FINAL REPORT
WTFRC Project # __ AH-01-66__ Organization Project # (if applicable) ___________.

Project title: Modeling of growth stage and temperature on spring nitrogen uptake and Modeling of apple crop load in relations to nitrogen reserve status and trunk size

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Objectives:

1. Determine the effect of fall foliar urea applications on N reserve and fruiting.
2. Determine the relationship of growth stage and temperature on the current season N uptake.
3. Develop a computer model to predict apple crop load based trunk size and reserve N status of dormant plants.
4. Develop a computer model on nitrogen uptake in relation to growth status and soil/air temperature.

Significant findings:

1. Fall foliar 3% urea application significantly increased spur reserve nitrogen of Gala and Cameo apple trees.
2. Fall foliar urea application significantly increased ‘Gala’, ‘Fuji’, and ‘Cameo’ fruit set and there was a trend of increasing tree fruit yield but not significantly.
3. These studies suggest that we may be able to predict fruit yield by relating fruit yield to trunk sectional area and based on this information we have developed a model and software for predicting fruit yield (e.g. fruit numbers and size) by measuring trunk cross-sectional area.
4. Spring nitrogen uptake in newly established potted Fuji apple trees and field grown 3-year-old Fuji trees were not detected until at least three weeks after budbreak. Spring nitrogen uptake in pot-in-pot grown ‘Fuji’ apple trees was not detected until about 30 days after budbreak; the uptake of nitrogen in the spring was temperature and growth stage dependent.
5. The results of this study suggest that we may be able to predict spring N uptake by relating N uptake to temperature and growth stage.

Methods:

Study I: Effect of fall foliar urea application and tree fruit number on tree yield and fruit size

Four year old ‘Fuji’/M26 trees grown in 20 gallon containers in a pot-in-pot system at the OSU Lewis-Brown Horticulture Farm, Oregon were used in this study. Trees were divided into two groups: 1) foliar urea at 3% was applied 2 times in October, 2000-2002 and the 2) control was sprayed with water on the same treatments dates. During the dormant season, after defoliation, spur and shoot samples were collected and analyzed for total nitrogen by the Kjedahl method

Study II: Effect of fall foliar urea application on reserve nitrogen, tree fruit number, yield and size

Three tree growth performance types of vigorous, moderate and weak of 'Cameo'/M9 bearing apple trees were selected at Fleming's orchard in Orondo, Washington. Each tree type was further divided into the following four subgroups: a) 3% urea applied at either 2 or 3 times beginning after harvest in late October. The treatments were applied at weekly intervals. During the dormant season, spur and shoot samples were collected and analyzed for total nitrogen by the Kjedahl method. Growth performance was recorded the following season, and fruit number, size and yield were measured at harvest time.

Study III: Effect of soil and air temperature and tree growth stage on N uptake

Pot-in-pot Fuji/M.9 trees growing at the LB Horticultural Farm, OSU were fertigated with 150 ppm N as urea from March 11 (about 20 days before bud break) to July 9. At different phenological stages samples were harvested and analyzed for N^{15}. The air and soil temperature at 20cm were recorded to determine the relationship between temperature, phenological stage and N^{15} uptake.

Study IV: Effect of soil and air temperature and tree growth stage on N uptake in orchard conditions

Fuji/M.9 trees were planted and fertigated with 150 ppm N of $Ca(NO_3)_2$ by using a atmometer-equipped drip system during the growing season at the Agriculture and Agri-Food Canada, Summerland, BC in 1999. In 2000, the trees were fertigated with 150 ppm N^{15}-$Ca(NO_3)_2$ from bud burst (March 28) to full bloom (July 28). At different phenological stages samples were harvested and analyzed for N. The air and soil temperature at both 10 and 20cm were recorded to determine the relationship between temperature, phenological stage and N^{15} uptake.

Results and discussion:

1. **Effect of Fall Foliar Urea application on Nitrogen reserves**
   - **Pot-in-pot system OSU Study at LB Farm of OSU:**

   Two applications of 3% urea applied as foliar sprays in the fall significantly increased spur reserve nitrogen of "Gala" and 'Fuji' apple trees grown in the pot-in-pot system at the LB Horticultural Farm of OSU. There was trend to increase shoot reserve nitrogen but not significantly based on the results of 3 years (Fig 1, 2 and 3).

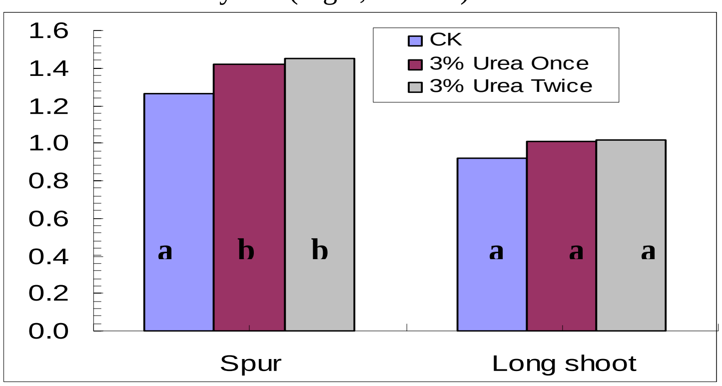

Fig 1. Effect of fall foliar urea application on Gala reserve N of pot-in-pot system (2001)

