Bulgarian Journal of Agricultural Science, 20 (No 2) 2014, 337-341
Agricultural Academy

YIELD AND QUALITY OF PARSLEY DEPEND ON WATER QUALITY

N. DINEV and I. MITOVA
Institute of Soil Science, Agrotechnologies and Plant Protection «N.Poushkarov», BG – 1080 Sofia, Bulgaria

Abstract

DINEV, N. and I. MITOVA, 2014. Yield and quality of parsley depend on water quality. *Bulg. J. Agric. Sci*., 20: 337-341

Food safety crop production depends largely on soil characteristics. Relatively little has studied the problem of the quality of irrigation water. The purpose of this paper is to establish the influence of nitrate contaminated irrigation water on production of parsley. In a greenhouse pot growing experiment with soil (Chernozem-smolnitza) it was investigated the effect of irrigation water taken from natural wells. Four increasing levels of nitrate 16.4, 77.1, 184.3 and 320.5 $mg.L^{-1}$ (at permissible level of 50 $mg.L^{-1}$) were used Changes in nitrate content (ranging from the first cut from 20.1 to 1970 $mg.kg^{-1}$), adequate to the concentrations of nitrates of water and declining over time were found. Content of sugars and solids in three cuttings are discussed. Parallel trend of nitrate concentration and pigment content in leaves is shown. The results provide specific recommendations for the safety of products of parsley and control of soil quality at nitrate-enriched water, used for irrigation.

Key words: food safety, vegetables, irrigation, contaminated water, sugars, pigments

Introduction

Globally nitrogen fertilizers play a decisive part in increasing the yield of crops. At the same time, nitrogen fertilization is the largest energy investment and value in production costs and a significant supplier of nitrate pollution of groundwater. Applied in optimum nitrogen fertilization rates can improve the quality of production and yields of 20-40% (Pokrovskaya, 1988; Stoychev et al., 1989). On the other hand, fertilization with nitrogen rates unreasonably high, especially when the soil nitrogen is not balanced with other nutrients, resulted in product-accumulated nitrates above the maximum. Studies of Kutev et al. (2010) on the balance of nitrogen and phosphorus on the farm level showed that under intensive vegetable production on the same farm during the years, after the vegetation soil contained from 40 to 100 kg nitrogen per hectare and gap of about 10 kg P_2O_5. It is known that vegetables are the main source of nitrate toxicity for humans. About 70% of the daily rate nitrates human gets with vegetables, 20% - with drinking water and 10% - with meat and other food products (Raikova and Rankov, 1984, Stoyanov, 1997). Most often, the accumulation of nitrate in the crop production is associated with high nitrogen fertilization (Rankov and Boteva, 1995). Numerous data suggest, however, that such similar interpretation is not always correct. In many cases, (Pokrovskaya, 1988; Raikova and Rankov, 1984; Cholakov et al., 2006) high nitrate content is found in the production obtained without any organic and mineral fertilization. High nitrate content in plants can also be provoked by not only nitrogen fertilization but also more than 20 other factors, such as biology of the crop and variety, climate and soil conditions, farming practices, etc.

Having in mind the importance of food safety production and increasing of knowledge in soil agrochemistry and plant biology we put as our aim to identify changes in yield, quality and some biochemical parameters during vegetation of parsley grown by irrigation with contaminated water.

Materials and Methods

Experiment was carried out in the green- house of the Institute of Soil Science "N.Poushkarov", Sofia. Used Chernozem-smoltitza soil is taken from the catchment area of village of Gurmazovo near Sofia. The soil is a medium rich with humus 3.7%, neutral pH in water-6.8, low content of mineral nitrogen-5.5 $mg.1000g^{-1}$, and very high available potassium and phosphorus: K_2O-218.5 $mg.100^{-1}g$ and P_2O_5-56.5 $mg.100^{-1}g$.

E-mail: ndinev@iss-poushkarov.org

Experimental scheme is composed of four variants, and each variant included six replications. Variants are based on ascending load irrigation water with nitrates. Water was taken from four wells operating in the village, which previous studies have shown accumulation of nitrates in plant production (Dinev and Mitova, 2011). Established contents of pollutant substances characterized water contaminated with nitrates in three of the wells, and the high levels of the sulfates (Table 1).

Twenty seeds of parsley (*Petroselinum hortense* var. Foliosum), cultivar "Festival 68", were planted in pots. Through daily irrigations, soil moisture was maintained at 75% of soil humidity. During the vegetation were made three cuts of plants.

