Research Paper

Influence of Fertilizers and Growth Regulators on Yield and Nutrients Content in Onion Culture

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ABSTRACT

Onion (Allium cepa L.) is an important food product in our daily diet and is a source of nutrients for human body. The purpose of this research was to determine the influence of different doses of fertilizers and growth regulators on macro and micronutrients accumulation and yield of onion culture, during three experimental years, 2011 to 2013. Field trials were conducted during 2011 to 2013 on a black Chernozem soil. The experiment was laid out in Randomized Complete Block Design (CRBD) with four replications. The nutrients analysis were carried out using AAS in the Laboratory of Soil Science and Plant Nutrition, Faculty of Agriculture, Banat’s University of Agricultural Sciences and Veterinary Medicine “King Michael I of Romania” from Timisoara. Most of the studied nutrients in onion samples were significantly influenced by the sole application of NPK fertilizers rates and growth regulators (Azyme and Pervaide). Copper (Cu) content revealed a deficiency as compared to the normal level in all variants during the three experimental years. Results demonstrated that nutrients content varied considerably depending on the fertilization doses and climatic conditions. Among the three experimental years were significant differences in mineral content of onion culture, being registered higher values in 2011 both for macronutrients (P, K and Mg) and micronutrients (Fe, Cu, Zn and Mn).

Key words: Onion, fertilizers, macronutrients, micronutrients, yields.

INTRODUCTION

Onion (Allium cepa L.) is a species of greatest economic importance of the Allium genus (Radulov et al., 2009). The main cultivation objects are the bulbs, which are widely used mostly for seasoning, although leaves are also of economic interest. Onion food value is given by the carbohydrate content (7 to 11%); protides (1.2 to 1.9%) and vitamin C (8 to 16 mg/100 g).

Onion is an integral part of our daily diet and its use is very common in almost all food preparations (Hossain and Islam, 1994). It is also used as preservative and medicine (Yoldas et al., 2011). Micro and macro components have essential and complex specific role in plant metabolism and direct action and are involved in enzyme activity; serve as a cofactor in many enzyme compositions, influence the photosynthesis, transfer, transport and storage of substances and water consumption.

Their insufficiency prevents fulfillment of plants life cycle (Argesanu, 2010). Fertilization is the most important and controllable factor affecting nutritional value of vegetables. The type and value of fertilizer and the level of application directly influence the level of plant available nutrients and indirectly influence plant physiology and nutrient content (Griepentrog and Porter, 2002).

Plants require a variety of elements for growth and development of which N, P and K are the most important of the essential nutrients to plants since they are required...
in large quantities (Alexa, 2008). The deficiency of these elements is manifested in the detrimental effects on the growth, development and yield of the plants (Tudorancea, 2008).

Phosphorus has a major role in germination and emergence, promotes early root formation and growth and improves the quality of vegetables. Phosphorus is an adenosine triphosphate component which supplies the energy for plant processes (Rabinowitch and Brewster, 1990). Magnesium is vital in chlorophyll and it has an important role in carbohydrate synthesis. Magnesium stimulates ribosome accumulation during protein synthesis and ATP production (Samuel et al., 2008).

Zinc is one of the essential micronutrients required for optimum crop growth and deficiency of Zn and causes various adverse effects on growth and yield of crops. Zinc in involved in the formation of Chlorophyll and carbohydrate (Singh et al., 2010). Iron is an essential component of various proteins and pigments in plants. Redox cycling between the ferric and ferrous forms of iron can also catalyze the production of dangerous free radicals and iron homeostasis is therefore tightly regulated (Greenshields et al., 2007).

Manganese (Mn) is an essential micronutrient in most organisms. In plants, it participates in the structure of photosynthetic proteins and enzymes (Milloleto et al., 2010). Its deficit is dangerous for chloroplasts because it affects the water-splitting system of photosystem II (PSII), which provides the necessary electrons for photosynthesis (Buchanan et al., 2000).

The purpose of this research was to determine the influence of different doses of fertilizers and growth regulators on macro and micronutrients accumulation and yield of onion (A. cepa L) culture during the year 2011 to 2013.

