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THE NITRATES NUTRITION STATUS ASSESSMENT AND MANAGEMENT OF THE HORTICULTURAL CROPS IN THE STEPPE ZONE OF UKRAINE

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Abstract: The main aims were: a) to prepare a database of the determination of nitrate in vegetable and fruit production; b) identify plants – accumulators of nitrates and determine the number of samples exceeding maximum permissible concentration (MPC); c) to compare trials and doses of artificial nitrogen fertilizers and vermicomposting extract application in the field experiments with some vegetable and fruit plants. The results of the determination of nitrates in vegetables, fruits and berries, which are most often used in the human diet in steppe zone of Ukraine are presented. Two foliar spraying with vermicomposting extract gives the best results for cabbage cultivation then drip fertigation. The best result for pumpkin cultivation was recorded after vermicomposting extract treatment with a dilution of 1:150. The same trend was observed when determining the optimal doses for the greatest number of seeds and lowest NO_3 content. The lowest level of nitrate in pepper fruits determined in trial with vermicomposting extract foliar spraying with a dilution of 1:100. The best dose-effect response for apple tree yield was fixed for trial with vermicomposting extract two time drip fertigation with dilution 1:50.
Keywords: vegetables, fruits, berries, nitrates, norm, maximum permissible concentration, yield, vermicomposting extract

1. INTRODUCTION

Approximately 80% of dietary nitrates are derived from vegetable consumption. Sources of nitrites include vegetables, fruit, and processed meats, which means that human exposure to nitrate is usually associated with intake through vegetables, and to a lesser extent, with other foods and water (Temme, 2011). Nitrates are, besides being used as food additives, found in nature as part of the nitrogen cycle, and play an important role during nutrition, growth and development of plants. Because of their cumulative properties, they are an important part of vegetables (Lucarini et al., 2012). Nitrate serves as a source for the production of nitrite and nitric oxide as well as other metabolic products. Nitrites are also produced endogenously through the oxidation of nitric oxide and through a reduction of nitrate by commensal bacteria in the mouth and gastrointestinal tract (Norman, 2009). Long-term use of contaminated with nitrates vegetables, fruits and water leads to development of chronic intoxication. In case when foods with a high content of nitrate both nitrate and their metabolites (nitrite and nitro-compounds) put to the human body. Thus a precise balance between nitrates income and outcome in the human body has not yet succeeded. Nitrates are not only entering to the body from outside, but also formed therein. Regarding to the rules by of nitrates – 5 mg nitrates per 1 kg of body weight of a person for an adult person is allowed, i.e. 0.25 g – for a person with weight 60 kg (Ganchuk et al, 2012; Menard et al., 2008).

Acceptable standard for child is not more than 50 mg. A person takes easy the daily dose of nitrates in 15–200 mg. 500 mg is the maximum permissible dose, and 600 mg is toxic dose for an adult person. Nitrogen – an essential element for all life forms. In the process of the nitrogen cycle in nature during the breakdown of proteins and other nitrogen-containing substances excreted ammonia. Nitrification bacteria substances make oxidation to nitrates, and those, in turn, are converted to nitrites. Under the action denitrification bacteria last turned back into nitrogen, which is released to the atmosphere.

The nitrogen is supplied in the soil with various kinds of fertilizers, residues of plants, ammonium and nitrogen nitrates salts, which are contained in rain water (Temme, 2011). Nitrates – are natural products of metabolism of all plants. They are vital to plants, because of it is impossible without them to provide their normal growth and development. However, uncontrolled use of nitrogen fertilizers has led to the accumulation of unlimited level in their products of plant origin (Berova and Karanatsidis, 2008). The main factors that cause the accumulation of nitrates in vegetables, fruits and berries include meteorological and agronomic conditions of cultivation, the level of soil fertility, varietal characters of plants (Iammarino et al, 2014) The fruit and vegetables grown in the south - eastern part of Ukraine, on the content of toxic substances, depending on their species and varietal facilities (carrots, beets, pumpkin, peppers, tomatoes, rhubarb, gooseberry, etc.), as well as in their anatomical parts.

These studies allowed identifying the safest crops and their varieties. The study of patterns of income and accumulation in plants nitrates is necessary for the proper reasoning for the development of activities to reduce their content in the finished product. Studies have shown that vermicompost plays a major role in improving growth and yield of different field crops, including vegetables and fruit crops. For example, the application of vermicompost gave higher germination, growth and yield of horticultural crops (Vigna radiate L.) compared with the control (Gutiérrez-Miceli et al., 2007; Sallaku et al., 2009).

Plants fertilized with vermicompost have shown greater ability to assimilate essential macro and micro nutrients, and resulted into improved root development (Atiyeh et al., 2001; Arancon et al., 2006). Nutrients in vermicompost are present in readily available forms for plant uptake; e.g. NO_3, exchangeable P, K, Ca and Mg (Edwards and Burrows, 1988). Better plant growth and yield of different crops have been reported when vermicompost was combined with artificial fertilizer in a certain ratio. The main aims were: a) to prepare a database of the determination of nitrate in vegetable and fruit production; b) identify plants – accumulators of nitrates and determine the number of samples exceeding maximum permissible concentration (MPC); c) to compare trials and doses of artificial nitrogen fertilizers and vermicomposting extract application in the field experiments with some vegetable and fruit plants.

