Effect of Organic Fertilization on Potato Production in the Mountain Area

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Abstract. In our country, potato is a highly important national crop, as a basic food element (almost the population’s second bread), while for the Apuseni Mountains area, potato holds the highest percentage and at the same time represents an essential food for locals and their animals, as a paramount food support of the population in the area.

Its specific renders this crop as a highly demanding species of plant in terms ecologic conditions, humidity and temperature, as well as nutritive elements, as it forms an abundant vegetative mass and a high tuber quantity for the surface unit. It is a highly consuming nitrogen, potassium, magnesium and calcium plant, as well as with respect to macroelements. Once the potato is harvested, the export of mineral elements from the soil is high, thus determining the rapid soil depletion and demanding for a suitable fertilization of potato crop, adequate to the household system specific to the mountain area.

Numerous researches conducted in the area under study reveal the fact that, from a pedoclimatic point of view, there are good and very good conditions for potato crop, considering the climatic abnormalities in the last period. But the severity of the climatic impact varies from one region to another and exerts a serious effect on agriculture. In this highly important sector, climate changes would influence crop harvest, animal breeding and location of production. The increased probability and severity of weather events will considerably increase the risk of crop calamities. The climate change will exert an influence on the soil, by decreasing the organic matter content - a major contributor to soil fertility. In this context, considering the basic occupation of locals in the area, especially animal breeding, alarge quantity of organic fertilizers is used and by meas of their rational employment, they represent the main fertilization source of crops in the area, recovery and maintenance of soil fertility.

Alongside being the basic food product of population in the area, the importance of potato increases once the altitude of the area also increases, being used as fodder for animal husbandry, due to the fact that the assortment of cultivated plants is limited to potato, rye, oat, some fruit trees, certain vegetables, while the rest of the surfaces is covered with natural pastureland and forests. In this respect, potato covers the largest surface, as corn hybrids, even early ones do not manage to reach maturity in this mountain area.

Keywords: soil, fertilization, mineral elements, potato.

INTRODUCTION

The paper presents the effect of organic fertilization for potato cultivated in the mountain area, in a more „hostile” natural environment, with a damp, chilly climate and a low soil quality. From a pedoclimatic point of view, these conditions are considered highly suitable for potato crop, requiring for a soil fertilization system that is ecologically protectivetowards obtaining a superior quantitative and qualitative production that would meet present norms for food security and safety.
In this context, the paper also aims at establishing the correct doses of fertilizers, especially existing organic resources in the area for potato crop, on the basis of the export of the main nutritive elements in the soil upon harvesting, and the value of relevant agrochemical indices to obtain ecologic productions and maintain or enhance soil fertility in the mountain area.

Rigorous experiments were conducted on a Districambisoil in the Apuseni Mountains area with organic and organo-mineral fertilization systems for the potato varieties within different earliness groups: Ostara, Roclas and Desiree.

Production results in the herby paper certify the significant effect of all fertilization systems and forms, under the proven consideration that the association of organic fertilization with the complex mineral one determines the highest production results (variant V4) in all varieties. In this variant, production results are relevant due to the presence of a complex mineral combination (NPK) on an organic support in optimum balanced ratios between nutrients that would provide the requirements for specific and global consumption of potato. Solely organic fertilization on these poor soils in the mountain area, does not entirely meet with the necessary of the potato’s specific consumption, thus proving it necessary to supplement with mineral fertilizers.

The organic matter formed in the soil on the basis of organic fertilizers positively influences the physical and chemical traits of the soil, contributing to the diminishing of wind and water erosion, as well as nutrition deficiencies, while enhancing the effect of mineral fertilizers complementarily applied to provide with the necessary of nutritive elements for potato plants.

