# DEVELOPMENT OF NUTRIENT MANAGEMENT TOOLS FOR DRIED PLUMS (Year 2)

**Project No:**

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## Objectives:

- To investigate the influence of yield, nitrogen plant status and fruit size on nitrogen removal by prune fruits.
- To investigate the seasonal pattern of nitrogen accumulation fruit.
- To develop early-season leaf sampling protocols and interpretation methods.

## Interpretive Summary

In California, there are 58,000 acres bearing orchards of dried plums. This makes up a significant area of land, which requires annual addition of nitrogen fertilizers to maintain high yields and produce quality. Currently, N management in prune is based on leaf sampling and analysis in summer, which is to late for N adjustment during the season. Further no guidelines are available to inform growers of the time and rate of fertilizer application. Due to the lack of N management support tools, there is potential for overuse of N fertilizer that could leach below root zone to ground water. There is increasing concern for ground water quality and the California Water

Board is working on legislation to reduce ground water nitrate pollution, which demands environmental stewardship from the farmers.

To provide better N management and monitoring tools to growers to guide the rate and time of fertilizer application and in season monitoring of tree N status, this experiment was continued during 2015. Influence of yield, tree nitrogen status and fruit size on nitrogen removal by prune fruits was monitored in the organic orchard by taking fruit samples at harvest, categorizing the fruits by size and determining N concentration. Seasonal accumulation of N in fruits was developed by monitoring N concentration and biomass accumulation in fruits. N removal from the orchard was calculated by monitoring trees for yield and nutrient concentration. Leaf samples were collected to relate N status with N export in fruit. Leaf samples from orchards at different sites were collected in July to understand the spatial and temporal variability of tree N status. Results show that N removal from the orchard in fruits ranged from 12.1 to 12.8 lbs per ton dry yield for the N rate treatment but there was no significant difference in N export between treatments. Perennial trees store a large quantity of N in the perennial biomass it takes 1-2 years for the treatment effect to establish. N export by the fruit size category was only significant under high N treatment where small fruits removed more N compared to large and medium fruits for the same quantity of yield (one ton dry yield). N accumulation in fruit continued throughout the season and 65% of the N accumulated in fruit by the first week of June. No significant statistical difference was observed in the leaf N status between N treatments in the N rate experiment, however orchards in different sites varied significantly in leaf N. The information from this project will be used to develop N management protocol for prune, based on N budget and in-season monitoring of leaf N.

**Materials and Methods**

Fruit load and N status influence on N removal (Objective 1)

There was significant variation between trees in the same orchard studied in 2014. In 2015 a more uniform organic orchard was selected to carry out this experiment. Thirty trees in the orchard were randomly selected and labeled in April. Trunk cross-sectional area (TCSA) measured at one foot above the soil surface. Three nitrogen fertilization treatments

were applied in order to generate a range of leaf nitrogen status. N – treatments were applied as follows: 1) Low Nitrogen (LN): 0 kg N $tree^{-1}$, 2) Medium Nitrogen (MN): 0.23 kg N $tree^{-1}$ equivalent to 104 kg N $ha^{-1}$ and 3) High Nitrogen (HN): 0.45 kg N $tree^{-1}$ equivalent to 204 kg N $ha^{-1}$. Nitrogen fertilizer was manually applied as organic nitrogen fertilizer. Each treatment was replicated on 10 trees.

Individual leaf samples were collected from every tree at the end of July. Samples consisted of one hundred non–fruiting spur leaves taken from exposed mid-canopy positions. Leaves were washed with deionized water and dried at 60$^{o}$C and then ground to pass a 30 mesh screen using Wiley Mill. The samples were analyzed for N, P and K in UC ANR Lab.

At harvest (August), yield of individual trees were determined. A subsample of 300 fruits was fresh weighted and sized (small fruits (<17 g $fruit^{-1}$), medium (between 17 and 25 g $fruit^{-1}$), and large (> 25 g $fruit^{-1}$)). 4 lbs samples were dried in a commercial drying facility to ~18 % moisture content to obtain the fruit hydration ratio. One sub-sample of 20 fruits by size range was selected on each tree (90 samples), weighted and carried to the laboratory to be processed. These samples were separated and weighed as mesocarp, endocarp, and seed, and then ground for analysis. Nitrogen concentration was determined both in the mesocarp and in the endocarp & seed.

Seasonal accumulation of nitrogen in fruit (objective 2)

In the same orchard used on the Objective 1, eight independent trees were sampled nine times during the season (approximately 14 day intervals). The experiment was designed with four subsamples (two trees per subsample). During the first two sampling dates we harvested 50 fruits, as fruits were small and 20 fruits on the subsequent sampling dates. Fruit samples were weighed in the field and dried in the laboratory. Biomass of the dried fruits was determined after drying in oven at 60$^{o}$C. N concentration in fruits in each sample dates were determined in the UC ANR Lab.