MATERIALS AND METHODS

Field trials were conducted during 2011 to 2013 on a black Chernozem soil, in Becicherecu mic city, Timis County, Romania. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and prepared in 28 beds of 1 x 1 m² each in size with a buffer zone of 0.5 m between all plots. The trial consisted of 7 treatment combinations: V₁= N0P0K0, V₂= N60P45K45, V₃= N90P60K60, V₄= N120P60K60, V₅= N60P60K60 + Aqzyme 1 l/ha, V₆= N60P60K60 + 2 × Pervaide 1 l/ha, V₇= Manure 20 t/ha. The fertilizers used were NPK complex type 16:16:16 (Buchanan et al., 2000). The detection limits for Cu, Zn, Fe and Mn were 0.02, 0.005, 0.06 and 0.02 mg/L, respectively. WHO/FAO Guidelines for metals concentration in vegetables established for Cu and Zn are 73.3 and 99.40 mg/kg respectively.

The onions were sampled from the experimental field to complete maturity of plant and 3 g of each onion sample was burned in mini muffle furnace (LEZ/11 Nabetherm) to a temperature of 600°C for 8 h. The ash was dissolved in 20% HCl in a volumetric flask brought to 20 ml. The macronutrients (K, P and Mg) and micronutrients (Fe, Cu, Zn and Mn) determination were carried out using AAS in the Laboratory of Soil Science and Plant Nutrition, Faculty of Agriculture, USAMVB Timisoara. The AAS (Varian 220 FAA equipment) was calibrated for all the nutrients by running different concentrations of standard solutions.

The experimental year 2011 was characterized by a high monthly temperature, higher than multiannual average and low rainfall that led to drought; the monthly average of rainfall in 2011 was 390 mm, much lower than multiannual average of 631 mm.

In 2012, an optimal rainfall of 201 to 277 l/m² was reported in the Banat region, which ensures the water needs of crops, the monthly average for 2012 being 611 mm, was close to multiannual average of 631 mm (Periods of heavy rainfall in short time sequences generating quick flash floods and flooding were reported
in spring fall 2013. In 2012 and 2013, there were small oscillations of the mean annual temperature and easy excess from the annual average temperature of 10.85°C. The year 2011 was extremely hot, especially in the first half with the annual average temperature value being 12.17°C.

Data obtained regarding macro and micronutrients were statistically analyzed (SD and Cv%) by OriginPro 8.1 SR 1 software for Microsoft Windows. Data regarding yield of onion were analyzed using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Figures 1 to 3 shows the results obtained regarding the macronutrients (K, P and Mg) while Tables 1 to 3 shows micronutrients (Fe, Cu, Zn and Mn) level in onion samples from experimental field, during 2011 to 2013. The macroelements (K, Ca and Mg) are indispensable for plant metabolism, participating in the amino acid and protein synthesis (Alexa, 2008).

In 2011, high amounts of K in all experimental variants, ranging between 1757.3 mg/kg (V7) to 2822.24 mg/kg (V4), than control variant (V1 - 1147.58 mg/kg) were registered. NPK fertilization did influence significant changes in potassium (mg/kg) content in onion samples, especially in variants with high K dose of 60 kg/ha (V3 – 1634.53 mg/kg and V4 – 1710.15 mg/kg) (Figure 1). In 2012, lower values of K in all variants, these framing between 1011.05 mg/kg (V1) to 2351.84 (V4) and even lower in 2013, variation limits being 860.43 mg/kg (V1) to 1916.61 mg/kg (V4) (Figure 1) were registered.

Potassium is a key nutrient in the plants tolerance to stresses such as cold/hot temperatures and drought. Potassium acts as catalysts for many of the enzymatic processes in the plant necessary for plant growth to take place. Another key role of potassium is the regulation of water use in the plant (McAfee, 2008). In 2011, higher amounts of K in all experimental variants, ranging between 1757.3 mg/kg (V7) to 2822.24 mg/kg (V4), than control variant (V1 - 1147.58 mg/kg) were registered. NPK fertilization did influence significant changes in potassium (mg/kg) content in onion samples, especially in variants with high K dose of 60 kg/ha (V3 – 1634.53 mg/kg and V4 – 1710.15 mg/kg) (Figure 1). In 2012, lower values of K in all variants, these framing between 1011.05 mg/kg (V1) to 2351.84 (V4) and even lower in 2013, variation limits being 860.43 mg/kg (V1) to 1916.61 mg/kg (V4) (Figure 1) were registered.

