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SEASONAL IONIC FLUCTUATIONS IN A *TYPHA* *GLAUCA* COMMUNITY¹

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Abstract. Calcium, magnesium, potassium, sodium, iron, and phosphorus concentrations were measured in rhizomes, leaves, and floral stalks of a *Typha glauca* community during the growth season of 1968. Leaf-length and plant-organ moisture contents were also determined and used as indicators of physiological aging. Seasonal fluctuation was found in all ions examined in the soil and all plant parts analyzed. The ions studied were grouped into three categories with reference to apparent seasonal fluctuations of ionic concentrations. Concentration changes of calcium and possibly magnesium in plant tissue were inversely related to apparent changes in substrate concentration. Changes in concentration of potassium and phosphorus in floral stalks and leaves were inversely related to apparent changes in ion concentration in the rhizome, although not related to changes in the substrates. Changes in concentration of sodium and iron in all plant parts sampled were directly related, but no relationship was detected between the apparent changes in concentration in plant tissue and those in the substrates.

INTRODUCTION

The plant-substrate interaction has been reviewed by Fried and Broeshart (1967). Most studies to date have been laboratory-oriented, and little work has been completed under natural conditions. When field work has been undertaken, most studies have concerned terrestrial vascular plants, in particular agriculturally important species. Westlake (1965) has indicated the basic need of chemical data for the aquatic vascular plants. Some data of seasonal changes of aquatic plant mineral analysis and pigment concentration are now available (Foresberg 1960, Stake 1967, 1968, Boyd 1969, 1970a, b, Boyd and Hess 1970). However, none of these studies has considered the nutrient levels of native substrates in detail.

The predominant plant species of southern Ontario marshes is the cattail (*Typha glauca* Godr.). Apparent ion fluctuations of plant parts and the relation of such ion fluctuations to the apparent changes in the natural substrates have not been investigated. Therefore the following study was undertaken to provide detailed data on both *T. glauca* and its native soil. To study apparent nutrient fluctuations in *T. glauca* and its natural soil, the least complex situation of one substrate complex and one plant species was chosen for initial analysis. A pure stand of *T. glauca* was selected in a marsh of approximately 166 ha at Ramsayville, Ontario. The marsh is closed, in that it replenishes its moisture only through precipitation and runoff from the hills which surround it.

MATERIALS AND METHODS

The plant

In the Ottawa district *Typha glauca* commences active growth in late April. The current shoots are

derived from shoots which were initiated in the previous fall in late September. With cooling temperatures these shoots enter a period of quiescence which is maintained into the spring. Such shoots remain under 4 cm in height before spring growth. The shoots grow from nodes on the rhizome as well as at the juncture of previous season's shoots. As in most monocotyledonous species, leaf growth results principally from the activity of basal meristems.

The inflorescence consists of male flowers superior in position to female flowers, borne on a stalk which emerges from the center of the leaf whorl. The stalks first appear in early July, and elongation of the stalks occurs until pollination in late July. The inflorescence is overtopped by the mature leaves.

Soil

The soil beneath the *Typha* stand belongs to the Gleysolic order, Rego Humic Gleysol subgroup (Canada Department of Agriculture 1970). It is overlain with shallow water throughout the entire growing season. All samples show well-defined Ah and Cg horizons. The L-H is extremely shallow, seldom in excess of 1 cm deep. The Ah horizon varies from 10 to 30 cm deep with the parent Cg extending below. The rhizosphere of the cattails is restricted to the Ah horizon, and all the soil chemical analysis appearing in this paper is based exclusively on the results from this horizon.

Sampling and analysis

Vegetation and soil samples were taken a minimum of twice weekly throughout the growing season commencing May 7, 1968, and continuing until October 1, 1968 (week 1 to week 22). Samples were then drawn on alternate weeks until November 15 (week 28), at which time sampling was terminated. Each plant to be sampled was chosen at random by throwing a meter stick into a delineated 30-m

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square homogeneous stand and picking the cattail closest to the resting point of the meter stick. A soil sample was then drawn close to the plant to be harvested. Soil samples were drawn with a split-core soil corer which produced an undisturbed core. A measure of growth was obtained by measuring leaf length of the chosen cattail. Finally, the plant was harvested and divided into leaf, rhizome, and floral stalk samples. All samples, both plant and substrate, were chilled in a portable cold chest. Small portions of the soil sample and the entire leaf, rhizome, and floral stalk samples for moisture determinations were sealed in airtight tins to prevent moisture loss during transport to the laboratory. All chemical and physical values were averaged to yield a mean value for each week. Week 1 was the week commencing May 5, and week 28 was the week commencing November 10.

