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Influence of Alternative Organic Fertilizers on the Antioxidant Capacity in Head Cabbage and Cucumber

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Abstract

Conventional mineral fertilizer was compared with alternative organic fertilizers for the crop of head cabbage and cucumber. There were seven different treatments: Agormin (an organo-mineral fertilizer), Agro (made from poultry bedding and molasses), conventional farmyard manure, compost, Dvorecký agroferm (dried, aerobically-fermented farmyard manure), mineral fertilizer, and an unfertilized control. All treatments were applied at rates providing approximately the same level of nutrients. The level of the total antioxidant capacity (TAC) was measured by FRAP assay immediately after harvest. Average value of TAC in fresh cabbage was 236 ± 60 mg GA.100 g-1 in the year 2005 and 295 ± 27 mg GA.100 g-1 in the year 2006. Average value of TAC in field cucumber was 125 ± 32 mg GA.100 g-1 in the year 2005 and 104 ± 60 mg GA.100 g-1 in the year 2006. This study shows that alternative, organic fertilizers have similar or even better positive effects than farmyard manure and that they can contribute to the improvement of the nutritional value of vegetable production.

Keywords: alternative organic fertilizer, cabbage, cucumber, FRAP, total antioxidant capacity

Introduction

In the past, agricultural production was focused on maximizing the quantity of fruits and vegetables produced for commercial market. However, modern consumers are now interested in optimizing the nutritional composition of foods. Therefore, much attention has now been placed on the agricultural practices that will enhance the nutritional content of fruit and vegetable being produced today (Wang, 2006). Fruit, vegetables, nuts and seeds, provides a rich source of antioxidant vitamins, and other phytochemicals with antioxidant characteristics. An antioxidant may be defined as any substance that when present at low concentrations, compared with those of the oxidizable substrate, significantly delays or inhibits oxidation of that substrate (Antolovich et al., 2002). The antioxidant content of fruits and vegetables may contribute to the protection they offer from disease. Because plant foods contain many different classes and types of antioxidants, knowledge of their total antioxidant capacity (TAC), which is the cumulative capacity of food components to scavenge free radicals, would be useful for epidemiologic purposes (Pellegrini, 2003; Lindsay and Astley, 2002). Antioxidant capacity has been assessed in many ways and there is large variety of ways and results. The total antioxidant capacity assays by 3 different methods were studied by Pellegrini, (2003). Table 1 shows different method with different results, which used different units.

Cruciferous vegetables, including cabbage (Brassica oleracea convar. capitata var. capitata), have a high nutritional value and contain organo-sulphur phytochemicals that increase their antioxidant capacity, which may have anticarcinogenic effects (Kim et al., 2004; Kurilich at al., 1999). The average value of TAC presented by Zloch, (2004) was 97 mg GA.100 g-1 in cabbage and 27 mg GA.100 g-1 in cucumber. Head cabbage and cucumber are the most important field vegetable crops in the Czech Republic, as well as in many other countries.

Cultivation of cabbage and cucumber demands for organic fertilization made by farmyard manures (Din et al., 2007; Murison and Napier, 2006). Farmyard manure is natural source of organic matter and vegetable produc-

Table 1 Values of TAC in vegetables presented by Pellegrini et al., (2003)

Assays methods	FRAP[a]	TRAP[b]	TEAC[c]
	(mmol Fe^{2+}.kg^{-1} f. m.)	(mmol Trolox.kg^{-1} f. m.)	
Cucumber	0.71	-	0.43
Cabbage, white	5.79	2.83	1.15

[a]FRAP = Ferric reducing antioxidant power (mmol Fe^{2+}.kg^{-1} f. m.)
[b]TRAP = Total radical-trapping antioxidant parameter (mmol Trolox.kg^{-1} f. m.)
[c]TEAC = Trolox equivalent antioxidant (mmol Trolox.kg^{-1} f. m.)