The investigation included observing of the following parameters: mass of green leaves and roots (g), plant quality assessment is made by nitrate (mg.kg^{-1}l) and total sugars- (%) (according to methods recommended for *RQ flex plus 10- Merck*), content of plastid pigments in fresh mass (the method of extraction with 80% acetone by Vernon) (mg. 100 g^{-1})). Absolutely dry matter was defined in % of fresh biomass.

Table 1
Concentrations of Nitrates, Chlorides and Sulphates (mg.l^{-1}) of irrigation water

Variant	NO_3^-	Cl^-	SO_4^{2-}
1	16.4	47	147
2	77.1	61	190
3	184.3	106	263
4	320.5	213	490
Maximal permissible level	50	250	250

Results

Test plants were grown for two months. Meanwhile three cuts of plants with well-shaped foliage were carried out. Remarkable are the small differences in the mass of plants of the first and second cuts than the first cut (Table 2), despite the fact that the nitrate content in irrigation water on the second variant is much higher. Vegetative masses in the third and fourth variants of the same cutting period are almost equal. At the advance of vegetation, the differentiation between variants seems clear. In the second and third cuts, differences between options are increasing. The first cut mass of plants from variant 4 is 31.83% higher than in the first one, then the second variant is already more than five times greater, and the difference in slope between fourth and first variant is thirteen times favor of the fourth variant at the third cut. Totally, foliage plant biomass from all three cuts at variant 4 is about three times greater than that of the first one. These differences between the experimental variants are very pronounced and the resulting root masses. In end of the experiment, the plant variants with the highest nitrate loads are nearly 6 times more root mass compared to variant 1.

The content of ash elements in green parts and parsley roots increases with increasing of nitrogen content in the irrigation water, in accordance with the increased consumption of water and formed larger leaf. At the same time, the content of dry matter and total sugars in the leaves was higher in the first variant and decreases with increasing of nitrate content in irrigation waters.

Table 2
Effect of nitrates in irrigated water on biomass (green and root) formation, g

Nitrates, mg. L^{-1}		Green biomass				Roots
		I cut	II cut	III cut	total	
16.4	average	6.00	1.32	0.57	7.89	1.79
	median	5.86	1.39	0.59		1.28
	std	1.12	0.27	0.13		1.34
77.1	average	5.43	1.94	1.30	9.32	5.55
	median	5.48	1.82	1.16		5.86
	std	0.55	0.40	0.38		2.38
184.3	average	7.90	4.66	5.23	17.79	9.57
	median	7.96	5.19	5.15		9.33
	std	1.81	1.33	0.99		3.20
320.5	average	7.91	6.95	7.85	22.71	10.39
	median	8.02	6.98	7.75		9.62
	std	2.19	0.89	0.77		2.52

In accordance with different load of irrigation water nitrate the recorded content in the crop is different. While the first cut of variant 1 has only 20.1 mg NO_3.kg^{-1} fresh mass, then at fourth option NO_3.kg^{-1} reach 1970.3 mg fresh weight. In next measure stages the nitrate contents fall. Parallel with the rise of the air temperature and solar activity as well as the progress the vegetation, nitrate reductase activity increased, which favors the transformation of nitrate in plant cells (Clarkson and Warner, 1979). In the third cut nitrate in foliage decreased two times in the first variant, about eight times for the second one, hindered times in the third and twelve times at 4 variant. However, that experiment displayed nitrate content in vegetative mass of parsley options even in high nitrate content in irrigation water is below the permissible concentrations, for spring growing vegetables the risk is a fact especially considering the low content with mineral nitrogen.

Agroecological interest is the calculation of the imported soil nitrate from irrigation waters, taking into account all the water needed for the output of the experiment. While sanitary clean irrigation water imported 27.88 g NO_3.kg^{-1} soil, under the most contaminated with nitrates water this quantity was 790.57 mg NO_3.kg^{-1} soil or 28.36 times. calculated per area, by the first variant were imported 0.126 kg N.ha^{-1}, by second-0.679 kg N.ha^{-1}, by third-1.984 kg N.ha^{-1} and by the latest variant imported 3.570 kg N.ha^{-1} .

