16 01

Interaction of ABA and cytokinins in yield formation of winter wheat

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The role of abscisic acid (ABA) in the formation of yield of winter wheat was studied from the following points of view: transport of ^{14}C-ABA from the flag leaf to the other parts of plant in the period prior to anthesis, effect of ABA on the transport of cytokinins to the ear and the transport of ^{14}C-sucrose to the kernels, and endogenous level of (+)-S-ABA in the flag leaf and ear in the period prior to and after anthesis. Experiments revealed that the transport of ^{14}C-ABA from the flag leaf is directed to the internode and ear. The application of ABA inhibited the transport of ^{3}H-zeatin to all parts of the developing ear in the period prior to anthesis and similarly, in long term experiments, the application of ABA inhibited the transport of ^{14}C-sucrose from the nutrient solution to the developing kernels simultaneously with the number of kernels. The interaction between ABA and cytokinins in the period prior to anthesis could be related to the effects on the respiration system which could consequently influence the transport of assimilates towards sink tissues and play an important role in yield formation. The endogenous level of ABA in the ear corresponded with its level in the flag leaf up to the period of kernel maturation; from this point the level sharply rose in the leaf whilst in kernels it started to decrease to low values. The results indicate that in this period the flag leaf could be more important source of ABA than the roots and that ABA biosynthetised in this leaf could be easily transported to the developing ear.

16 02

Sucrose, sources and sinks: what controls long distance transport?

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There is a large literature suggesting that phloem transport is controlled, variously, by input of assimilates by sources, by demand in or capacity of sinks, and by the transport system itself. It is more likely that control of phloem transport is distributed between each of these component parts, so that all must be considered in any attempt to understand the regulation of flux in the phloem. Evidence will be reviewed which suggests that within the phloem flux is determined by a gradient of turgor pressure; consequences of such a mechanism for flows in a system with more than one sink will then be discussed. The means by which turgor in the phloem if an organ is coupled to the metabolism within that organ will then be considered, and it will be suggested that this area is one where much future work should be concentrared.

16 03

NMR-imaging as a non-invasive approach of measuring phloem and xylem flow and metabolite concentrations within *Ricinus communis* seedlings

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A difficult problem to be overcome in the determination of phloem transport velocity and the assimilate concentration within the phloem tissue is the destructive character of the employed methods. The application of NMR-imaging techniques offers a new tool for non-invasive and non-destructive investigations of water and assimilate transport within plants. We quantified xylem and phloem volume flow and velocity simultaneously and with high spatial resolution in the hypocotyl of a *Ricinus* seedling *in vivo* by means of a flow sensitive NMR-imaging method. Furthermore we succeed in the determination of the sucrose concentration in the phloem and the parenchyma of intact seedlings using localized NMR spectroscopy. The existence of concentration gradients between the phloem and the parenchyma and within the parenchyma can be demonstrated. All results will be discussed in context of a mathematical model which describes transport in xylem and phloem.

16 04

Regulation of phloem loading and phloem unloading

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With the example of the Ricinus seedling, where controlled phloem loading and phloem sap analysis can be performed, results are presented and discussed concerning:
- substrate specificity and saturation of phloem loading
- pathway of phloem loading
- interaction among loaded nutrients
- effect of phytohormones
- effect of water potential gradients and water flow on translocation characteristics and unloading
- the effects of unloading specificity and unloading rates on flow and phloem loading (sink-source interaction).

16 05

Influence of UV-irradiation of pea grains on the distribution of [U-^{14}C]sucrose between organs of germinating seedlings

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Grains of *Pisum sativum* were incubated in the solution of [U-^{14}C] sucrose and 72 h after that they were irradiated by monochromatic UV-radiation of wavelengths of 250, 302 or 365 nm. Seedlings were grown 17 d under white light and then they were analyzed. UV-treatment increased fresh mass of seedlings (+15 %): in roots +45 %, in shoots and leaves +20 %. Mass of the grains was 10 % less than in control. In the whole plants higher ^{14}C content (+15 - 28 %) was observed. This occurs mainly in the alcohol-water-soluble fraction (+32 %) with slight decreasing in insoluble one. UV-treatment led to retention of ^{14}C within the grains: 1.8-fold in soluble and 1.4-fold in insoluble fraction. With a slope of UV wavelength there occurred a decrease of soluble compounds in the roots, decrease of both kinds of compounds in the leaves and increase in the shoots. UV-irradiation of pea grains had a prolonged effect on developing seedlings. With rise of quantum energy of UV-radiation the increase of restriction of sucrose transport in roots and leaves occurred.