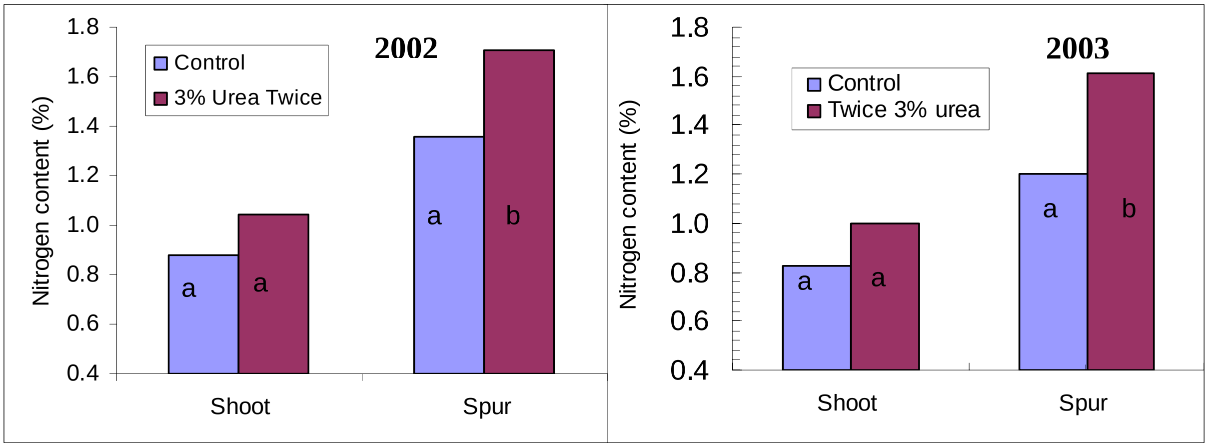

Fig 2. Effect of fall foliar urea application on Fuji reserve N of pot-in-pot system

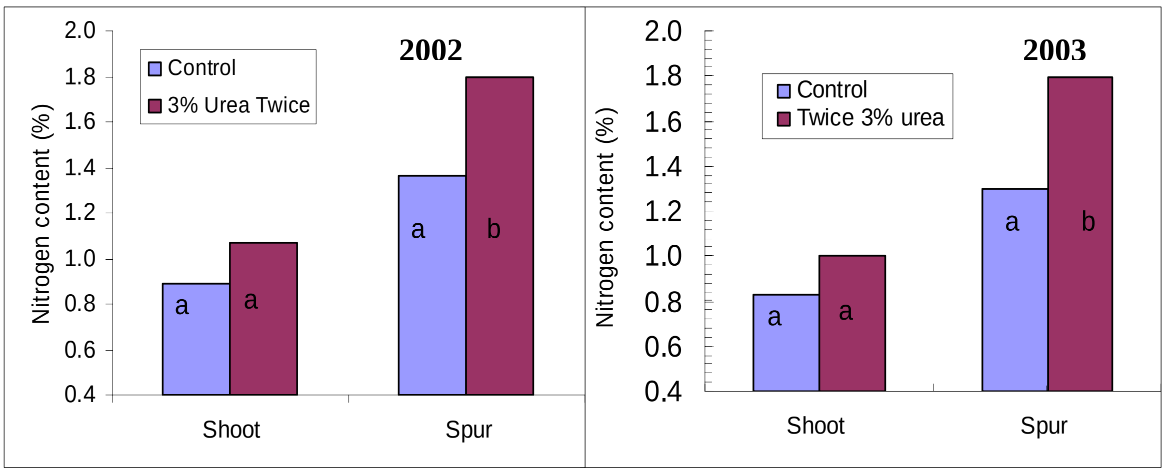

Fig 3. Effect of fall foliar urea application on Gala reserve N of pot-in-pot system

- **Field Study at Fleming Orchard:**

Fall foliar 3% urea application significantly increased spur nitrogen content in 'Cameo'/M9 apple grown at the Fleming's orchard in Orondo, Washington. Shoot reserve nitrogen increased slightly in 2001 and 2003 results (Fig. 4).

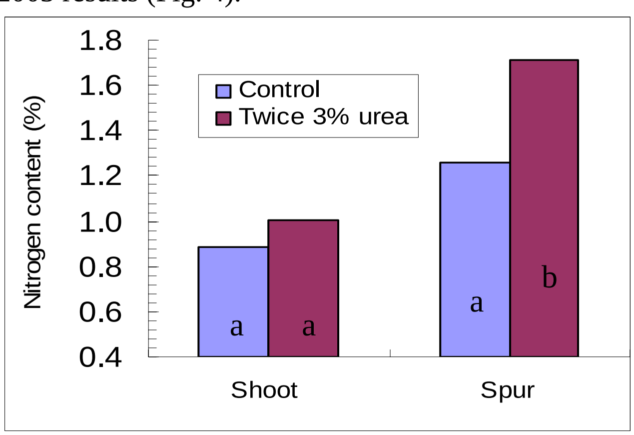

Fig4. Effect of fall foliar urea application on Cameo reserve N in orchard conditions (2002)

2. Effect of fall foliar urea application on fruit set in both pot-in-pot system and orchard conditions

Reserved N is very important for fruit cell division and fruit set. Fall foliar urea application significantly increased tree and cluster fruit numbers of 'Fuji' and "Gala' in the pot-in-pot system at OSU LB Horticultural Farm and Cameo/M26 under orchard conditions at the Fleming Orchard, Orondo, Washington (Fig.5 to 7).

