

SECTION 6 - MINERAL NUTRITION AND PRODUCTION

Expert system FYTOTROF supporting diagnostics of plant nutrition deficiency according to visual symptoms

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Based on visual symptoms of deficiencies of individual nutrition factors and simultaneous theoretical knowledge of uptake and utilization of mineral elements an expert system FYTOTROF was developed. The system is composed of a group of idioms describing states of the evaluated plant, the so called "declarations", as well as a system of rules. These rules represent a unit of knowledge which is a centerpiece of the expert system and are used for making decision about individual deficiencies. Work with the expert system is in fact a kind of consultation, resulting in "a measure of reasons", supporting diagnosis of the element deficiency, which is most supported by the described symptoms. The software offers other possible extensions, so it is usable not only for the diagnostics of deficiency in plant nutrition, but also as a software for teaching.

Changes of winter wheat growth-productive characteristics after infection by *Fusarium* species

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Changes in growth-productive characteristics of winter wheat after infection by *Fusarium* species and when growing on soil with different mineral nutrition were studied. The samples for growth analysis were collected at stages 1.1, 1.2, 1.3, 1.4 by Feekes. The values of growth-productive characteristics changed owing to infection by *Fusarium* sp. at various growth stages of plants and owing to various mineral nutrition.

Mathematical model of spring barley growth at different concentration of phosphorus in nutrient solution

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Growth of aboveground parts, roots and even assimilation area showed maximum values at 1/4 - 1/2 phosphorus concentration in standard nutrient solution. It is obvious, that the amount of phosphorus in the used Knop nutrient solution is excessive for young plants (up to 67 d). Dry matter increase of aboveground parts, roots and assimilation area as well correspond to the following regressive equation:

$$W = \frac{W_0 s}{(K + s)^n} = k E_0 \frac{s}{K + s} \frac{1}{(K + s)^{n-2}} \quad n \geq 1$$

Regressive equation can be expressed in product of two functions. The first function corresponds to a formula of enzymatic catalysis (Michaelis-Menten) and intensifies when increasing phosphorus concentration (of substrate) s . The second function detracts from increasing phosphorus concentration in nutrient solution and characterizes the decrease of maximum rate of enzymatic reaction W_0 (concentration of enzyme E_0). Effects of various phosphorus concentrations in nutrient solution on plant growth result in hypothesis about decreasing concentration of acid phosphatase when increasing phosphorus concentration in nutrient solution that was observed by many authors.

The influence of level of mineral nutrition on the enzymatic activities in wheat grains

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The response of enzymatic activities (α -amylases, phosphatases, exoproteinases, endoproteinases) to different level of mineral nutrition were studied in wheat cultivars Roxana and So 6346 under field conditions (during 1988-1990). The decrease of activities all following enzymes from the beginning of milk ripeness to full ripeness of grain were determined. On the other hand, no statistically significant differences were determined in the dynamics of enzymatic activities in the different level of mineral nutrition.

The characterization of protein synthetic process in developing endosperm of normal and high lysine barley

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The correlations between the protein accumulation in the grain and the biosynthesis of the single types of nucleic acids and between the tRNA "pool" and the protein content in the grain were

determined, which indicate an intermediate bond between the functionality of the proteosynthetic apparatus of the grain and the biosynthesis of reserve proteins. The lines Hiproly and Km-1065 deserve attention, where we have found a high proportion of tRNA (up to 76 %) and at the same time a high content of proteins (19 - 23 %).

Some possibilities and reasons of application HACTP in mineral nutrition of plants

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Ammonia volatilization and activity of soil urease were studied in model laboratory experiments with soil after the application of amidic nitrogen with the addition of hexaamidocyclo-triphosphasene (HACTP). HACTP used either pure or in a crude state (contaminated by residual ammonium chloride) is a comparatively effective inhibitor of soil urease. The losses of nitrogen caused by ammonia volatilization from the applied urea or from DAM-390 were reduced considerably in dependence on the used concentration of HACTP. It was observed especially during the first few days after the application of fertilizers. The application of amide nitrogen together with HACTP resulted in a slower urea hydrolysis in the soil. This combination formed more favourable conditions for the urea conversion in the soil. The significantly increased content of mineral nitrogen in the soil, the surface of which was dressed with DAM-390 with HACTP, led to the higher accumulation of nitrogen in the dry matter of above-ground parts of cultivated maize. These results suggested the application of fertilizers containing amidic nitrogen with HACTP could be reduced without the limitation of nitrogenous nutrition of plants. The results obtained indicate that HACTP can be used as a source of phosphorus and partly as a source of nitrogen and potassium without any considerable damage of plants.