2. MATERIAL AND METHOD

Monitoring of nitrates was conducted in field experiments with species and varieties of vegetable and fruit crops grown in the Steppe zone of Ukraine. Field experiments were laid out in 4-fold repetition in terms of vegetable and orchards variety testing stations of Dnipropetrovsk region in 2000–2004 and 2015-2016 years. Average samples of vegetables, fruits and berries were crushed and homogeneous. Then they were weighed to 10 g of powdered sample or squeezed juice, was added 50 ml of a 1 % solution of potassium alum to extract nitrate for 15 min. The control of nitrates content was carried out applying the potentiometric method with nitrate selective electrode (Products of fruits and vegetables, 1995). Assessment of cases of exceeding maximum permissible concentrations (MPC) has been done taking into account several references (Ganchuk et al., 2012; Menard et al., 2008; Mitek et al, 2013).

The contents of readily soluble proteins of sweet pepper tissue withdrawn by the buffer 0.05 M tris-HCl and pH 7.4 were defined according to the method of Bradford (Bradford, 1976). The activity of peroxidase was determined right after the secretion (Boyarkin, 1956). Protein spectra in the sweet pepper tissue were determined with SDS electrophoresis. Pepper, cabbage, pumpkin and apple were selected as test plants to examine the effectiveness of different forms of fertilizers. Scheme of field experiments with vegetables included the following options: foliar spraying with nitrogen fertilizer (50g NH_4NO_3 per 10 liters of water) and vermicomposting extract (dilution 1:100). Ratio of fertilizer and water in case of drip irrigation using: 1:200, 1:150 and 1:100. The two apple varieties (Gala Red and Pinova) were evaluated in field experiments with drip irrigation. Vermicomposting extract with ratio of fertilizer and water: 1: 100 and 1:50 two applied after time drip fertigation. Vermicomposting extract technology includes the following stages: mechanical decomposition of wastes to the certain parameters; crushing of crops wastes to certain fractions, fermentation of the ground raw material under the proper humidity and temperature, bioprocessing of the fermentated husk (sunflower, buckwheat or rice) by worms Eisenia foetida on the special shelves, extracting of biohumus with water (Kharytonov et al., 2009).

3. RESULTS

The results of determining the concentration of nitrates in fruits and berries are shown in Table 1. The average value of nitrates in fruits and berries were in the range of 20–50 mg/kg. The content of nitrates was studied in our work fruits and berries belong to the group of low concentration. The results of nitrate assessment in vegetable crops are given in Table2.

Table 1. Nitrate concentration in fruit and berries

Fruits, berries	Number of samples	Average meaning	Min – Max
Plum	7	50.4	23.9–81.9
Cherries	24	15.8	8.05–27.6
Apricot	6	45.6	20.3–82.0
Plum	4	40.7	28.9–51.7
Strawberry	5	42.0	34.9–50.5
Raspberry	7	33.3	16.2–91.4
Blackberry	17	22.8	14.4–28.7

Table 2. Nitrates concentration in vegetable crops, mg/kg

Vegetable crop	Number of samples	Average meaning	Min – Max	MPC	Number of samples, which exceed MPC
Radish	5	2727.6	2022–3596	1500	5
Beet	6	2886.5	1276–4527	1400	5
Carrot	6	485.0	161–1137	250	5
Pumpkins	6	669	291–1157	400	5
Potatoes	46	138.2	23–639	250	12
Cabbage	12	584.33	103–1833	900	2
Pepper	9	228.75	73–580	200	2
Tomatoes	19	44.1	16,5–82,0	150	0
Sugar pea	9	4.6	3,6–6,4		

The data of table 2 shows that 36 of the 111 samples tested for nitrate content exceed the maximum permissible concentration. The largest share of the maximum permissible concentration is observed in the vegetables: radishes, beets, carrots and pumpkin. In the determination of nitrate content in potatoes 12 samples from 46 exceeded the 1MPC, in cabbage 2 samples of 12, and pepper in 2 samples of 9 exceeded the 1MPC. The results of measuring of content of nitrates in of pepper fruits treated with solutions of mineral nitrogen fertilizers and vermicomposting extract shown in Figure 1.