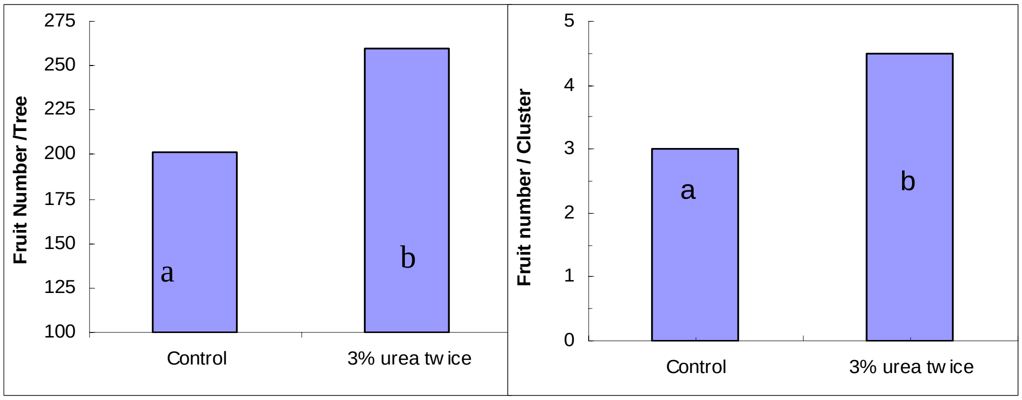

Fig5. Effect of fall foliar urea application on Fuji fruit set in pot-in-pot (2002)

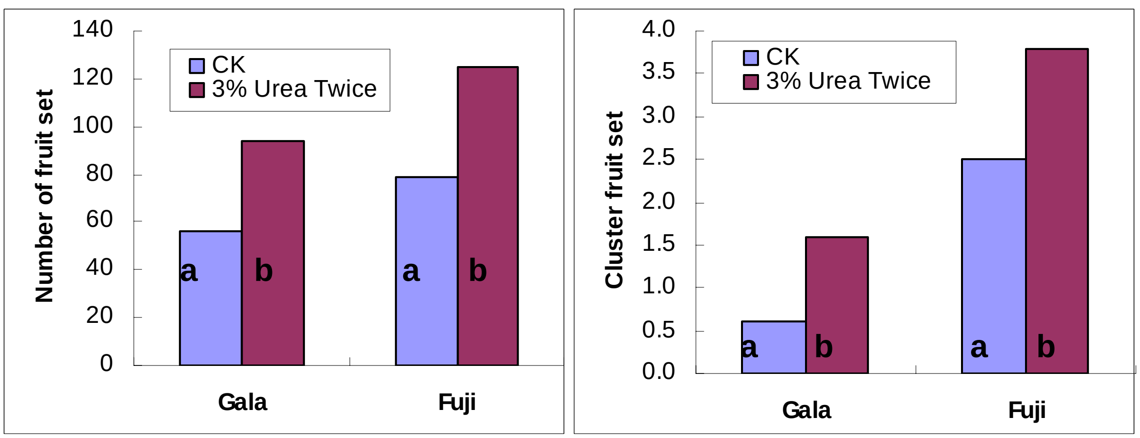

Fig 6. Effect of fall foliar urea application on Fuji fruit set in pot-in-pot (2003)

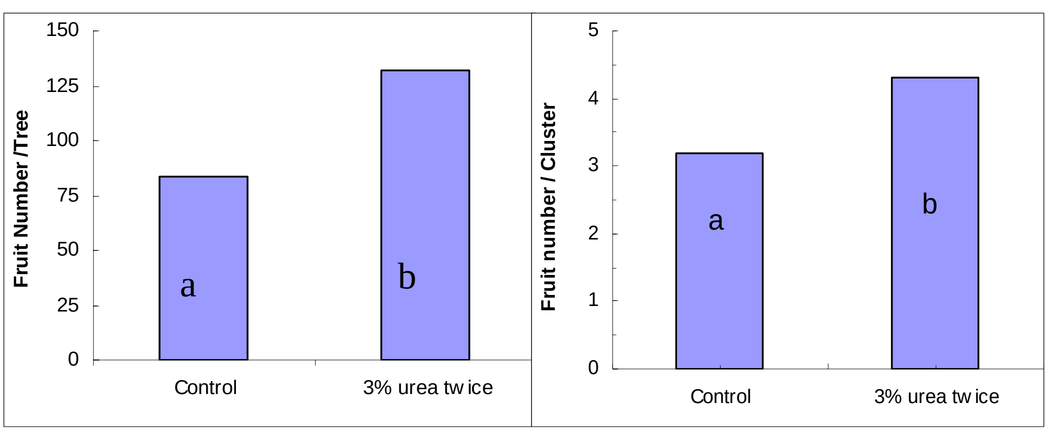

Fig 7. Effect of fall foliar urea application on Cameo fruit set in field conditions at Fleming Orchard, Orondo, Washington (2002)

