Star" (1.5 l ha^{-1}) and in Autumn the morpho-regulator "Caramba" (1 l ha^{-1}) have been applicated. After wintering the fertilizer "Sulfamo23" (23% N, 31% SO_3, 3% MgO) with consistence of 200 and 230 kg ha^{-1} has been added to the plants. Significant proportion of nitrogen was applied before sowing (150 kg N ha^{-1}) and the smaller part in spring before the growing season starts (80 kg N ha^{-1}) (in detail see Masarovičová et al., 2008).

Soil sampling: from the each plot with area 10 m^2 (1.25 × 8 m) were taken soil samples from three places from a deep of 10–20 cm. These three samples have been mixed into the one mixture soil sample. The soil samples were dried at laboratory temperature, crushed and sieved during riddle with sieve diameter of 2 mm. Acquired fine-soil was analysed for: content of NH_4^+ (mg kg^{-1}), NO_3^- (mg kg^{-1}), N_{an} (mg kg^{-1}) and P (mg kg^{-1}). The analyses were done performed at the Central and Testing Institute of Agriculture in Zvolen, Slovak Republic.

Content of inorganic nitrogen was evaluated according to Fecenko and Ložek (2000), (Table 1), phosphorus content was determined by Kotvas (2007), (Table 2).

Table 1. Assessment of nitrogen content N_{an} in the soil (Fecenko, Ložek, 2000)

Content N_{an} [mg g^{-1}]	Assessment
< .0	Very little
5.1–10.0	Little
10.1–20.0	Middle
20.1–40.0	Good
>40	High

Table 2. Assessment of phosphorus content in middle heavy soil (Kotvas et al., 2007)

Content P [mg kg^{-1}]	Assessment
<50	Low
51–85	Suitable
86–125	Good
126–165	High
>165	Very high

In our experiment we tested selected rapeseed varieties (Table 3).

Results and discussion

The soil on the experimental plot in spring before growing season contained following nutrient contents (Table 4).

Content of inorganic nitrogen ($N_{an} = N_{NO3^-} + N_{NH4^+}$) was assessed as "good". It was dominated ammonium nitrogen, what is usual typically for low production soil.

Table 3. Tested rapeseed varieties

Variety	Type of variety	Height	Resistance against lodging	Resistance against winter killing	Growing suitability in production region (PR)
Labrador	Serotinous	Low	Medium	Suitable	All PR
Oponent	Serotinous	High	Medium	Suitable	All PR
Baldur	Medium serotinous	Medium high	Good	Very good	All PR
Champlain	Medium early	Medium high	Medium to high	Very high	All PR
Slogan	Medium early	Low	Medium	Suitable	All PR
Dekade	Medium early	Low	Good	Very good	MPR, RPR, PPR
Maplus	Data unavailable				
Viking	Medium early	Medium high	Good	Good	All PR
Verona	Serotinous	Medium high	Very good	Very good	MPR, PPR

Source: (www.uksup.sk)

For optimal fertilized soil is typical balanced proportion of $N_{NH_4^+}$ and $N_{NO_3^-}$.

Table 4. The basic statistic parameters of nitrogen content in soil in the spring period

	N_{an} [mg kg^{-1}]	$N_{NH_4^+}$ [mg kg^{-1}]	$N_{NO_3^-}$ [mg kg^{-1}]
Min. value	17.10	11.60	3.50
Max. value	34.50	26.50	8.00
Average	26.44	21.19	5.25
Median	26.20	21.65	5.25
Variance	12.83	12.98	1.04
Standard deviation	3.58	3.60	1.02
Number of samples	22	22	22

As far as the nitrate nitrogen has a higher value for the rapeseed, the existing quantity is essentially reduced what was caused by the increased demand of the rapeseed during the intensive growth in the spring period.

