

18 01

Starch deposition during grain development in barley (*Hordeum vulgare* L.)

M. P. COCHRANE and C. M. DUFFUS

Scottish Agricultural College, West Mains Road, Edinburgh, EH9 3JG, Scotland, UK.

Spring barley cv. Blenheim was grown from anthesis to harvest-ripeness in a controlled environment room at a constant temperature of 13°C in a 16h day. Ears were harvested at intervals, and grains from mid-ear were sampled (1) to establish the pattern of dry weight accumulation, and (2) to examine starch granule formation using scanning electron microscopy (SEM). For SEM, grains were frozen in liquid nitrogen, cut transversely at mid-grain using a cryomicrotome, freeze-dried and coated with gold. The endosperm was examined cell by cell from the testa inwards along lines at right angles to the ventral and dorsal surfaces of the grain. Starchy endosperm cells adjoining the crease aleurone were also examined. Maximum dry weight per grain was reached 45 days after anthesis. SEM observations indicated that the number of B-type granules in an endosperm cell depended not only on the age of the grain, but also on the location of the cell. B-type granules were not detected in the starchy endosperm cells of grains harvested 15 days after anthesis. In mature grains, B-type granules varied greatly in size and shape. At all stages of grain development, the starch granules in the endosperm cells adjoining the crease aleurone were more or less uniform in size and shape.

18 02

Solute leakage from different plant parts of wheat

N. DEBRUNNER and U. FELLER

Institute of Plant Physiology, University of Bern, Altenbergrain 21, 3013 Bern, Switzerland.

Mobile nutrients are easily redistributed from senescencing leaves to growing plant parts. However, a loss of solutes is also possible by leakage in the rain, the fog or the dew. The leakage is more relevant in senesced leaves than in green leaves. The leakage properties were investigated repeatedly throughout the maturation period in detached parts of field grown wheat. For a better control of the leakage conditions the plant parts were incubated in deionized water for several hours in the dark either at 4°C (very low metabolic activities) or 20°C. Major quantities of amino acids are released only from green leaves or those in an early phase of senescence after incubation for several hours at 20°C. Cations (except sodium, which was retained in the plant parts) were released immediately from senesced plant material, regardless of the temperature. Cations appeared only after several hours at 20°C in the incubation medium of green or yellowing parts, while essentially no release from the same samples was detected at 4°C. Apparently, metabolic processes were relevant for the delayed leakage at 20°C. Our results suggest that changing properties of the leaf surface, the intactness of membranes and the compartmentation play an important role in the leakage of solutes. The control of such losses is important, since a high percentage of some nutrients (e.g. potassium) may be washed out in the rain from field grown wheat.

S309

18 03

A study of the physiological mechanism of the film "Polysvetan" action on crop yield.**A.V.DEDOV***Institute of Biology, Ufa Scientific Centre, Russian Academy of Sciences,
pr. Oktyabrya, 69, 450054, Ufa, Russia*

Tomato and lettuce cultivation under the film "Polysvetan" resulted in the increase of plant yield. However, the mechanism of the film action remains unknown. *Chlorella* cell culture was chosen as a model for its study. The biomass accumulation estimated by the light absorption in the culture, as well as the chlorophyll content calculated per cell was shown to be higher in the culture grown under the film as compared to the control one grown without it. The difference between *chlorella* cultures grown under the film and those without it disappeared under the influence of diuron. Since diuron is known to affect the process of noncyclic phosphorylation, the results obtained suggest that the mechanism of the film action on plants is connected with the process of photosynthesis. The physical mechanism of the "Polysvetan" film action is conditioned by the phototransformation of ultra violet and blue light into red resulting in the additional maximum in the region of 615-650 nm. As this region corresponds to the spectrum of phytochrome photoactivation and the latter is known to influence pigment formation and photosynthesis on the whole, we assume that the growth-regulating action of the "Polysvetan" film is connected with its action on photosynthesis through phytochrome stimulation.

18 04

Carbon and nitrogen partitioning in *Lolium perenne*: Quantification of stored and current assimilates used in growth by ^{13}C and ^{15}N steady-state labelling**R. DE VISSER*, H. VIANDEN** and H. SCHNYDER*****DLO-Res Inst for Agrobiolgy and Soil Fertility (AB-DLO), POBox 14, 6700 AA Wageningen, Netherlands*; Inst für Pflanzenbau, Univ of Bonn, Katzenburgweg 5, 53115 Bonn, Germany***

The partitioning of reserve and current C and N assimilates in growing tissues was examined in *Lolium perenne* L during regrowth after defoliation. Tissues differing in function and morphology were separated. Balance and fluxes of C and N were analysed. CO_2 and nitrate were steady-state labelled with the stable isotopes ^{13}C (Schnyder 1992) and ^{15}N , in order to discriminate between pre- and post-defoliation assimilates. Plant parts differed in the time course of δ , mainly due to different relative import rates of C, and in C-isotope discrimination (up to 1.8‰). However, the ratio of reserve-C/photosynthetic-C in the C imported was similar in most tissues. Photosynthesis is the main C source after the first day of regrowth. The first 2 days after defoliation most tissues accumulate about 80% old N, remobilized mainly from roots. Both the elongation zone of the leaf and the distant young root tips are equally effective in accumulating photosynthetic C, indicating that sink to source distance is not a dominant factor in sink competition. A flux model is presented describing the observed kinetics of δ and at% ^{15}N . Numerical simulations using data on isotopic composition and fluxes of C- and N-assimilates support the above conclusions.