Discussion

Nitrates are naturally occurring forms of nitrogen and are an integral part of the nitrogen cycle in the environment. Their presence in crop production (mainly vegetables) in high concentration poses a risk to human health. Reasonable, this implies control and impact on fertilizer products, widely used in modern agriculture. However, relatively little attention has been paid to other sources for the "import" of nitrates in the soil. Particularly, the importer is the quality of irrigation water for growing vegetables

Parsley is one of the main spices and herbs used traditionally in our country. In the same, parsley is among plant species, characterized in high risk of nitrate accumulation (Santamaria, 2006). Different capacity for accumulation of nitrate in plants may be related to the specific location of nitrate reductase activity and its expression+, and different levels of nitrate absorption and translocation within the plant.

This study takes into account the seasonal dynamics of absorption and transport of nitrate to the green parts of plants. During the vegetation stages not only vegetation biomass increases, but also the factors limiting enzyme activity change, (increase of sunshine, limiting the sources of nitrates) are improved. This naturally leads to a reduction in nitrate concentration in leaves. It is especially dramatic in the variants with high nitrate impute from irrigation water.

Changes in nitrate content in biomass have close relationships with other metabolic processes. It is known (Mengel and Kirkby, 1982), that the reduction of nitrates and their incorporation into organic compounds necessary energy that comes from the destroying of carbohydrates. In experimental conditions the highest content of total sugars is the first cut when enough biomass plant form and probably- adaptive mechanisms to deal with high nitrate levels (Table 3).

During the vegetation plants form also adequate physiological processes associated with the utilization of macronutrients, such are photosynthetic plastid pigments. The structure of chlorophyll includes mainly nitrogen-containing structures (enzymes and organic compounds). Undoubt-

Table 3
Effect of nitrates in irrigated water on the changes in quality parameters

Variant	1	2	3	4
I cut				
Ash elements, %	15.84	16.60	18.62	19.50
Absoluterly dry biomass, %	19.52	18.12	16.63	16.57
$NO_{3,}$ mg. kg^{-1}	20.1	221.4	1150.0	1970.3
Sugars- total, %	8.6	8.3	7.5	6.1
II cut				
Ash elements, %	16.60	17.40	18.31	19.72
Absoluterly dry biomass, %	20.25	17.07	14.44	14.07
NO_3, mg. kg^{-1}	19.0	26.23	62.75	412.38
Sugars- total, %	8.4	8.9	7.2	5.9
III cut				
Ash elements, %	15.07	16.11	17.34	18.03
Absoluterly dry biomass, %	15.24	13.16	11.74	12.68
$NO_{3,}$ mg. kg^{-1}	10.21	17.34	11.64	168.72
Sugars- total, %	7.5	7.4	5.7	3.9
roots				
Ash elements, %	17.04	15.87	15.16	16.23

ed interest is investigating connection and relationship between content of chlorophyll in leaves and nitrogen in the plant cycles (Tonkay, 2011). In this study the content of plastid pigments in foliage of parsley showed one direction trend with nitrate concentrations in irrigation water (Table 4). The content of Ch "a" + Ch "b" increased from the lowest to the highest concentration of nitrate and the highest one is in plant samples from the third (last) cut. Nearest point to an optimum ratios of Ch "a" / Ch "b" (between 1.82 and 2.28) is reported in samples from all four variants of the second burst

Parsley grown in variants with high levels of nitrates in irrigation waters, expressed fresh and leaf turgor, high chlorophyll content, which is also reflected in the absolute dry matter (dilution effect) (Mitova et al., 2011).

Data from this study indicate that concentration of pollutants did not surpass the standards for food safety of sanitary products. However, in management of vegetable production, it is necessary to consider not only the content of nitrates in the soil but also other imputes for risk assessment. Irrigation water greatly affect nutrient (representing a risk to national regulatory mechanisms, Ordinance 2/ 2007 concerning prevention of waters contamination with nitrates from agricultural sources) and creates a health risk through the transfer of nitrate in the plant.

Table 4
Plastid pigment content in green biomass of parsley

Variants	1	2	3	4
I cut				
Ch "a" (mg. g^{-1})	5.08	5.90	6.24	7.29
Ch "b" (mg. g^{-1})	2.73	3.06	3.88	3.85
Ch"a"+Ch"b" (mg. g^{-1})	7.81	8.96	10.12	11.14
Ch "a"/Ch "b"	1.86	1.93	1.61	1.89
carotenoids (mg. g^{-1})	1.95	2.04	1.98	2.18
II cut				
Ch "a" (mg. g^{-1})	6.88	7.02	7.58	9.09
Ch "b" (mg. g^{-1})	3.81	3.54	3.59	3.99
Ch"a"+Ch"b" (mg. g^{-1})	10.69	10.56	11.17	13.08
Ch "a"/Ch "b"	1.82	2.0	2.11	2.28
carotenoids (mg. g^{-1})	2.37	2.17	2.48	2.91
III cut				
Ch "a" (mg. g^{-1})	7.51	7.58	8.66	15.26
Ch "b" (mg. g^{-1})	4.23	3.65	5.53	12.67
Ch"a"+Ch"b" (mg. g^{-1})	11.74	11.23	14.19	27.93
Ch "a"/Ch "b"	1.78	2.08	1.57	1.20
carotenoids (mg. g^{-1})	2.26	2.44	2.31	2.98