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Table 2 Characteristics of applied fertilizers

Fertilizer (company)	Compounds	N (%)	P (%)	K (%)	Dose (t.ha^{-1})
Agormin (AGRO CS a.s., CZ)	peat, basic macroelements	3.7	1.4	7.1	2.5
Agro (MeMon B.V., NL)	poultry bedding, molasses	3.5	1.5	7	1
Dvorecký Agroferm (Agropodnik Dvorce a.s., CZ)	fermented and dried cow-dung	1.6	0.6	1.0	0.8-1
Farmyard Manure (local source - Lednice, CZ)	treated mixture – bedding, stiff and liquid feaces of livestock	3.0	1.4	2.7	55 cabbage 40 cucumber
Mineral Fertilizer (AGRO CS a.s., CZ)	ammonium sulphate potassium sulphate superphosphate	21 - -	- - 18	- 50 -	
Horticultural compost (AGRO CS a.s., CZ)	plant waste with added dolomitic calcite	1.0	0.4	1.7	30

tion requires continuous applications of organic compounds (Bunting, 1965). However, a lot of farms specialize in vegetable production these days and they have no animals, so traditional farmyard manure 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 total antioxidant capacity (TAC) of head cabbage and cucumber.

Materials and Methods

The two-year experiment took place at the Faculty of Horticulture of Mendel University of Agriculture and Forestry Brno, in Lednice in 2005 and 2006. There were established 7 variants with following treatments: Agormin (an organo-mineral fertilizer), Agro (an organic fertilizer), control (unfertilized), conventional farmyard manure, conventional mineral fertilizer, Dvorecký agroferm (an organic fertilizer), horticultural compost. More detailed characteristic of applied fertilizers is displayed in Table 2. Each treatment was provided with three replicates.

The application rates were in accordance with the manufacturers' guidelines and in the case of farmyard manure as recommended by Malý et al., (1998) (Table 2). All variants, except the control one, were fertilized on the same level of nutrients according to the soil analysis and sup-