It was found that already in the fall the rapeseed extracts high amount of nitrate from the soil. According to the state of the crop that makes 50–100 kg ha^{-1} (Mráz, 2009). Because of this fact it is necessary to realize regenerative fertilization in the spring period. It is not possible to fertilize the soil with inorganic forms of nitrate "in advance" because it can be flushed out, mainly under rainy weather.

It could be stated that from the aspect of nitrate contents the experiment plot showed a high homogeneity degree. Thus, all sampled rapeseed varieties had the same starting conditions for yield formation.

Phosphorus reserve in a soil before growing season in spring did reach high variability, their content was in a range from 109 to 274 mg kg^{-1} (Table 5). In general the phosphorus content assessed as "high".

Table 5. The basic statistic parameters of phosphorus content in soil in the spring period

	P [mg kg^{-1}]
Min. value	109
Max. value	274
Average	158.36
Median	147
Variance	156.69
Standard deviation	39.59
Number of samples	22

The high phosphorus content probably relates with supplying this nutrient to the soil during last years. Phosphorus mobility in a soil is low, it migrates to the distance of 0.2–0.3 m from fertilize application place, so a loss of phosphorus from the soil is very low (Šoltýsová, 2007). Total phosphorus content in a soil to a certain degree depends on the mechanic soil composition and organic matter content (Šoltýsová, 2007). Grained, moderate heavy soils with a high percentage of humus – that also occur in Borovce – show a reserve of phosphorus which is naturally high. From the aspect of phosphorus disposing in the soil the plot showed lower degree of homogeneity than was found for nitrogen.

Harvest of crops sensitively responded to the nitrogen and phosphorus ratio. Disturbing of N : P ratio to an advantage of nitrogen leads to a gigantic growth and delayed flowering, while an prevailing proportion of phosphorus induces accelerating of growing while it dries out & lowers the quality of the fruits at the same time (Bedrna, 2009). It is known that favourable ratio of N : P is 1 : 1. In a spring period for sampling rapeseed varieties were established the following N:P ratios (Table 6).

Efficiency of spring nitrogen fertilization depends on the rapeseed variety, however it was established, that higher nitrogen amount effectively increases of yield

and rapeseed production (Möllers et al., 1999, Budzyński and Jankowski, 2006). In our experiment by use of nitrogen amount of 80 kg ha^{-1} in spring the rapeseed varieties failed in use of the nitrogen as before which was reflected in the earnings.

Table 6. Ratio of nitrogen and phosphorus in soil in the spring period for tested rapeseed varieties

Variety	Content N_{an} [mg kg^{-1}]	Content P [mg kg^{-1}]	Ratio N : P
Labrador	23.4	194.5	1 : 8
Oponent	26.2	163.0	1 : 6
Baldur	25.85	153.5	1 : 6
Champlain	25.15	168.5	1 : 6
Slogan	27.25	149.0	1 : 5
Dekade	26.8	153.5	1 : 6
Maplus	27.95	133.5	1 : 5
Viking	26.3	126.0	1 : 5
Verona	27.4	165.5	1 : 6

Table 7. Values of yield (line up descending), nitrogen and phosphorus content in soil in the spring period

Variety	Yield [t ha^{-1}]	Content N_{an} [mg kg^{-1}]	Content P [mg kg^{-1}]
Labrador	4.68	23.40	194.5
Dekade	4.45	26.80	153.5
Verona	4.10	27.40	165.5
Champlain	4.08	25.15	168.5
Maplus	3.65	27.95	133.5
Slogan	3.46	27.25	149.0
Oponent	3.34	26.20	163.0
Viking	2.99	26.30	126.0
Baldur	2.88	25.85	153.5

In terms of climate conditions, all tested rapeseed varieties had the same suitable conditions for yield and seed production. The period from January to July was favourable for rapeseed growth. Average air temperature in January and February did not decrease under freezing point, what positively influenced a good wintering. In the time period from January to July did fall a total sum of precipitation of 616.9 mm, the greatest sum of precipitation did fall during the July (89.6 mm). In March, which is the revitalization time for rapeseed after wintering, 47.3 mm precipitation did fall and the average air temperature of 4.73 °C has been reached (Masarovičová et al., 2011).

