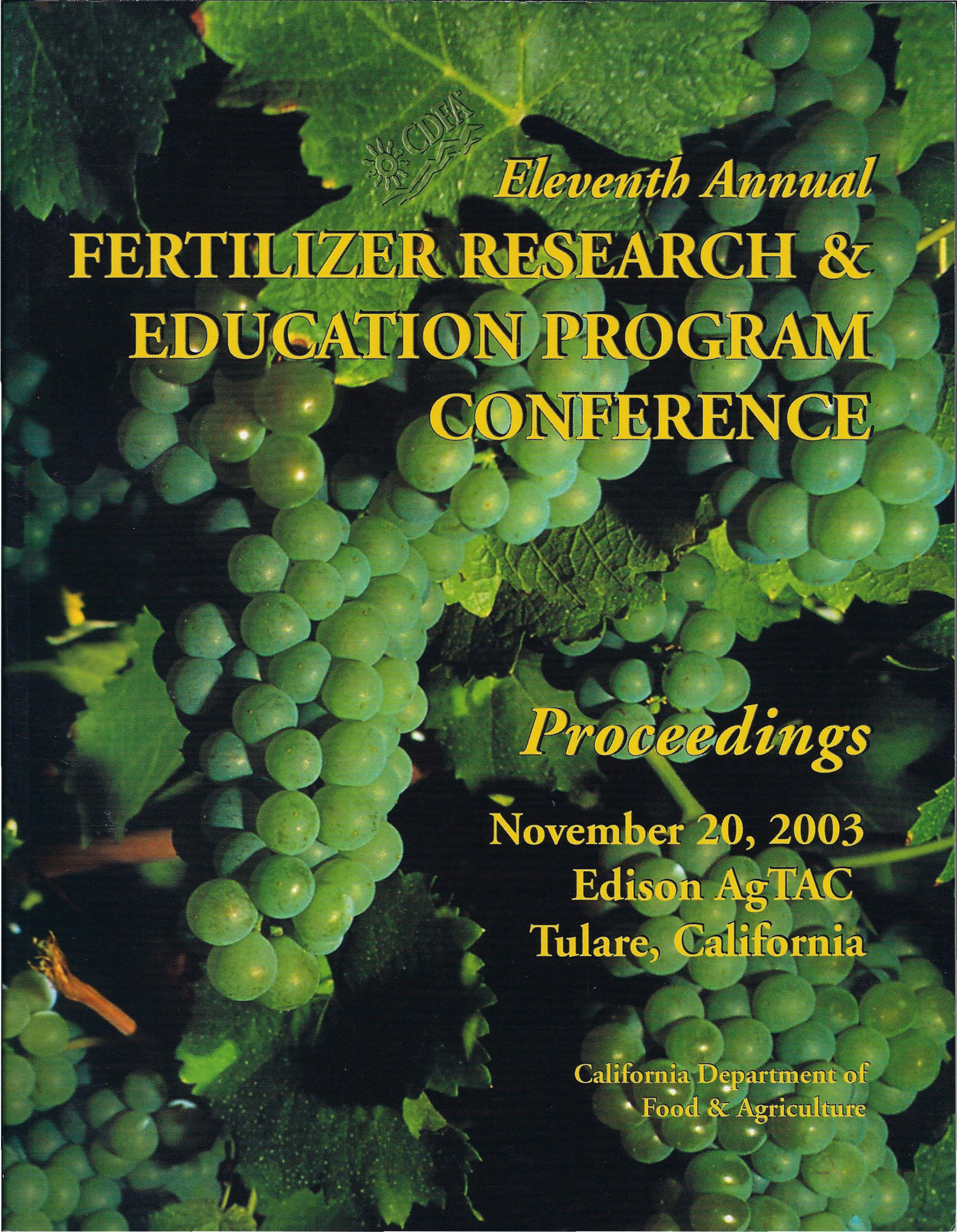

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SEASONAL PATTERNS OF NUTRIENT UPTAKE AND PARTITIONING AS A FUNCTION OF CROP LOAD OF THE 'HASS' AVOCADO

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INTRODUCTION

For the 'Hass' avocado (Persea americana L.) industry of California, optimal rates and times for soil fertilization of nitrogen, phosphorus and potassium have not been adequately determined. Fertilization rates and optimal leaf nutrient ranges have been borrowed from citrus. Competition from Mexico and Chile requires the California avocado industry to increase production per acre to remain profitable. Optimizing fertilization is essential to achieve this goal.

