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EFFECT OF WASTE ROCK WOOLS ON THE SPRING BARLEY (*Hordeum vulgare* L.) YIELD AND SOME SOIL PARAMETERS

ODDZIAŁYWANIE ODPADÓW WEŁNY MINERALNEJ NA PLONOWANIE JĘCZMIENIA JAREGO (*Hordeum vulgare* L.) I NIEKTÓRE WŁAŚCIWOŚCI GLEBY

Abstract: The effect of two recycled waste rock wools (Nobasyp and Agrodrap) on the yield parameters of spring barley and some agrochemical soil parameters has been studied in a pot trial conducted in a vegetation cage located at the SAU in Nitra (48º18′ N, 18º05′ E) on the Haplic Luvisol (25 kg soil per pot).

Achieved results have shown that the application of both kinds of rock wool had a positive but not statistically significant effect on the grain and straw yield of spring barley. The Nobasyp effect on the yield was more positive than the one of Agrodrap. Combined application of Nobasyp (20 Mg · ha^{-1}) and NPK fertilizers resulted in the highest grain and straw yields. On the other hand, combined application of Agrodrap and NPK fertilizers (under the use of both doses – 10 and 20 Mg · ha^{-1}) was not well-founded, because the yields achieved by interactive effect of NPK fertilizers and Agrodrap were lower than the ones achieved by solely use of NPK fertilizers. The rock wool + NPK fertilizers application inhibited the negative effect of nitrogen on increase of crude protein content and the decrease of starch in the barley grain.

Both kinds of rock wool significantly increased the cation exchange capacity, made the soil lighter, moderately increased pH of the soil and have had a positive effect on the total carbon content and the organic matter quality. The positive effect of Nobasyp on quantitative and qualitative parameters of spring barley and some soil parameters enables Nobasyp to be accepted not as a waste product but as a soil remediate substance, or an indirect fertilizer.

Keywords: rock(basalt) wools, soil amendment, indirect fertilizers (soil amended materials), spring barley (*Hordeum vulgare* L.)

Information about the application of rock wools in the field production is very rare [1, 2] even though they are marked out by high porosity – more than 90 %, good water capacity which never decreases below 80 %, elasticity of 95 % as minimum, 200 % and

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more absorbability. Their use has been connected mainly with the hydroponic plants growing [3, 4]. Kováčik [5] introduces their application as components of substrate for green roofs, sports and recreation areas, or for growing the carpet grass.

The goal of presented research was to learn the effect of two nearly identical recycled, not used basalt wools (Agroban and Nobasyp) – produced by the company of Izomat Nová Baňa for the use in hydroponic plant growing and for construction industry – on yield parameters of model crop (spring barley) and on some agrochemical soil parameters.

Material and methods

The effect of two recycled waste rock wools (Nobasyp and Agrodrap) on the yield parameters of spring barley and some agrochemical soil parameters has been studied in a pot trial conducted in a vegetation cage located at the Slovak Agricultural University in Nitra (48°18′ N, 18°05′ E) on the modal brown soil (Haplic Luvisol).

Nobasyp is a commercial name for loose thermoinsulating material sold as Nobasil. Nobasyp means loose Nobasil. It is produced as a result of milling (recycling) of Nobasil which has not met the requirements of the consumer (shape, thickness, colour, etc.). Agrodrap can be obtained by scrapping the pieces of garden rock wool sold as Agroban. Agroban means scrapped Agrodrap. Agrodrap is produced with the aim to evaluate Agroban which is made with different parameters from the ones the buyer requires.

There have been weighed out 23.5 kg of Haplic Luvisol into containers of 30 kg capacity. The agrochemical and hygienic-toxicological parameters of the soil are given in the Table 1.

Soil pH was measured in H_2O and 1 mol · dm^{-3} KCl solution (exchangeable soil reaction). Ammonium nitrogen and nitrate nitrogen were analysed colorimetrically: NH_4^+-N after reaction with Nessler agent and NO_3^--N after reaction with phenol-2,4-disulphonic acid. Inorganic nitrogen N_{an} was calculated as sum of $N\text{-}NH_4^+$ + + $N\text{-}NO_3^-$. Available phosphorus, potassium and magnesium were extracted according to Mehlich II method and next P was determined colorimetrically, K using flame photometry and Mg was determined with atomic absorption spectrophotometry. Total carbon content C_{ox} was analysed by Tiurin method, and carbonates $CaCO_3$ – volumetrically. Heavy metals Cd, Pb, Hg, As, Cr and Ni were determined with atomic absorption spectrophotometry after mineralization by acids mixture (HF + $HClO_4$).