**Prediction of July leaf nitrogen from early spring leaf nitrogen (Objective 3)**

Leaf samples from orchards from different sites were collected in April and July in 2014 and 2015. There was significant variation in N concentrations between orchards at different sites. The data will be used to develop protocol to predict July leaf N status and farmers will have the tool to adjust their N fertilizer application in the season. The development of early leaf N prediction is under process and will be available to growers in near future.

**Results and Discussion**

Influence of Fruit load and N status on N removal

In the organic Prune orchard, there was no statistical difference in yields between three N treatments. Dry yield for different N treatments ranged from 37 lbs to 43lbs per tree. Further there was no significant difference in July leaf N concentrations between N treatments. The average size distribution of fruit within the organic orchard was 23% small fruits, 53% medium fruits, and 20% large fruits. No statistical differences were observed in the whole fruit N concentrations of any fruit size category under N treatments (Table 1).

Table 1: Mean nitrogen concentrations (%) in different fruit size category. There was no statistical difference between fruit size on N concentrations.

| Treatment | Large fruit | Medium fruit | Small fruit |
|---|---|---|---|
| Control | 0.58 | 0.56 | 0.58 |
| Low Nitrogen | 0.57 | 0.58 | 0.60 |
| High Nitrogen | 0.52 | 0.54 | 0.61 |

Nitrogen export at harvest (lbs per ton dry yield) ranged from 12.1 lbs to 12.8 lbs per ton dry yield (Figure 1), however the differences between treatments were not significant. These results were slightly higher than the values obtained in 2014, with a mean N export of 11.6 lbs N per dry ton. The values in 2014 were slightly low as some orchards included in the sampling plan that year were under low N management plan.

When fruits were categorized based on size, N export per ton dry yield was significantly high in the small fruit category under high N rate only (Table 2).

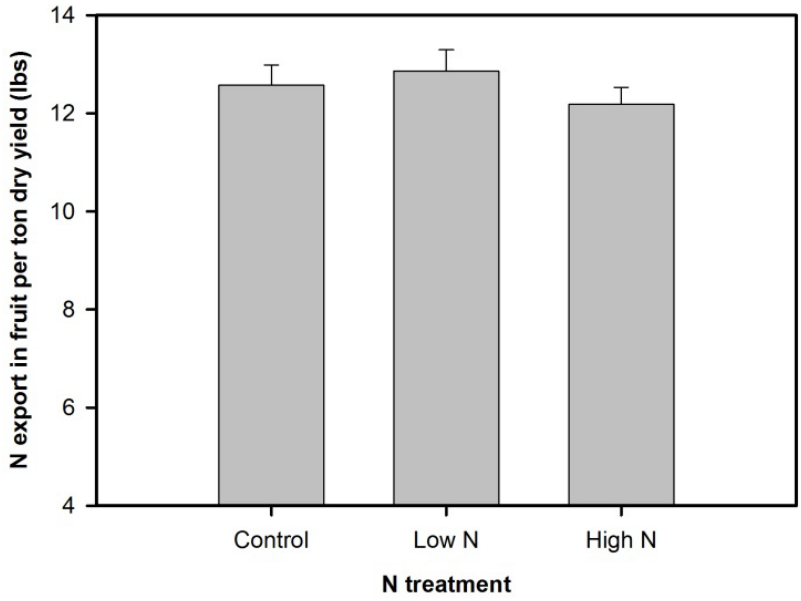


Figure 1: Effect of N treatment on N export per ton of dried fruit. There was no significant effect of N rate on N export in one ton dry yield from the orchard at 0.05 and 0.1 level of significance.

Table 2: Nitrogen export (lbs) in fruits per ton dry yield as affected by fruit size. Letters indicate significant differences within the same treatment at <0.05 level of significance, ns is not significant. Effect of treatment on N export in a given fruit size category was not significant.

| Treatment | Large fruits | Medium fruits | Small fruits |
|---|---|---|---|
| Control | 12.8 | 12.3 | 12.9 |
| | ns | | |
| Low N | 12.5 | 12.8 | 13.3 |
| | ns | | |
| High N | 11.5 | 11.9 | 13.4 |

| | | | |
|---|---|---|---|
| | b | b | a |

Seasonal pattern of N accumulation in fruits

Nitrogen accumulation in the fruit is expressed in N accumulated in fruit per ton dry yield. N accumulation in fruit continued throughout the season at nearly consistent rate until harvest (Figure 2). Twenty percent of the total fruit N was accumulated by last week of April, 47% by late May and 82% by the first week of July.