Growth functions of vegetative and reproductive growth

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The growth functions during vegetative and reproductive growth of spring barley cv. Koral and winter wheat cv. Košutka for quantitative distribution of organic compounds were found experimentally. The classical growth analysis was used to describe quantitatively the growth functions. To the calculation and estimation procedures besides typical growth analysis characteristics were included quantitative data on senescence rate, efficient surface of dry organ biomass, dead, yellow plant parts, biological time expressed by start of micro- and macrophenological growth phases and course of biologically efficient temperatures, too. Besides experimental results we established quantitative description by growth (logistic) curves individually for leaves, stems, ears and total biomass. Form of these functions was changed not only for individual species, but during vegetation period depending on environmental conditions, too.

Changes of storage capacity of stem in grain filling period of cereals

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Cereal grains are very small and leaf area is near the maxima immediately after flowering. The movement of photosynthates into the grain is limited and as leaves produce far more than grains can accept, photosynthates can be stored in the stems. The clear species differences in content of stem storage photosynthates were shown in spring barley, winter wheat and triticale grown in the field experiments. The rate of relocation from the stem depended on the rate of grain growth during the linear period of growth and on the function and duration of leaf area in this period. The close correlation ($r = 0.9307$) of content of carbohydrates stored in stem at the beginning of grain filling period with the grain mass was found in 22 cultivars of spring barley. It was shown that the higher grain mass of some cultivars was associated with the greater capacity to use stem as temporary sink and with the superior capability to relocate stored carbohydrates from the stem during the grain growth. Cultivars Lea, Serva, Courtine, Lilo, Berolina, Helena, Grand Prix exhibited the highest content of carbohydrates stored in stem at the beginning of grain filling period. We suppose that their mobilisation toward kernel especially in less favorable temperature conditions at the period of intensive grain growth shows they are more buffered against abiotic stress of high temperature in this period.

The evaluation of yields and quality of sugar beet for the period of 1956 - 1991

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The yields of roots, leaves, sugar content for the period 1956 - 1991 and technological quality for the period 1981 - 1991 were evaluated. The contribution shows the differences in yield of roots and leaves, sugar content, content of matters producing molasses in the period of the harvest of sugar beet (the middle of the October) among individual years and compares them with the long term mean values.

The influence of subsoiling on production and physiological characteristics of sugar beet

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The effect of subsoiling on the yield and physiological characteristics has been studied in sugar beet in the years 1986 - 1988. The trials have been established in the fields of the State Farm of Seed Production, Trnava, in arid maize growing region on medium heavy-textured loamy chernozem soils. The results indicated that the year was the strongest reason for variance during the whole experimental period. Subsoiling led to no significant differences neither in the yield, nor in the quality of sugar beet under the given soil and climatic conditions on an average for three years. Leaf area exhibited higher values in the period of its most intensive growth (July). The influence of

subsoiling was more considerable under the conditions of irrigation. Changes were recorded in nitrogen and potassium contents in the dry matter of leaf. The most significant effect of subsoiling was observed in the year with the highest precipitation out of the growing season under the given soil and climatic conditions. Refined sugar yield amounted to 6.34 t per ha for the period of 1986 - 1988 under study, towards the end of the growing season under the conditions of deep tillage, this amounted to 6.36 t per ha. This amounted to 7.63 t per ha under the conditions of irrigation and deep tillage, under the conditions of subsoiling - 7.95 t per ha.