100 spring barley (*Hordeum vulgare* L.) seeds, 'Express' var., have been sown into each container and the soil surface has been sandblasted by sterile sand (1.5 kg). The total weight of the soil was 25 kg. After the seeds have germinated, the number of plants per a container has been reduced to 75. The level of soil humidity has been kept by regular watering on the value of 60 % of full water capacity.

There have been 8 variants: 0 – control; NS_1 – Nobasyp dose of 20 Mg · ha^{-1}, AD_1 – Agrodrap dose of 20 Mg · ha^{-1}; NPK – the dose of NPK fertilizers consisting of 140 kg N · ha^{-1}, 50 kg P · ha^{-1} and 40 kg K · ha^{-1}; NPK + NS_1 – fertilizers + the basic dose of Nobasyp 20 Mg · ha^{-1}; NPK + $NS_{1/2}$ – half a dose of Nobasyp 10 Mg · ha^{-1},

Table 1

Agrochemical parameters of soil and tested materials used in pot experiment and limiting values of heavy metals for soil additives [6]

Material	NH_4^+-N	NO_3^--N	N_{an}	P	K	Ca	Mg	Cd	Pb	Hg	As	Cr	Ni	pH in		EC	$CaCO_3$	C_{ox}
	[mg · kg^{-1}]													H_2O	KCl	[mS · cm^{-1}]	[g · kg^{-1}]	
Soil	6.6	2.2	8.8	31.9	339	2050	331	1.2	38	0.073	9.58	48	40	6.19	5.66	0.03	19.6	18.8
Agrodrap[1]	10.1	0.5	10.6	34.5	602	3850	331	< 1	< 5	0.002	< 0.04	< 80	< 45	9.71	10.10	0.19	18.9	36.5
Nobasyp[2]	7.7	3.2	10.9	30.5	618	9100	361	< 1	< 5	0.002	< 0.04	< 80	< 49	10.4	10.08	0.19	32.9	33.4
Limiting values of heavy metals for soil additives								2.0	50	1.0	10	100.0	50	—	—	—	—	—

Explanations: [1] rock wool – recycled Agroban; [2] rock wool – recycled Nobasil; EC – electrical conductivity.

NPK + AD_1 – fertilizers + the basic dose of Agrodrap 20 Mg · ha^{-1}; NPK + $AD_{1/2}$ – fertilizers + half a dose of Agrodrap. All variants were repeated four times. The doses of NPK nutrients have been calculated taking into account the N_{an} and available P and K contents in the modal brown soil as well as the requirements of the nutrients for planned yield. N has been applied with the DAM 390 fertilizer, P in the form of plain superphosphate and K in the form of KCl as 60 % potash salt. The amount of applied doses of Nobasyp and Agrodrap were chosen in accordance with the earlier experiments of Kováčik [7].

The harvest of spring barley (DC 91) was realized in its growing phase. The grain and straw yields, N-substances (% N × 6.25) and starch (method of Ewers) contents in the grain have been evaluated. After harvest a soil sample was taken from each pot and some agrochemical and pedological parameters were determined. The cation exchange capacity was detected as a sum of the base of saturation and the total acidity of soil, while composition of humic substances was determined by Kononova-Beltchikova method [8].

Results and discussion

The factor of trial variant statistically significantly affected all investigated quantitative and qualitative yield parameters of spring barley (Table 2).

Table 2

Effect of variability sources on yielding parameters of spring barley

Source of variation	d.f.	F-calculated			
		grain	straw	crude protein	starch
Treatment	7	84.046^{++}	71.763^{++}	199.37^{++}	12.562^{++}
Replication	3	1.423	0.375	0.303	0.243
Residual	21				
Total	23				

d.f. – degree of freedom.

The application of both rock wools (Nobasyp and Agrodrap) affected the grain and straw yields of spring barley in a positive but not statistically significant way. At the same time there was found moderately negative affect on starch content (var. 2 and 3 versus var. 1 – Table 3).