The high yield of all tested varieties corresponded to the seed production. From this aspect it is possible to classify the studied rapeseed varieties into the following three categories – high, middle and low of production (Table 8).

Table 8. Values of yield (line up descending) and seed production for tested rapeseed varieties

Variety	Yield [t ha^{-1}]	Seed production [dkg plant^{-1}]
Labrador	4.68	2.46
Dekade	4.45	2.66
Verona	4.10	2.28
Champlain	4.08	2.46
Maplus	3.65	1.40
Slogan	3.46	1.63
Oponent	3.34	1.69
Viking	2.99	1.36
Baldur	2.88	1.43

Into the first category of high production varieties with both high yield and seed production can be categorized varieties – Labrador, Dekade, Verona and Champlain. The highest yield of 4.68 t ha^{-1} was reached by variety Labrador, regarding the aspect of seed production it is on second place. Yield of Labrador is comparable with results of work Bielíková et al. (2007), where in the time period of 6 years this cultivar did reached permanently high yield average 5.17 t ha^{-1}. The same seed production like the cultivar Labrador has been reached by the variety Champlain.

Comparing to the yield and seed production the best results have been achieved by the variety Dekade.

To the groups of middle production varieties belong Maplus, Slogan and Oponent. Smaller yield of Oponent in comparison to the other results (Koprna, 2006; Baranyk and Málek, 2009) probably relates with high phosphorus content in the soil and imbalance between nitrate and ammonium nitrogen concentrations. On the unsuitable one-way method of nitrogen fertilization and excessive phosphorus content in soil and their following decrease of the yield of rapeseed and their quality Matula (2009) already pointed out. The lowest values of studied production parameters were reached by the varieties Viking and Baldur (Fig. 1).

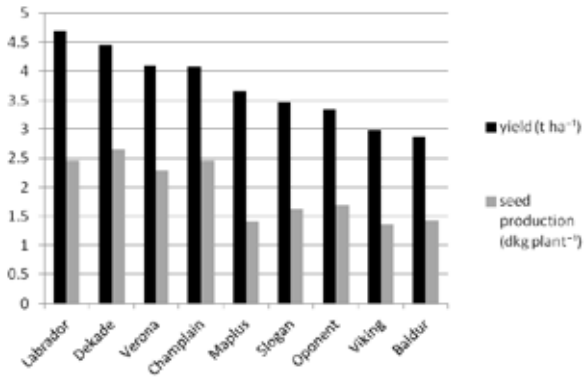

Fig. 1. Values of yield (t ha^{-1}) and seed production (dkg plant^{-1}) of tested rapeseed varieties.

Conclusions

All studied rapeseed varieties had the same conditions regarding soil, climatic conditions for yield formation and seed production, too. Different yield and seed production of individual rapeseed varieties were caused by the properties of genotype only. On the basis of our observations and results we classified the tested rapeseed varieties into the groups of high, middle and low production. The varieties Labrador and Dekade responded as best to the added restorative fertilization – both varieties reached the highest yield and seed production. The lowest yield and seed production had the varieties Viking and Baldur.

Acknowledgement

This study was in part financially supported by Association for Production and Use of Biofuels, Civil Society Organization, Bratislava, Slovak Republic.

References

Baier, J. 1962. *Abeceda výživy rostlin* [Basics of plant nutrition]. Praha: Státní zemědělské nakladatelství. 250 p.

Baranyk, P., Málek, B. 2009. Výsledky odrodových pokusov s repkou ozimnou v r. 2008 [Results of cultivar experiments with rapeseed in year 2008]. *Naše pole*, 1: 20–21.

Bedrna, Z. 2009. *Starostlivosť o pôdu v záhrade* [Care of garden soil]. Bratislava: Veda. 250 p.

