M. E. Patterson (personal communication) associated mechanical injury with pitting. M. Couey (personal communication) found that fruit sampled after specific points in sweet cherry packing lines where injury might be expected to occur (cluster clutter, dump tank) showed increased incidences of pitting, also implying an association with mechanical injury. Partially ripe cherries bruise more than ripe fruit (1) and mechanical harvesting (2) increased the incidence of pitting. These observations along with out data, lead us to imply that higher SS fruit bruise less, and that bruising increases pitting.

Preharvest chemicals. Sprays of GA_3 and GA_{4+7} were applied in an attempt to affect SS (6, 11). Neither compound had a significant effect on SS levels in either cultivar. GA_3 tended to increase fruit weight, decrease color and increase firmness, results similar to others (9). However, there was variation between years and cultivars (Table 7). GA_{4+7} did not influence fruit weight but did increase firmness and had some effect on reducing color. Again, there were differences between years and cultivars (Table 7). Pitting was reduced in all cases where appreciable pitting occurred in non-bruised fruit by GA_3 (1974 and 1977) and also where fruit were bruised (1975 to 1977). GA_{4+7} did not reduce pitting in bruised 'Bing' fruit in 1976 but was effective on 'Lambert' both years tested.

We suggest that crop is a major factor affecting SS and size (Table 5) and, therefore, pitting. Leaf/fruit ratio wax examined as a possible predictor variable. Increasing leaf/fruit ratio and/or increasing leaf area was negatively related to pitting ('Bing' correlation coefficients were r = –0.339, –0.445; 'Lambert' correlation coefficients were r = –0.345 and 0.399, respectively). It may be that the amounts of photosynthetic compounds available to a single fruit regulate, either through higher SS levels, changes in structural carbohydrates, pectic compounds, or orientation of all wall constituents, the response of that fruit to bruising. SS levels are probably only an indicator and not a reason for differences in pitting.

Literature Cited

1. Couey, H. M. and T. R. Wright. 1974. Impact bruising of sweet cherries related to temperature and fruit ripeness. *HortScience* 9:586.
2. ——————, M. W. Williams, A. G. Berlage, and R. P. Larsen. 1974. Effect of ethephon and harvest method on quality of stemless sweet cherries harvested for the fresh market. *HortScience* 9:587-588.
3. Curwen, D., F. J. McArdle, and C. M. Ritter. 1966. Fruit firmness and pectic compounds of Montmorency cherries as influenced by differential nitrogen, phosphorous, and potassium. *Proc. Amer. Soc. Hort. Sci.* 89:72-79.
4. Gerhardt, F. and A. D. Ryall. 1939. The storage of sweet cherries as influenced by carbon dioxide and volatile fungicides. U.S.D.A. Tech. Bul. 631.
5. Lidster, P. D., S. W. Porritt, and M. A. Tung. 1978. Texture modification of 'Van' sweet cherries by postharvest calcium treatments. *J. Amer. Soc. Hort. Sci.* 103:527-530.
6. Neubeller, J. and R. Stosser. 1972. The effect of gibberellic acid, benzyladenine and kinetin on sugar accumulation in ripening fruits of sweet cherry. *Mitteilungen Rebe und Wein, Obstbau und Fruchteverwertung* 22:211-216.
7. Ogawa, J. M., Elaine Bose, B. T. Manji, and W. R. Schroeder. 1972. Bruising of sweet cherries resulting in internal browning and increased susceptivity to fungi. *Phytopathology* 62:579-580.
8. Porritt, S., L. E. Lopatecki, and M. Meherink. 1971. Surface pitting – a storage disorder of sweet cherries. *Can. J. Plant Sci.* 51:409-414.
9. Proebsting, E. L., Jr., G. H. Carter, and H. H. Mills. 1973. Quality improvement in canned 'Rainier' cherries (*P. avium* L.) with gibberllic acid. *J. Amer. Soc. Hort. Sci.* 98:334-336.
10. Stanberry, C. O. and J. W. Clore. 1950. The effect of nitrogen and phosphorous fertilizers on the composition and keeping qualities of Bing cherries. *Proc. Amer. Soc. Hort. Sci.* 56:40-45.
11. Stosser, R. and J. Neubeller. 1972. The accumulation of sugars in cherry fruits by means of gibberellic acid. *Naturwissenschaften* 59: 167-172.