Nobasyp affected the yield more positively than Agrodrap. The affect of the wools on the level of N-substances was insignificant, however, the combined application of rock wools and NPK fertilizers inhibited the negative effect of nitrogen on the growth of N-substance content in the barley grain. This fact does not corresponds to the results of Orlik and Marzec [1] who, after application of 40 Mg · ha^{-1} of rock wools, did not find any increase in the grain yield of both spring barley and wheat.

Gilewska [2] points out that the possible reason of different achieved results in affecting rock wools on yield parameters of grown plants can lie in interdependence

between the phenol compounds and formaldehyde contents in rock wools and yield formation.

Table 3

The effect of Nobasyp and Agrodrap on quantitative yield parameters of spring barley

Treatment		Grain			Straw		
number	designation	[g · pot^{-1}]	[%]		[g · pot^{-1}]	[%]	
1	0	12.45 a	100.0	—	14.81 a	100.0	—
2	NS_1	15.50 a	124.5	—	16.68 a	112.6	—
3	AD_1	13.53 a	108.7	—	16.45 a	111.1	—
4	NPK	46.06 c	370.0	100.0	51.42 c	347.2	100.0
5	NPK+NS_1	54.01 c	433.8	117.3	59.72 c	403.2	116.1
6	NPK+$NS_{1/2}$	46.64 c	374.6	101.3	49.60 bc	334.9	96.5
7	NPK+AD_1	39.91 b	320.6	86.7	48.12 bc	324.9	93.6
8	NPK+$AD_{1/2}$	42.44 bc	340.9	92.1	44.81 b	302.6	87.1
$LSD_{0.05}$		5.474			6.419		
$LSD_{0.01}$		7.453			8.738		

LSD – limit of significant difference at the level $\alpha = 0.05$ and $\alpha = 0.01$.

Application of NPK fertilizers (var. 4) has statistically significantly increased the yields of grain, straw and the contents of nitrogenous substances and decreased the starch content what is equal to textbook knowledge about the effect of nitrogenous fertilizers on qualitative and quantitative parameters of the spring barley (Tables 3 and 4).

The grain yield increase amounted to 370 % that means it was 10 times higher than has been generally known while applying the fertilizers. Similar was the straw yield increase. From the above-mentioned results is clear that the effectiveness of Agrodrap and Nobasyp was positive, but in comparison with NPK fertilizers it was significantly lower – the crucial role in grain and straw yield formation played direct (NPK) fertilizers. This result corresponds with the earlier data of Kováčik [5] who has emphasized unreplaceable role of fertilizers in keeping up the permanent soil fertility as well as the necessity to apply both indirect (soil amended material) and direct fertilizers in plant nutrition.

Combined application of Nobasyp and NPK fertilizers (var. 5 and 6) resulted in the highest grain (in the case of both Nobasyp doses – 10 Mg · ha^{-1} and 20 Mg · ha^{-1}) and straw (just while applying the dose of 20 Mg · ha^{-1}) yields. At the same time non-significant decrease in N substance contents and the increase in starch content (var. 5) have been achieved what is considered to be a positive finding from a quantitative viewpoint. On the other hand, combined application of Agrodrap and NPK fertilizers was not well-founded, because the yields achieved by interactive effect of NPK fertilizers and Agrodrap (var. 7 and 8) were lower than the ones achieved by solely use of NPK fertilizers (var. 4, Table 3). Agrodrap, unlike Nobasyp, at the used dose of 20 Mg · ha^{-1} combined with NPK fertilizers significantly eliminated the negative effect of

NPK fertilizers on the increase of N substance content in the grain (var. 7) and insignificantly on the decrease of starch content (Table 4).

Table 4

The effect of Nobasyp and Agrodrap on qualitative yield parameters of spring barley

Treatment		Crude protein			Starch		
number	designation	[g · pot^{-1}]	[%]		[g · pot^{-1}]	[%]	
1	0	8.76 a	100.0	—	67.40 a	100.0	—
2	NS_1	8.63 a	98.5	—	67.14 a	99.6	—
3	AD_1	8.80 a	100.5	—	66.34 a	98.4	—
4	NPK	16.56 c	189.0	100.0	57.84 b	85.8	100.0
5	NPK+NS_1	16.11 bc	183.9	97.3	58.54 b	86.9	101.2
6	NPK+$NS_{1/2}$	16.26 c	185.6	98.2	57.70 b	85.6	99.8
7	NPK+AD_1	15.37 b	187.9	99.4	59.13 b	87.7	102.2
8	NPK+$AD_{1/2}$	16.46 c	175.5	92.8	57.32 b	85.0	99.1
$LSD_{0.05}$		0.817			3.959		
$LSD_{0.01}$		1.133			5.495		

LSD – limit of significant difference at the level $\alpha = 0.05$ and $\alpha = 0.01$.