Table 1. Micronutrients level in onion samples studied in 2011.

<table>
<thead>
<tr>
<th>Experimental variants</th>
<th>Fe (mg/kg)</th>
<th>Cu (mg/kg)</th>
<th>Zn (mg/kg)</th>
<th>Mn (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1 - NPK</td>
<td>2.87±0.52</td>
<td>0.819±0.105</td>
<td>5.20±0.69</td>
<td>1.17±1.35</td>
</tr>
<tr>
<td>V2 – N6P045K45</td>
<td>3.95±0.12</td>
<td>1.032±0.623</td>
<td>6.17±0.22</td>
<td>2.72±0.69</td>
</tr>
<tr>
<td>V3 – N9P060K60</td>
<td>3.25±0.18</td>
<td>0.119±0.435</td>
<td>6.58±0.85</td>
<td>2.83±0.38</td>
</tr>
<tr>
<td>V4 – N12P060K60</td>
<td>3.13±0.69</td>
<td>0.239±0.951</td>
<td>6.25±0.99</td>
<td>2.47±0.44</td>
</tr>
<tr>
<td>V5 – N6P60K60 + Aqzyme 1 l/ha</td>
<td>6.62±1.15</td>
<td>1.558±1.987</td>
<td>8.98±1.12</td>
<td>3.79±0.73</td>
</tr>
<tr>
<td>V6 – N6P60K60 + 2 × Pervaide 1 l/ha</td>
<td>4.43±1.39</td>
<td>1.732±1.861</td>
<td>1.59±1.28</td>
<td>1.63±1.23</td>
</tr>
<tr>
<td>V7 – Manure 20 t/ha</td>
<td>4.88±0.98</td>
<td>0.925±1.262</td>
<td>0.85±0.76</td>
<td>1.23±1.06</td>
</tr>
<tr>
<td>Cv (%)</td>
<td>0.314</td>
<td>0.659</td>
<td>0.567</td>
<td>0.437</td>
</tr>
</tbody>
</table>

*Results are given as average ± standard deviation (n = 3); Cv% = coefficient of variation for average.
values of K (mg/kg) in 2011 characterized by drought and high annual average temperature were registered. Similar values were reported by Resende and Costa (2014).

In experimental variant, V7 fertilized with manure 20 t/ha values lower than in the case of variants with NPK and growth regulators application were registered. The recorded concentrations were 1757.3 mg/kg (2011), 1459.43 mg/kg (2012) and 904.43 mg/kg (2013) (Figure 1). These results are in agreement with studies reported by Yoldas et al. (2012) that the decrease in the elements content of bulbs by applying manure was due to the element which causes enlargement of bulb and increasing yield consequently reduces the unit amount of these elements (dilution effect).

Figure 2 shows the phosphorus (mg/kg) content in onion samples from experimental variants of culture studied in the year 2011 to 2013, in experimental field. The phosphorus levels registered in 2011 widely ranged from 240.71 (V1) to 461.19 (V3) mg/kg; in 2012, the K values frame was between 205.21 mg/kg (V1) to 391.11 mg/kg (V4) and in 2013, the phosphorus content was between 148.32 mg/kg (V1) to 301.12 mg/kg (V7) (Figure 2). In all of three years of research the P (mg/kg) content in onion samples increased in variants with higher mineral fertilizers doses. In agreement with the current finding, Tekalign (2012) reported that the quality of onion can be affected by mineral nutrition and particularly, phosphorus content in bulbs increases once with the increase of NPK fertilizer doses.

Like K and P content in all experimental variants, the Mg (mg/kg) concentration was higher in 2011 with values ranging between 38.39 mg/kg (V1) to 80.37 mg/kg (V4) (Figure 3). At highest nitrogen rate associated with large potassium dose, variant V4 N120P60K60, magnesium content in onion samples ranged between 80.37 mg/kg (2011) to 66.05 mg/kg (2012) and 48.21 mg/kg (2013) being correlated with climatic conditions of drought and high temperatures in 2011 and normal air temperature in 2012 and 2013 close to the normal climatologically conditions for west of the Romania.

Figure 2. Phosphorus (mg/kg) content in onion samples in 2011 to 2013 (n=3).