MATERIAL AND METHOD

The experiment was conducted in similar conditions as the ones used to obtain a potato production in the mountain area, placed according to three experimental years on a brown acidic soil (Districambosoil). It was located in the high subarea of the Apuseni Mountains, between the Găina Cruce (altitude 1465 m) and Curcubăta Mare (altitude 1848 m) peaks at the base of the north-north western slope of the Arieșului Mic basin. The experimental field was placed in the inferior part of the mountain climatic level (under the level of beech and mixed forests). Geomorphologically and geologically, this is where solification phenomena occur, as well as phenomena of dealkalinization and decarbonatation, clayification and acidic humus accumulation in the forms of „acidic mull” and „moder”. The geolithologic substratum resides in metamorphic rocks, crystalline schists, conglomerates with loam and ferruginous sandstone insertions.

The experiment is polifactorial with two factors and placed according to the subdivided parcel method with the following graduations:

Factor A: potato variety with graduations: a₁ – Ostara; a₂ – Roclas; a₃ – Deesire.
Factor B: level of fertilization with graduations:

\[\begin{align*}
  b_{0} & : 0N + 0P_{2}O_{5} + 0K_{2}O \text{ (kg s.a./ha)} + 0 \text{ t/ha stable manure (M. unfertilized)}; \\
  b_{1} & : 0N + 0P_{2}O_{5} + 0K_{2}O \text{ (kg s.a./ha)} + 30 \text{ t/ha stable manure}; \\
  b_{2} & : 0N + 0P_{2}O_{5} + 0K_{2}O \text{ (kg s.a./ha)} + 40 \text{ t/ha stable manure}; \\
  b_{3} & : 50N + 30P_{2}O_{5} + 50K_{2}O \text{ (kg s.a./ha)} + 40 \text{ t/ha stable manure}; \\
  b_{4} & : 100N + 60P_{2}O_{5} + 100K_{2}O \text{ (kg s.a./ha)} + 30 \text{ t/ha stable manure};
\end{align*}\]
In the case of polifactorial experiments with two factors, the first with three graduations and the other with 5 graduations resulted into a number of 15 variants (table 1).

The biologic material employed in the experiment was the elite category of the Ostara, Roclas and Desiree varieties, which were sorted before planting, using solely healthy tubers, weighing between 40 and 70 g.

The potato varieties under experiment belong to different earliness groups widespread in the mountain area under study, as they are suitable for the pedoclimatic conditions that are generally less favourable to growth and development of most cultivated agricultural plants. In choosing the cultivation spot for the potato experiment, its biologic traits were considered, as well as the high requirements related to soil preparation and structure. As such, during the three experimental years, the preceding plant was rye, which cleared the land early on, providing the basis for land preparation through summer ploughing at a 15-20 cm depth suitable for potato cultivation.

In the autumn, namely October, organic fertilizers were applied, as well as chemical phosphorus and potassium ones in doses according to experimental variants.

Soil fertilizer incorporation was conducted through autumn ploughing at a 25-30 cm depth.

Parcel fertilization with chemical nitrogen fertilizers was conducted in the spring, namely March, using urea for the production of each experimental year, according to doses supplied by experimental variants.

Soil incorporation of chemical nitrogen fertilizers was conducted immediately following application, at a 17-18 cm depth.

In order to ensure the best soil aeration, structure, as well as dispersion for planting at a 17-18 cm depth, the land was prepared with the tiller.

Tuber planting during the three experimental years was conducted manually at the end of March and beginning of April, according to the fertilization pattern.

Maintenance works during the vegetation period aimed at dispersing the soil, weed and pest control.

Disease and pest control was conducted over time, according to the emergence and cultivation year, applying three treatments each year to fight the Colorado beetle and blight, either in an insecticide mixture or by themselves. This was performed according to the degree of attack starting with June, until the physiologic maturity of potato plants.

Before harvesting, front, vaccinal and all around eliminations were performed, according to experimental technique.

Harvesting was conducted by hand, 10-15 days from the physiologic maturity of each variety, sufficient time for the peridermis (skin) of tubers to suberize.

Production determination was conducted by weighing according to each variant, the production was reported for each surface unit (hectar), packed in raffia bags for transportation, storage and capitalization.

