Plant Stress

Abbreviation: Plant Stress (PS)
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Scope and target readership: *Plant Stress* deals with the network of biotic and abiotic aspects inducing stress in plants.

Plant Stress will consider manuscripts that explore the following topics:
1) Environmental stress;
2) Modelling stress and stress-reduction;
3) Physiological, biochemical, molecular, ecological, genetic and economic aspects of plant stress at the cellular, tissue, organ or whole plant level. Preference will be given to multi-level studies;
4) Programmed Cell Death directly related to a stress factor;
5) Reactive oxygen species and destructive cellular mechanisms;
6) Stress caused by diseases (temperate and tropical) induced by fungi, bacteria, insects, viruses, phytoplasmas and nematodes.

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Cover photo: Main physico-chemical events taking place in the rhizosphere during soil waterlogging and the resulting modifications in plant metabolism and physiology followed by the initiation of adaptive responses (Parent *et al*., pp 20-27).

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Boris B. Vartapetian (Russia), Martin M. Sachs (USA), Kurt V. Fagerstedt (Finland) Plant Anaerobic Stress II. Strategy of Avoidance of Anaerobiosis and Other Aspects of Plant Life under Hypoxia and Anoxia (pp 1-19)

ABSTRACT

Invited Review: This review is a logical follow-up of previous publications (Vartapetian and Crawford 2007; Sachs and Vartapetian 2007) where an attempt was made to summarize the results of earlier periods of investigations of plant anaerobic stress and the activity of members of the International Society for Plant Anaerobiosis (ISPA) that ultimately brought about the establishment and international recognition of a new scientific discipline in the field of plant ecological physiology, biochemistry and molecular biology devoted to plant life under hypoxia and anoxia. Special attention was also paid to the strategy of metabolic adaptation of plants to hypoxia and anoxia, realized at the molecular level, including both the molecular biological and molecular genetic aspects of the problem. Continuing the discussion of strategies of plant adaptation to anaerobic environments in this review we pay particular consideration to the strategy of adaptation accomplished at the whole plant level by the formation of a continuous network of gas-filled spaces (aerenchyma), which development, provoked by specific signaling systems and programmed cell death, provides facilitated long-distance oxygen transport from aerated plant parts to organs (roots, rhizomes) under anaerobic conditions, that is a strategy of avoidance of anaerobiosis, or the phenomenon of "apparent" tolerance. Additionally, the following important aspects of plant hypoxic and anoxic stress are also considered here: post-anaerobic plant injury by reactive oxygen species and protection against oxidative injury by plant antioxidants; the Davies-Roberts pH-stat theory; alternative electron acceptors; demonstration of the adaptation syndrome in plants under anaerobic stress; genetic and cellular engineering in generating plants tolerant to anaerobic stress.

Claire Parent, Nicolas Capelli (France), Audrey Berger, Michèle Crèvecoeur (Switzerland), James F. Dat (France) An Overview of Plant Responses to Soil Waterlogging (pp 20-27)

ABSTRACT

Invited Review: Under natural conditions, plants are frequently exposed to transient or permanent soil waterlogging. Flooding drastically influences the soil physico-chemical properties, most notably soil redox potential, pH and O_2 level. Thus, conditions of hypoxia or anoxia are commonly encountered by plant root systems. These O_2 restrictive conditions dramatically affect plant growth, development and survival. One of the best characterised plant responses to soil waterlogging is the metabolic switch from aerobic respiration to anaerobic fermentation. In fact, most proteins induced during hypoxic conditions are enzymes involved in the establishment of this fermentative pathway. Because the plant cells need to keep a continuous ATP supply, the use of alternative electron acceptors and/or alternative pathways may be key elements of survival under soil waterlogging. The plant response may also include a reduction in stomatal conductance and photosynthesis, as well as root hydraulic conductivity. These physiological modifications may in turn affect carbohydrate reserves and translocation. In fact, efficient use of carbohydrates may discriminate between tolerant and intolerant species. Other observed adaptations include morphological changes which comprise the formation of hypertrophied lenticels, the initiation of adventitious roots and/or the development of aerenchyma. Our knowledge of the basic adaptive mechanisms of plants to soil waterlogging has benefited from large scale genomic and proteomic approaches, however, the diversity of the adaptive responses involved underlines the difficulty when studying this stress. This update reviews our current comprehension of the metabolic, physiological and morphological responses and adaptations of plants to soil waterlogging.