J. Amer. Soc. Hort. Sci. 104(5):710–712. 1979.

The Development of Standard Ranges for Leaf Nitrogen in the Filbert[1]

M. H. Chaplin and A. R. Dixon
Department of Horticulture, Oregon State University, Corvallis, OR 97331

Additional index words. hazelnut, mineral nutrition, pH-nutrient uptake, *Corylus avellena*

Abstract. **Nitrogen, as urea, was applied to filbert (*Corylus avellena* L.) trees at the rates of 0, .68, 1.36, and 2.72 kg N/tree/year from 1971-1977. Nitrogen applications significantly increased leaf N, yield, and tree size. Leaf P levels were reduced by N applications in all years. Soil pH, measured after 7 years of N application, significantly declined as N application rate increased. Leaf Mn levels were increased by N applications in all years, probably due to the decrease in soil pH. Yields were expressed as a quadratic function of N and the standard ranges for leaf N in filbert were categorized as follows: deficiency (visible symptoms present) < 2.0% dry weight; below normal 2.0 – 2.2%; normal 2.2 – 2.4%; above normal > 2.4%.**

In the United States, 97% of the filberts are grown in the Pacific Northwest. Proper N management is an important cultural practice in the filbert orchard. Furthermore, the cost of N fertilizer is estimated to vary from 50% to 100% of the annual fertilizer cost of the orchard. Leaf analysis is the principal diagnostic technique for determining N by a high percentage of filbert growers. A tentative optimum range for mid-shoot leaves collected in August (2.3% – 2.5%) was developed by Painter (2) through surveys of good and poor orchards and has been used as the basis for commercial fertilizer programs (5). Because of the several limitations pointed out for the survey method for developing standard ranges (3) a nitrogen fertilizer trial was established in 1971 to further elucidate standard ranges for N in filbert and to determine the effects of continued N fertilizer applications on uptake of other nutrients.

[1]Received for publication February 1, 1979. Oregon Agricultural Experiment Station Technical Paper 5071.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

Methods and Materials

A 30-year-old filbert orchard growing on a well drained silty clay loam soil and located near McMinnville, Oregon was selected for the study. Trees were of uniform size and had completely filled the 7.6 m spacing. Pretreatment leaf analysis showed normal or above normal levels of P, K, Ca, Mg, Mn, Fe, Cu, B, and Zn and deficient or below-normal levels of N when compared to the standard leaf values currently used in Oregon (5). Visible N deficiency symptoms were observed on most trees.

Experimental design was a randomized block with 14 blocks and 4 treatments consisting of 0, .68, 1.36, and 2.72 kg of N per tree, per year, supplied as urea. N applications were made in February or March from 1971 through 1977. Leaf samples were collected yearly in August from mid-shoot leaves of current season's growth. Nitrogen was analyzed by an automated micro-Kjeldahl method (4). Potassium, P, Ca, Mg, Mn, Fe, Cu, B, and Zn were analyzed by direct-reading emission spectrometry (1). Nut yields were measured only in 1972, 1973, 1975, and 1977. Tree size was measured by the cross-sectional area method (6). Regression analysis was utilized to elucidate treatment effects.

Results and Discussion

Leaf N was significantly linearly or quadratically related to applied N in all years (Table 1). N levels in all trees (including controls) generally rose from 1971 to 1976 with a slight decline in 1977. The increase observed in the controls could have been due to root-grafting and cross-feeding with the roots of adjacent trees since there were no non-treated guard trees between treatments. Percentage increase in tree size over the 7-year period, as determined by change in trunk cross sectional area, was significantly quadratically related to N applications with the greatest increase occurring at the .68 kg/N treatment level (Table 2).

Yields were quadratically related (significant at 1% level) to leaf N in 3 of the 4 years that yields were measured (Fig. 1). There was considerable variation in yield from year to year, however, a general trend appeared which showed yields rising until a 2.2% leaf N level was reached followed by a leveling off in yields at 2.4% leaf N and then a slight decline. Visible N deficiency symptoms were generally observed in plants with less than 2.0% N. Based on this information, we categorized the standard ranges for filbert as follows: deficiency (visible deficiency symptoms present) < 2.0%; below normal 2.0 – 2.2%; normal 2.2 – 2.4%; above normal and excessive > 2.4%.