3. Effect of urea treatments on fruit yield of Fuji apple in pot-in-pot system

Two foliar applications of 3% urea during the fall slightly increased 'Fuji', 'Gala' and 'Cameo' apple tree total yield, unit trunk sectional area, fruit weight and fruit size but not significantly (Fig.8 to 12). There are two possible reasons why fall foliar urea application did not increase fruit yield: (1) Fruit development was mainly based on the current year nitrogen uptake; and/or (2) Fruit thinning abated the fall foliar application effect.

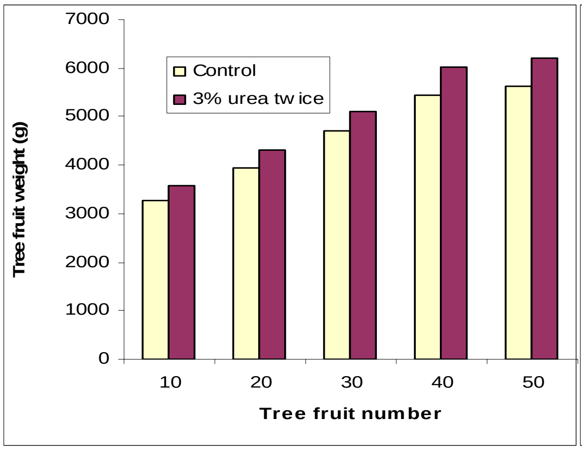

Fig 8. Effect of 3% fall foliar urea application on 'Fuji' tree yield (2002)

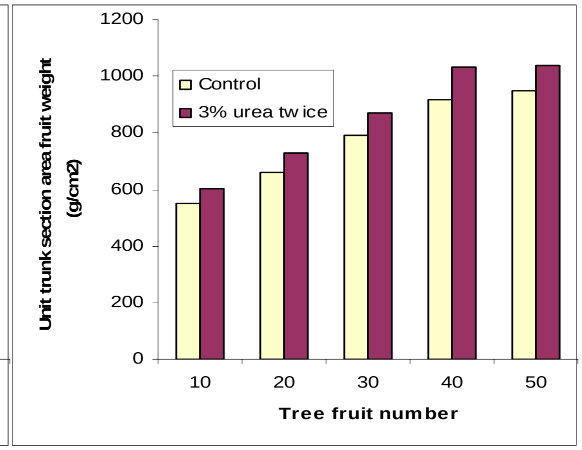

Fig 9. Effect of 3% fall foliar urea application on 'Fuji'unit trunk section area crop load (2002)

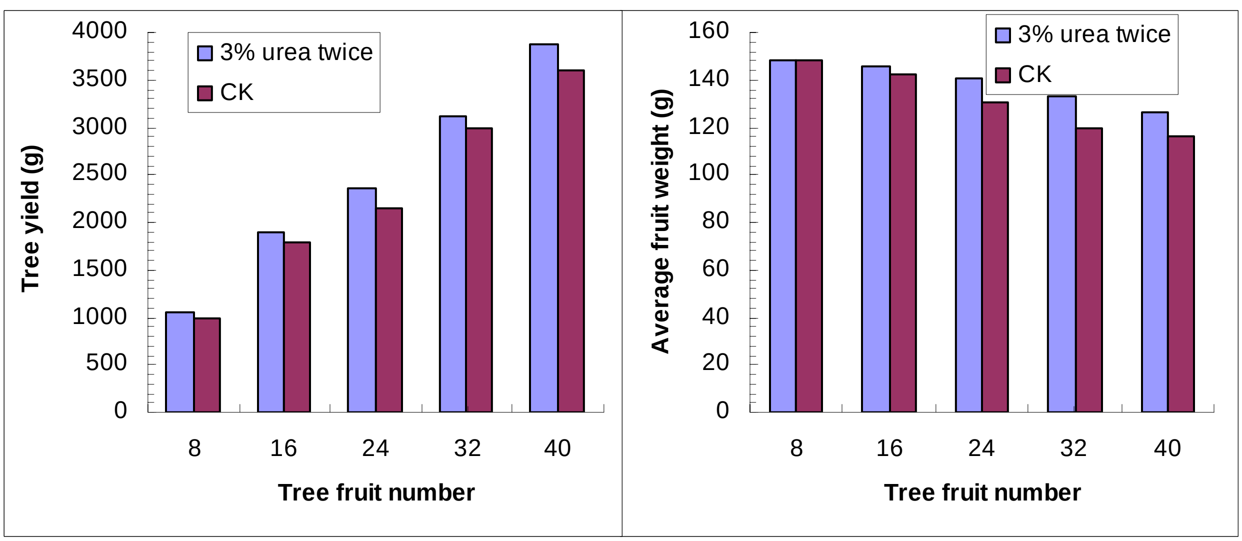

Fig10. Effect of 3% fall foliar urea application on Gala tree yield and fruit size (2003)

