The effect of Lignofert organic fertilizer on formation and quality of head lettuce yield

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ABSTRACT: Nowadays soils for vegetable growing are poor in humus because the possibility of using stable dung is limited. The application of Lignofert organic carbonaceous fertilizer made of ground lignite seems to be a solution. It is intended as a fertilizer for the field or greenhouse growing of vegetables, as a component to composts, soil substrates and likewise. Lignofert effects on the formation of lettuce yield, weight of heads and $NaNO_3$ content were studied in 2003 to 2005. Head lettuce grown in a greenhouse and in field conditions was a biological material. Average lettuce yields and average weight of heads in 2005 were statistically highly significantly higher in variants with Lignofert in comparison with the control variant grown in the greenhouse and in the field. The Lignofert effect on nitrate content in lettuce heads was not proved statistically.

Keywords: Lignofert – organic carbonaceous fertilizer; head lettuce; quality; yield

This solution was a part of Research and Development Project No. 2003 SP 27/028 OD 01/028 OD 01-01-06-03. The effects of Lignofert as a regulatory agent in vegetable growing technologies were studied at growing several vegetable sorts. This study presents the results of experiments aimed at the growing of head lettuce in 2003 to 2005. The goal of the study was an analysis of Lignofert effects on the formation and quality of lettuce crops grown in field and forced conditions on arenaceous (sandy) soils.

Kráľovič et al. (1997) reported that Lignofert as an organic carbonaceous fertilizer is mechanically processed lignite with particles of 0.1–10 mm in size. It contains at least 60% of organic substance weight in dry matter, which has quite a high content of humic acids (22%). It equals 4 tons of stable dung, 8 tons of compost or 6 tons of garden or composted peat. It is efficient chiefly on arenaceous and medium-heavy soils. Chemical composition of Lignofert is very similar to that of peat. Ložek et al. (1995) regarded as appropriate to use this organic fertilizer everywhere stable dung or other organic fertilizers were not used. It comes from the Baňa Záhorie Holíč (Záhorie Mine in Holíč) as a side product of brown coal mining. Lignofert is produced from young lignite that also contains a low amount of calcium and magnesium besides carbonaceous substances. According to Jandl (1999), the feedstock is young lignite that is ground and sorted out to a desired particle size. Weismann and Kráľovič (1993) described the ecological importance of Lignofert residing also in its ability to block and retain hazardous substances (in particular heavy metals) in the form of indissoluble compounds. According to Pekař and Klučáková (2003), it can find its application in the regeneration of contaminated soils with regard to positive effects of lignite on plant production.

MATERIALS AND METHODS

The Lignofert organic carbonaceous fertilizer produced by Baňa Záhorie (Záhorie Mine) was a tested material. Its composition and characteristics are described by the producer (Anonym 2000). Cabbage lettuce of King of May variety was a plant material. The variety is suitable for early field growing as well as for forcing.

Variants of greenhouse experiments:

- A_1-Lignofert – the Lignofert fertilizer was applied at a dosage of 50 kg per 100 m^2 four weeks prior to the experiment establishment. According to the producer's recommendation Lignofert was worked into the soil to a depth of 100 mm.
- A_2 – Control

Variants of field experiments:

- A_1-Lignofert – the Lignofert fertilizer was applied at a dosage of 50 kg per 100 m^2 four weeks prior to the experiment establishment. According to

the producer's recommendation Lignofert was worked into the soil to a depth of 100 mm.

– A_2 – Control

Observed parameters always in comparison with the control:

– Yield of lettuce (t/ha),
– Average weight of head (g),
– Nitrate content per head ($NaNO_3$).

Lettuce was grown in field conditions and as a forced vegetable in a greenhouse. The plants were grown from seedlings. Common agronomic practices were used to tend the lettuce crop (Valšíková et al. 1996). Harvest was done manually and gradually. Lettuce heads were weighed on PE 11 digital scales. Average weight of heads and yield per hectare were calculated from the measured values.

Among qualitative characteristics, $NaN0_3$ content in lettuce heads was observed. $NaN0_3$ content was determined with an ionoselective electrode (ISE). Average values obtained by the analysis of ten heads in three replications are quoted in results. Analysis of variance was used for statistical processing of experimental results.