The seasonal pattern of nutrient uptake is a key component of fertilizer management. Matching fertilizer application times and rates with periods of high nutrient demand not only maximizes yield, but also increases nutrient-use efficiency and, thus, reduces the potential for groundwater pollution. Experiments on nutrient uptake and allocation are routinely done to develop best management practices for commercial annual crops. However, determining nutrient uptake in mature trees is considerably more difficult, requiring repeated tree excavations at important phenological periods over the season. Thus, few best management practices have been developed for perennial tree crops.

The goal of this project is to determine the seasonal pattern of nutrient uptake and partitioning in alternate-bearing 'Hass' avocado trees. The research will quantify the amount of each nutrient partitioned into vegetative or reproductive growth and storage pools. The research will identify the periods of high nutrient use from bloom to harvest as a function of crop load, and thus identify the amount of each nutrient required and when it is required to produce an on-crop and good return crop the following year. The results will enable us to provide guidelines for fertilization based on maximum nutrient-use efficiency and eliminate applications made during ineffective periods for uptake to thus protect the groundwater and increase profitability for California's 6,000 avocado growers.

PROJECT OBJECTIVES

1. Quantify the seasonal pattern of N, P, K, B, Ca, and Zn uptake and partitioning in 'Hass' avocado trees bearing.
2. Quantify the effects of different crop loads on these seasonal patterns of nutrient uptake, partitioning into vegetative and reproductive growth, and storage.
3. Determine the seasonal patterns of nutrient uptake in alternate bearing avocado trees and develop best management fertilizer practices for the 'Hass' avocado tree.

PROJECT DESCRIPTION

The research was conducted in a commercially bearing avocado orchard in Somis, CA. In June 2001, 60 trees were selected for inclusion in the project based on their trunk diameter, height, canopy size, and fruiting potential. Thirty of these trees were subsequently defruited to establish both lightly fruiting and heavy fruiting trees. The experiment was set up as a completely randomized design, with factors: 1) cropping status (heavily cropping—On and lightly cropping—Off trees), and 2) time of excavation. Two trees (an on- and an off-year tree) were excavated monthly between November 2001 and December 2002 for a total of 13 excavation dates. The entire tree (roots and shoots) was excavated every third month (4 dates), and the above ground dry matter was harvested for the other nine dates. Trees were dissected into the following components, and the total weight of each component determined: leaves, new shoots, inflorescences or fruit (separated into seed and flesh), small branches (£ 2.5 cm), mid-size branches (2.5-5.0 cm), scaffolding branches, scion trunk, rootstock trunk, scaffolding roots, small roots, and new roots. Sub-samples were dried, ground, and analyzed for carbon, nitrogen, nitrate-nitrogen, phosphorus, potassium, calcium, iron, magnesium, manganese, zinc, boron, sulfur, copper, sodium, chloride, and aluminum.

Ten percent ^{15}N enriched ammonium sulfate was applied on three dates (August 15, 2002; November 14, 2002; June 15, 2003) and whole trees were excavated three months after application and analyzed for percent ^{15}N recovery. ^{15}N analyses from the June 15 tree excavation are currently being conducted, and these data will be reported at a later time. These data will be used to determine periods of high N uptake capacity in avocado trees and evaluate the effects of alternate bearing on N uptake and recovery. Such data are required to develop best management N fertilized practices.

Data Analysis

The results obtained were used to calculate gram nutrient per tree by the following equation using nitrogen as the example:

g N/g dry wt tissue X g dry wt tissue/g fr wt tissue X total fr wt tissue/tree = total g N/tree

Nutrient uptake was determined as the difference in total tree nutrient contents from sequential tree excavations and from ^{15}N recovery in the various tree parts

RESULTS AND CONCLUSIONS

Leaf N Concentrations.