Moisture content of plant material was determined when the samples were returned to the laboratory. Samples were then dried and ground for chemical analysis according to methods described in Jackson (1965). The ground plant samples were dry-ashed, and the ash was extracted for total cations with 6N HCl (Jackson 1965). Bertramson's modified dry-ashing procedure was employed for extraction of total phosphorus as described in Jackson (1965). Available cations in soil samples were extracted by the centrifuge method with neutral 1 N ammonia acetate extracting solution (Jackson 1965). Dilute fluoride dilute acid-soluble phosphorus was extracted from all soil samples by the filtration method (Jackson 1965). Determination of calcium, magnesium, iron, and sodium concentrations of soil and plant material were made using the absorption mode of the Jarrell-Ash flame spectrophotometer, model 82-270. Potassium was determined with the same instrument on the emission mode. Phosphorus content was determined colorimetrically by the method of Daniel and Neal (1967) with a Bausch and Lomb Spectronic 20.

RESULTS

Growth phenomena and moisture content

Moisture content of the leaf tissue was high until the 12th week (July 21) after which it decreased continually until termination of sampling (Fig. 1). Floral-stalk tissue exhibited a continual decline from initial detection; rhizome tissue maintained a constantly high moisture level. Leaf length peaked in the 12th week (July 21) (Fig. 2). After this date, desiccation, shrinkage, and fragmentation of the terminal portions of the leaves resulted in a reduction of leaf length. The end of leaf elongation was coincident with pollination and apparent reduction of moisture content of the aerial portions of the plant (Fig. 1).

FIG. 1. Seasonal (May–November) moisture content of leaves, rhizomes, and flower stalks of *Typha glauca*.

FIG. 2. Seasonal (May–November) leaf length of *Typha glauca*.

If constancy of percentage moisture in plant material is considered a measure of regularity of metabolic activity, any deviation suggests a departure from such regular behavior. In the case of leaves of perennials, this deviation may represent incipient senescence. However, increasing weight of supporting tissue and cutins without decrease in weight of mesophyll tissue per unit area also results in an apparent moisture loss of plant material. The observed moisture-content decrease can be attributed to the sum of these two processes. Since moisture-content loss in the aerial portions of these cattails is coincident with decrease in leaf length, initiation of senes-

FIG. 3. Seasonal variation in calcium content of leaves, rhizomes, and flower stalks of *Typha glauca* and in calcium content of the soil at the plant site.

cence is considered to have occurred shortly after the 12th week of sampling.

Calcium

Calcium content in the leaf tissue of *T. glauca* increased at the seventh week (June 16) (Fig. 3), coincident with the period of leaf extension (Fig. 2). This increase continued until the 12th week (July 21), which coincides with the peak of leaf extension

and the initiation of senescence. With the advance of senescence the calcium content of the leaf tissue was reduced. The apparent decrease of leaf-tissue calcium at this point of the growth season is due to the removal of the soluble fraction of calcium by translocation and leaching from the senescing leaf tissue. Insoluble structural calcium remains in the leaf tissue and accounts for the apparent increase of calcium in the last month of sampling. The latter apparent increase of structural calcium is relative to the loss of other components from this tissue such as magnesium (Fig. 4), sodium (Fig. 5), potassium (Fig. 7), and phosphorus (Fig. 8). Upon first appearance of the floral stalks in week 8 (June 23) high concentrations of calcium were detected in this tissue. A rapid decline of calcium occurred in the floral-stalk tissue in week 9–10 (June 30–July 7) with a continuous lower rate of decline from this point until the end of the sampling period. The early high concentrations of calcium in this tissue represent the sum of the soluble calcium being translocated to the inflorescence and the structural calcium bound within the floral stalks. The sharp decline of calcium from week 9 to 10 is the result of the termination of translocation of the soluble calcium to the inflorescence, and levels detected at this time presumably represent the structural calcium remaining in the floral stalk. Further decline in calcium content of the floral stalk, with senescence of the floral stalk after termination of flowering, is presumably due to leaching of calcium from the structural component. The rhizome-tissue calcium-concentration curve parallels that of the leaf tissue with a smaller overall variation of the minimal and maximal values. The apparent increase of calcium in the rhizome may be due to the absorption of the soluble calcium in response to demands by the developing leaves and floral stalks. The low calcium content in the rhizome tissue at termination of sampling indicates that soluble calcium lost from the leaf and floral stalk is not retained in the rhizome tissue, but rather is returned to the substrates. The soil sample shows a coincident loss of calcium with increase in the plant material, and a coincident increase when calcium content in the plant material decreases.