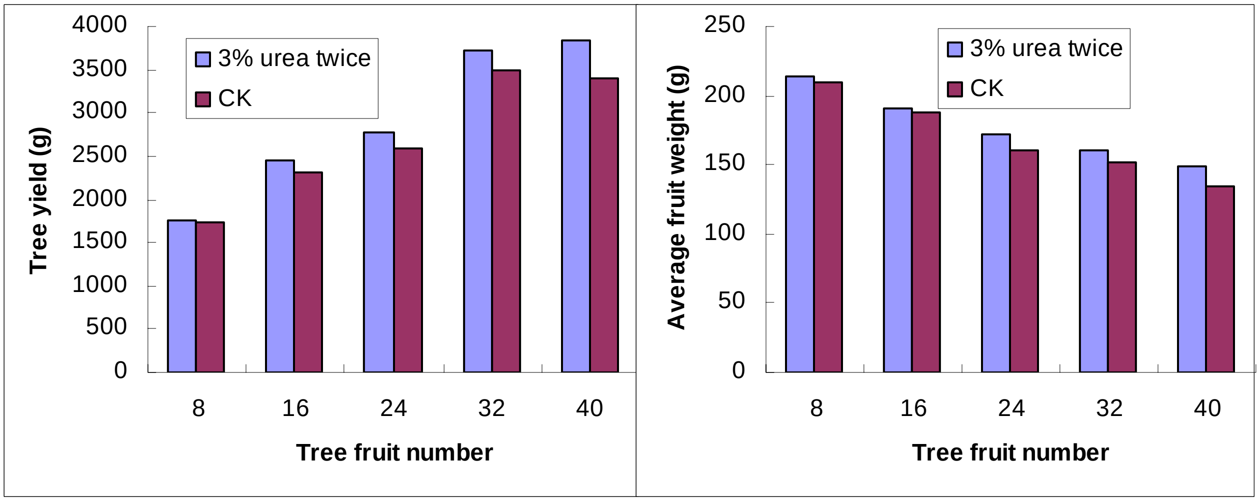

Fig11. Effect of 3% fall foliar urea application on Fuji tree yield and fruit size (2003)

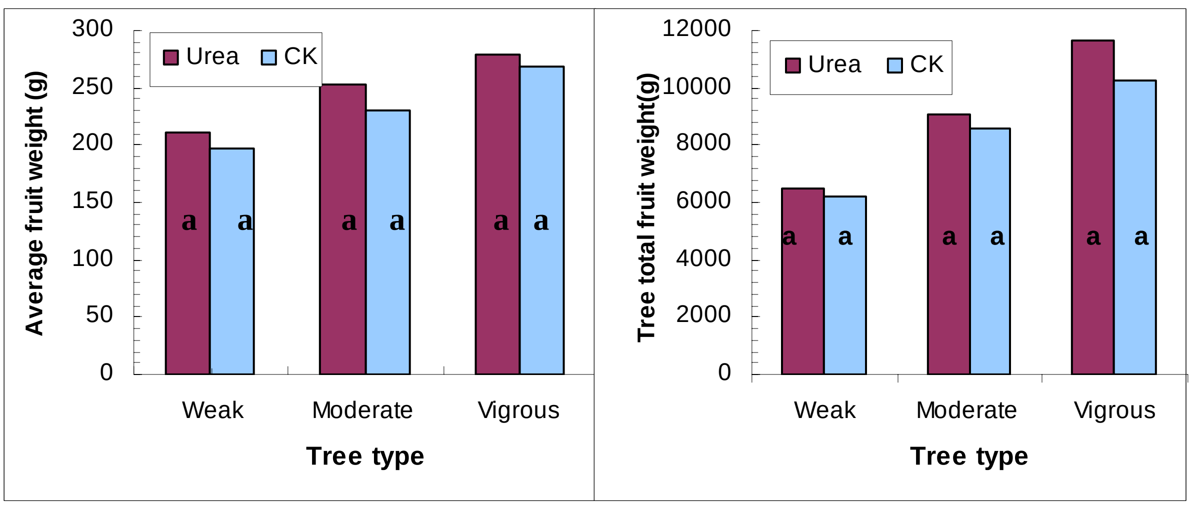

Fig12. Effect of 3% fall foliar urea application on Cameo tree yield and fruit size (2003)

4. Relationship between tree fruit number and yield and fruit size

Tree yield was directly related to the tree fruit number (crop load), and the fruit size was inversely correlated with tree fruit number. Increasing crop (Tree fruit number) significantly increased tree yield and unit trunk sectional area fruit weight but decreased fruit size (figure 13-17). The results for ‘Fuji’, ‘Gala’ in pot-in-pot system and ‘Cameo’ in orchard conditions were very similar.