Achieved positive influence of combined application of NPK fertilizers and both kinds of rock wool on spring barley qualitative parameters (in case of applied Nobasyp also on quantitative parameters) has exceptional meaning in malt barley growing.

Agrochemical parameters have been also determined in the tested materials. Both rock wools inhibited the soil acidity; they moderately increased pH of the soil, calcium content as well as magnesium content (significantly – Table 5, var. 2 and 3). Their application has not caused the increase of salts in the soil.

Table 5

Some agrochemical and pedological parameters of the soil after the experiment

Treatment		pH_{KCl}	Ca	Mg	[1]CEC	[2]Vw	EC
number	designation		[g · kg^{-1}]		[mmol · kg^{-1}]	[g · cm^{-3}]	[mS · cm^{-1}]
1	0	5.76 c	1.80 a	0.25 a	174.95 a	1.22 d	0.03 a
2	NS_1	5.90 c	2.00 bcd	0.47 e	237.35 d	1.15 b	0.03 a
3	AD_1	5.92 c	1.90 abc	0.38 b	204.99 c	1.19 bcd	0.02 a
4	NPK	5.17 a	1.85 ab	0.26 a	180.78 a	1.21 cd	0.25 d
5	NPK + NS_1	5.61 bc	2.15 d	0.48 e	205.27 c	1.09 a	0.23 c
6	NPK + $NS_{1/2}$	5.35 ab	2.05 cd	0.44 d	199.36 bc	1.18 bcd	0.25 d
7	NPK + AD_1	5.30 ab	2.10 d	0.42 c	196.99 bc	1.16 bc	0.21 b
8	NPK + $AD_{1/2}$	5.22 a	2.05 cd	0.39 b	186.26 ab	1.19 bcd	0.25 d
$LSD_{0.05}$		0.334	0.175	0.1693	15.905	0.0563	0.0155
$LSD_{0.01}$		0.463	0.243	0.235	22.074	0.0754	0.0215

[1]CEC – cation exchange capacity, [2]Vw – volume weight of dry soil.

Based on the knowledge of the parameters of rock wools used in hydroponic plant growth, there has been expected that their application will increase the cation exchange capacity (CEC) and decrease volume weight of dry soil (bulk density). The assumptions have been confirmed (Table 5).

Loose Nobasyp in comparison with scrapped Agrodrap increased the CEC more significantly as a result of its even application into the soil. The effect of both materials was statistically highly significant. Both kinds of rock wool decreased the bulk density, loosening (aerating) effect of Nobasyp on the soil has been more significant than the Agrodrap effect.

Effect of NPK fertilizers on agrochemical soil parameters corresponded to general knowledge presented by different authors [8]. Their application has statistically significantly decreased the pH value and increased salts content (Table 5, var. 5). Their combined application with Nobasyp and Agrodrap inhibited the negative influence of NPK fertilizers.

Both waste rock wools have had a positive effect on the total carbon content and the organic matter quality, thereby have increased the humic acid share in the soil, whereas Agrodrap has had more significant effect on these parameters than Nobasyp (Table 6).

Table 6

Some pedological parameters of the soil after the experiment

Treatment		C_{OX}	C_{HK} from C_{OX}	C_{FK} from C_{OX}	HA/FA
number	designation	[g · kg^{-1}]	[%]		
1	0	11.66 a	12.01	18.87	0.636
2	NS_1	11.90 ab	11.81	18.49	0.639
3	AD_1	12.74 cd	11.77	17.27	0.682
4	NPK	11.67 a	12.63	16.57	0.762
5	NPK + NS_1	12.30 bc	12.03	16.54	0.727
6	NPK + $NS_{1/2}$	12.62 cd	11.75	17.62	0.669
7	NPK + AD_1	12.95 d	12.71	15.89	0.800
8	NPK + $AD_{1/2}$	12.59 cd	13.13	16.99	0.773
$LSD_{0.05}$		0.589			
$LSD_{0.01}$		0.817			

The combined application with NPK fertilizers has increased the positive effect of the wools on the increase of the organic matter quality of the soil.