Transport in substrate and uptake of NO_3^- and P by pot grown tomato plants

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Tomatoes (*Lycopersicum esculentum* L.) were grown in pots filled with sand and fertilized by a drip irrigation system ($\text{KNO}_3 + \text{H}_3\text{PO}_4 + \text{Fe} + \text{microelements}$) using different amounts of water (100 %, 200 %), discharge rates (2 l h^{-1} and 4 l h^{-1}) and pots of different shapes and sizes (cylinder $r = 110 \text{ mm}$, $h = 220 \text{ mm}$, cylinder $r = 150 \text{ mm}$, $h = 300 \text{ mm}$ and a box of $300 \times 600 \times 120 \text{ mm}$). From planting till fruit formation the following data were collected at representative intervals: quantity and mineral composition of applied water, dry mass and mineral composition of plants, quantity and mineral composition of drainage water, daily transpiration rate and root distribution in substrate. At the same time a simulation model of water and nutrient transport (based on Richards equation and Langmuir adsorption isotherm) and their uptake by plants (based on Michaelis-Menten uptake kinetics) was developed. Concentration of nutrients in drainage water increased throughout the experimental period. That of nitrate reflected changes in concentration of irrigation water. Phosphorus concentration in drainage water was an order of magnitude lower than that of irrigation water during the whole experimental period, because of adsorption of P in the substrate. Most of the roots were found in the top 100 mm of the pots. Comparison of simulated and measured data showed that the model can simulate correctly $\text{NO}_3\text{-N}$ dynamics of the system, but it cannot explain the measured P data. The values of V_{max} and K_m used in the model to calculate nutrient uptake were calibrated from the experimental data. For nitrate these were $V_{\text{max}} = 14 \text{ mM d}^{-1} \text{ g}^{-1}$ (dry mass of roots), $K_m = 2 \text{ mM}$. Reasons for the disproportions in P simulations will have to be found. The model could be used for fertilization management.

The characteristics of the growth and forming technological quality of sugar beet in the vegetation period

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The study evaluates the results of the field experiments of the evolution of sugar beet. The experiments were realized in "Research and Breeding Institute, Bučany", in maize growing region during 36 years. This stand is characterized by medium heavy-textured loamy fertile chernozem, with pH 7, with middle to high supply of accessible nutrients. The mean values of the leaf and root growth, sugar content and yield of the polarization sugar during the vegetation period were evaluated as well as the amplitude of these values in the studied period of the growth and development. The biggest amplitude of the leaves' yield was in the period between the second half of July to mid-August, in the phase when the growth of leaves was on the maximum level. This

phase of the evolution is the most important for the yield and quality of sugar beet. The amplitude of the root yields to the 60-th d after the emergence is very low, but the amplitude rises together with the acceleration of the leaf growth. The amplitude of sugar content is very narrow in the middle of July and September. The sugar content usually has no big changes after the 1th September.

The effect of mineral nutrients on heterotrophically grown barley seedling

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The influence of mineral nutrients on plant growth and productivity has been most frequently studied as a relationship between mineral nutrition and photosynthesis or assimilate allocation. However, when evaluating net dry matter production, the losses due to respiration have to be taken into account. Spring barley (*Hordeum vulgare* L. cv. Korál) kernels were germinated and subsequently cultivated in full darkness in various nutrient solutions for 21 d. Hoagland 3 and nutrient solutions containing individual substances (i.e. $\text{Ca}(\text{NO}_3)_2$, KNO_3 , KH_2PO_4 and MgSO_4 , as well as NaCl) were used. Samplings were made during the period of fast substrate export from the kernel (5 to 9 d from the start of germination) and by the end of the experiment (21 and 22 d) when the kernel utilizable substrate was exhausted. The amount of respired substrate at any sampling date was calculated as the difference between the initial kernel dry mass and the sum of the actual shoot + root + kernel dry mass. Nutrient solutions significantly affected both shoot and root growth, shoot/root ratio and the amount of substrate respired. The highest amount of respired substrate per seedling (21.4 mg) as well as the lowest shoot/root ratio (1.50) was found in plants cultivated in pure water. On the contrary, KNO_3 solutions brought about the lowest dry matter loss due to respiration (17.8 mg) and the highest shoot/root ratio (3.25) of dark grown seedlings. Values measured on plants grown in KNO_3 solution were similar to those of plants from the complete Hoagland 3. By the end of the experiment the values of growth efficiency calculated as the ratio of dry matter of (shoot + root) / (shoot + root + respired substrate) varied from 0.41, 0.42 and 0.43 for plants from distilled water, $\text{Ca}(\text{NO}_3)_2$ and MgSO_4 , respectively, to 0.50 and 0.54 for KH_2PO_4 and KNO_3 , respectively. Analyses of all the experimental series highlighted the relationship between changes of shoot/root ratio and the amount of respired substrate as brought about by nutrient deficiencies. An increase in the amount of respired substrate was associated with a decrease in the shoot/root ratio and *vice versa*. It seems that the higher specific respiration rate of the roots as reported in the literature could explain this finding.