N application uniformly depressed leaf P levels in all years (Table 3) which is consistent with reports for other crops on a worldwide basis (3). Mg leaf levels were significantly increased, the response being proportional to the amount and the number of years of N treatment with Mn levels reaching 1035 ppm for the 2.72 kg/N treatment in 1977 (Table 1). The Mn levels required to produce toxicity symptoms and/or yield reductions in filbert are unknown. However, it is common to observe levels reaching 1500 ppm in Northwest filbert orchards without visible toxicity symptoms. In 1977, the Fe

Table 1. Effect of N applications on leaf nitrogen content in filbert (1971-1977).

N applied per tree as urea (kg)	Leaf N (%), dry wt basis						
	1971	1972	1973	1974	1975	1976	1977
0	1.71	1.72	1.79	1.96	2.12	2.30	2.07
.68	1.95	1.82	2.04	2.12	2.37	2.41	2.34
1.36	2.04	1.86	2.15	2.08	2.42	2.44	2.38
2.72	2.10	1.94	2.19	2.13	2.54	2.54	2.40
Linear	**	**	**	*	**	**	**
Quadratic	**	NS	**	NS	*	NS	**

*, **, NS Significant at the 5% (*) or 1% (**) level or nonsignificant (NS).

Table 2. Effect of N applications (1971-1977) on tree size.

Treatment (kg N/tree)	increase in trunk cross sectional area (%)
0	32.7
.68	58.7
1.36	50.1
2.72	41.6
Linear	NS
Quadratic	**

**, NS Significant at 1% level (**) or nonsignificant (NS).

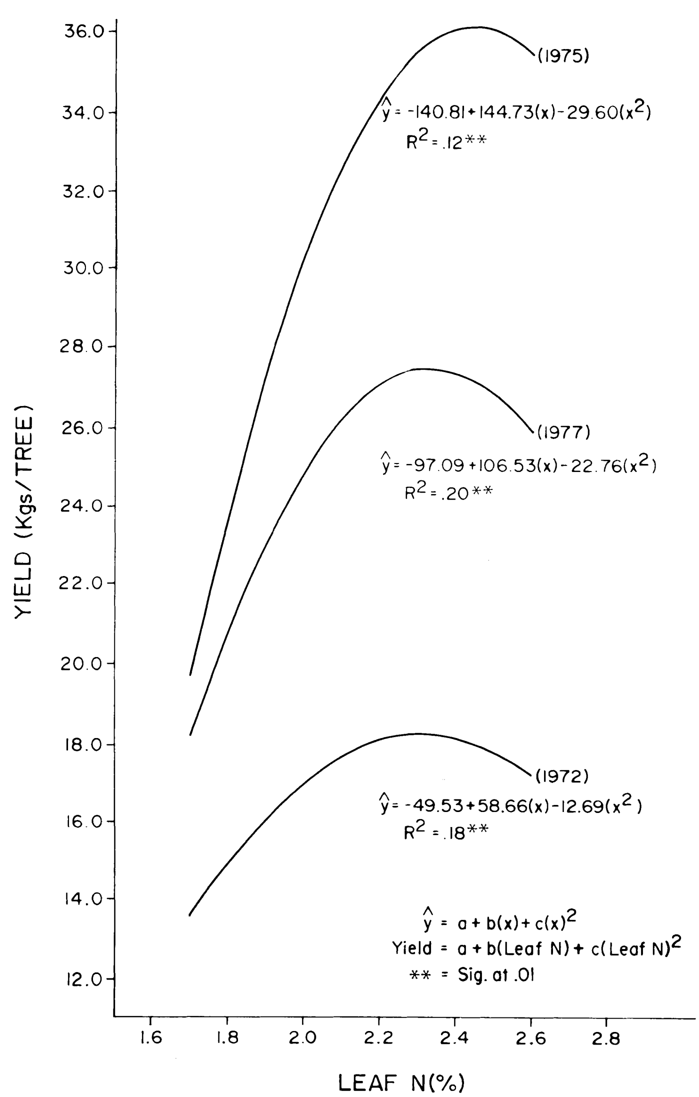

Fig. 1. Relationship between leaf N content (% dry weight) and yield (kg/tree) in filbert for 1972, 1975, and 1977.

Table 3. Effect of N applications on leaf element content in filbert.