18 05

Juvenile plant characters as a performance prediction indicators of breeding material of spring barley (*Hordeum vulgare* L.)

J. EHRENBARGEROVÁ and J. DÍTĚTOVÁ

University of Agriculture, Department of Plant Production and Breeding, Zemědělská 1, 613 00 Brno, Czech Republic

From 1988 to 1989, growth characteristics of barley seedlings (length of coleoptile, total length of primordial roots and DM ratio of coleoptile/roots) were studied in sixteen lines of fodder spring barley (eight parents components and eight filial hybrids). Four grains from ear central part of juvenile plants and four grains from the second row of ear of mature plants were used. Therefore we could estimate relationship between characters of juvenile and mature plants. We found a positive relationship between number of seedling roots of juvenile plants and mature plant yield-forming factors, but not for all examined lines. Typical character of juvenile plants was the number of seedling roots. In some lines the DM ratio of coleoptile/roots (1.24 - 1.73) seemed to be an available prediction indicator of level of yield-forming factors of mature plants and an indicator for sampling parents' components for hybridization.

18 06

Transport of inorganic pollutants via xylem and phloem in maturing wheat

U. FELLER and R. HÖLZER

Institute of Plant Physiology, University of Bern, Altenbergrain 21, CH-3013 Bern, Switzerland

Interactions between the two long-distance transport systems xylem and phloem are important for the delivery of nutrients and assimilates to the ear of maturing cereals. Pollutants were far less considered in this context. Therefore the transport of selected heavy metals (Co, Cr, Cu and Ni) and of radioactive cesium was investigated in the experiments reported here. Detached wheat shoots (*Triticum aestivum* L., cv. Arina) were incubated standing in feeding solutions containing the pollutants mentioned. Rb and Sr were included to allow a comparison with previous experiments. Cr, Cu, and Cs were removed from the xylem sap during the acropetal translocation (as Rb). These elements accumulated in the stem and in the leaf sheaths. On the other hand Ni and Co remained in the transpiration stream and were distributed in a similar manner as Sr. Highest contents of these elements were observed in the leaf laminae. Our results strongly suggest that heavy metals and radioactive pollutants can be selectively removed from the xylem in the stem of wheat. Some of these elements may be transferred to the phloem and reach the developing grains via the symplast. A phloem interruption below the ear reduced the transport of Cs to the maturing grains. These preliminary results indicate that a xylem-to-phloem transfer in the stem of cereals may be also relevant for radionuclides present in the fallout (e.g. after the Chernobyl accident) and also for some heavy metals.

S311

18 07

The contribution of pre-anthesis photosynthate to yield of spring wheat (*Triticum aestivum* L.) as affected by differential nitrogen supply

T. GEBBING, H. SCHNYDER and W. KÜHBAUCH

Institut für Pflanzenbau, University of Bonn, Katzenburgweg 5, 53115 Bonn, Germany

The contribution of pre-anthesis and post-anthesis photosynthesis to grain filling was studied by growth analysis and labelling of all photosynthate fixed during the grain filling period. Two varieties grown at two nitrogen supply levels were studied in 1991 and 1992. Single plants were grown outdoors. At anthesis plants were transferred to a growth cabinet and all photosynthetic products labelled with stable carbon isotopes until maturity. Nitrogen and watersoluble carbohydrate (WSC) contents of the vegetative plant parts and grains were analysed at anthesis and maturity. In both years grain dry matter per main tiller was similar. The contribution of pre-anthesis photosynthate to grain filling (22% versus 16% of grain mass) was higher at low N supply and was associated with increased WSC contents in the vegetative plant parts at anthesis. Environmental conditions before anthesis had a strong effect on the utilisation of reserves in grain filling (14% in 1991, 24% in 1992). Higher contributions of pre-anthesis reserves to grain filling occurred together with increased amounts of WSC in the vegetative dry matter at anthesis in 1992. Significant contributions of pre-anthesis reserves to grain filling were observed even when growth analysis suggested low contributions. Results indicated that WSC present in the plant at anthesis were used more efficiently in grain filling when N supply was low.

18 08

Nitrate reductase activity in haploids and doubled haploids of *Hordeum vulgare* L.

H.GNIAZDOWSKA-SKOCZEK*, M.SURMA**, T.ADAMSKI**

*Department of Plant Physiology, Agricultural University, Wołyńska 35, 60-637 Poznań, Poland***Institute of Plant Genetics, Polish Academy of Sciences, Strzeszyńska 34, 60-479 Poznań, Poland***

Transgressive barley doubled haploid (DH) lines with regard to the full NADH : nitrate reductase (NADH : NR) activity were selected. From two lines, significantly differing in NADH : NR activity, haploid plants were obtained by H. bulbosum method. Haploids like DH lines significantly differed by NADH : NR activity. In several DH lines, extreme with reference to NADH : NR activity, the partial activities of enzyme, i.e. NADH : cytochrome c reductase (NADH : CR) activity as well as reduced methyl viologen : nitrate reductase (MV : NR) activity were characterized. Significant differences in partial activities were found between lines. The obtained results indicate differential NR gene expression in the studied barley DH lines.