The development and survival of florets in "duospiculum" spike type of wheat

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Published analyses of some supernumerary spikelet wheat types have shown that the potentially higher kernel number per ear is not found at maturity because of the higher floret sterility. In order to better understand this phenomenon, the apex development and floret survival were examined in normal (N) and "duospiculum" (DS) spike type of wheat. The DS is represented by a pike having twin spikelets per rachis internode. Below some of the primary spikelet primordia secondary spikelets in DS became apparent at the terminal spikelet stage. There were no differences in the number of initiated primary spikelet florets between N and DS. The reduction rate of florets was the

same or slightly lower than in N (55 - 65 %). However, because of the later initiation of the secondary spikelets, their floret number was lower and their reduction rate higher (71 - 83 %) than those in primary ones due to the incompletely developed distal florets. Nevertheless, on the per spike basis, the formation of secondary spikelets in DS brought about a higher number of initiated florets (by 34 %), fertile florets at anthesis (by 29 %) and kernels at maturity (by 20 %) than in N. Hence, the DS spike type provides a means of genetically increased sink capacity of the wheat ear.

Distribution of energy into individual organs of spring barley (*Hordeum vulgare* L. var. *nutants*) in the period of sprouting

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We have studied accumulation of energy in organic dry matter and its distribution into individual organs in spring barley (cv. Kredit) grown in distilled water under the irradiance of 100 W m⁻² and the dark in air conditioned chamber. Energy values (burning heat 1 h) of organic dry matter of roots and aboveground parts (in the light and the dark as well) were relatively stable and the differences among measured values varied by 5.2 %. The amount of energy per 1 g of organic dry matter of the grain rests (in the light and the dark as well) was statistically significantly increasing from the 3rd till the 17th d. It was obviously caused by the fact, that for the metabolic processes including respiration saccharides as energetically less important supply matter were probably preferentially used. From the 3rd d the energy of plant grown in the light and the dark as well was preferentially distributed into aboveground parts. From the 6th sprouting day we have observed significant beginning of autotrophic nutrition.

The use of waste frits for fertilization of plants by microelements

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The fundamental information about potential use of waste frits from enamelworks *SFINX* in České Budějovice for fertilizer purpose was verified. Fytotoxicity of waste frits and their microelement contents, especially B, were tested. Four types of materials were used: basic type of frit - ZP 10 842, covering types - KP 12 805 and KP 15 806, and "mixture" of frits. Biotest of toxicity was carried out according to modified method of Zuccony. The principle of this method is a reaction of watercress (*Lepidium sativum*) to fytotoxin presence in water extract from frits. According to the results of experiments, frits ZP 10 842, KP 12 805 and KP 15 806 did not exhibit any fytotoxicity, even in the highest concentration - 1 g(frit) cm⁻³ of water. However, the mixture of frits was toxic in this test. For pot experiment the following plants were selected: turnip (*Beta vulgaris* var. *crassa*, cv. Media) and oat (*Avena sativa*, cv. Zlaták). For each treatment the following doses of frits were used: 0.4, 0.8 and 1.2 g per pot (5 kg soil). Number of plants, fresh mass and dry mass were evaluated. The plants fertilized with ZP 10 842 absorbed more B than the mixture of frits. Fytotoxicity of the mixture, estimated by biotest, was not confirmed in experiment, on the contrary, it supported the growth of plants. From obtained results it can be confirmed that waste frits are acceptable as fertilizer. The presence of frits increased the yield of turnip and beet-root: the yield of

oats was affected negatively. Wheat has less demand for B than *Brassicaceae*. The optimum interval for wheat is very narrow and its excess probably have an adverse affect.