RESULTS AND DISCUSSION

In the experimental year 2003, when lettuce was grown as a forced vegetable, no significant differences were observed in all studied parameters. The effect of Lignofert did not show to be positive (Table 1). At lettuce growing in the open field, the control variant had a conclusively higher yield per hectare than the Lignofert variant (average of the control 6.49 t/ha, average of Lignofert 5.95 t/ha, Table 2). The control variant reached higher average weight of heads than the Lignofert variant (control 152.3 g, Lignofert 137.3 g, Table 2). $NaN0_3$ content was also significantly lower in the control variant (2,334.33 mg/1,000 g) than in the Lignofert variant (2,652.66 mg/1,000 g, Table 2). Nitrate content expressed as $NaN0_3$ did not exceed the highest allowable amount for lettuce – 3,285 mg/1,000 g in any variant. In the experimental year 2003, the positive effect of Lignofert organic carbonaceous fertilizer on the yield formation and quality of lettuce grown in field and forced conditions was not proved.

The statistical evaluation of experiments in 2004 shows that growing lettuce in the forced environment, higher average weight of heads was found out in the control variant (control 145.66 g, Lignofert 117.07 g, Table 3). Nitrate content was significantly lower in the control variant (control 335.69 mg/1,000 g, Lignofert 701.93 mg/1,000 g, Table 3), however $NaN0_3$ was profoundly below the allowable norm of 3,285 mg/1,000 g. In field conditions, in all observed parameters statistically insignificant differences between Lignofert variant and the control were determined (Table 4). It can be stated that neither in this observed year was the positive effect of Lignofert on the formation and quality of lettuce crop proved.

It follows from the statistical evaluation of experiments in 2005 that growing lettuce in the greenhouse with application of Lignofert, highly significantly higher yield in Lignofert variant in comparison with

Table 1. Lettuce of the King of May variety in greenhouse in the year 2003

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	6.14	A_2	6.32	A_1	178.3	A_2	189.3	A_1	2,874	A_2	2,789
A_1	7.30	A_2	7.57	A_1	182.5	A_2	157.9	A_1	2,596	A_2	2,509
A_1	7.13	A_2	7.02	A_1	153.4	A_2	175.6	A_1	2,467	A_2	2,688
Ø	6.86	Ø	6.97	Ø	171.04	Ø	174.27	Ø	2,645.66	Ø	2,662
Difference between A_1 and A_2 – not significant				Difference between A_1 and A_2 – not significant				Difference between A_1 and A_2 – not significant			

Table 2. Lettuce of the King of May variety in field conditions in the year 2003

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	6.39	A_2	6.46	A_1	148.9	A_2	159.7	A_1	2,364	A_2	2,354
A_1	5.38	A_2	6.06	A_1	126.5	A_2	160.3	A_1	2,983	A_2	2,167
A_1	6.09	A_2	6.96	A_1	136.5	A_2	136.9	A_1	2,611	A_2	2,482
Ø	5.95	Ø	6.49	Ø	137.3	Ø	152.3	Ø	2,652.66	Ø	2,334.33
Difference between A_1 and A_2 – significant				Difference between A_1 and A_2 – significant				Difference between A_1 and A_2 – significant			

Table 3. Lettuce of the King of May variety in greenhouse in the year 2004

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	8.40	A_2	7.96	A_1	114.52	A_2	168.59	A_1	397.57	A_2	256.69
A_1	8.58	A_2	8.75	A_1	110.10	A_2	149.57	A_1	1,146.62	A_2	379.68
A_1	8.06	A_2	8.41	A_1	126.60	A_2	118.66	A_1	561.59	A_2	370.70
Ø	8.34	Ø	8.37	Ø	117.07	Ø	145.66	Ø	701.93	Ø	335.69
Difference between A_1 and A_2– not significant				Difference between A_1 and A_2 – significant				Difference between A_1 and A_2 – significant			

control variant was registered (Lignofert average 8.77 t/ha, control 7.59 t/ha, Table 5). The application of Lignofert also increased the average weight of heads highly significantly (Lignofert average 219.32 g, control 189.87 g, Table 5). Nitrate content expressed as $NaN0_3$ did not exceed the highest allowable amount of 3,285 mg/1,000 g (Lignofert average 1,401.96 mg/1,000 g, control 1,358.78 mg/1,000 g, Table 5) and was statistically insignificant in the observed variants. By the application of Lignofert in field conditions, highly significantly better yield was reached (Lignofert 9.30 t/ha, control 7.35 t/ha, Table 6). The application of Lignofert also resulted in an increase in the average weight of heads (Lignofert 232.51 g, control 183.78 g, Table 5). Nitrate content expressed as $NaN0_3$ did not exceed the highest allowable amount.