Possible use of these results to predict yield and fruit size. The relationship between fruit number and tree yield, the relationship between fruit number and tree fruit size, and the relationship between unit trunk section area crop load and fruit size (Fig 13 to 17) suggests the possibility of using trunk cross-sectional area to predict tree yield and fruit size by adjusting the crop load by thinning early in the season. The results of these studies indicate that orchardists might be able to predict the size of the fruit by measuring trunk cross-sectional area and thinning the flowers/fruits in early spring. The following equation may be used to predict crop load and fruit size by knowing the cross-sectional area of the tree trunk: ***Fruit number= 22.0234+3.2818*Trunk section area-0.08634*Fruit size***. For example, if the trunk sectional area of a tree is 10 cm^2, and the orchardist is interested in producing 300g size apples; this size tree should have a crop load of 29 apples. During the discussion we will present a table and software that may represent the type of model an orchardist might use to predict fruit numbers and fruit size by simply measuring the trunk cross-sectional area.

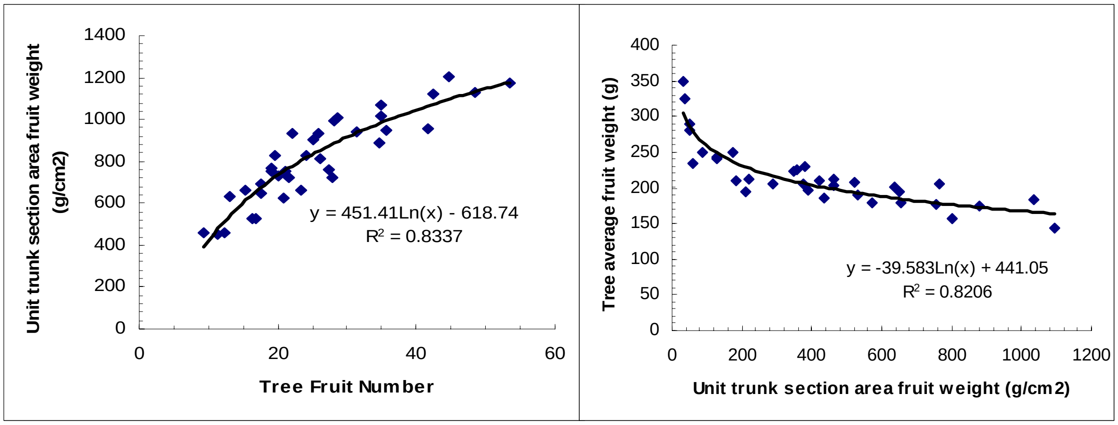

Fig.13 Relationship between fruit number, tree unit trunk section area and yield and fruit size (Cameo/M26 apple, Washington 2002)

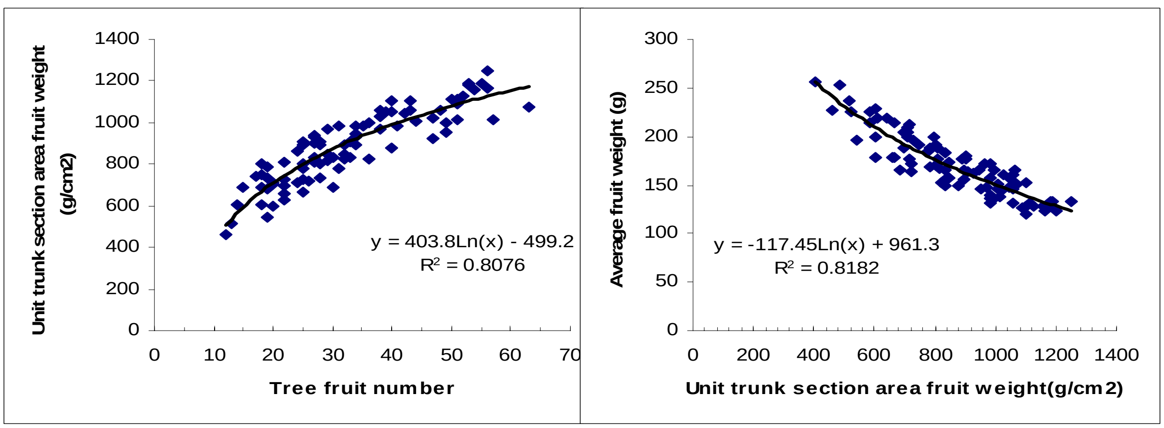

Fig.14 Relationship between fruit number, tree unit trunk sectional area and yield and fruit size (Pop-in-pot Fuji/M26 apple, OSU, 2002)

