EFFECTS OF ORGANIC AND MINERAL FERTILIZATION ON NPK STATUS IN SOIL AND PLANT, AND YIELD OF RED BEET (*Beta vulgaris* var. *conditiva*)

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Introduction

Vegetables are sources of minerals (Russo, 1996) as well as vitamins and essential amino acids (Custic et al., 2002), and their consumption is thought to be beneficial to human health (Fritz et al., 1989; Vogel, 1996). Red beet (*Beta vulgaris* var. *conditiva*) is often recommended for the prevention of development or occurrence of cancer (Bobek et al., 2000; Kapadia et al., 1996). Because of that, nutrient removal by edible plant parts is a very important component of soil fertility (Alt and Wiemann, 1987). On the other side, fertilizers influence soil fertility and the environment. Lešić et al. (2004) reported that 150 kg N, 50 kg P, 220 kg K and 30 kg Mg are necessary for red beet yield of 60 t ha^{-1}. Kadar and Erno (2000) reported that for the *Beta vulgaris* L. the optimal values of soil are 200 mg K_20 kg^{-1} and 150-200 mg P_20_5 kg^{-1}. Some authors (Michalik and Grzebelus, 1995; Ugrinovic, 1999) reported that the dry weight content in storage root varied from 80 to 164 g kg^{-1} and was decreased by nitrogen abundance (Michalik and Grzebellus, 1995; Salo et al., 1992). A number of papers (Stopar el al., 1988; Salo et al., 1992; Goh and Vityakon, 1983; Cerne, 1981; Fritz et al., 1989; Vogel, 1996) deal with the influence of nitrogen fertilization (from 120 to 600 kg N ha^{-1}) on the red beet yield (from 20 to 70 t ha^{-1}). Cerne et al. (2000) and Ugrinovic (1999) determined that mineral fertilization with 150 kg N ha^{-1} could result in a good yield. For this reason, the goal of these investigations was to determine the influence of organic and mineral fertilization on the content of nitrogen, phosphorus and potassium in soil and plant, as well as on the level of dry weight and yield of red beet. This investigation might suggest some new solutions, methods and rates of fertilizing red beet.

Material and methods

Two identical field fertilization trials with red beet, cultivar Bikor, were carried out in northwestern Croatia: Zumberak in 2003 and Lika 2004. The trial was set up according to the Latin square method with four fertilization treatments (5 kg m^{-2} stable manure, 50 and 100 g NPK 5-20-30 m^{-2} and unfertilized control). Each plot size was 12 m^{-2} with plants spaced 0.40 m x 0.07 m. In both years direct sowing was in the III decade of May and harvest was in the III decade of August. Ten red beetrots and soil samples for chemical analyses were taken at the harvesting time randomly from each plot. Dried homogenized plant (105 ºC) and air dried soil samples were analyzed in triplicate and the results are presented as mean values. Potassium and phosphorus in soil were determined according to Egner et al. (1960) and the digestion method with concentrated HNO_3 in plant was used. Total plant and soil nitrogen was determined by the Kjeldahl method (AOAC, 1975). Statistical data analyses were performed using the SAS 8.2 System (1999-2000). In 2003, there was a lack of precipitation with relatively high temperature in the periods

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of pre-sowing and growth beginning. In view of precipitation and air temperature, the 2004-year was almost optimal for red beet growth.

Results

Nitrogen levels in soil varied from 1.6 to 2.1 g N kg^{-1} and were generally higher in 2003 with highest value in the treatment with stable manure. The content of total nitrogen in red beetroot ranged from 31.8 to 34.2 g N kg^{-1} in 2003 and from 14.4 to 15.5 g N kg^{-1} in 2004 without significant differences according to fertilizing rates. The obtained results show that the content of total N in red beet in 2004 is within the limits 13.58-25.00 g N kg^{-1} reported by Ugrinovic (2004) while the results for 2003 are higher. The highest N content in red beet was determined in the treatment fertilized with stable manure in 2003 and in the treatment with 100 g NPK m^{-2} in 2004. Higher values of N implicate higher crude proteins, which is important for the nutritive quality of vegetables (Custic et al., 2002).