Alternate bearing had little effect on the changes in leaf N concentrations over the season (Figure 1). Leaf N concentrations tended to increase over the season; however, few differences were seen between on- and off-year trees. This is surprising since avocado trees accumulated significant quantities of nitrogen in their fruit and this demand was not reflected in lower leaf N concentrations. In other alternate bearing species such as pistachios, leaf N concentrations are frequently lower in on- vs off-year trees. This indicated that avocado leaves are highly buffered against large N demands by the fruit.

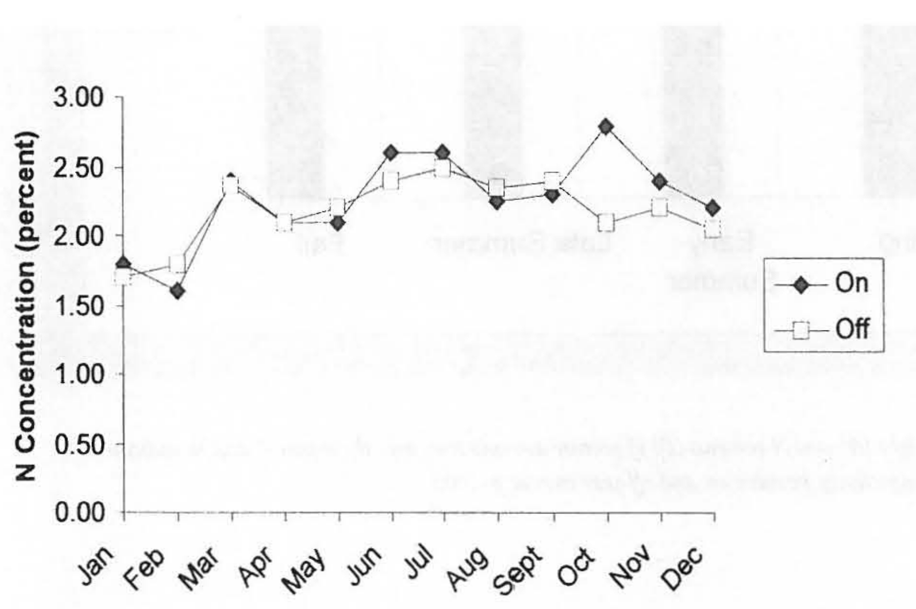

Figure 1. *Effect of alternate bearing on leaf N concentration over the 2002 season.*

Total Tree N Accumulation

Total aboveground tree dry weight and N contents were averaged over a three-month period in the spring (January - March), early summer (April - June), late summer (July -September), and fall

