

**LIPID PEROXIDATION AND THE
ANTIOXIDANT SYSTEMS IN SOYBEAN SEED
MATURATION AND GERMINATION**

By

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ABSTRACT

The biochemical changes taking place during soybean seed development and germination, and some aspects of desiccation tolerance were assessed with reference to lipid peroxidation and antioxidant systems. During normal seed development, fresh weight and dry weight increased between 20 and 50 days after flowering (DAF), concomitant with the accumulation of triacylglycerols and sugar reserves, after which dry weight remained almost unchanged, and fresh weight decreased. Seed moisture content decreased rapidly during the last stages of development. High levels of lipid peroxidation were evident between 20 and 45 DAF, and decreased thereafter. An examination of antioxidant systems revealed that whereas total glutathione levels accumulated continuously throughout the 80 days of seed development, both dehydroascorbic acid (DHA) reductase and ascorbate free radical (AFR) reductase increased concurrently with the increase in total ascorbate content, and the overall levels did not decrease markedly during maturation drying. Ascorbate peroxidase (ASC POD) activity was high during the period of greatest ascorbate accumulation. Both catalase (CAT) and superoxide dismutase (SOD) activities increased progressively during early seed development (20-40 DAF), but showed variable patterns of change during maturational drying, in marked contrast to ASC POD which declined from 40 DAF to undetectable levels at 70 DAF.

An assessment of the relationship between the antioxidant systems and lipid peroxidation was made during imbibition and germination, as it has been suggested that controlling free radicals was a critical event in early imbibition. Unexpectedly, lipid peroxidation increased progressively in both seeds and isolated axes, and were eight-fold higher at 48 hours of imbibition compared to dry tissues. A progressive, and co-ordinated, increase in CAT, total glutathione, total ascorbate pool, guaiacol POD, ASC POD, and SOD appeared to parallel the rise in lipid peroxidation in both whole seeds and axes. Variable responses were evident between seeds and axes for the enzymes AFR reductase and DHA reductase.

In order to gain a further insight into the dynamics of desiccation-tolerance and desiccation-sensitivity, imbibing seeds were subjected to an unscheduled dehydration treatment, and then rehydrated for up to 24 hours. During these hydration-dehydration-rehydration (H-D-R) treatments, changes in lipid peroxidation and antioxidant systems were measured. Concurrent with the loss of viability in the axes of seeds dehydrated after 24 and 36 hours of imbibition, there were increases in both lipid peroxidation and solute leakage. Unscheduled drying was seen to be a critical stage, as intolerant axes showed four- to eight-fold increases in lipid peroxidation, which were only partially reduced on subsequent rehydration. Tolerant axes, on the other hand, were able to maintain low, basal levels of lipid hydroperoxides on drying. The relationship between these observations and the antioxidant systems showed that the antioxidant enzymes CAT, ASC POD, AFR reductase, DHA reductase, guaiacol POD and SOD declined markedly during the unscheduled drying, whereas GSH and ASC declined only slightly. On rehydration, most of the enzymes,

total glutathione, and total ascorbate pool increased, the only exception being the loss of ASC POD activity. DHA reductase, which was seen to decrease as a part of normal germination, declined progressively also in H-D-R treatments. These results suggested that loss of viability was not attributable to a decline of the antioxidant systems but rather to the combined deleterious effects of increased lipid peroxidation, and a generalized and moderately compromised antioxidant system.

These studies have indicated that the occurrence of lipid peroxidation can be seen as a normal part of seed development and germination. The H-D-R studies, on the other hand, supported the concept that the balance between peroxidation reactions and the protective systems was critical to the development of desiccation tolerance.