Table 1. Mean values of investigated treatments in years 2003 and 2004 for nitrogen (N), phosphorus (P_2O_5), potassium (K_2O) in soil and plant, and yield of red beet

Year	Treatment	Soil			Red beetroot				Yield
		N g kg^{-1}	P_2O_5 mg kg^{-1}	K_2O mg kg^{-1}	N g kg^{-1}	P_2O_5 g kg^{-1}	K_2O g kg^{-1}	D.W.[1] g kg^{-1}	kg m^{-2}
2003	unfertilized	2.0 a[2]	21 c	120 c	32.4	4.5 b	34.2	71 a	0.31 c
	manure	2.1 a	47 b	169 b	34.2	6.2 a	35.1	62 b	0.99 a
	NPK50	2.0 ab	41 b	158 b	31.8	4.6 b	32.9	67 ab	0.59 bc
	NPK100	1.9 b	73 a	213 a	32.6	4.3 b	33.1	69 ab	0.82 ab
2004	unfertilized	1.6	89 c	313 c	14.4	4.0 b	26.9 b	147 ab	4.10
	manure	1.6	139 a	390 a	14.6	5.1 a	31.1 a	139 b	4.26
	NPK50	1.7	108 bc	330 bc	14.9	4.5 ab	28.7 ab	150 ab	4.41
	NPK100	1.7	127 ab	342 ab	15.5	4.5 ab	28.7 ab	156 a	4.59

[1]Dry Weight

[2]Means followed by the same letter are not significantly different according to Tukey's Studentized Range (HSD) Test at p=0.01. For means without any letter ANOVA was not significant.

Phosphorus levels in soil varied significantly in fertilization treatments in 2003 (21 to 73 mg P_2O_5 kg^{-1}) and in 2004 (89 to 139 mg P_2O_5 kg^{-1}), which is lower than reported by Kadar and Erno (2000). Highest phosphorus content in soil was determined in the treatment with 100 g NPK m^{-2} and with stable manure in 2003 and 2004, respectively. Total phosphorus in red beetroot varied from 4.3 to 6.2 g P_2O_5 kg^{-1} in 2003 and from 4.0 to 5.1 g P_2O_5 kg^{-1} in 2004. Significant highest phosphorus content in plants was determined in the treatment with stable manure in both years. Significant differences in potassium levels in soil between fertilization treatments were recorded in both years. Highest content of potassium in soil was determined in the treatment with 100 g NPK m^{-2} in 2003 and with stable manure in 2004 (213 and 390 mg K_2O kg^{-1}, respectively). Soil potassium values determined in 2003 are lower and those in 2004 higher that Kadar and Erno (2000) reported for *Beta vulgaris* L. Potassium levels in red beet varied significantly between fertilization treatments in 2004. The highest potassium content in red beetroot was determined in the treatment with stable manure in 2003 and 2004 (35.1 and 31.1 g K_2O kg^{-1}, respectively). The obtained results for dry weight in red beet in the dryness 2003 (62 to 71 g kg^{-1}) are lower than Ugrinovic (1999) reported, and in 2004 (139 to 156 g kg^{-1}) are in agreement with Michalik and Grzebelus (1995). Regardless treatments there were big differences in red beetroot yield between 2003 and 2004 due to agro-ecological conditions. The year 2003 was expressly unfavourable, with a long dry period and relatively high temperatures that had an adverse effect on yield. In 2004, red beetroot yield (4.10-4.59 kg m^{-2}) is in agreement with Ugrinovic (1999) and generally higher than in 2003. Comparison of yield per fertilization treatment shows that the control treatment gave the lowest yield in both years. The highest yield in 2003 was determined in the treatment with stable manure (0.99 kg m^{-2}) and was not significantly different compared to the 100 g NPK m^{-2} treatment (0.82 kg m^{-2}). Treatment with 100 g NPK m^{-2} gave the highest yield (4.59 kg m^{-2}) in 2004 and was not significantly different compared to the stable manure treatment (4.26 kg m^{-2}).

Conclusion

The obtained results allow the conclusion that the application of 5 kg stable manure m^{-2} or 100 g NPK m^{-2} ensured the highest values of researched parameters. In the dryness 2003, the highest content of phosphorus and potassium in soil were determined in the treatment with 100 g NPK m^{-2}. In 2004 the highest content of phosphorus and potassium in soil and red beetroot was obtained in the treatment with stable manure. The highest nitrogen, phosphorus and potassium content in red beetroot as well as yield were determined in 2003 in the treatment with stable manure. Regardless fertilization, the N content, dry weight and yield of red beetroot were strongly influenced by agro ecological conditions. The application of 5 kg stable manure m^{-2} or 100 g NPK 5-20-30 m^{-2} can be recommended for good nutritive quality of red beet as well as standard yield if the weather conditions are favourable.

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