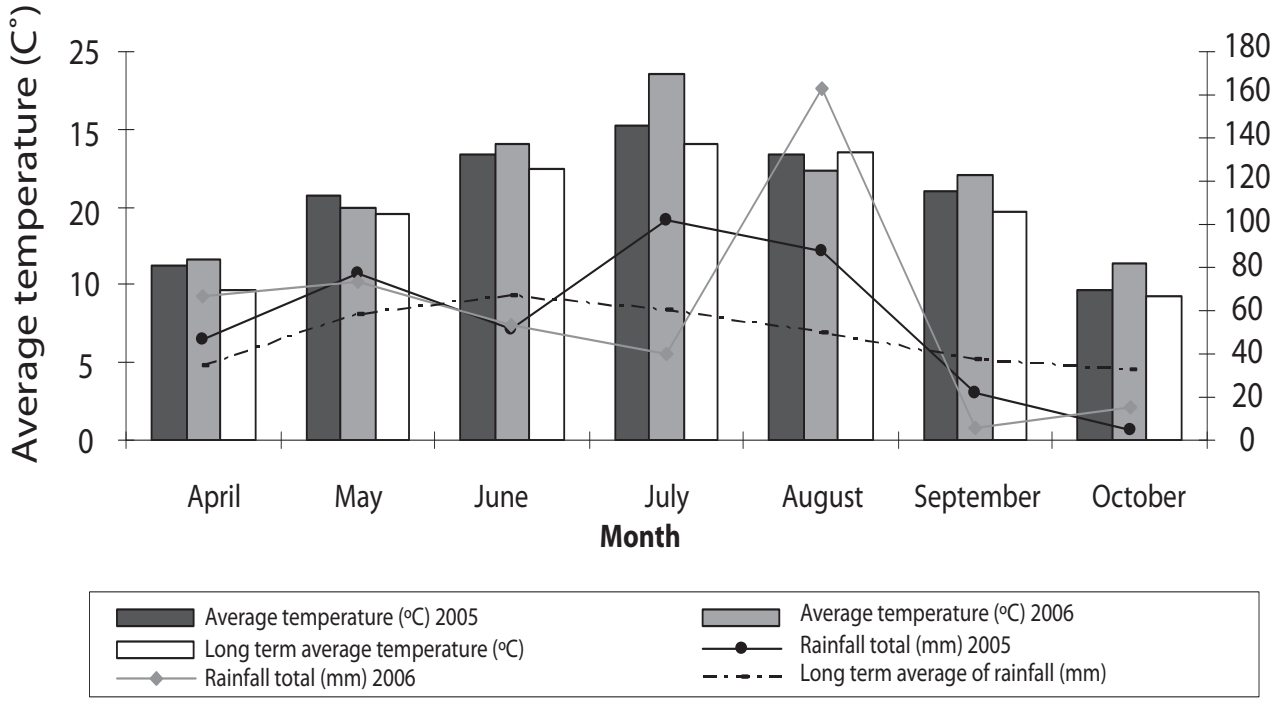

Figure 1 Climatic condition

Table 3 Mean value of TAC in cabbage in the years 2005 and 2006

Fertilizer	TAC in 2005 (mg GA.100 g^{-1})		TAC in 2006 (mg GA.100 g^{-1})	
Agormin	292 ± 16	ab	292 ± 21	a
Agro	212 ± 43	ab	295 ± 19	a
Hort. Compost	201 ± 34	ab	284 ± 22	a
Control	233 ± 32	ab	299 ± 27	a
Dvorecký agroferm	314 ± 30	b	316 ± 52	a
Farmyard manure	211 ± 65	ab	296 ± 32	a
Mineral fertilizer	186 ± 73	a	281 ± 5	a
Mean	236 ± 60		295 ± 27	

Means are followed by standard deviation; Different letters indicate significant differences at P≤ 0.05 (Tukey's HSD test)

posed yield (1 ton of cabbage uptake is as follows: 3.57 kg N; 0.57 kg P; 3.57 kg K and 1 ton of cucumber uptake is as follows: 1.67 kg N; 0.70 kg P; 2.33 kg K). Corrections were made depending on the organic fertilizer, the preceding crop and the content of nutrients in the soil (Hlušek, 1996).

The cultivar of head cabbage used was 'Trvalo F1' (Semo Smržice, CZ), which is acceptable for long-term storage. Harvesting was done on October 11th 2005 and on October 20th 2006 and the heads were classified as Grade I or II quality in accordance with local norm ČSN 463113 (UNECE STANDARD FFV-09). The cultivar of cucumber used was 'Linda F1 MIX' (Semo Smržice, CZ), which is acceptable for field cultivation. Sequential harvesting (7-days intervals) started on August 9th and finished on September 22nd in the year 2005. Following year harvest started on July 25th and continues until September 4th. The fruits were classified as Grade extra class, I or II quality in accordance with local norm ČSN 463155 (UNECE STANDARD FFV-15).

The climatic conditions during years 2005 and 2006 compared with long-term averages are presented in Figure 1. Analyses were done from average samples by measuring immediately after harvest. Average sample was composed from 3 cabbage heads without stalk and from 5 cucumbers fruits. Total antioxidant capacity (TAC) was assessed by FRAP (Ferric Reduction Ability of Plasma) assay according Zloch (2004) using a Jenway 6100 (Jenway, UK) spectrophotometer. The results were expressed as mg of gallic acid equivalents per 100 g of fresh matter (mg GA.100g^{-1}). All the results were processed by ANOVA and Tukey's test using the statistical program Unistat 5.1 (Unistat, USA) at probability 95%.

Results and Discussion

Cabbage

The average value of TAC in cabbage was 236 ± 60 mg GA.100 g-1 in year 2005 and 295 ± 27 mg GA.100 g-1 in year 2006 immediately after harvest. The mean values of TAC in cabbage heads for each treatment are shown in Table 3. The results show threefold higher value of TAC in winter cabbage in comparison with data, which mentioned Zloch, (2004). The highest mean levels of TAC were observed in Dvorecký agroferm, and were significantly higher than those of the mineral fertilizer treatment in 2005. There were no significant differences between the treatments in levels of TAC in the year 2006, however the highest value of TAC was found in Dvorecký agroferm (Figure 2). According to Ismail et al., (2004) the variation between years is due to environmental factors, such as a climatic growth conditions. The different climatic conditions of years 2005 - 2006 could probably influence these results.

Cucumber

The average value of TAC in cucumber was 125 ± 32 mg GA.100 g^{-1} in year 2005 and 114 ± 57 mg GA.100 g^{-1} in year 2006. The mean value of TAC in cucumber for each treatment is shown in Table 4. The results show three as far as fivefold higher value of TAC in cucumber in comparison with data of Zloch (2004). The differences of the results obtained from this study compared to the literature may have been due to the differences in geno-