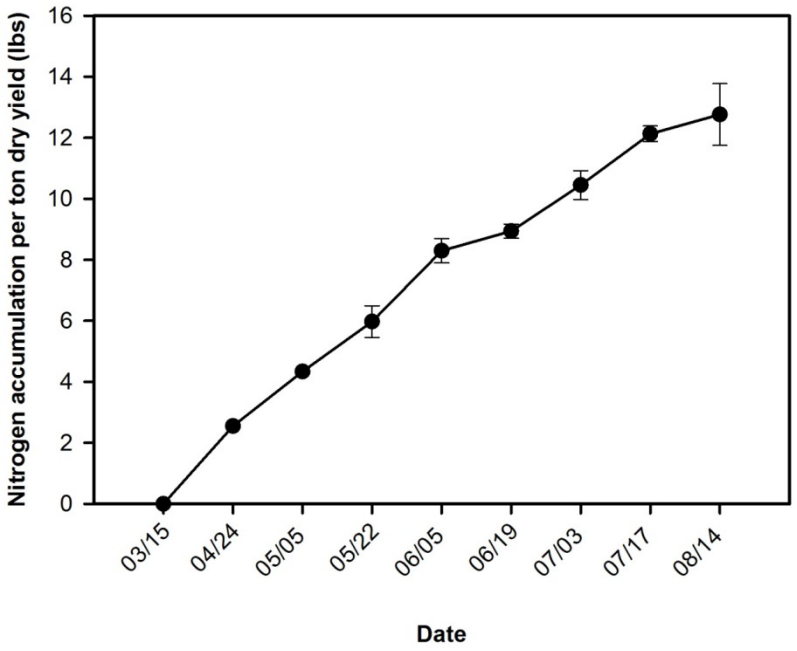


Figure 2: Seasonal pattern of N accumulation in fruit (lbs) per ton dry yield. Each point represents the mean and std. error of the mean.

Leaf Nitrogen

Nitrogen status of orchards in different sites varied significantly in 2015 (Figure 3). N concentration ranged from 2.2-2.4% in 2014 and 2.1% to 2.6% in 2015 between different sites. The year to year variations of N status within the same site were very small except for Rai and Hops. This information will be used to develop in-season leaf management protocol for prune in combination with fruit N removal and seasonal accumulation pattern after the completion of nutrient monitoring in 2016.

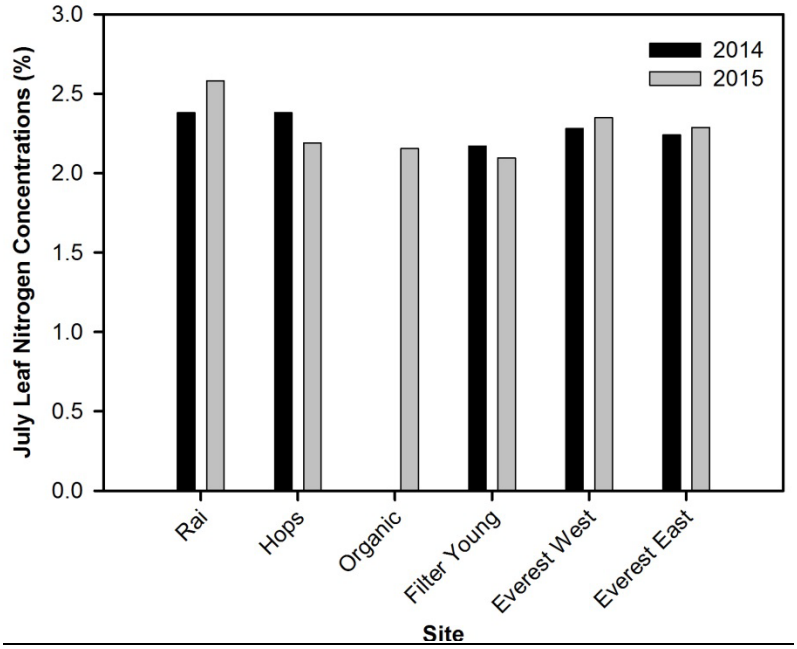


Figure 3. Mean nitrogen concentrations (%) in leaf samples in July in 2014 and 2015 from different sites.

**Discussion**

The results show that there were considerable differences in the tree N status between sites and the N status of the same orchard changes in different years suggesting each orchard should be managed according to specific need of that orchard. In the organic site where the influence of fruit load and tree N status and fruit size is under investigation, no significant effect of N rate on fruit yield, July leaf N and fruit N has been observed. Our previous work in almond shows that perennial fruits store large amount of N in the perennial biomass which is used by the tree in the subsequent season for flowering, fruit and leaf growth and it takes more than one year to establish treatment effect.

The seasonal pattern of N accumulation in fruit was studied by collecting samples at biweekly intervals. The information created can be used to derive the total demand of the orchard based on expected yield and fertilizer can be applied in multiple split according to crop demand. N demand of the crop is small in the early spring (2.6 lbs per ton dry yield) which can be supplied by N stored in the perennial parts of the tree. In areas with high

spring rainfall, fertilizer application can be delayed until late April which will reduce nitrate loss to ground water and will increase N use efficiency.

A grower friendly model will be generated integrated the result of leaf analysis and the N accumulation in fruits and will be available to growers by the end of the current year after analysis of data from 2016.