N applied as urea (kg)	Year	Leaf element content (dry wt basis)								
		K (%)	P (%)	Ca (%)	Mg (%)	Mn (ppm)	Fe (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)
0	1974	1.07	.28	1.45	.24	296	238	6	83	21
.68		.98	.18	1.48	.23	356	228	7	69	22
1.36		.95	.17	1.43	.22	476	241	6	72	22
2.72		.97	.17	1.44	.23	577	236	6	76	21
Linear		NS	**	NS	NS	**	NS	NS	NS	NS
Quadratic		NS	**	NS	NS	NS	NS	NS	NS	NS
0	1975	.93	.26	1.36	.22	266	131	6	68	25
.68		.87	.18	1.44	.24	346	154	7	61	25
1.36		.86	.17	1.43	.24	525	148	7	58	24
2.72		.90	.17	1.45	.23	819	144	6	61	26
Linear		NS	**	NS	NS	**	NS	NS	NS	NS
Quadratic		NS	**	NS	NS	NS	NS	NS	NS	NS
0	1976	1.36	.21	1.20	.23	240	108	7	84	20
.68		1.31	.16	1.19	.23	293	116	7	71	21
1.36		1.20	.15	1.22	.23	529	113	7	67	19
2.72		1.28	.15	1.24	.23	794	112	7	74	19
Linear		NS	**	NS	NS	**	NS	NS	NS	NS
Quadratic		*	**	NS	NS	NS	NS	NS	NS	NS
0	1977	1.08	.24	1.40	.24	269	99	6	63	26
.68		1.10	.18	1.52	.25	356	125	6	63	24
1.36		1.09	.17	1.49	.26	664	117	6	57	24
2.72		1.11	.16	1.48	.25	1053	116	6	55	25
Linear		NS	**	NS	NS	**	NS	NS	**	NS
Quadratic		NS	*	*	NS	NS	*	NS	NS	NS

*, **, NS Significant at 5% (*), 1% (**), or nonsignificant (NS).

content was significantly increased while the B content was significantly decreased. These changes are probably the result of altered soil ion availability due to the significant reduction in soil pH produced by N applications (Table 4). It should be noted however, that leaf Fe content for all treatments fell dramatically between 1974 and 1976. The reasons for this reduction are unknown. It cannot be explained on the basis of soil pH reduction.

The following lines of evidence would support maintaining N status and plant productivity by regular minimal applications of N fertilizer rather than heavier intermittent or continuous dosages:

1) The lowest N application rate (0.68 kg/N/tree) produced optimum leaf N levels of 2.2 – 2.4% dry weight by the 5th year of application and this level was maintained through the seventh year when the experiment was terminated.
2) Higher application of N in the earlier years increased leaf N levels towards the optimum but it is questionable if the increased yields offset the added cost of the fertilizer.
3) Analysis of filbert shells and kernels indicates that only 15 kg/N would be removed by a 100 kg crop/ha.
4) Reductions in soil pH are proportional to N application rates and can have detrimental effects on soil ion availability including reduction of N uptake due to retardation of nitrification. The application of lime could eventually be required to counteract these effects.

Table 4. Effect of 7 years of N applications (as urea) to filbert on soil pH.

N applied per tree as urea (kg)	Soil pH 1977
0	5.2
.68	5.1
1.36	4.8
2.72	4.4
Linear	**
Quadratic	NS

**, NS Significant at 1% level (**) or nonsignificant (NS).

Literature Cited

1. Chaplin, M. H. and A. R. Dixon. 1974. A Method for Analysis of Plant Tissue by Direct Reading Spark Emission Spectroscopy. *Appl. Spectroscopy* 28:5-8.
2. Painter, John H. 1963. A Recent Leaf Analysis Service Development of Importance to Nut Growers in Oregon. *Proc. Ore. & Wash. Nut Growers Soc. 49th Annu. Meeting.* p. 6-8.
3. Smith, Paul F. 1962. Mineral Analysis of Plant Tissues. *Ann. Rev. Plant Physiol.* 13:81-108.
4. Schuman, G. E., A. M. Stanley, and D. Knudsen. 1973. Automated Total Nitrogen Analysis of Soil and Plant Samples. *Soil Sci. Soc. Amer. Proc.* 37:480-481.
5. Stebbins, R. L., L. C. Baron, E. H. Gardner, and M. H. Chaplin. 1976. Oregon State University Fertilizer Guide for Filberts. Oregon State Univ. Ext. Service Fertilizer Guide 54.
6. Westwood, M. N. and A. N. Roberts. 1970. The Relationship Between Trunk Cross-sectional Area and Weight of Apple Trees. *J. Amer. Soc. Hort. Sci.* 95:28-30.