Priscilla P. Bettini, Elena Cosi, Daniela Bindi, Marcello Buiatti (Italy) Reactive Oxygen Species Metabolism in Plants: Production, Detoxification and Signaling in the Stress Response (pp 28-39)

ABSTRACT

Invited Review: The production of reactive oxygen species (ROS), such as superoxide radical ($O_2^{\bullet-}$), hydroxyl radical ($OH^{\bullet}$) and hydrogen peroxide (H_2O_2), in plants is a common event in metabolic and physiological processes. ROS are normally formed in photosynthesis and respiration by the chloroplast and mitochondrial electron transfer chains, respectively, and in metabolic reactions taking place in the peroxisomes. As these active oxygen species are destructive to cellular components such as lipids, nucleic acid and proteins, plant cells are equipped with non-enzymatic and enzymatic antioxidant defense systems comprising ascorbate, glutathione, phenols, catalases, superoxide dismutases and peroxidases. Biotic and abiotic stress, such as salinity stress, excess of heavy metals, mechanical shock, UV light, exposure to ozone, water deficiency and pathogen attack, also

increase ROS production. In the latter case the release of ROS, referred to as the “oxidative burst”, is one of the earliest responses activated following pathogen recognition and has been suggested to play a pivotal role in the integration and the coordination of the plant defense responses. In this review we summarize the current knowledge about ROS production and oxidative defense in plants. The role of ROS will be discussed in the frame of stress responses, with emphasis on the plant-pathogen interaction.

ABSTRACT

Mini-Review: Drought is the major limitation to the productivity of plants and an upcoming global threat. Many weeds, minor crops and other plants thriving in arid environments have evolved several mechanisms of drought escape, tolerance and avoidance. Consequently, the careful observation of the adaptive mechanisms of some of these wild or cultivated species could offer new choices in the exploitation of poor, arid regions, and important alternatives toward the development of drought adaptive crop strategies. Therefore, the information concerning their high competitiveness, proliferation and survival under water deficit conditions are urgently needed. In this paper we present and classify some outstanding cases of drought adaptive weeds and other neglected plants, which could be potentially useful in the future.

ABSTRACT

Original Research Paper: The effects of extreme drought stress and subsequent re-hydration on photosynthetic activity and carbohydrate content were investigated in resurrection plant *Caragana korshinskii*. Extreme drought stress was imposed by withholding water and covering plants with a polyvinyl chloride sheet during rain 53 days after all leaves had shed. Thereafter, plants were watered at 7-day intervals. Drought-induced leaf abscission and photosynthetic rate drastically decreased, while carbohydrate concentration increased in stems and in leaves prior to leaf abscission. Re-hydration promoted the emergence of new leaves, reactivated photosynthetic machinery function, and reduced soluble carbohydrate, sucrose and fructose concentrations. The results indicate that *C. korshinskii* plants are able to sustain drought stress through leaf abscission and carbohydrate concentration accumulation in stems. The high carbohydrate concentration in stems can stimulate the emergence of new leaves and regrowth if soil moisture reaches a normal level.

ABSTRACT

Original Research Paper: Studying the traits that enable Fool’s watercress (*Apium nodiflorum*) to survive oxygen deprivation in its wetland environment, we put forward the hypotheses that calcium, magnesium and potassium homeostasis may alter with age, and that their pools may fluctuate in size as a response to short-term hypoxic conditions at the whole plant level. Young and mature plants presented similar behaviour and allocation with regard to the examined nutrients. Under normoxia, calcium and magnesium homeostasis altered with age and calcium and magnesium levels found to be decreased drastically in the aged plants. In contrast, potassium homeostasis did not alter with age. Oxygen deprivation caused major alterations in the cases of calcium and magnesium homeostasis and minor fluctuations in that of potassium. In all organs of young and mature plants Ca concentration was decreased drastically after the hypoxic treatment. In contrast, Ca concentration in all organs of aged plants was increased drastically under hypoxia. Hypoxic duration of 3 and 4 h caused reduction of Mg concentration in all organs of young and mature plants, while in aged plants Mg concentration of no organ was influenced by the various hypoxic treatments. In contrast to calcium and magnesium, potassium oscillated at approximately the same level regardless of the age and hypoxic treatment. The changes of calcium concentration in the petioles of all ages, as well as the more rapid reduction of magnesium concentration in the petioles of young and mature plants (within one hour) compared to the leaves, the stems and the roots (within three hours), renders them suitable as organs of choice for diagnostic purposes.

