Effect of alternative organic fertilizers on the nutritional value and yield of head cabbage

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ABSTRACT: Commercial brands of alternative, organic fertilizers were compared with conventional, mineral fertilizers using head cabbage. There were six different treatments: conventional farmyard manure, Agro (made from poultry bedding and molasses), Dvorecký agroferm (granulated, made from dried, aerobically-fermented farmyard manure), Agormin (an organo-mineral fertilizer), compost manufactured from plant waste material, mineral fertilizer, and an unfertilized control. All the treatments were applied at rates providing approximately the same level of nutrients. After harvest, the levels of the minerals (K, Na, Ca, and Mg), ascorbic acid, nitrates and yield were measured. There were no significant differences between the treatments in levels of K, Na and Ca in case of organic fertilizers (farmyard manure, Agro, Agormin and compost). The unfertilized control had the highest levels of ascorbic acid; it was significantly higher than in case of farmyard manure which, in turn, had significantly higher values than compost. Significant differences between the treatments were found in the levels of nitrates; the lowest in case of Dvorecký agroferm and in the control. The highest marketable yields were recorded with farmyard manure and Dvorecký agroferm, the latter being significantly higher than the control. This study shows that alternative, organic fertilizers (except compost) have similar qualities as farmyard manure.

Keywords: cabbage; alternative organic manure; fertilizer; yield; nutritional value

Head cabbage is one of the most important and most widely cultivated vegetables in the Czech Republic. It occupies the second place, after onions, even though the acreage of cabbage has decreased in the last five year (Situační a výhledová zpráva … 2005). Cultivation of cabbage needs fertilizing by farmyard manures (Hlušek 1996), which are natural source of organic matter. Organic matter is known to improve soil fertility by changing its physical, chemical and biological character (Bunting 1965; Richter et al. 1994); vegetable production requires continuous applications of organic matter (Balík 1993; Richter 1997). However, a lot of farms specialize in vegetable production these days and they have no animals, so traditional farmyard manure (FYM) is consequently in short supply. On the other hand, the farms specialized in rearing livestock have the opposite problem, namely, an abundance of manure which is difficult to dispose of. This surplus farmyard manure can be returned to the soil by processing it to make an organic fertilizer by aerobic fermentation and drying (Debosz et al. 2002). The aim of this study was to observe the effect of these alternative organic fertilizers on the nutritional value and yield of head cabbage.

MATERIAL AND METHODS

The two-year experiment took place at the Faculty of Horticulture of Mendel University of Agriculture and Forestry Brno, in Lednice in 2004 and 2005.

Treatments:

- conventional farmyard manure,
- Agro, an organic fertilizer made from poultry bedding and molasses, granulated (made by MeM B.V., Holland, and distributed in the Czech Republic by AGRO CS, a. s.),
- Dvorecký agroferm, an organic fertilizer made from fermented and dried cow-dung, granulated (made by Agropodnik Dvorce, a. s., CR),
- Agormin, an organo-mineral fertilizer made from peat, with added basic macroelements (made by AGRO CS, a. s., CR),
- Zahradnický kompost (an organic fertilizer made from plant waste with added dolomitic calcite, made by AGRO CS, a. s., CR),
- conventional mineral fertilizer,
- control (unfertilized).

Each treatment was replicated three times. The application rates were in accordance with the manufacturers' guidelines; and in the case of FYM

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Table 1. Percentage of N, P, K and application rates of fertilizers

Fertilizer	N	P	K	Rate (t/ha)
Dvorecký agroferm	1.70	0.47	2.99	0.8–1.0
Agro	3.87	0.97	5.72	1.0
Agormin	1.14	0.21	3.55	2.5
Farmyard manure	0.97	0.61	1.04	55.0
Compost	0.57	0.09	0.21	30.0