Conclusion

Differentiation between vegetative masses formed between variants increases.in the vegetation Totally foliage of plants of the three variants in the slope with the highest nitrate load (320.5 mg.L^{-1}) is greater than that of the first one (16.4 mg.L^{-1}). The differences between the variants are very pronounced and resulting in root masses. In cuts the experience of plant variants with the highest nitrate loads are nearly 6 times more root mass compared to variant 1.

The first cut of the first variant is 20.1 mg NO_3.kg^{-1} fresh weight. Variant, irrigated with the contaminated water expressed - 1970.3 mg NO_3.kg^{-1} fresh weight. At the end of the study nitrate in foliage decreased two times for the first option, for the second eight times, and a hundred times in the third and fourth times in the last variant.

Changes in nitrate content in all variants are close related with concentration of total sugar and expressed similar trend in plastid pigment content.

By irrigation norm for maintaining relative humidity of 75%, depending on the nitrate content in irrigation water in the output experiences were imported between 1.26 and 35.70 kg N.ha^{-1}.

References

Cholakov, T., S. Masheva, M. Mihov, H. Boteva, V. Yankova, I. Tringovska, T. Dincheva and B.Arnaudov, 2006. Environmentally friendly technology elements in the production of vegetables. Reports from the First International Symposium «Ecological approaches to the production of safe food,» NTS-Plovdiv, pp. 33-40.

Clarkson, D. T. and A. J. Warner, 1979. Relationship between root temperature and the transport of ammonium and nitrate ions by Italian and perennial ryegrass (*Lolium multiflotum* and *Lolium perenne*). *Plant Physiology,* **64:** 557-561.

Dinev, N. and I. Mitova, 2011. Quality and safety of lettuce (Lactuca sativa) depending on irrigation water. *Proceedings of Conference* "Food Science Technologies-2011", 14 - 15.10.2011, Plovdiv, pp. 415-420.

Kutev C., D. Slavov, L. Kozelov, I. Yanchev - 2010. Achieve nutrient balance at farm level: a management tool for sustainable agriculture. ISBN 978-954-90671-9-4.- Ambrosia NT Publishing Ltd. Pp. 95.

Mengel K. and E. A. Kirkby, 1982. Principles of plant nutrition, International Potash Inst. Bern, Switzerland, 654 pp.

Mitova, I., N. Dinev and Ch. Stoykov 2011. Effects of temperature, soil moisture and nitrogen form on the phenomena of growth and physiological performance in Beijing cabbage (*Brassica pekinensis* Lour.). *Soil Science, Agrochemistry and Ecology*, **XLV** (1-4): 170-175 (Bg).

Pokrovskaya, 1988. Ways for decreased nitrate level in vegetables. Agroinrform IS Review, Moscow 61 pp. (Ru).

Rankov V., c. Boteva, 1995. Biological export of nutrients to the extraction of parsley. *Proceedings of Agricultural Institute*, Plovdiv, **XL** (2): 32-37 (Bg).

Raykova, L. and C. Rankov 1984. Terms of accumulation and capacity to regulate nitrates in vegetable and fodder crops under intensive fertilization. Overview. *Agrohraninform*, Sofia, 82 pp. (Bg).

Santamaria, P., 2006 - Review - Nitrate in vegetables: toxicity, content, intake and EC regulation. *J. Sci. Food and Agriculture,* **86**: 10-17.

Stoyanov, S., 1997. Nitrates, nitrites, nitrosamines. Pensoft, ISBN 954-642-031-x, 102 pp.

Stoychev, D., A. Kitipov and I. Atanasov, 1989. Mineral nitrogen in agriculture as a potential source of nitrate pollution. *Soil Science and Agrochemistry*, (4): 23-30 (Bg).

Tonkay, O., 2011. Relationship between nitrate, chlorophyll and chromaticity values in rocked salad and parsley. *African Journal of Biotechnology*, **10** (75): 17152- 17159.

Received December, 2, 2012; accepted for printing October, 5, 2013.