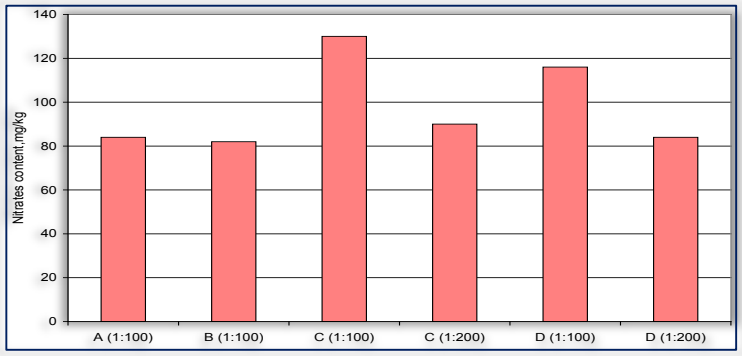

Figure 1 - The content of nitrates in fruits of pepper in different variants of the field experiment: A – foliar spraying with nitrogen fertilizer (1:100) ; B – foliar spraying with vermicomposting extract (1: 100); C – drip fertigation with nitrogen fertilizer (1: 100; 1: 200); D – drip fertigation with vermicomposting extract (1: 100; 1: 200).

The highest level of nitrates was recorded in the cultivation of pepper drip irrigation in the cultivation of nitrogen fertilizers in the ratio 1:100. The same pattern is recorded, and when vermicomposting extract has been applied. The lowest level of nitrate determined in trial with vermicomposting extract spraying (B 1:100). In other words, these options provide higher environmental quality of the pepper fruits.

The results of the electrophoresis of peroxidase protein of sweet pepper tissue are given in table 3.

Table 3. Isoelectric points (PI) of isoenzymes of peroxidase tissues of sweet pepper grown under different conditions

№	pI	Treatment					
		A (1:100)	B (1:100)	C (1:100)	C (1:200)	D (1:100)	D (1:200)
1	4,00	+	+	+	+	+	+
2	4,05	++	++	++	++	++	++
3	4,07	+++	+++	+++	+++	+++	+++
4	4,09	+	++	++	++	++	++
5	4,12	-	+	+	+	+	+
6	4,20	-	-	+	+	-	-
7	4,25	+	+	+	+	+	-
8	4,30	-	+	+	-	+	-
9	4,40	-	-	+	-	+	+
10	4,50	-	-	-		+	+
11	5,25	-	-	-		+	+
12	6,40	-	-	-		+	-

The highest number of protein fractions and enzyme concentration is noted for the variant D - drip fertigation with vermicomposting extract (1: 100). The data obtained in field experiments with cabbage variety "Langedijk" in research vegetable variety testing station are shown in table 4.

It was found that two foliar spraying with vermicomposting extract gives the best results in terms of yields comparatively to control. The vermicomposting extract drip fertigation with a dilution of 1:200 gives higher application yield than trial with a dilution of 1:100.

Table 4. Vermicomposting extract application in field plots of cabbage

Trials	Average yield, ton/ha	Additionally, %
Control (water)	35.7	-
Drip irrigation (1:100)	43.4	21.5
Drip irrigation (1:200)	46.9	31.2
Foliar spraying (1:100)	48.8	36.6
LSD_{05}	5.1	

The results of the experiments with the pumpkin variety "Valok" for the study of optimal dose of the vermicomposting extract are given in table 5.

Table 5. Vermicomposting extract influence on pumpkin yield and NO_3 content

Trial	Average fruit weight, kg	Seeds weight, g (in average of 3 fruits)	NO_3 content, mg/kg
Control	9. 45	263	225
1:200	10.30	272	158
1:150	11.00	294	164
1:100	10.00	264	172
LSD_{05}	0.84	50	

The best result was recorded after vermicomposting extract treatment with a dilution of 1:150. The same trend was observed when determining the optimal doses for the greatest number of seeds and lowest NO_3 content.

The results of the field experiments with vermicomposting extract (VCE) application in apple orchard based on two varieties testing are presented in Figure 2. The best dose-effect response for apple tree was fixed for trial with vermicomposting extract dilution 1:50.

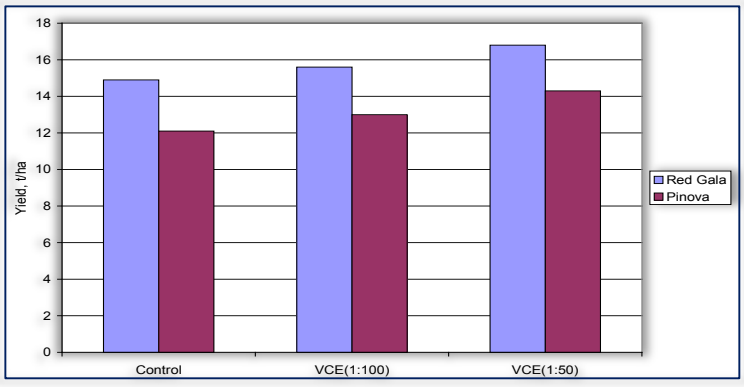

Figure 2 - The vermicomposting extract dose-effect search in apple orchard

4. CONCLUSIONS

The data obtained shows that 36 of the 111 vegetable samples tested for nitrate content exceed the maximum permissible concentration. The content of nitrates was studied in our work fruits and berries belong to the group of low concentration to 100 mg/kg. The lowest nitrate content we found in green peas.

The field experiments data showed the best result in case of vermicomposting extract application both from productive and ecological points of view. Thus, the application of the bioconversion products can provide reliable ways to environmentally friendly agriculture.

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