as recommended by Malý et al. (1998) (Table 1). After doing soil analyses, the rates were adapted to a target yield of 50 t/ha, assuming that the rates of nutrients required to produce 1 ton of cabbage are as follows: 3.57 kg N, 0.57 kg P and 3.57 kg K. Corrections were made depending on the organic fertilizer, the preceding crop and the content of nutrients in the soil (Hlušek 1996). The varieties of head cabbage used were Pavlo F1 in 2004, and Trvalo F1 in 2005. Nutritional value was assessed by measuring the content of minerals, vitamin C and nitrates. The minerals (potassium, sodium, calcium and magnesium) were determined by IONOSEP 900.1. Vitamin C was determined using HPLC chromatography. Nitrates were determined using ion selective electrodes. Harvesting was done on 8. 9. 2004 and on 11. 10. 2005 and the heads were measured and classified as Grade I or II quality in accordance with local norms (ČSN 46 3113). All the results were processed by ANOVA and Tukey's test using the statistical program Unistat 5.1 (Unistat USA).

RESULTS AND DISCUSSION

Nutrient content

Minerals

The average amount of minerals in cabbage heads for each treatment is shown in Table 2. The observed differences between the treatments in 2005, with the exception of magnesium, were not significant (Table 3.). Magnesium is important for human health mainly for skin, bones and enzyme production, and its levels were significantly higher when the organic fertilizers (FYM, Agormin, Agro and compost) were used (Kopec 1998). There were no significant differences observed between individual organic fertilizers, which is in agreement with previous studies on potatoes, where an increase in magnesium and sodium was recorded comparing compost with a mineral fertilizer (Warman et al. 1998). The published results on the influence of organic fertilizers on levels of minerals differ. For example, Netherlands (1974) observed a higher level of potassium and calcium in potatoes and spinach after the application of organic fertilizers (farmyard manure and compost); on the contrary, Toor at al. (2006) found no differences in calcium levels in cherries after using organic fertilizers.

Vitamin C

The highest average levels of vitamin C were observed in the unfertilized control (Table 3.), and were significantly higher than those of the FYM treatment in 2004. The latter were higher than the results of the compost treatment. Augustin (1975) in Seung et al. (2000), confirmed that higher doses of nitrogen reduce levels of vitamin C, as was previously stated by Netherlands (1996) and Lisiewska and Kmiecik (1996). Toor et al. (2006), Ševlíková (1976), and Premuzic et al. (2004) showed an increase in vita-

Table 2. Effect of fertilizers on the content of potassium, sodium, calcium, magnesium, vitamin C and nitrates. Average of the years 2004–2005

Nurients (mg/kg)	Farmyard manure	Dvorecký agroferm	Agormin	Agro	Compost	Mineral fertilizer	Control
Potassium	1,929	1,975	1,978	1,865	1,974	1,940	2,075
Sodium	167	183	169	151	96	187	152
Calcium	250	267	276	222	240	259	289
Magnesium	143	132	153	125	128	111	139
Vitamin C	418	405	406	410	399	412	431
Nitrates	121	40	153	94	49	71	40

Table 3. Recognized conclusive differences in the content of nutritional value (2004–2005), 95% interval of significance level

			Mineral fertilizer			Compost			Dvorecký agroferm			Farmyard manure			Agro			Agormin			Control		
			2004		2005	2004		2005	2004		2005	2004		2005	2004		2005	2004		2005	2004		2005
			vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg	vit. C	NO_3^-	Mg
Mineral fertilizer	2004	vit. C						*						*			*			*			
		NO_3^-														*			*				
	2005	Mg																					
Compost	2004	vit. C										*											
		NO_3^-																					
	2005	Mg			*																		
Dvorecký agroferm	2004	vit. C																					
		NO_3^-																					
	2005	Mg																					
Farmyard manure	2004	vit. C				*															*		
		NO_3^-																	*				
	2005	Mg			*																		
Agro	2004	vit. C																					
		NO_3^-		*																			
	2005	Mg			*																		
Agormin	2004	vit. C																					
		NO_3^-		*									*									*	
	2005	Mg			*																		
Control	2004	vit. C										*											
		NO_3^-																	*				
	2005	Mg																					

*Designates significant differences in concrete year

Table 4. Recognized conclusive differences in yield characteristics (2004–2005), 95% interval of significance level