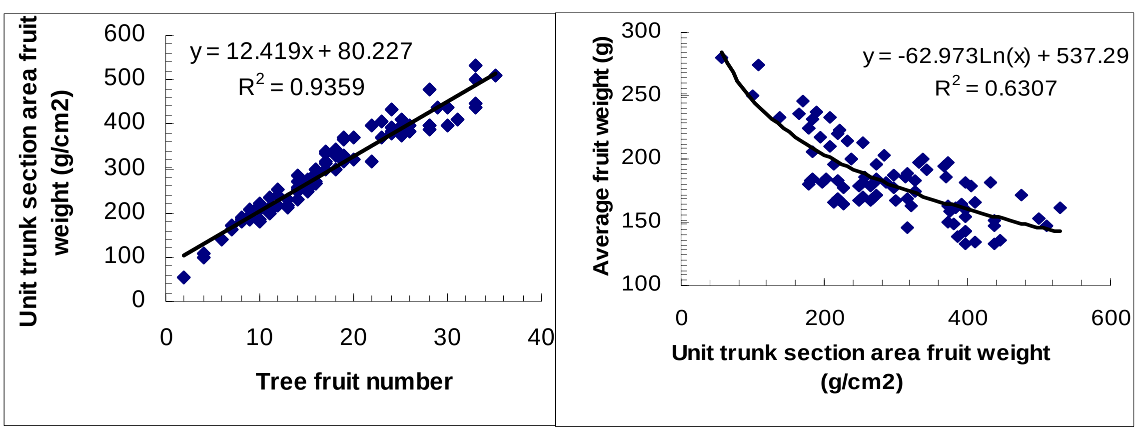

Fig15. Relationship between fruit number, tree unit trunk sectional area and yield and fruit size (pot-in-pot Fuji/M26 apple, OSU, 2003)

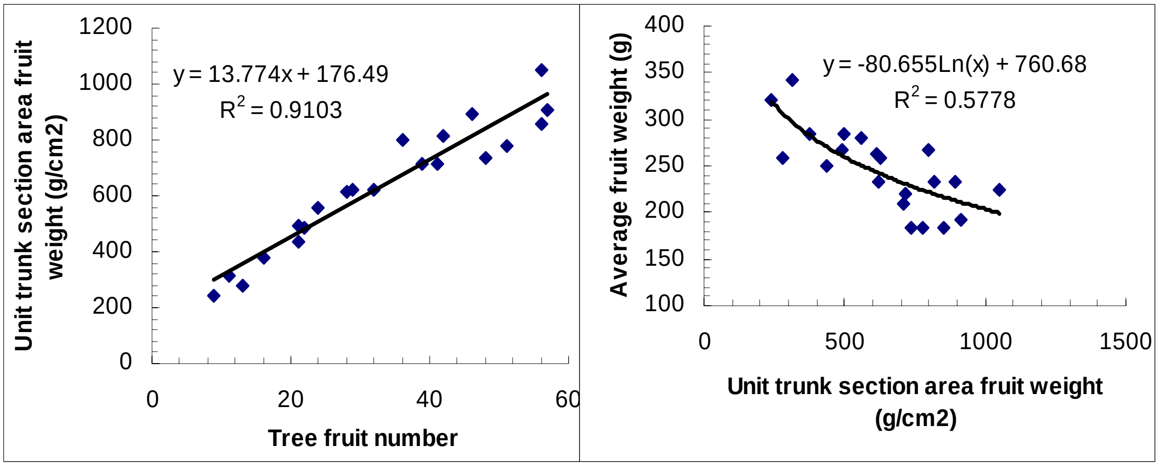

Fig16. Relationship between fruit number, tree unit trunk section area and yield and fruit size (Cameo/M26 apple, Washington, 2003)

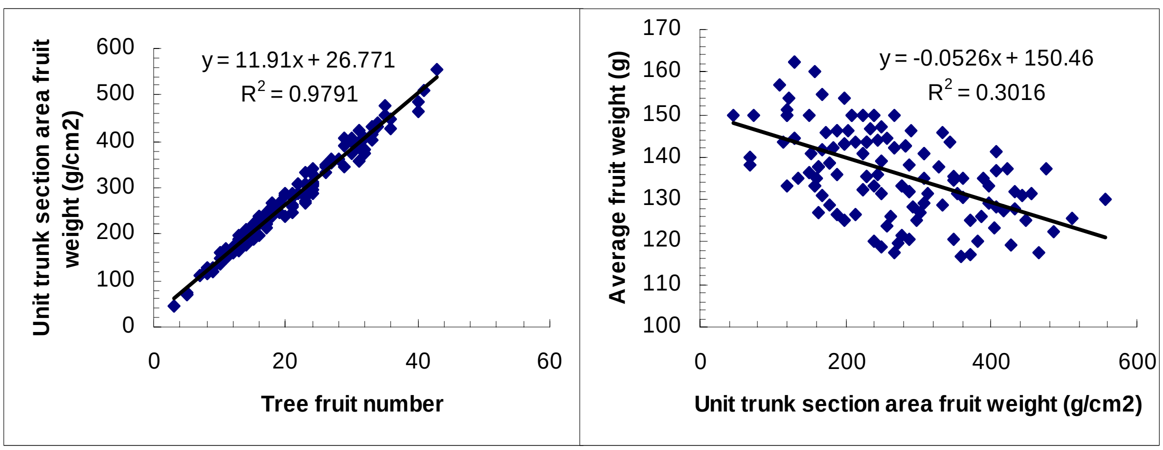

Fig17. Relationship between fruit number, tree unit trunk sectional area and yield and fruit size (Pot-in-pot Gala/M26, OSU, 2003)

5. Effect of temperature and growth stage on N^{15} uptake

Spring nitrogen uptake in newly established potted Fuji apple trees and field grown 3-year-old Fuji trees was not detected until at least three weeks after budbreak. The studies on the pot-in-pot Fuji apple at OSU showed that N^{15} uptake 30 days after bud break was dependent on soil and air temperatures. At approximately 18^{o}C soil and air temperatures, respectively, the rate of N uptake increased exponentially. These studies suggest that we may be able to predict N uptake based on either soil or air temperature and growth stage (Fig. 18 and 19). The preliminary data suggests that application of N fertilizer to the root zone for best N uptake is about 25 days after bud break when the air temperature is about 14^{o}C and the 20 cm soil temperature is about 15^{o}C.