The calcium contents determined on the cattail stand suggest that soluble calcium ions are absorbed by the plant tissue and translocated to active sites of growth. This apparent uptake by the plant tissue is reflected by a coincident depletion in the soil substrates of the rhizosphere. The remaining soluble calcium not utilized in structural components of the cattail tissue is returned to the substrates upon termination of active growth. Some structural calcium may be removed to the substrates directly by leaching, but this is a minor component. The low levels of calcium at termination of sampling in each organ are con-

sidered to represent the total amount of calcium structurally incorporated into the plant tissue.

FIG. 4. Seasonal variation in magnesium content of leaves, rhizomes, and flower stalks of *Typha glauca* and in magnesium content of the soil at the plant site.

Magnesium

In all plant tissue studied, magnesium declined gradually from initiation of sampling in May until termination of sampling in November (Fig. 4). A slight increase may occur in the soil. The decreases in magnesium coincident with senescence indicate that some magnesium is lost from the plant tissue

FIG. 5. Seasonal variation in sodium content of leaves, rhizomes, and flower stalks of *Typha glauca* and in sodium content of the soil at the plant site.

after active growth and returned to the substrate since a decrease occurs in the rhizome tissue.

Sodium

Sodium concentrations of the leaf and rhizome tissue (Fig. 5) both peaked in week 12 (July 21) and thereafter declined continuously until termination of sampling (Fig. 5). The floral stalks showed a continual decline of this ion from first detection. These high levels are coincident with both flowering and high levels in the soil samples. Although the initial gradual increase in this tissue may be associated with the early growth phenomena, the coincident peaking in the soil sample suggests that the concentration increase in these tissues is a passive response to the plant environment. The marsh receives some runoff from a nearby road system, which is salted in the winter, so that sodium increases in the substrate are to be expected.

Iron

Iron concentration was inversely related to calcium in all tissues (Fig. 6). Initial and terminal peaks were observed in the leaf and rhizome tissue. The floral-stalk tissue showed an initial low with a slight increase to termination of sampling. The soil did not show coincident fluctuations in iron. The apparent

FIG. 6. Seasonal variation in iron content of leaves, rhizomes, and flower stalks of *Typha glauca* and in iron content of the soil at the plant site.

decrease at the 12th week may be considered as a concentration effect within the plant tissue due to high levels of other ions at this point of accelerated growth and flowering. With high total ion concentration at early growth stages, iron concentration appears low. Upon senescence and loss of calcium and other ions from plant tissue, the iron concentration appears to increase relative to the overall ion concentration.

FIG. 7. Seasonal variation in potassium content of leaves, rhizomes, and flower stalks of *Typha glauca* and in potassium content of the soil at the plant site.

Potassium

The leaf-tissue concentration of potassium was inversely related to the rhizome-tissue concentrations (Fig. 7). Leaf-tissue concentration was high during early meristematic activity and then declined continually from week 4 (May 26), which is prior to completion of elongation or senescence in the leaf tissue. The floral-stalk tissue maintained a high potassium level throughout the sampling period. The soil sample did not show coincident fluctuations with the plant material. Potassium is apparently primarily transferred from the leaf tissue to the rhizome tissue for storage after initiation of early meristematic activity and initial leaf elongation. No transfer was detected between plant and soil material.

Phosphorus

The leaf-tissue concentration of phosphorus was inversely related to the rhizome-tissue concentrations

FIG. 8. Seasonal variation in phosphorus content of leaves, rhizomes, and flower stalks of *Typha glauca* and in phosphorus content of the soil at the plant site.

(Fig. 8), as it is for potassium. An initial high peak in leaf-tissue phosphorus was reached in the months of May and June; a gradual continual decline set in after week 8 (June 23) and continued until termination of sampling. The rhizome tissue showed a coincident and opposite response. The floral stalks, as in the other ions analyzed, exhibited a continual decline from first appearance of the stalk. Soil concentration of potassium varied independently of plant tissue. Phosphorus is apparently maintained in the leaf tissue during the period of active growth (Fig. 2) and is apparently transferred to the rhizome tissue for storage upon senescence of the leaf tissue. No transfer was detected between the soil and plant material.

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