Fertilization as a Factor Determining Quality of Plant Materials in Sustainable Agriculture

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PLAN OF THE PRESENTATION

- The relativity of the concept of quality of the crops
- The place of fertilization in determining of crops quality
- Nitrogen – main factor influencing on quantity and quality of yield
- Influence of potassium on yield quality
- Significance of phosphorus, magnesium and sulfur for yield quality
- Micronutrients and yield quality
- Interaction of mineral and organic fertilizing in the forming of the quality of the crop
- Summary
GLOBAL CONTEXT

⇒ Biological progress is becoming the driving force of the farming. It is more than 50% of agricultural progress

⇒ Height of the human population and the decreasing surface of the farmlands per 1 resident

⇒ Environmental increasing problems - legal restrictions on the use of fertilizers
Quality the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs

FOCUS ON PRODUCT on the level of the agricultural raw material

FOCUS ON THE PRODUCTION PROCESS on the level of the farm or processing plant

FOCUS FOR SALE social concept of quality
YIELD QUALITY

Consumption value

Fodder value

Technological value

Plant health
YIELD QUALITY

- Genetic Factor
- Climatic Conditions
- Soil Conditions
- Fertilization
- Age
- Agrotechnology
  - Plant Protection
The role of the traditional tools of determining yields in sustainable agriculture to biological development is reduced?

NO

Requires more precision in the application than the traditional agriculture in order to the expected yield quality characteristics resulting from the genotype could be fully realized.

PRECISION AGRICULTURE
THE RECIPIENT OF THE AGRICULTURAL PRODUCE DETERMINES THE QUALITY PARAMETERS DEPENDENT ON THE PURPOSE - COMPLYING WITH THE REQUIREMENTS OF THE QUALITY IS A CONDITION OF THE COST-EFFECTIVE PRODUCTION

IN OUR TIMES ABOUT QUALITY DETERMINES THE APPROPRIATE SELECTION OF THE VARIETY, WHICH IS ONLY A POTENTIAL PATTERN OF THE REQUIRED CHARACTERISTICS THAT COULD BE ACHIEVED UNDER OPTIMAL GROWTH CONDITIONS AND PLANT NUTRITION

THE FARMER MUST MANAGE OF FIELD ENVIRONMENT, SO THAT DESIRED QUALITY FEATURES SAVED IN THE GENOTYPE CAN BE FULLY REALIZED
FERTILIZATION

MAIN FACTOR IN YIELDING IN XX CENTURY

DEVELOPMENT OF QUALITY

ENVIRONMENTAL EFFECTS

FERTILIZER APPLIED CORRECTLY

PERFECT TOOL FOR DEVELOPMENT OF YIELD QUALITY

FERTILIZER APPLIED INCORRECTLY

SIGNIFICANT DECLINE OF YIELD QUALITY
INFLUENCE OF FERTILIZATION ON YIELD QUALITY

DIRECT

on value traits of yield

INDIRECT

Improvement of soil properties:
- abundance in nutrients
- soil reaction
- content of organic matter

The indirect impact of fertilization is particularly important in sandy soils
Influence of nitrogen fertilization on yield quantity and yield quality
Non-protein nitrogen content
- free amino-acids
- amides
- nitrate

In fertilization the ratio of N: K is important
Effect of potassium on carbohydrate metabolism

1. Potassium increases the synthesis of disaccharides and polysaccharides

- Sucrose → sugar beet
- Starch → potatoes, cereales
- Cellulose:
  - lodging of cereals
  - the technological value of fiber of flax and hemp

2. Potassium fertilization is supporting collecting reserves of carbohydrates in spare organs of perennial and winter plants:
   - better wintering
   - better spring shoot

3. Moreover potassium fertilization leads to:
   - growth in manufacturing of organic acids - improvement of the quality of fruits and vegetables
   - rise in the content of the vitamin C
Effect of potassium on nitrogen metabolism