ABSTRACT

Original Research Paper: An experiment was conducted to investigate the water relations of potted young olive trees (*Olea europaea* L.) cultivar 'Biancolilla', 'Giarraffa' and 'Nocellara del Belice' during water stress and after relief from stress. The aim was to highlight the different responses of the three cultivars and obtain a decision-making aid for planning an efficient watering schedule for potted plants grown in nurseries. Leaf water potential (Ψ), relative water content (RWC) and conductance to water vapour (g_L) were measured in three-year-old plants. All three olive cultivars were able to survive the severe stress imposed by withholding water for three weeks, but gas exchange was strongly impaired and recovery after rewatering was slow, resulting in a potential reduction of growth. The cultivars showed different responses to drought: 'Giarraffa' was the most sensitive, showing the earliest reduction in Ψ and the lowest recovery in g_L. 'Biancolilla' showed higher g_L, leaf hydration and Ψ under water deficit and appeared to be best adapted to drought. The behaviour of 'Nocellara del Belice' was similar to that of 'Biancolilla', and a particularly good recovery of g_L after rewatering occurred.

ABSTRACT

Original Research Paper: Analysis of the effect of a water stress (41 mM of polyethyleneglycol, or PEG) and a salt stress (150 mM NaCl) on enzymes implicated in the antioxidant system of two cultivars (Vita 3 and Vita 5) of *Vigna unguiculata* showed modifications in the SOD-APX-GR cycle. Catalase (EC 1.11.1.6) activity was strongly increased in both cultivars, under either PEG or NaCl treatment; superoxide-dismutase (EC 1.15.1.1) activity increased only for Vita 3 during water stress. On the other hand, ascorbate peroxidase (EC 1.11.1.11) activity increased only for Vita 5 following PEG treatment. Glutathione reductase (EC 1.6.4.2) and NADP-dependent malic enzyme (EC 1.1.1.40) activities increased significantly for Vita 3 under PEG treatment. Besides, the malondialdehyde (MDA) content increased more in Vita 5. The modification in the SOD-APX-GR cycle demonstrated that both treatments triggered an oxidative stress in both cultivars. Except for the results obtained for APX, Vita 3 had more efficient mechanisms to counteract reactive oxygen species than Vita 5. An increase in NADP-ME activity could maintain a more reductive environment (more NADPH). Therefore, we conclude that NADP-ME is also involved in the detoxification process in C_3 plants.

ABSTRACT

Original Research Paper: Phytoremediators use their internal defence system during phytoremediation leading to environmental restoration. *Eichhornia crassipes* (Mart.) Solms is an efficient remediator of heavy metals and grows luxuriantly in wastewaters especially in tropical climates. The present study was undertaken to determine the oxidative stress caused by Hg in *E. crassipes* and corresponding variations in the antioxidants. We found that malondialdehyde content of the plants increased up to 3.7-fold, thereby indicating a high level of Hg stress. The plants counteracted this stress by stimulation of antioxidant production, viz. ascorbic acid, glutathione and vitamin E. The three antioxidants increased up to 7.9-, 1.14- and 4.2-fold more, respectively than the control.