The evaluation of experiments during the observed period of 2003–2005 shows that Lignofert decomposes slowly in the soil and gradually increases humus content. Its positive effect appears in the third year after application. In Lignofert variant average yield in t/ha in lettuce for forcing increased for the observed period of 2003–2005 by 0.35 t/ha and in field conditions even by 0.64 t/ha in comparison with the control variant (Tables 7 and 8). Growing lettuce in the greenhouse, the highest average yield in Lignofert variant was reached in 2005 (8.77 t/ha) and in control variant in 2004 (8.37 t/ha). A highly significant increase in average yield from 2003 to 2005 was found in A_1 (1.91 t/ha, Table 7). In the open field growing the Lignofert variant reached the best average yield in 2005 (9.30 t/ha) and control variant in 2004 (8.05 t/ha). A highly significant increase in yield (3.35 t/ha) from 2003 to 2005 was recorded in variant A_1 (Table 8).

Lignofert is intended to be used in light sandy soils that are poor in organic material. Such soils occur in the territory of Southern Slovakia. Lignofert can be used as a single fertilizer or in combination with a commercial fertilizer or mould (Králová, Barkoci 2002). Lignofert does not cause nuisance

Table 4. Lettuce of the King of May variety in field conditions in the year 2004

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	7.06	A_2	8.28	A_1	189.84	A_2	197.59	A_1	932.01	A_2	890.06
A_1	9.39	A_2	7.97	A_1	234.68	A_2	199.29	A_1	723.47	A_2	975.93
A_1	7.59	A_2	7.90	A_1	176.52	A_2	207.02	A_1	1,021.92	A_2	630.11
Ø	8.01	Ø	8.05	Ø	200.35	Ø	201.30	Ø	892.47	Ø	832.03
Difference between A_1 and A_2 – not significant				Difference between A_1 and A_2 – not significant				Difference between A_1 and A_2 – not significant			

Table 5. Lettuce of the King of May variety in greenhouse in the year 2005

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	8.78	A_2	7.90	A_1	219.49	A_2	197.59	A_1	1,257.24	A_2	910.79
A_1	8.97	A_2	7.66	A_1	224.32	A_2	191.66	A_1	1,045.73	A_2	1,582.77
A_1	8.57	A_2	7.21	A_1	214.15	A_2	180.36	A_1	1,902.91	A_2	1,582.77
Ø	8.77	Ø	7.59	Ø	219.32	Ø	189.87	Ø	1,401.96	Ø	1,358.78
Difference between A_1 and A_2– highly significant				Difference between A_1 and A_2 – highly significant				Difference between A_1 and A_2 – not significant			

Table 6. Lettuce of the King of May variety in field conditions in the year 2005

Yield (t/ha)				Average weight of head (g)				$NaN0_3$ content (mg/1,000 g)			
A_1	10.01	A_2	7.76	A_1	250.33	A_2	194.06	A_1	1,735.48	A_2	1,817.26
A_1	9.43	A_2	7.22	A_1	235.86	A_2	180.55	A_1	2,395.62	A_2	1,992.59
A_1	8.45	A_2	7.07	A_1	211.33	A_2	176.72	A_1	2,086.50	A_2	1,902.91
Ø	9.30	Ø	7.35	Ø	232.51	Ø	183.78	Ø	2,072.53	Ø	1,904.25
Difference between A_1 and A_2 – highly significant				Difference between A_1 and A_2 – highly significant				Difference between A_1 and A_2 – not significant			

by smell, does not bring any weed seeds and other harmful factors into the soil such as diseases and pests. The producer of Lignofert recommends doses of 30–50 kg/100 m^2 every 4 years. Lignofert is light, therefore it floats according to the uneven terrain when intensively watered (Barkoci 2003). In conditions of intensive use of frequent watering and high temperatures when Lignofert decomposes faster, it is recommended to use Lignofert every 2 years, at a smaller dose (Králová, Barkoci 2002).