1. Reduction of high concentration of NH$_4^+$ in plant

\[ \text{NH}_4^+ \quad \text{K stimulates the synthesis of proteins} \quad \text{protein} \]

2. K deficiency in the leaves of plants causes symptoms of poisoning NH$_4^+$ ions
   - leaf chlorosis
   - necrosis
   - damage of shoots
Effect of potassium on nitrogen metabolism

Reduction of nitrate in the roots of crops

$\text{NO}_3^- \rightarrow \text{NH}_2 \rightarrow \text{protein}$

KNO$_3$ in the form of organic salts
Darkening of raw tuber flesh

Phenolic compounds (tyrosine) → oxidation → Melanin pigments

Polyphenol oxidase

Darkening of tubers after cooking

Phenolic compounds (chlorogenic acid) + Fe → Dark complex compounds

Reducing sugars
Large N doses

Citric acid
Ascorbic acid
Potassium fertilization
Effect of potassium on nitrogen metabolism

nitrosamines and potassium fertilization

In conditions of the K deficiency plants accumulate amines (e.g. putrescine)

Content of putrescine $\mu$M g$^{-1}$ fresh matter

<table>
<thead>
<tr>
<th>Plant with K deficiency</th>
<th>Plants well stocked with K</th>
<th>Ratio</th>
</tr>
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<tbody>
<tr>
<td>8.7</td>
<td>0.21</td>
<td>41 : 1</td>
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amines + nitrates $\rightarrow$ nitrosamines

↑

strongly carcinogenic compounds
Phosphorus and yield quality

CEREALS
- Early developmental phases
  - Number of spikelets per m²
  - Yield
- After flowering
  - 1000 grain weight
  - Grain filling

POTATOES
- Starch content
  - Yield of starch
- increasing the esterification
  - The increase in stickiness of starch
- faster ripening of tubers
  - Reduces mechanical damages

GRASSLANDS
- The share of legumes
Effect of sulfur fertilization on selected parameters of wheat grain quality

<table>
<thead>
<tr>
<th>Feature</th>
<th>Sulfur fertilization</th>
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<tbody>
<tr>
<td></td>
<td>- S</td>
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<tr>
<td>Total protein (%)</td>
<td>12.9</td>
</tr>
<tr>
<td>Glassiness of grain (%)</td>
<td>3.7</td>
</tr>
<tr>
<td>Gluten content (%)</td>
<td>22.9</td>
</tr>
<tr>
<td>Porosity of bread crumb (%)</td>
<td>72.7</td>
</tr>
<tr>
<td>Bread volume (cm³)</td>
<td>293</td>
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</tbody>
</table>
Effect of soil and foliar fertilization on the content of zinc and qualitative composition of the protein in grains

<table>
<thead>
<tr>
<th>Content in grain</th>
<th>Zn dose (kg ha(^{-1}))</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Zinc (mg kg(^{-1}))</td>
<td>11.8</td>
</tr>
<tr>
<td>protein polymers – glutenin (% of total protein)</td>
<td>36.3</td>
</tr>
<tr>
<td>Gliadyne (% of total protein)</td>
<td>46.1</td>
</tr>
</tbody>
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* - foliar application

[Peck i in. 2008]
INTERACTION OF MINERAL AND ORGANIC FERTILIZATION

- Indirect impact on the quality through the influence on the fertility of the soil

- Organic fertilizers as a buffering agent to deficiencies or excesses of nutrients

- Special significance
  - on sandy soils
  - in conditions of the extensive farming
WAYS OF THE QUALITY ASSURANCE OF THE CROP IN MINERAL FERTILIZATION

- INTERACTION OF MINERAL AND ORGANIC FERTILIZATION
- TERMS OF USE OF FERTILIZERS
- ENSURING THE BALANCE OF THE ELEMENTS IN FERTILIZATION
- ROLE OF TRACE ELEMENTS IN SUSTAINABLE AGRICULTURE