ABSTRACT

Original Research Paper: This study contributes to enhance the knowledge about cucurbits' behaviour in relation to heavy metals, in particular mercury chloride ($HgCl_2$), and their combination with plant growth hormones (here IAA). There is very little information on the effects of heavy metals on flowering and fruit formation in plants, particularly in cucurbits; this in itself makes the issue of interest apart from the interaction of heavy metals with hormones. Changes in various morpho-anatomical traits indicated that IAA can partially alleviate the detrimental effect of mercury in Hg-treated cucurbits. Effects of Hg and IAA were studied on flowering in *Cucumis sativus* L. and *Momordica charantia* L. It is suggested that plants under the stress of heavy metals can be treated with growth hormones to improve growth parameters, to avoid delay in flowering and likewise the quality

of fruit can be improved. The application of 400 mg/l IAA caused precocious flowering, leading to early fruit development. Mercury caused a significant delay in flowering, consequently leading to a reduction in the number of pistillate and staminate flowers. However, when IAA was applied with $HgCl_2$, there were fewer staminate and pistillate flowers, indicating the dominant effect of IAA. This study reveals that the inhibitory effects of heavy metals on flowering coudbe partially restored by phytohormones.

Zamin Shaheed Siddiqui, M. Ajmal Khan (Pakistan/South Korea), Beom-Gi Kim, Jeon-Sook Huang, Taek-Ryoun Kwon (South Korea) Physiological Responses of *Brassica napus* Genotypes to Combined Drought and Salt Stress (pp 78-83)

ABSTRACT

Original Research Paper: Physiological responses of *Brassica napus* genotypes were studied when drought and salinity stress were applied together. Irrigation of plants, which first started with 150 mM NaCl solution, was stopped when soil EC (electrical conductivity), NaCl EC and water fraction volume (WFV) values reached 0.04 dSm^{-1}, 0.64 dSm^{-1} and 15%, respectively. Growth, osmotic potential, ion concentration and stomatal conductance were determined. Fresh weight and dry weights were significantly affected by the combined stress. Fresh weight was abridged more than dry weight. The dry weights and leaf area per unit dry weights of treated plants were considerably reduced compared to unstressed, control plants. The osmotic potential of each genotype decreased in the combined-stressed plants compared to unstressed plants showing a variable trend regarding osmotic adjustment. Na^+ ions of each genotype increased significantly in the combined-stressed plants compared to unstressed plants. There were less K^+ and Ca^{++} ions in the stress-treated plants than in the control, unstressed plants. Stomatal conductance of each genotype was retarded by the stress combination. Variable physiological responses were found among the genotypes showing slow- and fast-growing ecotypes.

Marina I. Sysoeva (Russia), Grete G. Patil (Norway), Elena G. Sherudilo (Russia), Sissel Torre (Norway), Eugenia F. Markovskaya (Russia), Roar Moe (Norway) Effect of Temperature Drop and Photoperiod on Cold Resistance in Young Cucumber Plants – Involvement of Phytochrome B (pp 84-88)

ABSTRACT

Original Research Paper: The aim of this work was to study the importance of day length and the involvement of phytochrome B in plant responses to temperature drop. Experiments were conducted with the cucumber (*Cucumis sativus* L.) phytochrome B deficient mutant (*lh*) and the wild type (WT) under two photoperiods: short day (SD, 10 h at a PPFD of 180 $\mu mol \cdot s^{-1} \cdot m^{-2}$) and long day (LD, 16 h, 115 $\mu mol \cdot s^{-1} \cdot m^{-2}$). The following temperature treatments were used under both photoperiods for 6 days at the stage of first true leaf: constant temperature of 20°C (control), 12°C (long-term treatment) and temperature drop to 12°C for 2, 4, 6 or 8 h at the end of night and for 2 h at the beginning of the day under LD (drop treatments). Temperature drop was more efficient than a constant low temperature in increasing cold resistance under both photoperiods. LD increased the potential of the plants to develop a high cold resistance in response to a temperature drop. Maximal effect of temperature drop on the petiole length decreasing in the night was accompanied by the maximal cold resistance increment. The *lh* mutant showed the same cold resistance as the WT when grown at 20°C, but developed systematically lower cold resistance in response to a drop treatment in the night period than the WT. There was no effect of temperature drop duration in the night on cold resistance in *lh* mutant under both photoperiods but in WT under SD the cold resistance decreased with increasing duration during the night, while under LD it increased. The results suggest that phytochrome B is required for a maximum increase in cold resistance in cucumber under drop treatment.