Figure 3. Magnesium (mg/kg) content in onion samples in 2011 to 2013 (n=3).
The content and absorption of Mg in vegetables were influenced by the antagonist interaction that occurs between magnesium and other nutrients. Application of high potassium rates and growth regulator Pervaide diminishes the magnesium content in onion samples in variant V6; the concentration recorded the following values: 45.83 mg/kg (2011), 34.32 mg/kg (2012) and 28.16 mg/kg (2013). The results regarding K, P and Mg concentration in onion culture are in accordance with researches made by Coolong et al. (2004), which stated that in onion bulbs the three macronutrients content mentioned before was increased by NPK application. Therefore it is necessary to make a gradual fertilization especially for those with high leaching rate, such as nitrogen fertilizers. Products slow leaching rate such as of phosphorus fertilizer can be applied once with basic preparation of seedbed (Islam et al., 2007).

Tables 1 to 3 shows the results regarding the micronutrients (Fe, Cu, Zn and Mn) level in onion samples from experimental field, during 2011 to 2013.

Micronutrients level registered in all experimental variants in 2011 are framing in the variation limits cited in literature studies for each element analyzed (Garban, 2004; Gherghi et al., 2001). Iron registered values were in the range of 2.87 mg/kg (V1) to 6.62 mg/kg (V5) framing in the level of literature studies. Regarding Zn content was set out a maximum admitted limit in fresh vegetables of 15 mg/kg. In 2011, the variation limits were 0.85 mg/kg (V7) to 8.98 mg/kg (V5 - N60P60K60 + Aqzyme 1 l/ha) to 8.98 mg/kg (V5 - N60P60K60 + Aqzyme 1 l/ha). Higher value registered in V5 variant was due to Aqzyme growth regulator containing Zn in a proportion of 0.05%.

WHO/FAO in 1989 established maximum level of 73.3 mg/kg for Cu but Romanian Government set out a maximal level of 5 mg/kg throughout by Order no. 640 of 19/09/2001 regarding security and quality conditions of fresh vegetables and fruits for human consumption. In the onion samples studied in 2011, very low values of Cu ranging between 0.819 mg/kg for V1 (control variant) and 1.732 mg/kg for V6 (N60P60K60 + 2 x Pervaide 1 l/ha) (Table 1) were registered. These results are in accordance with other studies made by Romanian researchers who showed values between 0.09 to 5.15 mg/kg (Banu, 2007; Vohra et al., 1994) but other researchers Tekalign et al. (2012) on the contrary reported very high values of 16.17 to 89.50 mg/kg for copper in onion culture. Plants require small amounts of copper, an average content for normal growth and are situated between 5 to 20 mg/kg (Argesanu, 2010). Above this amount copper is considered toxic. Variable quality of soil copper accumulation affects plant roots. It is supposed that some reactions that modify the qualities of the soil nitrogen content are important factors for passive transport of copper (Poiana et al., 2009).

Regarding Cu, Zn, Fe and Mn content in onion samples in 2012, in all experimental variants higher amounts than in control variant (V1) were registered. The variation limits for Fe (mg/kg) in 2012, were between 2.59 mg/kg (V1) to 5.65 mg/kg (V3); for Cu the range was 0.612 mg/kg (V3) and 1.132 mg/kg (V5); for Zn the values registered were between 1.99 mg/kg (V1) and 7.51 mg/kg (V3). Regarding Mn (mg/kg) content in onion samples in the 2012, values between 0.87 mg/kg (V1) to 3.68 mg/kg (V5) (Table 2), framing in level of 3 to 5 mg/kg according to literature studies (Banu et al., 2007; Gherghi et al., 2001; Vohra et al., 1994) were registered. The micronutrient fertilizer Aqzyme had a great influence in microelements accumulation in onion culture and higher values than in other variants being registered in all three years, in variant V5 - N60P60K60 + Aqzyme 1 l/ha (Tables 1 to 3).

In all experimental years, as Tables 1 to 3 illustrates, the iron content in onion increases as the mineral fertilizers dose increases, the variation limits ranging between 2.87 mg/kg (V1) to 6.62 mg/kg (V5) in 2011 (Table 1), 2.59 mg/kg (V1) to 5.65 mg/kg (V3) in 2012 (Table 2) and 2.45 mg/kg (V1) to 5.31 mg/kg (V3) in 2013 (Table 3). Similar situation was in the case of Mn, the amounts were higher in 2011 for all variants (1.17 to 3.79 mg/kg) (Table 1), decreasing in 2012, 0.87 to 3.68 mg/kg (Table 2) and in 2013, 0.69 to 3.24 mg/kg (Table 3), being correlated with climatic conditions in 2011 to 2013.