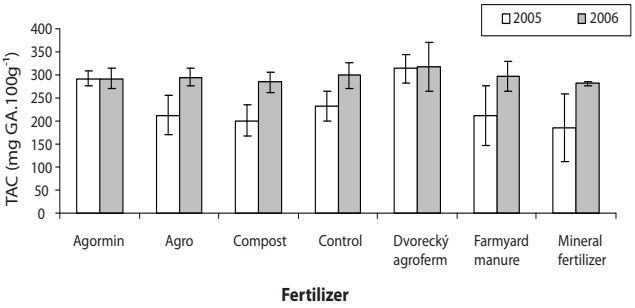

Figure 2 Effect of applied fertilizers on TAC (mg GA.100 g^{-1}) in head cabbage (2005-2006), 95% interval of significance level

type of the cabbage and cucumber used or due to the different climate conditions. The highest mean levels of TAC were observed in Dvorecký agroferm (2005) and control (2006) however control and Agormin recorded the lowest value of TAC in 2005. The variation between 2 years is due to environmental factors. As show figure 1, years 2005 and 2006 were really different as far as average tem-

Table 4 Average value of TAC in cucumber in the years 2005 and 2006

Fertilizer	TAC in 2005 (mg GA.100 g^{-1})		TAC in 2006 (mg GA.100 g^{-1})	
Agormin	103 ± 50	a	175 ± 11	b
Agro	141 ± 23	a	111 ± 4	ab
Hort. compost	133 ± 10	a	60 ± 38	a
Control	108 ± 14	a	184 ± 1	b
Dvorecký agroferm	142 ± 44	a	157 ± 14	b
Farmyard manure	129 ± 32	a	62 ± 12	a
Mineral fertilizer	117 ± 43	a	53 ± 33	a
Mean	125 ± 32		114 ± 57	

Means are followed by standard deviation; Different letters indicate significant differences at P≤ 0.05 (Tukey's HSD test)

perature and total rainfall. There were no significant differences between the treatments, in the year 2005. Agormin, Dvorecký agroferm and control shown significantly higher TAC in cucumber than compost, farmyard manure and mineral fertilizer, in the year 2006.

Many experiments have shown that cabbage gives a good response to manure and most of earlier experiments indicate a superiority of manure over commercial fertilizers (Din et al., 2007). The studies by Abou El-Magd et al. (2006) and Toor et al., (2006) are quoted in support of nutritional benefit of organic fertilizers. According to Toor, (2006) organic fertilizers may increase content of ascorbic acid and total phenolic in tomato. Abou El-Magd showed that organic fertilizers could be followed for production high yield of broccoli with high quality of heads.

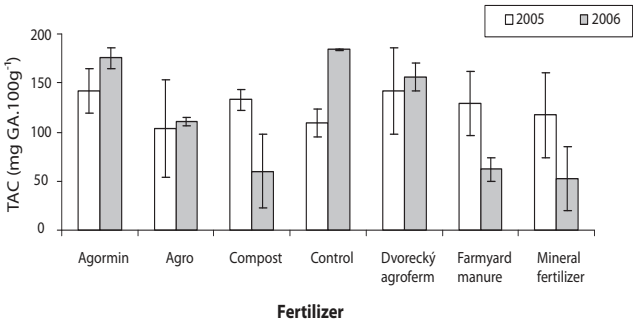

Figure 3 Effect of applied fertilizers on TAC (mg GA.100 g-1) in cucumber (2005-2006), 95% interval of significance level

For simplified evaluation of cucumbers and cabbages results was used Table 5, which showed the order of treatments according to value of TAC. There were 7 different treatments, consequently treatment with highest value was classified as number 1 and the treatment with lowest value of TAC had number 7. Theoretical value of the best treatment is 2 and the worst is 14, because biennial records are presented. This table showed that the best treatment was Dvorecký agroferm and the worst one was mineral fertilizer. Farmyard manure was worse than control and other alternative organic fertilizers (Agro, Agormin) showed similar or the same results as well as farmyard manure.

Conclusions

The finding of this study indicate that different fertilizers contributed to affecting of TAC and so affected nutritional value of vegetable. Alternative organic fertilizers can positive influenced TAC in vegetable. Also their effect to nutritional value can be positive. Alternative, organic fertilizers as well as Dvorecký agroferm and Agormin have similar or even better qualities as farmyard manure, so they can contribute to the improvement of nutritional value of vegetable production.

Acknowledgement

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Table 5 Order of TAC in cabbage and cucumber during 2 years

Treatment	Agormin	Agro	Control	Dvorecký agroferm	Farmyard manure	Mineral fertilizer	Hort. compost
Cabbage	7	9	5	2	7	14	12
Cucumber	9	6	7	4	9	12	9

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