S312

18 09

The influence of respiration and photosynthesis on the relative growth rate of four *Triticum aestivum* L. cultivars.

S. GOUBITZ, R. VAN DEN BOOGAARD and E.VENEKLAAS

Department of Plant Ecology and Evolutionary Biology, Utrecht University, P.O. Box 80084, 3508 TB, Utrecht, The Netherlands.

Previous experiments revealed differences in relative growth rate between ten wheat cultivars. These differences were associated with differences in net assimilation rate. How can these differences in net assimilation rate be explained?

The present experiments were done to evaluate the influence of respiration and photosynthesis on the net assimilation rate and the relation of these rates to the allocation of biomass. Photosynthesis is expected to be the most important factor affecting the net assimilation rate.

Four cultivars of the species *Triticum aestivum* L. were grown in a climate room in nutrient solution. Respiration and photosynthesis of the whole shoot and the whole root were measured for 24 hours. A growth analysis was carried out to determine the relative growth rate and the allocation of biomass.

18 10

Day CO₂ Exchange of Maize Canopy

A.P.GRIGORTSCHUK

Institute of Plant Physiology and Genetics, Academy of Sciences, Vasilkovskaya 31/17, 252022 Kiev, Ukraine

CO₂ exchange of leaves at different tiers and of plant canopy of maize hybrid with leaf area index 2.6 at silking were investigated under field conditions at uncloudy days. The intensity of canopy net photosynthesis varied almost directly proportionally to light flux density (I) during the day. It has been found that with sun raising in vertical canopy profile the share of leaf surface with values of I at which maximum efficiency of leaf photosynthesis takes place, is increased. At the midday hours leaf photosynthesis of the whole canopy occurs under this light conditions. The index of the effectively photosynthesizing leaf surface was proposed. It has been shown that CO₂ assimilation rate of the canopy is closely correlated with this index in the day pattern ($r = 0.97$).

18 11

Irrigation and nitrogen management for optimum tuber quality in *Solanum tuberosum*

LK HILLER

Horticulture & Landscape Architecture Department, Washington State University, Pullman WA 99164-6414

Water management through proper irrigation scheduling is a critical management factor for potato production and quality. Yield and quality of potato (*Solanum tuberosum*) tubers can be affected by water stress at any time during development following initiation. Leaching of various nutrient and pesticide additives from the soil is an undesirable consequence of improper irrigation scheduling. Several methods available to potato growers were evaluated in field trials and will be discussed in terms of water applications, total water applied, plant responses, tuber yields and quality. The neutron probe method used less water and the canopy temperature-based method resulted in the largest water stress. Excess water applications were the result of overestimation of peak K_c value and perhaps overprediction of potential ET. The different methods of irrigation scheduling were capable of producing schedules that preserved maximum total yields and quality. Nitrogen monitoring and root growth and development were monitored and differential responses will be discussed.

18 12

Allelopathic effects of grasses to *Trifolium*

J. HORÁK and A. FOJTÍK

Plant Breeding Station, 742 47 Hladké Životice, Czech Republic

We tested allelopathic effects of various grass cultivars to *Trifolium pratense* and *T. repens* or to various grass species. Sterilized clover and grass seeds were sown on agar plates with water leachates from various grass organs. Germination, root and hypocotyl length of clover seedlings were evaluated. Germination of clovers was inhibited by grass leaves leachates sampled in July, August or November as well as enhanced N-fertilization of grasses. Extracts from grass seeds never significantly affected seedling growth. Leachates from straw of *Festulolium Felina* and Bečva totally inhibited clover germination. Level of infection by fungus *Acremonium coenophialum* in *Festuca pratensis* and *F. arundinacea* did not enhance level of clover and grass germination. Leachates from *Festulolium Felina* leaves stimulated germination of *Poa palustris*, that means to be in good correlation with higher yields of both species mixture in field trials. Recently we have tested responsibility of red clover to cereals sown as cover crops in the Czech Republic.

18 13

Elongation growth and water relations of wheat seedlings adapted to water stress

J. JANÁČEK*, Š. MOCOŮV** and J. ZÁMEČNÍK*

*Research Institute of Crop Production, Drnovská 507, 161 06 Prague, Czech Republic**

*Faculty of Natural Sciences, Charles University, Viničná 5, Prague, Czech Republic***

The etiolated seedlings of winter wheat (cv. Zdar) grown at low water supply (LWS, 8ml per 80 seedlings) had lower osmotic potential (measured psychrometrically by WESCOR) and lower amount of water per gram of dry matter than the seedlings grown at high water supply (HWS, 15ml per 80 seedlings). The excised 2 cm long coleoptile segments of both variants were incubated in ten concentrations of PEG 8000 (from -0.1 to -1.1 MPa) up to 3 days. The elongation kinetics of these segments was measured either by ruler or by image analysis (LUCIA D). Segments from LWS plants ceased growth at -0.68 MPa and segments from HWS at -0.46 MPa of external osmotic potential. The growth of segments from both treatments was ceased at the non zero turgor pressure. This turgor pressure is assigned as yield threshold for cell wall loosening. The yield threshold was 0.17 and 0.31 MPa for HWS and LWS respectively. The adaptation of LWS plants consists in osmotic adjustment and in increase of the yield threshold.

