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Storage reserves in the roots of leafy spurge

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Introduction

Many persistent weeds are perennial species in which the aerial parts die back annually leaving underground organs which must survive the winter and support the growth of new shoots in the spring. There are a number of types of perennial organs including corms, tubers, bulbs, rhizomes and roots which develop from shoots, roots or leaf bases. Despite their diverse developmental origins, these organs have in common the ability to accumulate abundant storage materials which are then mobilized to support regrowth of buds. Knowledge of the metabolism of storage compounds in perennial organs can provide information which may be useful in the application of management schemes.

In leafy spurge, the extensive root system is the perennial organ and possesses abundant carbohydrate and nitrogenous reserves. Carbohydrates comprise the bulk of storage reserves and are present in roots as starch and sucrose. Nitrate, amino acids and proteins are potential stores of nitrogen. We have been interested in the seasonal dynamics of storage reserves and in the environmental cues which regulate their metabolism.

Nitrogenous reserves

An examination of the free amino acid and soluble protein content in roots indicates that these compounds undergo extensive changes prior to the onset of winter. These compounds are present in relatively low quantities during the growing season, May to September. There is a dramatic increase in both amino acids and protein in October which is maintained through the winter until spring when shoots emerge. The specific amino acids and proteins which account for these changes were investigated further. Changes in aspartic acid, asparagine, glutamine, proline, and arginine accounted for most of the increase in free amino acids. These particular amino acids are common storage compounds because of low carbon to nitrogen ratio. The remaining amino acids showed little or no seasonal changes.

Extracts from leafy spurge roots were examined for the presence or storage proteins. Changes in specific proteins were determined by isolating soluble proteins from roots and separating them by SDS-Polyacrylamide gel electrophoresis. A protein with a molecular weight of 26 KD is present in roots which shows a seasonal pattern of accumulation and degradation. It is present in greatest quantities in extracts from September to January and absent or present in reduced quantities in other months. This protein is present only in the roots and is not visible in protein extracts from seeds or leaves. The seasonal pattern of accumulation of this protein suggests that it is a reserve of nitrogen which can be degraded to provide nitrogen to the root and buds.

Carbohydrate storage reserves

Seasonal changes in non-structural storage carbohydrates have been observed in roots of leafy spurge and in other perennial species. In general, there is a rapid accumulation of non-structural carbohydrates in roots after seed dispersal until top growth dies back followed by a decline in spring as buds emerge. Further changes occur in non-structural carbohydrates during winter months when polymeric reserves are depleted and lower molecular weight compounds accumulate.

In leafy spurge roots, starch accumulates in late summer and fall and is depleted during the winter months. In contrast, sucrose content is low in the season and in the fall and accumulates in winter months. The breakdown of starch provides energy for the root during the winter months and is a source of carbon for sucrose synthesis. Starch breakdown and accumulation of sucrose occur in other organs, such as potato tubers, and may aid in survival of low temperatures during the overwintering period.

The distinct changes in quantities of starch and sucrose suggest seasonal changes in the activities of enzymes responsible for synthesis and degradation of these compounds. We have investigated the enzymes involved in starch degradation in leafy spurge roots and the yearly pattern of activity of these enzymes. The complete degradation of starch to glucose requires the action of several enzymes. The activity of two enzymes, α-amylase and β-amylase, increases significantly in the fall and winter months concommitant with the decline in starch content. The activity of other enzymes in the pathway did not change significantly throughout the year.

Conclusions

Leafy spurge roots contain abundant stores of carbohydrates and nitrogen which are important in the overwintering and regeneration of new shoots in the spring. The storage reserves are present in roots in relatively low quantities during the growing season and accumulate in fall when top growth dies. Breakdown of starch and protein and synthesis of certain amino adds and sucrose occur in the winter months indicating that leafy spurge roots are not dormant at this time.