The composition of Zn and Cu varied markedly among the three years of study, so, in 2011, the level of Zn ranged between 0.85 to 8.98 mg/kg, than in 2012 and Zn content frame ranged between 1.99 to 7.51 mg/kg (Table 2) and in 2013, the variation limits of Zn content in onion samples at complete maturity were 1.79 to 6.49 mg/kg (Table 3); the values obtained were below maximum admitted limit of Zn
The researches made in Romania and presented in this paper are according with researches made by Yoldas et al. (2011) regarding micronutrients accumulation in onion culture to different organic and mineral fertilizers doses, which highlighted that the content of Zn, Cu, Fe and Mn in onion increases as the fertilizers dose increases. Results are also similar with studies made in Poland that showed that the vegetables could generally be characterized by low levels of cadmium and lead (less than 0.1 mg/kg⁻¹) and relatively high levels of zinc, iron and manganese (3 to 10 mg/kg⁻¹) (Czech et al., 2012). Other studies made by Coolong et al. (2004) stated that Mn, Fe and Zn contents have the tendency to increase by NPK application and Cu content is not affected.

The applications of fertilizers and growth regulators affected onion yield. Table 4 shows the average yield in the experimental variants to onion culture while Table 5 shows the influence of fertilizers and growth regulators on yield to onion (A. cepa L). culture.

Table 4. Average of yield in the experimental variants to onion culture 2011 to 2013.

<table>
<thead>
<tr>
<th>Experimental variants</th>
<th>Yield average / variant (g/m²) ± SD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₅ - N₀P₀K₀ + 2 × Pervaide 1 l/ha</td>
<td>3050±0.150</td>
</tr>
<tr>
<td>V₄ - N₁₂₀P₆₀K₆₀</td>
<td>2832±0.080</td>
</tr>
<tr>
<td>V₃ - N₀P₀K₀</td>
<td>2462±0.197</td>
</tr>
<tr>
<td>V₂ - N₀P₀K₀ + Aqzyme 1 l/ha</td>
<td>2380±0.440</td>
</tr>
<tr>
<td>V₁ - Manure 20 t/ha</td>
<td>2262±0.180</td>
</tr>
<tr>
<td>V₀ - N₀P₀K₀</td>
<td>1363±0.710</td>
</tr>
</tbody>
</table>

*SD-Standard deviation.

Table 5. Influence of fertilizers and growth regulators on yield to onion culture 2011 to 2013.

<table>
<thead>
<tr>
<th>Experimental variants</th>
<th>Absolute yield (t/ha)</th>
<th>Relative yield (%)</th>
<th>Yield difference (t/ha)</th>
<th>Significant differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>V₁</td>
<td>30.500</td>
<td>128.31</td>
<td>+ 6.730</td>
<td>xxx</td>
</tr>
<tr>
<td>V₂</td>
<td>28.320</td>
<td>119.14</td>
<td>+ 4.550</td>
<td>xx</td>
</tr>
<tr>
<td>V₃</td>
<td>24.620</td>
<td>103.58</td>
<td>+ 0.850</td>
<td>-</td>
</tr>
<tr>
<td>V₄</td>
<td>23.880</td>
<td>100.46</td>
<td>+ 0.110</td>
<td>-</td>
</tr>
<tr>
<td>V₅</td>
<td>23.770</td>
<td>100.00</td>
<td>Control</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>23.770</td>
<td>100.00</td>
<td>Control</td>
<td>-</td>
</tr>
<tr>
<td>V₆</td>
<td>22.870</td>
<td>96.21</td>
<td>- 0.900</td>
<td>-</td>
</tr>
<tr>
<td>V₇</td>
<td>22.620</td>
<td>94.76</td>
<td>- 1.150</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>23.630</td>
<td>107.34</td>
<td>- 10.14</td>
<td>000</td>
</tr>
</tbody>
</table>

DL₀₀ = 2.325 t/ha, DL₁₀ = 3.472 t/ha and DL₀₁₀ = 4.983 t/ha.