Conclusions

The application of both kinds of rock wool had a positive but not statistically significant effect on the grain and straw yield of spring barley. The Nobasyp effect on the yield was more positive than the one of Agrodrap.

Combined application of Nobasyp (20 Mg · ha^{-1}) and NPK fertilizers resulted in the highest grain and straw yields. On the other hand, combined application of Agrodrap and NPK fertilizers (under the use of both doses – 10 and 20 Mg · ha^{-1}) was not well-founded, because the yields achieved by interactive effect of NPK fertilizers and Agrodrap were lower than the ones achieved by solely use of NPK fertilizers. The rock wool + NPK fertilizers application inhibited the negative effect of nitrogen on increase of crude protein content and the decrease of starch in the barley grain.

Both kinds of rock wool significantly increased the cation exchange capacity, while the effectiveness of Nobasyp was higher than Agrodrap. Loosening (aerating) effect of Nobasyp on the soil is also more significant than the Agrodrap effect. Both kinds of rock wool moderately increased pH of the soil and have had a positive effect on the total carbon content and the organic matter quality.

The positive effect of Nobasyp on quantitative and qualitative parameters of spring barley and some soil parameters enables Nobasyp to be accepted not as a waste product but as a soil remediate substance, or an indirect fertilizer.

Yield of grain and straw has been affected in a statistically significant way by NPK fertilizers what at the same time decreased both the quality of barley grain and the starch content and increased the content of nitrogenous substances.

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ODDZIAŁYWANIE ODPADÓW WEŁNY MINERALNEJ NA PLONOWANIE JĘCZMIENIA JAREGO (*Hordeum vulgare* L.) I NIEKTÓRE WŁAŚCIWOŚCI GLEBY

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Abstrakt: W doświadczeniu wazonowym, prowadzonym w hali wegetacyjnej Słowackiego Uniwersytetu Rolniczego w Nitrze (48°18′ N, 18°05′ E), założonym na glebie płowej (25 kg gleby w wazonie) badano

oddziaływanie dwóch odpadów wełny mineralnej (Nobasyp i Agrodrap) na parametry plonu jęczmienia jarego i niektóre agrochemiczne parametry gleby.

Uzyskane wyniki wykazały, że stosowanie obydwóch rodzajów wełny mineralnej miało pozytywny, ale statystycznie nieistotny wpływ na plon ziarna i słomy jęczmienia jarego. Wpływ Nobasypu na plon był bardziej widoczny niż ten wywołany przez Agrodrap. Łączne zastosowanie Nobasypu (20 Mg · ha^{-1}) oraz nawozów NPK skutkowało największymi plonami ziarna i słomy. Z drugiej strony, łączne stosowanie Agrodrapu oraz nawozów NPK (w obydwu zastosowanych dawkach – 10 i 20 Mg · ha^{-1}) nie było w pełni uzasadnione, ponieważ plony uzyskane w wyniku wzajemnego działania nawozów NPK i Agrodrapu były mniejsze niż te uzyskane po użyciu wyłącznie nawozów NPK. Stosowanie wełny mineralnej i nawozów NPK łagodziło ujemny wpływ azotu, który powodował wzrost zawartości białka surowego i obniżanie zawartość skrobi w ziarnie jęczmienia.

Obydwa rodzaje wełny mineralnej znacząco zwiększały kationową pojemność wymienną, czyniły glebę bardziej pulchną, umiarkowanie podnosiły wartość pH gleby oraz miały pozytywny wpływ na ogólną zawartość węgla i jakość materii organicznej.

Pozytywne oddziaływanie Nobasypu na ilościowe i jakościowe parametry jęczmienia jarego oraz niektóre parametry gleby umożliwia jego uznanie za substancję ulepszającą glebę lub nawóz pośredni, a nie jako produkt odpadowy.

Słowa kluczowe: wełny mineralne(bazalt), poprawa właściwości gleby, substancje ulepszające glebę (nawozy pośrednie), jęczmień jary