18 14

Role of Cytokinins in Control of Wheat Grain Development and Utilization of Nutrients

M. KAMÍNEK*, M. TRČKOVÁ**, V. MOTYKA*, A. GAUDINOVÁ*

*Institute of Experimental Botany, Ke dvoru 15, 166 30 Prague 6, Czech Republic**

*Research Institute of Crop Production, 161 06 Prague 6, Czech Republic***

Dynamics of the content of cytokinins and cytokinin oxidase activity during wheat grain development was determined. Transient accumulation of cytokinins (zeatin, zeatin riboside and unidentified cytokinin-like compounds) which occurred at the beginning of grain fresh weight increase after anthesis was followed by the increase of cytokinin oxidase activity. In order to test the effect of exogenous cytokinin on grain formation the highly active cytokinin N⁶-(meta-hydroxybenzyl)adenosine was applied as spray (1 µM) to wheat plants grown in nutrient solution containing optimal (1 mM) and suboptimal (0.7 mM) concentration of nitrate. The cytokinin application increased the number of grains per ear (by 10.1% and 26.4%, respectively) and grain weight per plant (by 4.2 % and 23.9 %, respectively). When applied to plants grown at suboptimal concentration of nitrate the cytokinin actually removed the reduction of grain number and grain weight per plant caused by limited nitrogen supply.

S315

18 15

Tissue-specific expression of barley aspartic proteinase and studies on its function

J. KERVINEN*, K. TÖRMÄKANGAS*, P. RUNEBERG-ROOS*, S. GAL**, V. KOVALEVA**, N. RAIKHEL** and T.H. TEERI*

*Institute of Biotechnology, P.O. Box 45, Karvaamokuja 3 A, FIN-00014 University of Helsinki, Finland**; *MSU-DOE Plant Research Laboratory, Michigan State University, East Lansing, MI 48824-1312, USA***

The tissue-specific expression of barley aspartic proteinase (HvAP = *Hordeum vulgare* aspartic proteinase), originally purified from barley grains, was studied in different plant tissues by using immunocytochemical and *in situ* -hybridization techniques. In developing grains, HvAP is expressed in the embryo, aleurone layer, testa and pericarp. During the late stages of development, HvAP disappears from the aleurone layer but reappears during germination. However, the HvAP-encoding mRNA is stored in the embryos and aleurone during grain maturation. Based on the primary structure, computer modelled 3-D structure (Dr. K. Guruprasad and Prof. Tom Blundell, Birkbeck College, London), hydrolytic specificity and vacuolar localization, HvAP resembles the mammalian cathepsin D and yeast proteinase A. Therefore HvAP may deal with cellular protein turnover and the processing and activation of other enzymes. Indeed, we have shown that the C-terminal vacuolar targeting signal of barley prolectin was cleaved off *in vitro* by purified HvAP whereas the N-terminus stayed intact during hydrolysis. However, prolectin also seemed to be processed *in vitro* by carboxypeptidase Y, and thus its vacuolar targeting signal may be susceptible to hydrolysis by several enzymes. Lectin and HvAP were also shown to be colocalized in root vacuoles.

18 16

Effect of decapitation on photosynthesis and productivity of sugar-beet

D.A. KIRIZIY

Institute of Plant Physiology and Genetics, Academy of Sciences, Vasilkovskaya 31/17, 252022 Kiev, Ukraine

Removal of apex and unfolding leaves in the middle of vegetative period resulted in the optimization of assimilation activities and increase of lifetime remained 18-20 leaves. This number of leaves which appeared in a first half of vegetative period is perfectly able to maintain further normal dry matter production and sucrose accumulation in the root of sugar-beet.

18 17

Effect of some growing and post-harvest factors on polyphenoloxidase and peroxidase activities in stored glasshouse lettuce */Lactuca sativa L./*

M. LEJA

*Department of Plant Physiology, Faculty of Horticulture, Agricultural University,
29 Listopada 54, 31-425 Kraków, Poland*

The effect of high and low temperature, mechanical damage and different forms of nitrogen fertilizers on polyphenoloxidase /PPO, EC 1.10.3.2./ and peroxidase /POD, EC 1.11.1.7./ in stored lettuce was investigated. A significant increase of PPO activity was caused by high /20°C, 4 days/ as well as low /5°C, 14 days/ temperature storage of lettuce heads. Activity of polyphenoloxidase in stored lettuce treated during growth with reduced forms of nitrogen /ammonium or urea/ was considerably higher than enzyme activity in samples treated with nitrate. A slight predominance of PPO activity in wounded lettuce leaves as compared with the intact ones, was found in the samples analysed immediately after damage and was intensified during the whole storage period.

Changes of peroxidase activity in stored lettuce, affected by external factors were similar to those obtained in the case of polyphenoloxidase. Both these enzymes, involved in phenolic metabolism, seemed to be the best index of leafy tissue response to stress. Their increased activity preceded any visible symptoms of senescence and physiological disorders.