Regulation of nitrate movement in lucerne plants

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Highly significant correlations established between nitrate content and nitrate reductase content in leaves as well as in stems of lucerne plants demonstrated the influence of nitrate content on N-metabolism. Relatively high nitrate content in stems and low in leaves and roots showed the regulation processes of nitrate movement in lucerne plants. It was demonstrated that the rate of nitrate movement in transpiration stream caused rapid changes of nitrate movement in different parts of stems as well as in leaves, which demonstrated some transport delays. The same transport delays were established in potassium movement which were in time correlation with nitrate delays and demonstrated common way of both counterions in xylem flow. The determined transport delays could be caused by ion adsorption on xylem walls. The regulation of nitrate transport from stems to leaves was higher in intact plants. After plant decapitation, nitrate added to transpiration medium entered into leaves and was there accumulated in a high concentration without any limitation. It showed the regulation role of root in nitrate transport from stems to leaves which was noticed also in other experiments (e.g. Shaner and Boyer 1976).

Reference:

Shaner, D.L., Boyer, J.S.: Plant Physiol. 58: 499, 1976.

The effect of various doses of nitrogen fertilization on the changes in the production and technological quality of the monogerm variety of sugar beet

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In the given soil and climatic conditions various doses of nitrogen had no significant effect on the yield of sugar beet but they had significant influence on the content of sugar. The results are from three years. When medium or high concentrations were present in the soil before sowing we do not recommend to fertilize with N, whereas in the conditions of little to middle concentrations we recommend to apply doses 50 - 100 kg N ha⁻¹ and in the conditions of the very little concentration we recommend to fertilize with the doses 100 - 150 kg N ha⁻¹.

The utilization of plant analyses for the fertilization of sugar beet

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We aimed to contribute to the explanation of the concentration of the nutrients in sugar beet in the various conditions of N fertilization. We achieved the highest yield of the root (61.16 t ha⁻¹), the

yield of polarized sugar (9.47 t ha^{-1}) and the highest production of the white sugar (7.66 t ha^{-1}) in the ratio of nutrients N:P:K = 1:0.19:0.82 - in the tops, N:P:K = 1:0.33:0.43 - in the roots, in the variant with the dose of N 30 kg ha^{-1} .

The changes in the uptake of the main nutrients of sugar beet in the graded N fertilization in the years 1986-88

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The content of N decreases in the dry matter of the shoots and roots during the vegetation period, but this one rises to the end of the vegetation period. The uptake of P rises till the harvest. The uptake of the K is in the non-linear function with this content in the dry matter of the tops and roots during the vegetation period. The mean yield of roots (58.8 t ha^{-1}) and leaves (41.5 t ha^{-1}) receives from the soil 306.23 kg N, 73.3 kg P and 201.5 kg K in our soil-climatic conditions.

The influence of foliar application of nitrogen-magnesium fertilizers on spring barley yields (*Hordeum vulgare* L.)

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In spring barley, cultivated in Mitscherlich vessels at increased fertilization with potassium before sowing, we have proved at the beginning of offshooting the influence of spraying with solutions of nitrogen-magnesium fertilizers *Premag N 10* or *Folimag*. Under the influence of foliar application of nitrogen-magnesium fertilizers the yield of barley increased in comparison with control sprayed only with water. The conclusive evidence of yield differences was increased by spray repeating, i.e. by increasing nutrient doses. When comparing yields of variants sprayed with the above mentioned fertilizers with the variants sprayed only with the same dose of nitrogen in urea the conclusive yield differences have not always been achieved. In variants fertilized before sowing with a higher dose of potassium the effect of nitrogen-magnesium fertilizers were shown better. There were mostly no significant differences between the total mass of caryopses from the main stems of the individual variants. Higher yields were achieved first of all by higher productivity of offshoots. The contents of nitrogen in barley caryopses were increased by foliar application of fertilizers used, especially at repeated spraying, but the contents of further elements were not significantly influenced.