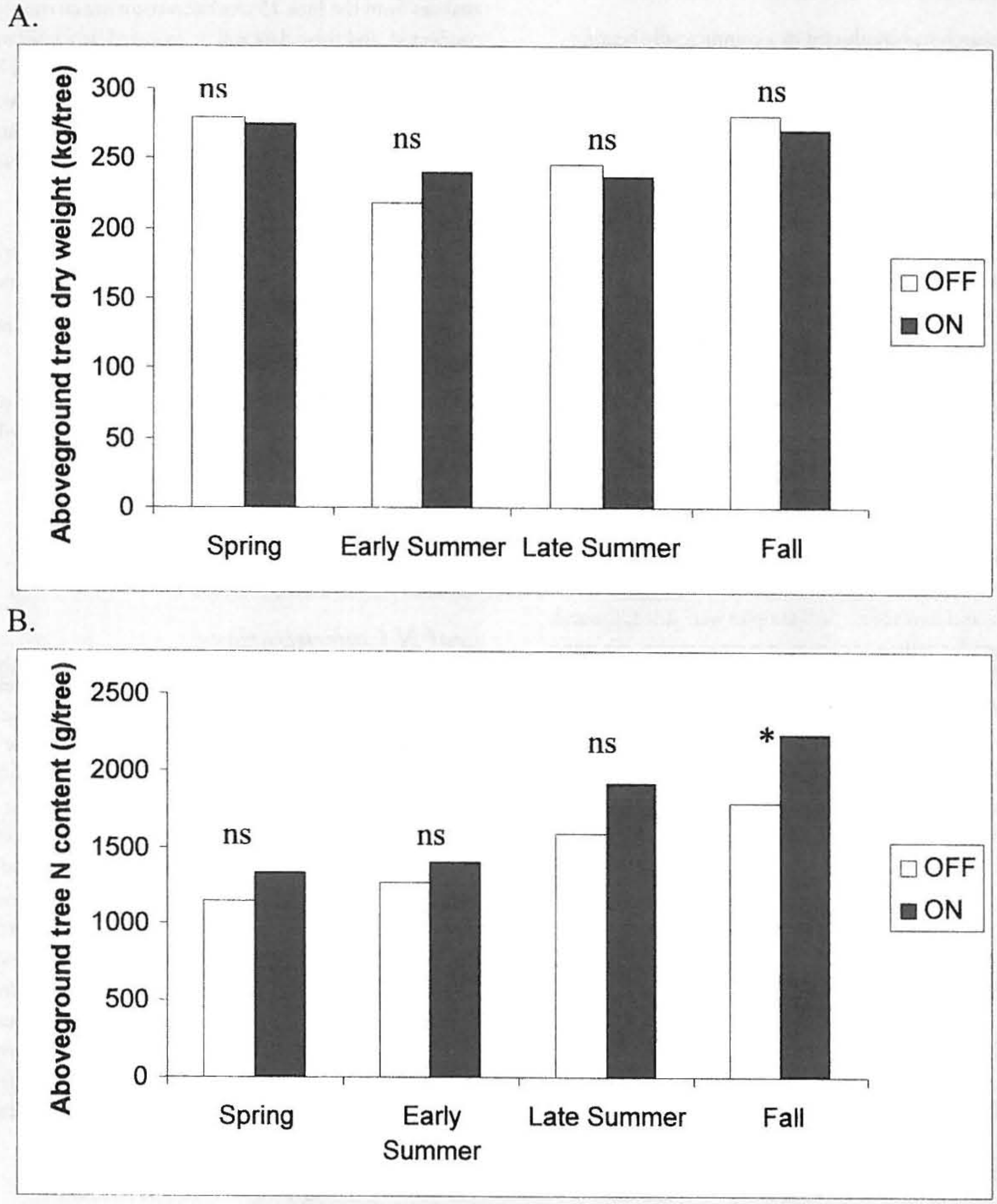

Figure 2. *Aboveground tree day weight (A) and N contents (B) of mature avocado trees over the season. * and ns indicate significance and non-significance, respectively, between on-and off-year trees at p=0.05.*