18 18

Determination of soluble sugars by high performance anion exchange chromatography (HPAE) and pulsed electrochemical detection (PED) in five varieties of *Glycine max* L. during storage

R. LOCHER and P. BUCHELI

Nestec Ltd, Nestlé Research Center, Vers-chez-les-Blanc, P.O. Box 44, CH-1000 Lausanne 26, Switzerland

Soluble sugars in soybean consist essentially of sucrose and the flatulent sugars raffinose, stachyose and verbascose. We present evidence that poor storage conditions (high relative humidity (R.H.) and high temperature) can induce increasing levels of reducing sugars. Five soybean (*Glycine max* L.) varieties were analysed for soluble sugar changes during storage under control and humid & hot conditions. Soluble sugars were measured by HPAE and PED using melzitose as internal standard. For control beans, total soluble sugar content ranged within 70-100 mg per g soy meal according to variety. When beans were kept under control conditions their soluble sugar content remained fairly constant over 160 days of storage. However, under humid & hot storage conditions total soluble sugar content decreased linearly between 20 and 160 days. Reciprocally, degradation products of soluble sugars increased substantially during the same time suggesting a high metabolic activity. Levels of degradation products, consisting essentially of galactose, glucose and fructose, increased approximately 25-50 times. Soluble sugar degradation during storage seemed to be variety dependent. It was also shown that the flatulent sugars raffinose, stachyose and verbascose were entirely metabolised probably by endogenous enzymes such as α -galactosidase(s) and invertase(s), within the 160 days of storage.

S317

18 19

Evaluation of salinity tolerance in *Sorghum*

E.H. MAJIDI and A.A. FOOMAN

Seed and Plant Improvement Institute, Karaj 31585-4119, Iran

Nine cultivars of *Sorghum bicolor* L. evaluated for salt tolerance were grown under saline and nonsaline field conditions or phytotrons using Hoagland's solution. Compared with the nonsaline treatment, salinity reduced plant height, fresh and dry matter and water potential of leaves that was negatively correlated with cell membrane stability (CMS). Free proline, soluble sugar, K, Ca and Na were accumulated in plant tissues grown under saline conditions and positively correlated with decrease of CMS and increase of relative water content. Cultivars Speed Feed and Fsia were more salt tolerant than Sugar Graze and SX-121.

18 20

Fructan exohydrolase activities in stems and roots of perennial ryegrass (*Lolium perenne* L.)

S. MARX

Inst. Plant Sci. Crop Sci., ETH Zentrum, LFW, Universitätsstr. 2, 8092 Zürich, Switzerland

Fructans are the main reserve carbohydrates of the perennial forage grasses in the temperate regions. These fructans are stored in leaves, stems and roots of the grasses. During the kernel filling period, during seasonal growth and after defoliation by cutting and grazing, fructans are mobilized by exolytic hydrolase activities. Grasses contain fructan of complex and branched structures with β 2-1 and β 2-6 linked fructose residues. Hence, in order to hydrolyse such fructan it is assumed, that several different hydrolases participate. Little is known about enzymatic hydrolysis of fructan in forage grasses. Therefore we purified enzyme activities catalyzing fructan degradation from stems and roots after defoliation. Using ammonium sulfate precipitation, lectin affinity chromatography, ion exchange chromatography and size exclusion chromatography different hydrolytic activities were partially purified. Analysis with sensitive AEC-HPLC shows, that active fractions differ in their affinity to different, highly purified fructan oligomers. Results of purification and characterization of these different fructan-hydrolysing activities are presented and discussed.

18 21

Comparative study of soybean varieties with regard to seed coat properties: measurement of penetration force, structure of seed coat surface, water uptake and germination test

I. MEYER, W. M. MACINNES, C. SCHLIENGER and P. BUCHELI

Nestec Ltd., Nestlé Research Center, Vers-chez-les-Blanc, P.O. Box 44, CH-1000 Lausanne 26, Switzerland

Hard seededness of soybean affects the germination rate and quality of stored seeds. Development of "hard seed" (HS) character has been attributed to several factors such as genetics, climatic conditions, seed size, storage conditions and degree of ripeness. There are indications, that soft seeded soybean varieties have permeable seed coats with many pits in contrast to hard seeded varieties, which show very little pitting. We evaluated 21 soybean varieties (*Glycine max.*) for penetration force, water uptake, germination rate and observed some of them by scanning electron microscopy (SEM). Measured penetration force ranged from 5 to 21.2 N, but is strongly influenced by moisture content. Varieties with low penetration force tended to have higher numbers of pits. Nevertheless, the known hard seeded variety MD 27-15 had the lowest penetration force (having few pits, low water uptake and germination rate). Thus differentiation between hard and soft seeded varieties using penetration force is not as reliable as using water uptake and germination rate kinetics.