Bielek, P. 1998. *Dusík v poľnohospodárskych pôdach Slovenska* [Nitrogen in agricultural soils of Slovakia]. Bratislava: Výskumný ústav pôdnej úrodnosti. 250 p.

Bielíková, L., Vencel, M., Šalom, P., Hrbáček, L., Horejsek, J. 2007. Náhled na výnosový potenciál odrůdy Labrador (Saatbau Linz ČR) v souvislosti s výsledky pokusů ÚKZÚZ v letech 2002 – 2007 [Insight on yield potential of cultivar Labrador (Saatbau Linz CR) in relation with results Of ÚKZÚZ experiments during 2002–2007]. In *Prosperujíci olejniny 2007. Zborník referátov z konferencie*. Praha: Česká zemědělská univerzita, p. 103–106.

Bokor, P. Fyziologické poruchy a choroby repky na jeseň [Physiological disorders and diseases of rapseed in autumn]. *Agromanuál. Region. Príl.,* 6: 4–5.

Budzyński, W.S., Jankowski, K.J. 2006. Vlyv hnojení dusíkem na výnos a kvalitu řepky ozimé [Effects of nitrogen fertilization on the yield and usability of winter rape seeds]. In *Řepka, mák, horčice 2006. Zborník referátov z konferencie*. Praha: Česká zemědělská univerzita, p. 71–78.

Fecenko, J., Ložek, O. 2000. *Výživa a hnojenie poľných plodín* [Nutrition and fertilization of agricultural crops]. Nitra: Slovenská poľnohospodárska univerzita v Nitre. 452 p.

Koprna, R. 2006. Oponent – nová liniová odrůda sdružení „Česká řepka" [Oponent – new line variety of the "Czech rapeseed" association]. In *Řepka, mák, hořčice 2006. Zborník referátov z konferencie*. Praha: Česká zemědělská univerzita, p. 133–135.

Kotvas, F., Koutný, B., Vojtek, R., Gáborík, Š. 2007. *Výsledky agrochemického skúšania pôd na Slovensku v rokoch 2000 – 2005* [Results of agrochemical soil testing in Slovakia in years 2000–2005]. Bratislava: Ústredný kontrolný a skúšobný ústav poľnohospodársky. 98 p.

Masarovičová, E., Kráľová, K., Malovcová, Ľ., Surovčík, J., Brestič, M., Olšovská, K. 2008. Genotypové rozdiely repky olejky z hľadiska obsahu oleja, kvality oleja a produkcie semien [Genotypic differences of rapeseed from the aspect of oil content, oil quality and seed production]. In *Nové poznatky z genetiky a šľachtenia poľnohospodárskych rastlín. Zborník referátov z konferencie*. Piešťany: SCPV – VÚRV, p. 19–22.

Masarovičová, E., Kráľová, K., Malovcová, Ľ. 2011. Production of some rapeseed genotypes under various climatic conditions of Slovakia. *Ekológia (Bratislava)*, 30: 360–368.

Matula, J. 2009. Význam základného hnojenia a diagnostiky výživového stavu pôdy pri výžive repky olejky. 2. časť [The importance of basic fertilization and diagnostics of nutrition state of soil at rapeseed nutrition. 2. part]. *Naše pole*, 3: 22–23.

Möllers, CH., Kahlmeyer, M., Kessel, B., Ossenkop, A., Becker, H.C. 1999. *Genotypic variation for nitrogen efficiency in winter rapeseed cultivars* [cit. 2011-06-24]. http://www.regional.org.au/au/gcirc/4/358.htm

Mráz, J. 2009. Podzimní aplikace dusíku v řepce – přednosti a rizika [Autumn application of nitrogen in rapeseed – advantages and risks]. In *Prosperující olejniny 2009. Zborník referátov z konferencie*. Praha: Česká zemědělská univerzita, p. 143–144.