CONCLUSION

Application of organic fertilizers is preferred from the aspect of sustainable development of vegetable growing. The Lignofert organic carbonaceous fertilizer belongs to such fertilizers. Its positive effects on the formation and quality of field and forced lettuce yields appear in a longer time horizon. It was proved by highly significant yield increase and average weight of heads in the Lignofert variant in comparison with the control variant in 2005. The influence of Lignofert organic fertilizer on nitrate content of lettuce heads was not significant (Tables 5 and 6).

Statistically insignificant differences between Lignofert variants and control variants in the observed parameters were registered from average values for the period of years 2003–2005. It does not imply that Lignofert application does not have a positive effect, but it is necessary to take into account a certain decomposition period of this organic fertilizer. That was proved by a highly significant

Table 7. Lettuce of the King of May variety in greenhouse in the years 2003–2005

	Yield (t/ha)		Average weight of head (g)		$NaN0_3$ content (mg/1,000 g)	
	A_1	A_2	A_1	A_2	A_1	A_2
2003	6.86	6.97	171.40	174.27	2,645.66	2,662.00
2004	8.34	8.37	117.07	145.66	701.93	335.69
2005	8.77	7.59	219.32	189.87	1,401.96	1,358.78
Ø	7.99	7.64	169.26	169.93	1,583.18	1,452.16
Difference between A_1 and A_2 (0.35 t/ha) – not significant. Average increase of yield from 2003 to 2005 in A_1 by 1.91 t/ha – highly significant			Difference between A_1 and A_2 – not significant		Difference between A_1 and A_2 – not significant	

Table 8. Lettuce of the King of May variety in field conditions in the years 2003–2005

	Yield (t/ha)		Average weight of head (g)		$NaN0_3$ content (mg/1,000 g)	
	A_1	A_2	A_1	A_2	A_1	A_2
2003	5.95	6.49	137.30	152.30	2,652.66	2,334.33
2004	8.01	8.05	200.35	201.30	892.47	832.03
2005	9.30	7.35	232.51	183.78	2,072.53	1,904.25
Ø	7.75	7.11	190.05	179.13	1,872.55	1,690.20
Difference between A_1 and A_2 (0.64 t/ha) – not significant. Average increase of yield from 2003 to 2005 in A_1 by 3.35 t/ha – highly significant			Difference between A_1 and A_2 – not significant		Difference between A_1 and A_2 – not significant	

increase of yield from 2003 to 2005 in the variant with Lignofert (Tables 7 and 8).

The producer of Lignofert recommends to apply Lignofert every 4 years. Thus research of its effect on the formation and quality of yield should also be conducted in a longer time horizon than three years. Ecological importance of the Lignofert organic carbonaceous fertilizer consists in that it complies with ecological agriculture requirements. It is included in the list of fertilizers and ancillary substances permitted in ecological agriculture in terms of § 3 letter d) of Act No. 42/2004 on Ecological Agriculture.

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Vplyv organického hnojiva Lignofert na tvorbu a kvalitu úrody hlávkového šalátu

ABSTRAKT: V súčasnosti sú zeleninárske pôdy chudobné na humus, nakoľko je obmedzená možnosť hnojenia maštaľným hnojom. Ako riešenie sa ponúka použitie organického uhlíkatého hnojiva Lignofert, ktorý je vyrábaný z mletého lignitu. Je určený ako hnojivo pre poľné a skleníkové pestovanie zelenín, komponent do kompostov, pôdnych substrátov a pod. V rokoch 2003 až 2005 bol sledovaný vplyv Lignofertu na tvorbu úrody šalátu, hmotnosť hlávok a obsah $NaNO_3$. Biologickým materiálom bol šalát hlávkový, pestovaný v poľných podmienkach a rýchlený v skleníku. Priemerné úrody šalátu hlávkového a priemerná hmotnosť hlávok boli štatisticky vysoko preukazne vyššie pri variantoch s Lignofertom v porovnaní s kontrolou pri pestovaní v skleníku aj pri poľnom pestovaní v sledovanom roku 2005. Vplyv Lignofertu sa štatisticky nepotvrdil na obsah dusičnanov v hlávkach šalátu.

Kľúčové slová: Lignofert – organické uhlíkaté hnojivo; šalát hlávkový; kvalita; úroda

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