18 22

Two methods and equipment for studying the physiological state of seeds, seedlings and plants

V.F. NIKOLENKO and D.I. ALEXEEVA

Agrophysical Research Institute, Grazhdansky pr. 14, 195220 St. Petersburg, Russia

One of the most important aim of plant physiology is the evaluation of plant genetic resources and the exposure the donors with usefull properties. These investigations must be based on the quantitative quick methods which do not cause the damage and loss of analysed samples. Two methods and devices ("SEMIA" and "LIST") designed in Agrophysical Institute (St. Petersburg, Russia) are described. In the first method the soft X-rays are applicated. X-rays pass through the seeds and make their roentgen image in natural size or 2, 3, 5, 10 times magnified. These roentgenograms may be used for analyzing the internal structure of seeds. In the second method temporal and temperature dependences of variable and stationary delayed fluorescence of chlorophyll in leaves are registrated. It is known that these parameters characterize the physiological state of plant (for example resistance to unfavourable climate conditions). The study of summer wheat grain was carried out. All grain used for analysis looked like and were without external differences. But after X-ray analysis grain was divided into two subgroups: with normal and small cracking grain. It was shown that grain with the small cracks had less germination, the worse sowing quality and the different parameters of fluorescence. The presence of cracks in grain (seeds) in the cause of the misrepresentative facts about genotypes, therefore only normal, biological homogenous samples must be used for analysis.

S319

The influence of environment conditions on dry matter production and accumulation of energy in spring barley plants

V. NOVÁK*, M. DVOŘÁK**, Y. KUMAR*

*University of Agriculture in Prague, 165 21 Praha 6 - Suchbát, Czech Republic**

*Department of Plant Physiology and Anatomy, Charles University, Viničná 5, 128 44 Praha 2, Czech Republic***

We grew spring barley (*Hordeum vulgare* L.) plants in air conditioned chamber from sprouting till the 17th d. In field we studied the influence of magnetic field on grains before sowing and of various doses of nitrogen fertilizer on dry matter production and energy accumulation. The energy content in sprouting plants in both the chamber and field corresponded to increase in dry matter of their parts. The energy content per dry matter unit of roots, stalk with leaves and ear (excluding ashes) was very stable. It was not influenced either by growing of sprouting plants in light or in the dark or by magnetic effect on grains or by various nitrogen fertilization. Up to 0.61 - 1 % of incoming solar radiant energy during the whole vegetation season was incorporated in dry matter of plants.

Osmotic adjustment in chickpea cultivars (*Cicer arietinum* L.) during drought stress and rewetting

B. ORTHEN and M. POPP

Institut für Angewandte Botanik, Hindenburgplatz 55, 48143 Münster, Germany

The potential for osmotic adjustment might depend on the capability to accumulate different kind of osmolytes. One aim of this study was to compare drought susceptible (Phule G5) and drought resistant (ICCV 10) chickpea cultivars for their capacity of pinitol accumulation under control and drought treatment. During a 13 days drying cycle pinitol and in addition proline, another well known compatible solute, accumulated in the leaves up to 100 and 40 mol m⁻³ (plant water) respectively, in resistant as well as in susceptible cultivars. This lack of difference between cultivars of different drought resistance might be due to the limited irradiance (360 µmol m⁻² s⁻¹), the small pot size leading to a very quick drying process and various other differences between greenhouse and natural site conditions. Nevertheless the experiment was very useful to prove the fate of the accumulation stress metabolites after rewetting. While proline decreased to control level within 5 d after rewetting, pinitol content stayed constant calculated per plant even after 8 d after stress release. This is further evidence for a different functioning of ionic (proline) and non-ionic (pinitol) stress metabolites in stress adaptation.

18 25

The importance of the light response for determining plant performance under elevated CO₂ conditions

OTTOSEN, C.-O. and MENTZ, J,

Department of Ornamentals, Kirstinebjergvej 10, DK-5792 Årsløv, Denmark.

Three species of ornamentals *Dentranthema grandiflorum*-hybrids, *Hibiscus rosa-sinensis* L. and *Schefflera arboricola* Hayat. grown in open top chambers in greenhouses were subjected to three different CO₂-concentrations: 350, 700 and 1050 ppm from the phase of rooted cutting to mature flowering plants under various climatic conditions, however, with an adequate water and nutrient supply.

The growth and development of the above ground biomass showed distinct differences indicating a growth enhancing effect of CO₂ though not identical in response in the examined species. Light response curves indicated differences in maximum rate of photosynthesis, while only minute changes were found in quantum yield. There was no evident differences in gas exchange between plants of different age.

18 26

The water content per blade area did not change during the induction of frost resistance in the mature wheat leaf.

I. PRÁŠIL

Research Institute of Crop Production, Drnovská 508, 161 06 Praha, Czech Republic

Winter wheat plants were cultivated in 15 °C (16 hours of daylight) until the second leaf blade was developed. Then the plants were hardened in 5 °C for another 5 weeks. During this hardening the critical temperature (CT₅₀) decreased from -6 to -17 °C, the ratio g water/g dry weight decreased, specific leaf area increased and g water/leaf area did not change. The induction of frost resistance in the mature leaf blade was connected with an accumulation of dry weight but not with a change of water content per leaf area.

S321

18 27

Genetical and physiological approach of carbohydrate metabolism regulation in maize leaves. Use of recombinant line for mapping of Quantitative Trait Loci (QTL).

J.L. PRIOUL*, J.P. ROCHER*, M. CAUSSE** and D. DE VIENNE**

Structure et Métabolisme des Plantes - Bât. 630 - I.B.P.* and Station de Génétique Végétale - La Ferme du Moulon** Université de Paris-Sud - 91405 ORSAY Cedex.