RESULTS AND DISCUSSIONS

The statistical processing of the average tuber production of the experimental period (2007-2009) allows for an assessment of differentiated fertilization effects in the case of the Ostara, Roclas and Desiree potato varieties under study in the pedoclimatic area of the Apuseni Mts. (Tab. 1).
Tab. 1.

The effect of differentiated organo-mineral fertilization on average tuber production in the Ostara, Roclas and Desiree potato varieties in the Apuseni Mts area (period 2007-2009)

<table>
<thead>
<tr>
<th>No</th>
<th>Variety</th>
<th>Fertilization variant</th>
<th>Average production (t/ha)</th>
<th>%</th>
<th>Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ostara</td>
<td>V0 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 0t/ha stable manure (Control)</td>
<td>13,21</td>
<td>100,0</td>
<td>0,00</td>
<td>Mt.</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>V1 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>18,84</td>
<td>137,0</td>
<td>5,63</td>
<td>**</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>V2 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>19,07</td>
<td>138,5</td>
<td>5,86</td>
<td>**</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>V3 – 50N+ 30P₂O₅+ 50K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>24,16</td>
<td>172,0</td>
<td>10,95</td>
<td>***</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>V4 – 100N+ 60P₂O₅+ 100K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>25,78</td>
<td>182,6</td>
<td>12,57</td>
<td>***</td>
</tr>
<tr>
<td>6</td>
<td>Roclas</td>
<td>V0 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 0t/ha stable manure (Control)</td>
<td>17,77</td>
<td>100,0</td>
<td>0,00</td>
<td>Mt.</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>V1 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>18,01</td>
<td>101,2</td>
<td>0,24</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>V2 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>21,76</td>
<td>120,2</td>
<td>3,99</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>V3 – 50N+ 30P₂O₅+ 50K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>25,45</td>
<td>138,8</td>
<td>7,68</td>
<td>***</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>V4 – 100N+ 60P₂O₅+ 100K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>29,25</td>
<td>158,1</td>
<td>11,48</td>
<td>***</td>
</tr>
<tr>
<td>11</td>
<td>Desiree</td>
<td>V0 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 0t/ha stable manure (Control)</td>
<td>14,18</td>
<td>100,0</td>
<td>0,00</td>
<td>Mt.</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>V1 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>19,55</td>
<td>133,2</td>
<td>5,37</td>
<td>**</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>V2 – 0N+ 0P₂O₅+ 0K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>22,65</td>
<td>152,3</td>
<td>8,47</td>
<td>***</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>V3 – 50N+ 30P₂O₅+ 50K₂O (kg s.a./ha)+ 40t/ha stable manure</td>
<td>34,50</td>
<td>225,6</td>
<td>20,32</td>
<td>***</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>V4 – 100N+ 60P₂O₅+ 100K₂O (kg s.a./ha)+ 30t/ha stable manure</td>
<td>35,66</td>
<td>232,8</td>
<td>21,48</td>
<td>***</td>
</tr>
</tbody>
</table>

Average production results (Tab. 1), achieved during the three experimental years in the Apuseni Mts. area for the experimental varieties were inferior to the genetic potential of the varieties. This account mostly reveals the negative effect of climate changes and the low fertility level of soils in the mountain area, which did not allow for a production emphasis of productivity soil traits. An analysis of the differentiated effect of fertilization (organic, organo-mineral, complex-mineral) and the multiannual experimental results obtained reveal...
the positive significance of increasing fertilizer doses in this crop, but also relevant differentiations determined by the nature and structure of fertilizer assortments applied and the soils biologic potential.

First and foremost, a positive effect resides in the nutritive and fertilizing value of organo-mineral combinations with an organic substratum (30-40 t/ha stable manure) complemented by a mineral support of nitrogen, phosphorus and potassium. These systems reveal the summing and even synergic effect of these combinations for tuber production. This combining positive effect is due to the initial precarious fertility level of the soil representative for the area, but also to the ability of the potato crop that can positively capitalize on organo-mineral interactions.