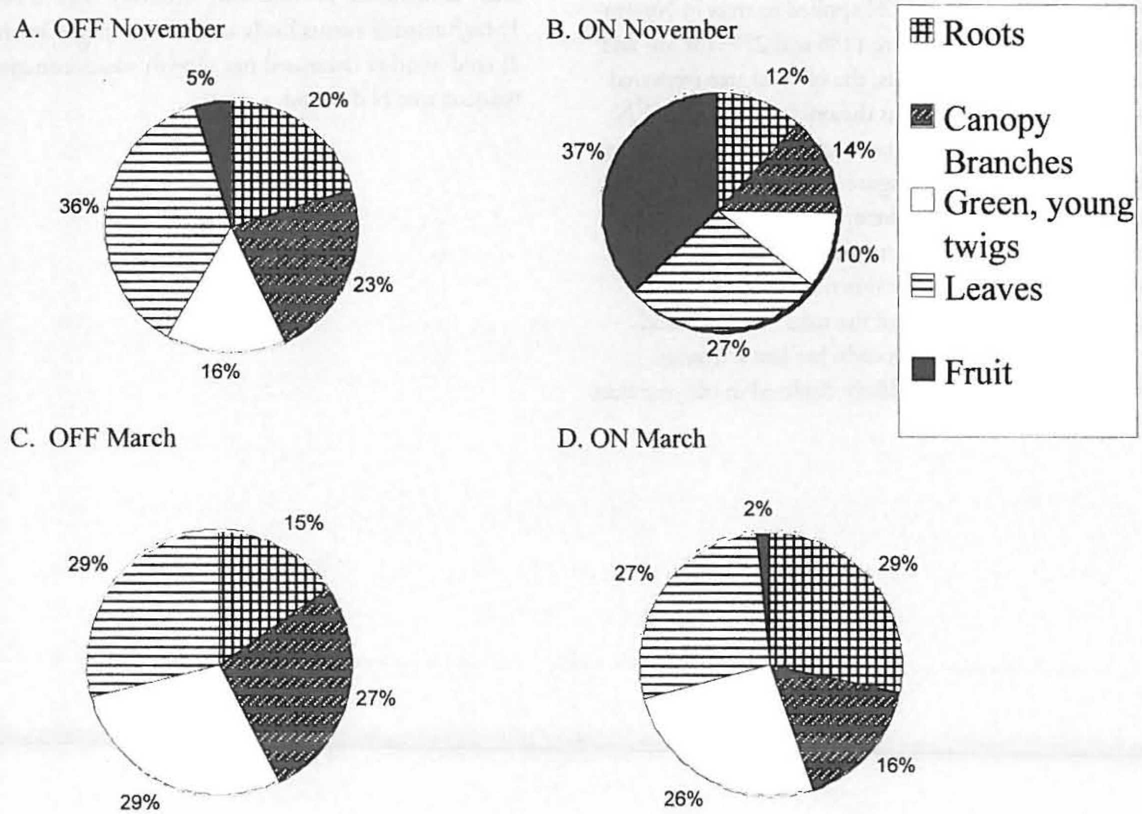

Figure 3. *^{15}N distribution of mature off-(A) and on-year (B) avocado trees, applied August 15, 2002 and excavated on November 14, 2002, and ^{15}N distribution in off-(C) and on-year (D) trees applied November 14, 2002, and excavated on March 15, 2003.*

(October - December) for both on- and off-year trees (Figure 2). No significant differences were found in total tree dry weight over the season. In contrast, tree N contents increased over 50% in both on-and off-year trees between the spring and fall. Increases in leaf N and fruit N (in on-year trees only) pools over the season were the primary factors in producing these increases in tree N status (data not shown). In the fall, heavy fruit loads resulted in on-year trees containing significantly more N than off-year trees (Figure 2B).

^{15}N Uptake and Distribution

^{15}N was applied to an on- and off-year tree in August 2002 and trees were excavated in November 2002. Percent ^{15}N recoveries in November were 59% and 35% for the on and off-year tree, respectively. The on-year tree recovered almost double the amount of ^{15}N as the off-year tree (data not shown). Most of the ^{15}N recovery in the on-year tree accumulated in the fruit, whereas leaves were the main repositories for ^{15}N in the off-year tree (Figure 3). In both the on- and off-year tree, the majority of the ^{15}N was translocated out of roots and accumulated in actively growing tissues such as fruit, leaves, and green twigs (Figure 3). These results support the hypothesis that N uptake is regulated by tree N demand. On-year trees have a large N requirement and therefore more is taken up to meet that demand.

These recovery percentages in both on- and off-year avocado trees are high compared to the typical 15-30% ^{15}N recovery rates reported in the deciduous fruit crop literature. This indicates that August fertilizer N applications are efficiently taken up by roots and mobilized by the tree.

Avocado trees have very dense root mats, which may have contributed to the high ^{15}N recovery rates.

The percent recovery rates of ^{15}N applied to trees in November and excavated in March were 11% and 27% for on- and off-year trees, respectively. Thus, the off-year tree recovered more than twice as much ^{15}N as the on-year tree. The ^{15}N accumulated equally between leaves, green twigs, and canopy branches in the off-year tree (Figure 3). In contrast, the roots accumulated the most ^{15}N in the on-year tree. This lack of ^{15}N translocation out of roots may indicate a lower N requirement for on-year trees at this time. Young fruits accumulated only two percent of the total ^{15}N recovered. Anthesis and fruit growth in avocado has just started in March, whereas N reserves are likely depleted in off-year trees at this time.

The ^{15}N recovery rates were markedly lower when applied in November compared to August. The cold and wet weather likely contributed to these lower recovery rates in two ways: 1) high rainfall events likely increased nitrogen leaching, and 2) cold weather decreased tree growth which concomitantly reduced tree N demand.