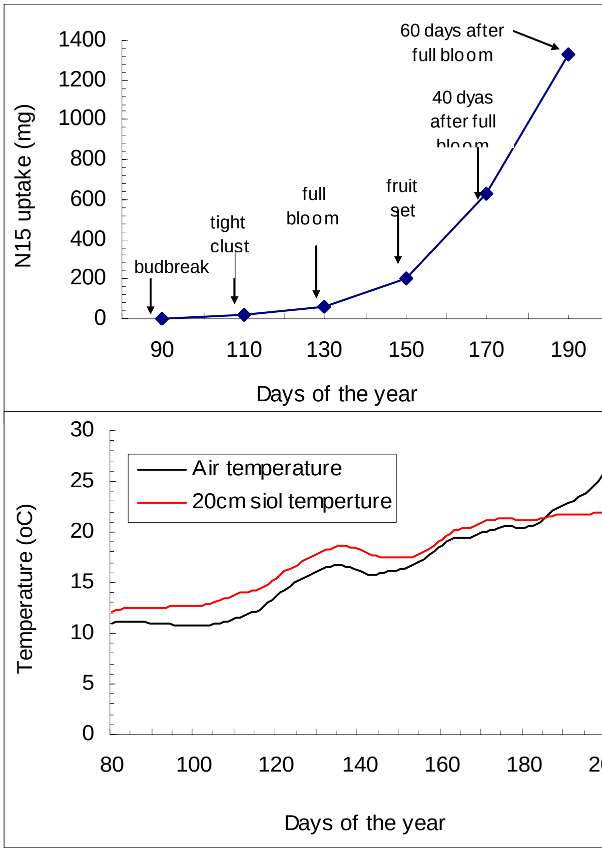

Fig.18 Effect of soil, air temperature and growth stage on N uptake

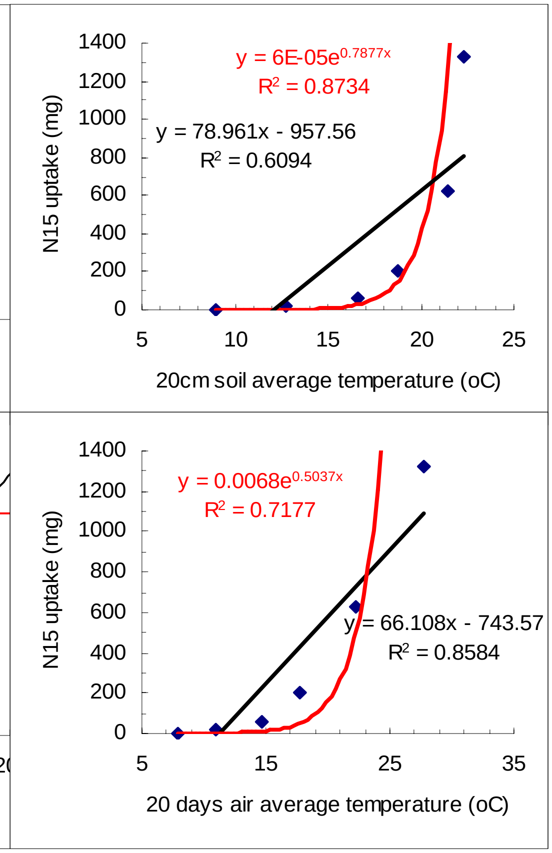

Fig.19 Relationship between 20 day average temperature of 20 cm soil and air and N uptake

BUDGET

Project title: Modeling of growth stage and temperature on spring nitrogen uptake and Modeling of apple crop load in relations to nitrogen reserve status and trunk size

PI: Leslie H. Fuchigami

Project duration: 2001-2003

Current year: 2003

Project total (3 years): **$58,650**

Current year request: **$22,500**

Year	Year 1 (2001)	Year 2 (2002)	Year 3(2003)
Total	16,150	22,500	$20,000
Item	Year 1 (2001)	Year 2 (2002)	**Year 3(2003)**
Salaries	15,000	17,000	**17,000**
Benefits (%)	510	510	**510**
Equipment	0	0	**0**
Materials and Supplies	340	3,990	**1,490***
Travel	300	1,000	**1,000****
Total	16,150	22,500	**20,000**

*Nitrogen and chlorophyll analysis $10.00 per sample.

**Travel to Washington to collect samples and take readings with the chlorophyll and nitrogen meters.