			Mineral fertilizer			Compost			Dvorecký agroferm			Farmyard manure			Agro			Agormin			Control		
			2004		2005	2004		2005	2004		2005	2004		2005	2004		2005	2004		2005	2004		2005
			MY	BP	SS	MY	BP	SS	MY	BP	SS	MY	BP	SS	MY	BP	SS	MY	BP	SS	MY	BP	SS
Mineral fertilizer	2004	MY																					
		BP					*																
	2005	SS												*									
Compost	2004	MY																					
		BP		*						*													
	2005	SS																					
Dvorecký agroferm	2004	MY																					*
		BP					*																
	2005	SS																					
Farmyard manure	2004	MY																					
		BP																					
	2005	SS			*																		
Agro	2004	MY																					
		BP																					
	2005	SS																					
Agormin	2004	MY																					
		BP																					
	2005	SS																					
Control	2004	MY								*													
		BP																					
	2005	SS																					

*Designates significant differences in concrete year, MY– marketable yield: I. + II. quality, BP – biomass production, SS – substandard

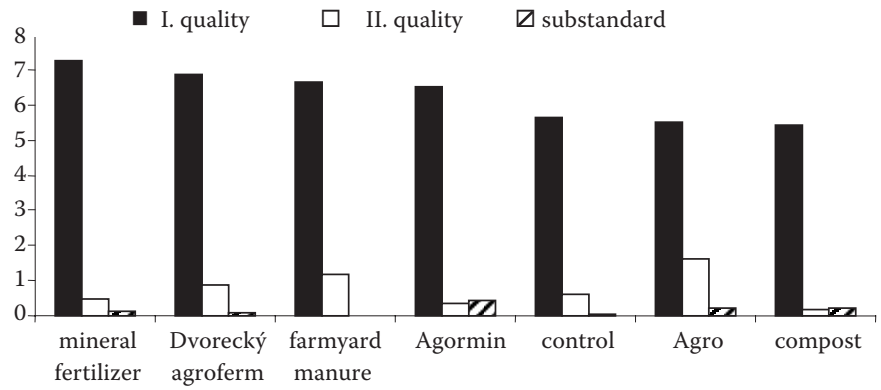

Fig. 1. Influence of different fertilizers on quality (kg/m^2); average of 2004 and 2005

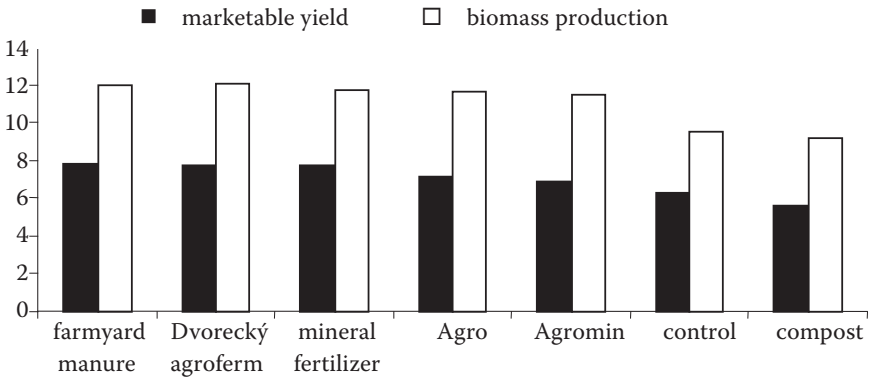

Fig. 2. Influence of fertilizers on marketable yield (kg/m^2) and biomass production (kg/m^2); average of 2004 and 2005 (marketable yield: grades I and II combined)

min C in response to organic fertilizers; however this was not confirmed in our experiment.

Nitrates

Nitrates are not desirable in the parts of vegetables to be consumed. The unfertilized control provided an average acceptable level of nitrates, with a value of 40 mg/kg (Table 3). A similarly low average value was observed in the variant with Dvorecký agroferm. The highest levels of nitrates were recorded in Agormin. This increase was statistically significant compared to the unfertilized control, mineral fertilizer and FYM in 2005. Providing that all the variants, except for the control, had the same start dose of N_{min}, different final values of nitrates can be attributed to different mineralization level of nitrogen in each variant.