(mg/kg) in fresh vegetables of 15 mg/kg as established by WHO/FAO Guidelines.

The researches made in Romania and presented in this paper are according with researches made by Yoldas et al. (2011) regarding micronutrients accumulation in onion culture to different organic and mineral fertilizers doses, which highlighted that the content of Zn, Cu, Fe and Mn in onion increases as the fertilizers dose increases. Results are also similar with studies made in Poland that showed that the vegetables could generally be characterized by low levels of cadmium and lead (less than 0.1 mg/kg⁻¹) and relatively high levels of zinc, iron and manganese (3 to 10 mg/kg⁻¹) (Czech et al., 2012). Other studies made by Coolong et al. (2004) stated that Mn, Fe and Zn contents have the tendency to increase by NPK application and Cu content is not affected.

The applications of fertilizers and growth regulators affected onion yield. Table 4 shows the average yield in the experimental variants to onion culture while Table 5 shows the influence of fertilizers and growth regulators on yield to onion (A. cepa L). culture.

Table 4 shows the yield average/ experimental variant range between 1363 g/m² in V₁ (control) and 3050 g/m² in V₆ (N₆₀P₆₀K₆₀ + 2 × Pervaide 1 l/ha). The absolute yield (t/ha) registered in the seven experimental variants frame was between 13,630 t/ha (V₁) to 30,500 t/ha (V₆) (Table 5).

The applications of fertilizers and growth regulators affected onion yield. The highest yield was obtained in variant V₆ with the application of mineral fertilizers at a dose of N₆₀P₆₀K₆₀ + 2 × Pervaide 1 l/ha. This application increased yield by 28.31% as compared to the control plot. Compared to the control (unfertilized) variant (V₁) and variant V₆ (N₀P₀K₀ + 2 × Pervaide 1 l / ha) achieved a very significant difference of yield of 6730 kg/ha and variant V₄ (N₁₂₀P₆₀K₆₀) presents significant differences of production being recorded 4550 kg/ha (Table 5).

The other variants (V₃, V₅, V₂ and V₇) recorded very
significant differences compared to yield mean and instead control variant \((V_1)\) recorded a relative production only of 57.34\% (Table 5). Similar findings were also reported by Islam et al. (2007) and Yoldas et al. (2011) regarding yield and growth of onion.

**Conclusions**

Climacteric conditions of the 3 experimental years influenced the nutrients accumulation in onion samples and in 2011 was a year characterized by drought and high temperatures.

Phosphorous (P) and potassium (K) content increased with increasing K and P up to 60 kg/ha. NPK fertilization did influence significant changes in potassium \((mg/kg)\) content in onion samples, especially in variants with high K dose of 60 kg/ha. Application of high potassium rates and growth regulator Pervaide diminished magnesium content in onion samples in variant \(V_6\): 45.83 mg/kg (2011), 34.32 mg/kg (2012) and 28.16 mg/kg (2013).

Copper (Cu) content revealed a deficiency in onion culture as compared to the normal level in all experimental variants in 2011 and 2012.

The composition of Zn varied markedly among the three experimental years and ranged between 0.85 to 8.98 mg/kg in 2011 and 1.79 to 6.49 mg/kg (Table 3) in 2013 and the values obtained were below maximum admitted limit of Zn \((mg/kg)\) in fresh vegetables of 15 mg/kg.

The applications of fertilizers and growth regulators affected onion yield. The highest yield was obtained in variant \(V_6\) with the application of mineral fertilizers at a dose of \(N_0P_60K_60 + 2 \times Pervaide 1 l/ha\). This application increased yield by 28.31\% as compared to the control plot.

In conclusion, we could say that our results demonstrated that nutrients content varied considerably depending on the fertilization doses and climatic conditions. Among the three experimental years were significant differences in mineral content of onion culture, being registered higher values in 2011 both for macronutrients \((P, K \text{ and } Mg)\) and for micronutrients \((Fe, Cu, Zn \text{ and } Mn)\).

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Order of Romanian Government no. 640 of 19/09/ (2001) regarding security and quality conditions of fresh vegetables and fruits for human consumption established maximum admitted limit of heavy metals in fresh vegetables.


Yoldas F, Ceylan S, Mordogan N, Esetli BC (2011). Effect of organic and...

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