16 06

Carbohydrate source-sink interactions

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During all stages of growth, partitioning of available carbohydrate between the sinks is tightly controlled. Currently there is little mechanistic understanding of this control, reflected by crop modellers using empirical descriptions based upon allometry, concepts of priority or functional equilibrium. Recently we have shown that relative priority of sinks and aspects of their functional equilibrium are a simple consequence of Münch pressure driven phloem flow with saturatable sink kinetics. Predictions made by this model, and now verified, will be discussed. Root shoot interactions requires a role for nitrogen in influencing carbon partitioning. Recent work will be described in which we have found that changes in nitrate uptake can have a rapid (<1 hr) effect upon carbon partitioning while not affecting photosynthesis. Possible integration of these observations into the mechanistic model will be discussed.

16 07

Sucrose fluxes through *Ricinus* cotyledons: Uptake and export

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The cotyledons of *Ricinus* seedlings take up external sucrose from the endosperm in vivo and export about 80% of it to the growing sinks, hypocotyl and root. Intact or exuding seedlings, with the cotyledons incubated in sucrose solution, represent a system of sucrose fluxes into and out of the cotyledons. Phloem loading is achieved by uptake of sucrose into the sieve tubes directly from the apoplasm and after transit through the mesophyll.
The cotyledons of intact seedlings were preincubated in 10, 100 (physiological concentration provided by the endosperm) and 300 mM external sucrose for different periods of time until a steady state was reached; the internal sucrose concentrations were then found to be 200, 200 and 320 mM in the cotyledons and 300, 400 and 500 mM in the sieve tube exudate, respectively. Under these conditions the sucrose uptake and export rates were determined with intact and exuding seedlings.
It is shown to what extent the fluxes of sucrose at the mesophyll and at the sieve tubes contribute to phloem loading at different sucrose concentration ratios (apoplast/mesophyll ; mesophyll/sieve tubes) and whether export of sucrose is saturable.

16 08

Nicotianamine as a transporter of copper in the xylem of tomato

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The amino acid nicotianamine, (2S:3'S:3''S)-N-[N-(3-amino-3-carboxypropyl)-3-amino-3-carboxypropyl]-azetidine-2-carboxylic acid, is generally distributed among plants. Its metabolic function depends on its capacity to form chelate complexes with divalent heavy metals. By far the most stable chelate is formed with Cu(II) at log K = 18.6. In the nicotianamine-less tomato mutant *chloronerva,* Cu is accumulated in the roots and only poorly transported to the leaves which reveal only 10 to 20% of wild type concentrations. Its concentration in the xylem exudate of the mutant is only 20 to 25% as compared with the wild type. Treatment of *chloronerva* leaves with 50 or 500µM nicotianamine leads to a twofold increase of Cu in the leaves concomitant with a decrease in the roots. At the same time the Cu concentrations in the xylem exudate increase about threefold. It is therefore concluded that Cu is transported in the xylem by chelate formation with nicotianamine.

16 09

Realization of the water flux continuum in the distal transport system

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The water filaments within the pores of the vessel walls of a xylem and parenchyma cells, being fixed with their ends by the osmotic forces of parenchyma and with their other ends by the cohesion and adhesion forces (on the xylem water touching ends) are a skelet enforcing the water body of the transporting system. The effectivity of this structure is provided by the peculiarities of the stalk tissues: the elasticity of accompanying parenchymatous cells, their developed surfaces, their high osmotic pressure, and the uncompressibility of the walls of xylem as well. The interaction of the forces controlling the feedback system: the more is the transpiration activity the more are the forces stabilising the water filaments integrity. The physical model of getting over the air embolization of the vessels is shown.

16 10

The fate of sugars along the phloem path in the *Cyclamen* petiole

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The native spectrum of sugars and their radiolabelling following $^{14}CO_2$ assimilation was analysed in the vascular symplast and apoplast as well as in the parenchyma of the petiole. Detached leaves representing a simple experimental source-sink system were used to control the basipetal movement and distribution after injection of different sugars into the upper petiole parenchyma. Sucrose was the main sugar translocated basipetally without any hydrolysis. It was actively absorbed by the cells of the vascular bundle. The tested hexoses (glucose, fructose, 3-oxymethylglucose) and mannitol were taken up by diffusion. In contrast to sucrose, the transport of radiolabel following glucose and fructose application was significantly smaller. However, the distribution within the petiole tissues was almost identical. Both hexoses were transformed to sucrose and allocated by the phloem stream. Sucrose synthesis by sucrose phosphate synthase (SPS) was located in the cells of the vascular bundle. The transport of 3-oxymethylglucose and mannitol was very small. Considerable amounts of both compounds were leaked out along the path.
The results support the view that the translocation path in the petiole is accompanied by a source like metabolic machinery facilitating the acquisition of monosaccharides for the long distance stream in the phloem.