Classification of marketable yield

The highest marketable yield (quality grades I and II combined) was recorded with FYM and Dvorecký agroferm, the lowest with compost (Fig. 2), the latter being statistically significant (Table 4). The highest yield of grade I heads was recorded with mineral fertilizer, and the lowest with compost (Fig. 1), although the differences between the treatments were not significant. The total production of biomass (marketable yield + poor quality heads + the postharvest remains) is shown in Fig. 2. The highest biomass production was observed in the treatments with the highest marketable yield.

The lowest biomass production was recorded with compost, being significantly lower than Dvorecký agroferm and mineral fertilizer (Table 4). In published studies on the influence of different types of fertilizers on marketable yield, we often see that the highest marketable yield is obtained with mineral fertilizers and the lowest in unfertilized controls (Toor et al. 2006; Warman et al. 1997; Bunting 1965). It might be caused by the fact that these experiments were conducted on soils with high humus content, so that the treatments with mineral fertilizer provided faster mineralization of organic matter and a greater release of other nutrients. In our experiment the humus content was about 4% and it gave a high yield when mineral fertilizers were used. In both years the compost treatment variant gave low yields, possibly because the mineralization of nutrients was much slower than in case of the other treatments.

CONCLUSION

The organic fertilizers (farmyard manure, Agormin, Agro and compost) increased levels of Mg in one year (2005), but did not affect the levels of

other minerals. The highest levels of vitamin C were recorded in the unfertilized control in 2004, being significantly higher than FYM. Nitrate levels were very low in all the treatments; the highest values were however recorded with Agormin in 2005, being significantly higher than with mineral fertilizer, FYM and the unfertilized control. The average marketable yield was 70 t/ha, and a statistically significant increase was observed in the case of Dvorecký agroferm. Total biomass production was higher with Dvorecký agroferm and with mineral fertilizer compared to compost. The use of alternative organic fertilizers, except for compost, had similar effects on all measured properties.

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Vliv alternativních organických hnojiv na nutriční hodnotu a výnos hlávkového zelí

ABSTRAKT: Pokus probíhal v letech 2004 a 2005 s alternativními organickými hnojivy: Agro – vyrobeno z drůbeží podestýlky s přídavkem melasy, Dvorecký agroferm – aerobně fermentovaný chlévský hnůj, sušený, granulovaný, Agormin – organominerální hnojivo, kompost, dále varianta s minerálním hnojivem, s chlévským hnojem a nehnojená kontrola. Všechny varianty kromě kontroly byly hnojeny na stejnou úroveň živin. Pěstovaná plodina byla hlávkové zelí. Ve sklizených hlávkách byla zjištěna: nutriční hodnota (minerály K, Na, Ca, Mg), vitamin C a obsah dusičnanů. Dále byl zjištěn výnos a jakostní třídění podle normy ČSN 46 3113. Při hodnocení obsahu minerálů byl průkazný rozdíl zjištěn pouze u hořčíku ve prospěch organických hnojiv (chlévský hnůj, Agro, Agormin a kompost). V obsahu K, Ca a Na průkazný rozdíl mezi variantami zjištěn nebyl. Nejvyšší obsah vitaminu C měla kontrolní varianta – tento rozdíl byl průkazně vyšší proti chlévskému hnoji; tato varianta však měla průkazně vyšší obsah vitaminu C

než varianta s kompostem. Průkazný rozdíl byl zjištěn i v obsahu dusičnanů, přičemž nejnižší hodnoty byly dosaženy u varianty s Dvoreckým agrofermem a u varianty s kompostem. U tržního výnosu byly zjištěny průkazné rozdíly mezi variantou s Dvoreckým agrofermem a kontrolní variantou, a to ve prospěch Dvoreckého agrofermu, který měl nejvyšší hodnotu tržního výnosu spolu s variantou, kdy byl aplikován chlévský hnůj. Tento experiment ukázal, že alternativní organická hnojiva mají podobné vlastnosti jako chlévský hnůj.

Klíčová slova: zelí; alternativní organická hnojiva; hnojení; výnos; nutriční hodnota

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