Surovčík, J. 2000. Response of rapeseed yield to application of pesticides. In Šafránková, I., Salvet, V., Šefrová, H. (eds). *Sborník referátů z XV. české a slovenské konference o ochraně rostlin v Brně 12.–14. září 2000: Proceedings of the XVth Czech and Slovak Plant Protection Conference in Brno September 12.–14., 2000*. Brno: Publishing House Konvoj, p. 253–254.

Šoltýsová, B. 2007. *Fosfor v pôde* [Phosphorus in soil] [cit. 2011-06-24]. http://www.scpv-ua.sk/index.php/2007-pr-16/15--fosfor-v-prirode-a-v-pode

Tatarková, Z., Malovcová, Ľ., Bedrna, Z., Masarovičová, E., Kráľová, K. 2010. Production potential of rapeseed from the aspect of soil quality. *Phytopedon*, 1: 35–41.
Varga, L., Ducsay, L., Marček, M. 2007. *Optimalizácia výživy repky ozimnej* [Nutrition optimization of Rapeseed] [cit. 2011-06-24].
http://www.agromanual.cz/cz/clanky/vyziva-a-stimulace/hnojeni/optimalizacia-vyzivy-repky-ozimnej.html [cit. 2011-06-24].
http://www.podnemapy.sk [cit. 2011-06-24].
http://www.uksup.sk/download/odrody/20090728_opisy_repka.pdf [cit. 2011-06-24].

Vplyv obsahu dusíka a fosforu v pôde na úrodu vybraných odrôd repky olejky

Súhrn

Práca prezentuje výsledky výskumu, ktorý bol zameraný na reakciu deviatich sledovaných odrôd repky olejky, forma ozimná na aplikované regeneračné hnojenie (jarné obdobie). Experiment bol vykonaný na pokusných plochách Centra výskumu rastlinnej výroby – Výskumný ústav rastlinnej výroby Borovce pri Piešťanoch. Región spadá do kukuričnej výrobnej oblasti a tamojšie pôdy sú veľmi vhodné na pestovanie repky. Odber pôdnych vzoriek bol vykonaný na jar pred začiatkom vegetačného obdobia. Homogenizované pôdne vzorky boli analyzované na obsah anorganického (N_{an}), amónneho ($N_{NH_4^+}$), dusičnanového dusíka ($N_{NO_3^-}$) a fosforu (P). Na základe výsledkov skúmané odrody repky možno rozdeliť na vysoko, stredne a nízko produkčné. V jarnom období aplikovaný dusík a fosfor dokázali najlepšie využiť a tým pádom dosiahnuť najvyššiu úrodu a produkciu semena odroda Labrador s dosiahnutou úrodou 4,68 t ha^{-1} a produkciou semena 2,46 dkg $rastlina^{-1}$, nasledujú odrody Dekade (úroda 4,45 t ha^{-1}, produkcia semena 2,66 dkg $rastlina^{-1}$), Verona (úroda 4,10 t ha^{-1}, produkcia semena 2,28 dkg $rastlina^{-1}$) a Champlain (úroda 4,08 t ha^{-1}, produkcia semena 2,46 dkg $rastlina^{-1}$). K stredne produkčným odrodám začleňujeme odrody Maplus (úroda 3,65 t ha^{-1}, produkcia semena 1,40 dkg $rastlina^{-1}$), Slogan (úroda 3,46 t ha^{-1}, produkcia semena 1,63 dkg $rastlina^{-1}$) a Oponent (úroda 3,34 t ha^{-1}, produkcia semena 1,69 dkg $rastlina^{-1}$). Odrody Viking a Baldur dosiahli najnižšiu úrodu ako aj produkciu semena s nasledovnými hodnotami: Viking – úroda 2,99 t ha^{-1}, produkcia semena 1,36 dkg $rastlina^{-1}$, Baldur – úroda 2,88 t ha^{-1}, produkcia semena 1,43 dkg $rastlina^{-1}$.

Received September 29, 2011
Accepted November 26, 2011