16 11

Phloem unloading in osmotically stressed root tips of pea seedlings and the structure of plasmodesmata within the unloading pathway

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Phloem transport was investigated in pea seedlings with cotyledon-applied [^{14}C] sucrose after immersion of the root tip in water (control) or sugar solutions. Within a 2-h transport period, most label accumulated in the root tip with apical meristem and extension zone. Compared to controls, phloem import into the tip segment was raised by mannitol solutions up to 350 mM, but reduced by plasmolytic conditions. The promotion of phloem transport and unloading under non-plasmolytic conditions is interpreted as supplying the assimilates for a short-term osmoregulation of roots that are subject to a lowered water potential.
Since unloading in pea roots follows a symplasmic pathway, assimilates have to traverse plasmodesmata in order to reach meristematic and differentiating cells. Ultrastructural changes were recorded in plasmodesmata of cortical tissue of tips immersed in 350 mM mannitol or 1000 mM sucrose. They included an increase of plasmodesmatal diameter and the appearance of electron-dense material in the "cytoplasmic sleeve", respectively. In addition, disruption of plasmodesmata was evident between cells treated with 1000 mM sucrose. The ultrastructural results indicate a short-term effect on the plasmodesmatal substructure that is induced by an increased assimilate demand of the cortex cells.

16 12

Source-sink response to chilling stress in tomato plants

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The investigation were conducted on two cultivars: sensitive to low temperature (Robin) and tolerant (New Yorker). The plants were grown in hydroponic culture. Two series of plants were selected with bigger and smaller biomass of roots. One half of each experimental series was chilled to 1-2^{o}C for 20h in darkness. In New Yorker immediately after stress, greater reduction in stomatal conductance (g) than in photosynthesis (P_n) was observed , causing increase of P_n/g ratio, persistent during the six day period, when P_n completely recovered. Assimilation of CO_2 in Robin cultivar continued to decline the next day after stress and then also recovered. In contrast to New Yorker chilling diminished P_n/g ratio during the regeneration period.Low temperature stress stimulated root growth in New Yorker, but drastically decreased it in Robin.The second part of investigations was performed on rooted cuttings c.v. Robin, with various fruit size.Low temperature decreased $^{14}CO_2$ assimilation rate, changed the pattern of ^{14}C-distribution, without affecting ^{14}C-export from the blades while ^{14}C-supply to roots was most significantly reduced. In conclusion the more resistant tomato cultivar had a higher ability to chilling acclimation by a quick and prolonged decrease of stomatal conductance. The increasing biomass allocation towards the roots causes a lower shoot/root ratio, preventing unbalanced water conditions.

16 13

Apoplastic phloem loading of micronutrients in *Ricinus* cotyledons is made plausible by the pH dependence of metal nicotianamine complex concentrations

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The non-protein amino acid nicotianamine (NA) is ubiquitous in the plant kingdom. It forms stable complexes with divalent transition metals. The complex stability decreases in the order Cu>Zn>Fe>Mn (log K_{MeNA} 18.6 - 8.8). These complexes dissociate increasingly in the course of pH lowering from pH 8.5 to 1.0 depending on the individual formation constants.
The metals and NA are cotransported in the phloem of *Ricinus* seedlings in concentrations of comparable order. Analyses of the *Ricinus* seedling sieve tube sap, obtained after removing of the endosperm and adjusting of the apoplast pH by a 2 h preincubation period with buffers, revealed a varying decrease of the concentrations of Cu, Zn, Fe, and Mn, corresponding to the individual complex dissociation patterns. This suggests the involvement of an apoplast passage and a control function of NA in the phloem loading.

16 14

On the different water flows in root

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Exploring water transport in roots of maize seedlings we revealed that not only detached roots but also their segments (as ordinary orientated as reversed with their apical end upwards) were able to exudate. The influence of capillary forces seems to be excluded as segments' exudation was energy dependent and had high Q_{10} (3.9 for ordinary orientated segments and 2.7 for reversed ones). Exudation intensity of ordinary orientated segments was 2-3 times higher than that of the reversed segments at the background of decreased exudate osmotic pressure. Exudate of reversed segments differed from that of ordinary orientated ones in some amino acids and in carbohydrate composition especially. Probably, working with reversed segments we investigate the descending water flow. So, futher studies can provide valuable information on the root water circulation pattern.

16 15

Interaction of contractile proteins, biomediators and phytohormones in root water transport regulation

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Our previous data contradict the conception, which equates root pumping activity to the osmometer work. These data demonstrated the existence of a metabolic constituent of root pressure and the direct participation of energy dependent intracellular contractile systems (cytoskeleton proteins) in the metabolic constituent buildup. Our new data make possible an important role of acetylcholine, other biomediators and phytohormones in contractile proteins functioning during root water transport regulation. In the presence of contractile proteins inhibitors (cytochalasin B, colchicine) biomediators and phytohormones do not influence on root exudation. So, the system regulating root water transport probably includes the interaction of contractile proteins, biomediators and phytohormones.