Against these limitations, the population of the mountain area is too poor to afford the purchase of mineral fertilizers, and thus is forced to practice a subsistence agriculture, with limited natural resources from household animal breeding. Natural organic fertilizers, employed as the main fertilizers in the area, are highly diversified assortments, from plant to animal residues, natural composts or sediments that have an organic matter and substances intake exerting positive effects on poor quality soils, specific to the area, as well as on the quality of agricultural and horticultural crops.

Compared to the highly significant effects of differentiated fertilization, relying on the organo-mineral interaction of nutrients, one-sided fertilizations, either nitrogen, phosphorus and potassium mineral ones or solely organic with stable manure fertilization prove the limiting character of these interventions and their inability to meet normal production levels on a multiannual basis.

Solely mineral fertilization, as well as the one-sided character of the organic one prove partiality in term of fertilizing effects and a limiting of approaches in the case of these solutions for the cultivation technology of potato in the Apuseni Mts. area, where potato is a basic food for the population.

A thorough study on the complex approach regarding the efficiency of differentiated fertilization systems in potato crop for representative soils in the Apuseni area, where limited levels of fertility and productive capacity can be signaled, requires for a rigorous study and control of the evolution of these basic soil traits on a qualitative level and establishing the risk domains. The solutions of one-sided fertilizations, either mineral or organic, can determine impact states of acidification and limited nutrient supply compared to the organo-mineral fertilization system. The latter is able to exert a meliorating influence on the soil, influence its buffering capacity and thus emphasizing an important agrochemical aspect related to the application of complementary mineral fertilization for the potato crop in the mountain area, on an appropriate organic substratum provided to the soil by systematic organic fertilizations.

The organic support provided through the systematic application of stable manure in doses of 30-40 t/ha ensures a favorable and meliorating agrochemical environment for the soil’s physico-chemical traits. The complementary application of mineral fertilization determined a higher bioavailability of nutrients and their better capitalization by potato plants, an implicitly the obtaining of superior qualitative and quantitative productions.

**CONCLUSIONS AND RECOMMENDATIONS**

The brown acidic soil (districambisoi) characteristic to the Apuseni Mts. Area, under potato cultivation, through the application of differentiated organo-mineral fertilization systems, under an annual substantial organic substratum essentially modifies its chemism and meets with the high nutrient requirements of the potato in the area.
Organic systematic fertilization in cultivated plants of the mountain area positively modifies on the long-term the acidic reaction (specific to mountain soils) by neutralizing it, the content of raw humus, the regime of nutritive elements, alkalinization of the adsorptive complex of the soil and implicitly the soil’s physical and chemical traits.

Organo-mineral fertilization, the most compatible with biologic and nutrition requirements of the potato, enhances the bioavailability regime of nutritive elements in the soil on an organic substratum, improves the acidic reaction of the soil, maintains and enhances soil fertility in the mountain area.

It is now increasingly recommended on soils with limited levels of fertility and productive capacity, to use natural fertilizers as basic fertilizers, as through a rational employment of plant residues and all animal residues, it can contribute to the increase of the organic matter content in soils and the nutritive reserve for plants, complemented by mineral fertilizers where the specific and global consumption requirements of plant species demand it.

As organic fertilizers show an intake of essential fertilizing elements with a multiannual effect in a series of technologies and crops, it is practiced either directly or in interaction with mineral fertilizers. In order to create rational fertilization systems, one should envision the intakes of these fertilizers for the soils directly or subsequently in the years following their application.

In the mountain area animals are raised in a household system, and thus the quantity of natural fertilizers obtained complemented by mineral fertilizers, and a positive organo-mineral interaction can provide the fertilization of significant land areas for ecologic productions on the one hand and on the other to maintain and enhance soil fertility in the mountain area.

At present, there is an increasing interest for conservative agriculture that involves a more efficient management of plant and natural resources, thus providing the sustainable employment of the land for the long term, preventing its degradation and the degradation of ecosystems, as well as obtaining superior plant products that meet food safety and security parameters.

REFERENCES