Sucrose and starch metabolism control the exporting capacities of source leaves. Key-enzymes for that regulation are Sucrose-P-synthase and ADPglucose-pyrophosphorylase. Similarly in sink organs, sucrose synthase and invertase are essential for sucrose utilization. The genetic control of carbohydrate metabolism was analyzed in a family of genetically fixed lines, derived from the crossing of two contrasting parental lines. Each line represent a random combination of parental alleles, it is called a recombinant line. Carbohydrates and enzyme activities were mesured in 90 lines which were previously mapped by RFLP. The correlation between each RFLP marker and each physiological measurement (Quantitative Trait) allowed the localization of the traits on the map. These localization was compared with that of the structural genes for the corresponding enzymes. Several significant QTL were obtained. Some of them are common to several traits which suggest localization of regulatory genes. A few QTL-enzyme were mapped at the same position as the structural gene.

18 28

Testing causal relationships between physiological traits by QTL analysis - a method to identify traits for improved resistance of crops to stress.S. A. QUARRIE¹, A. STEED¹, C. LEBRETON², V. LAZIC-JANCIC³ and S. PEKIC⁴*John Innes Centre, Norwich Research Park, Colney, Norwich NR4 7UH ¹**Ecole Supérieure d'Agriculture, 55 Rue Rabelais, B. P. 748, 49007 Angers Cedex, France ²**Maize Research Institute, Slobodana Bajica 1, PO Box 89, 11081 Belgrade-Zemun, Serbia ³**Faculty of Agriculture, University of Belgrade, Nemanjina 6, 11081 Belgrade-Zemun, Serbia ⁴*

Many traits that affect crop performance under stress conditions are inherited in a complex manner. For example, abscisic acid (ABA) has a major role in determining plant responses to drought, but it has been difficult proving that genetic variation in ABA content affects drought resistance because many genes appear to be involved in regulating ABA content. Isogenic lines are, therefore, difficult to make. The development of molecular markers for many crops allows the preparation of closely-spaced genetic maps which can be used to determine the minimum number and location of genes having major effects on the expression of physiological traits: quantitative trait loci (QTL). By comparing the coincidence of QTL for different traits, the likelihood of causal relationships between traits can be tested, and traits likely to be important in conferring improved stress resistance identified. In a study of QTL for responses of maize to drought stress we have tested the likely roles of ABA on stomatal and rooting behaviour under stressed conditions. ABA appeared not to affect the stomata, but may have affected root development. We were also able to show that differences in photosynthetic efficiency were likely to be determined by differences in leaf thickness. We are currently testing the lines for yield under drought in the field.

18 29

Response of oxidative stress enzymes and α -amylase to high levels of NaCl in calli and plants of *Helianthus annuus* L. cv. Girapac SH222.

CONCEIÇÃO V. SANTOS AND GUSTAVO CALDEIRA,
Departamento de Biologia, Universidade de Aveiro, 3800 Aveiro, Portugal

We studied the effect of high NaCl concentrations on the activities of α -amylase and some oxidative stress enzymes (peroxidase, catalase and superoxide dismutase) on sunflower *calli*, and on roots and leaves of intact plants. *Calli* and plants were exposed to 0, 50, 100, 200 and 300mM of NaCl, to KCl and to Na₂SO₄ stresses. Osmotic stress was also imposed to *calli* and plant cells by addition of PEG. It has been showed that α -amylase activity decreases with time in control *calli* but it increases dramatically when cells are exposed to high levels of NaCl and other salt stresses. Guaiacol peroxidase showed an increase in activity for all concentrations (12 days of treatment), but after this time it decreases in *calli* exposed to high levels of salt. Superoxide dismutase activity is also affected by NaCl presence. The present study demonstrates interactions between NaCl and/or osmotic stresses and some enzyme activities in sunflower cells. It also demonstrates that *calli* cells show a different behaviour to salt and osmotic stress than cells from intact plants (roots and leaves). On the other hand, *calli* cells are, in general, much less sensitive to NaCl stress than intact plants, with selection of lines tolerant to 200 mM of NaCl and plant regeneration.

18 30

Superoxide dismutase and amino acid compositions in leaves of different wheat cultivars

D. ŠTAJNER*, O. GAŠIĆ*, B. MATKOVICS**, Sz.I. VARGA**, N. MIMICA-DUKIĆ* and M. POPOVIĆ*

*Institute of chemistry, Faculty of Science, University of Novi Sad, Yugoslavia**
*Biological Isotope Laboratory, József Attila University, Szeged, Hungary***

Superoxide dismutase (SOD; EC 1.15.1.1.) in leaves from different wheat cultivars were characterized using native polyacrylamide gel electrophoresis. The plants studied included five wheat (*Triticum aestivum* L.) cultivars from different parts of Earth. The three molecular forms of SOD were distinguished from each other by their different sensitivity to cyanide and H₂O₂. Two Cu, Zn-SOD and one Mn-SOD were present. Activity of Mn-SOD was lower in spring cultivar Siete Cerros from Mexico. Amino acid composition of examined cultivars was almost the same in all wheat cultivars, with high content of lysine. Results obtained confirm that SOD production in different wheat cultivars is under control of similar genes, and that young leaves of wheat seem to be convenient source of SOD.

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18 31

Acquisition and translocation of mineral nutrients in crop plants**B. TOURAINE***Biochimie et Physiologie Végétales, ENSA-M/INRA/CNRS URA 573, 34060 Montpellier Cedex, France*

Biological organisms achieve selective accumulation of particular elements to create the chemical milieu in which life processes can occur. In higher plants, this has involved the evolution of cellular mechanisms and whole-plant processes which are adapted to a static life form. These strategies include morphological features, biochemical characteristics and physiological adaptations. Besides features involved in nutrients acquisition, an essential element in mineral nutrition of higher plants is the pattern of root-shoot exchanges. Basically, these exchange processes rest upon membrane transport steps, which present both similarities and particularities with ionic uptake systems. Until recently, mechanistic models designed to describe nutrient acquisition and utilization in plants were largely based upon circumstantial evidence. However, the application of the tools of molecular biology and the improvement of the techniques of electrophysiology and membrane biochemistry have resulted in spectacular successes in the field of identification of transport systems. On the other hand, to fathom the complexity of plant responses now requires to bridge the gaps between molecular findings and physiological expression of the nutrient systems at the whole plant level. In this respect, the control of ionic uptake in roots by the nutritional status of the whole plant ("nutrient demand") represents a fundamental feature which may involve some coordination between the rates of nutrient acquisition and nutrient translocation within the plant.

18 32

The use of carbon isotope discrimination as an indicator of efficient water use**E.J. VENEKLAAS^{1,3}, R. KREULEN², H.A.G.M. VAN DEN BOOGAARD¹, H. LAMBERS¹ and J.M. PEACOCK³***Plant Ecology and Evolutionary Biology, Utrecht University, Sorbonnelaan 16, 3584 CA Utrecht, The Netherlands¹; Geochemistry, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands²; International Center for Agricultural Research in the Dry Areas, PO Box 5466, Aleppo, Syria³*

Differences in plant dry matter increase per unit water used are often due to differences in assimilation/transpiration ratio (photosynthetic Water Use Efficiency, WUE_i). WUE_i and ¹³C discrimination ($\delta^{13}\text{C}$) are correlated because both are related to the CO₂ pressure gradient between outside and inside of the leaf. Transpiration, and consequently WUE_i, are moreover related to the vapour pressure gradient between outside and inside of the leaf. Therefore there is no fixed quantitative relation between $\delta^{13}\text{C}$ and WUE_i, which limits the use of $\delta^{13}\text{C}$ as an indicator of WUE. This is not problematic if used for comparisons between plants with similar leaf-to-air vapour pressure deficits (vpd). However, erroneous interpretation of differences in WUE may result from (i) differing time trends of CO₂ assimilation (e.g. greater activity in periods with low atmospheric humidity); or (ii) different leaf-to-air vpd's during plant growth (e.g. due to weather conditions, microclimate, different leaf temperatures). Our study addresses leaf, plant and stand level aspects by means of experimental and theoretical analysis.

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18 33

Assimilate competition between the ear and vegetative regrowth in *Lolium perenne*?**J.W. WARRINGA and M.J. MARINISSEN***Research Institute for Agrobiological and Soil Fertility (AB-DLO), Bornsesteeg 65, 6700 AA Wageningen, the Netherlands.*

Within single plants of two clones of *L. perenne*, competition for assimilates between the ear and secondary regrowth at anthesis was investigated. Artificially vernalized tillers were brought to flowering in a greenhouse, under 17 h daylength and 20/17 °C. Three more clones were used as borderplants and to ensure successful pollination. At anthesis treatments were applied to induce differences in number of secondary tillers. Tillering was manipulated by removing all tillers with the exception of the main flowering tiller and the largest 4-10 flowering side tillers. Removal of tillers was combined with stimulation and inhibition of tillering by red light emitting diodes (660 nm) or blue/amber filter around the plant base, respectively. Stimulation and inhibition did not influence final tiller number unless all tillers present at anthesis were first removed. Total dry weight of secondary tillers was not affected. Removal stimulated secondary tillering and increased the dry weight of the stems and ears of the remaining flowering tillers. It seems that secondary regrowth does not compete for assimilates with the ear. In a further experiment attempts will be made to increase the total dry matter in secondary regrowth.

18 34

Antifreeze proteins detected in triticale genotypes with different frost tolerance.**J. ZÁMEČNÍK and J. BIEBLOVÁ***Research Institute of Crop Production, Drnovská 507, 161 06 Prague, Czech Republic*

Antifreeze proteins were detected by their ability to inhibit the ice crystals growth in low temperature estimated by "splat cooling" method. The antifreeze proteins were detected in segments of seven triticale cultivars differing in frost tolerance estimated by electrolyte leakage method. The elution profile from fractionation of total soluble proteins revealed three peaks of proteins. Only in the first peak the antifreeze proteins were found. Higher inhibition of crystal growth was found in extract from more frost tolerant cultivars than in less frost tolerant cultivars. The obvious evidence of antifreeze proteins localisation in extracellular space is their occurrence in extracellular washing as well as in guttation water. It is concluded that triticale plants can produce specific proteins which inhibit ice crystal growth in extracellular space, where ice crystals during equilibrium freezing are formed. Antifreeze proteins may be associated with freezing tolerance of the cultivars tested induced during cold hardening.

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