

# **Farm Effects on Runoff Quality in Oregon's Tualatin River Basin**

## **Part 1: Farm Survey**

**Washington County  
Oregon**

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**by**

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Catherine Darby, with the Natural Resources Conservation Service, collated, refined and condensed the spreadsheet data into a manageable form for this report.

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## Glossary and Acronyms

Cover Crop – A conservation practice in which close-growing crops are grown to reduce erosion and runoff, to add organic matter to the soil or to recycle nutrients rather than to harvest.

EPIC - Erosion Productivity Impact Calculator, a computer runoff model.

K – Potassium. Soil test results are typically expressed in terms of elemental K.

K<sub>2</sub>O – Potash. This is the typical formula for expressing the amount of potassium (K) in manure or fertilizer. For every 1 lb of K in manure or fertilizer, there are 1.20 lb of K<sub>2</sub>O.

lb – pound(s).

lb/ac – pounds per acre.

Legume - Nitrogen fixing crop such as crimson clover, red clover, or alfalfa.

N - Nitrogen.

Nutrient Management – A conservation practice in which the amount, placement and timing of fertilizer and manure is matched to crop needs as determined by soil and/or crop tissue tests. The goal is to optimize crop profitability while reducing risk of runoff and leaching of nutrients.

OSU - Oregon State University.

ppm – parts per million by weight.

P – Phosphorus. Soil test results are typically expressed in terms of elemental P.

P<sub>2</sub>O<sub>5</sub> – Phosphate. This is the typical formula for expressing the amount of phosphorus (P) in manure or fertilizer. For every 1 lb of P in manure or fertilizer, there are 2.29 lb of P<sub>2</sub>O<sub>5</sub>.

Residue Management – A conservation practice in which moderate to high levels of plant residue on the soil surface are used to reduce erosion and runoff.

Row Crop – An annual crop planted in a row, such as sweet corn, silage corn or snap beans.

Small Grain – Wheat, oats, barley, rye or triticale.

USDA - United States Department of Agriculture.

# Executive Summary, Conclusions and Recommendations

## Survey

In 1995, the Washington County Soil & Water Conservation District interviewed 90 farmers in northwest Oregon's Tualatin River Basin, using a survey developed by the USDA – Natural Resources Conservation Service (NRCS) and Oregon State University (OSU) Extension Service. Crop rotations, yields, tillage, fertilizer and irrigation practices were recorded. Soil samples from each field were analyzed, allowing us to compare actual fertilizer use with OSU recommendations.

The goal of this project is to help improve water quality, increase farm profits and strengthen the agricultural industry so it continues to play a vital role in the economics and quality of life of the Tualatin River Basin. The intended audience includes agency personnel, leaders of farm organizations and agribusiness leaders. This document is Part I of a two-part series. Part II, computer modeling of farm runoff, will be published separately. Condensed versions of this information will also be available. Recommended action:

- **Repeat this survey in 2005 to determine how farm management has changed in 10 years. Future surveys should record conservation programs in which farmers have participated. This may suggest ways of maximizing the effectiveness of these programs in the future.**

## Crops

Seven crops: snap beans, blueberries, sweet corn, black raspberries, strawberries, silage corn and winter wheat were surveyed. Important area crops *not* covered in the survey include nurseries, Christmas trees, grass seed, spring grains, hazelnuts (filberts), hay and pastures. Recommended action:

- **Include additional crops in future surveys.**

## Nitrogen (N) Application

Generally, snap bean, sweet corn, strawberry, silage corn and winter wheat growers applied nitrogen (commercial fertilizer plus manure) according to published OSU recommendations. Farmers tended to exceed N recommendations on blueberries and black raspberries. Some silage corn fields received high N applications via dairy manure. Recommended actions:

- **Conduct research or demonstration plots for N fertilizer on blueberries and black raspberries. Help dairy farmers apply manure in lower rates by using more fields on their farms or by trucking the manure to other farms.**

## Phosphate (P<sub>2</sub>O<sub>5</sub>) Application

Generally, winter wheat farmers applied phosphate (commercial fertilizer plus manure) according to OSU recommendations. Growers tended to exceed phosphate recommendations on blueberries, sweet corn, black raspberries, strawberries and silage corn. The highest applications of phosphate to silage corn were via dairy manure. Recommended actions:

- **Conduct research or demonstration plots for P<sub>2</sub>O<sub>5</sub> fertilizer rates on blueberries, sweet corn, snap beans, black raspberries, strawberries and silage corn. The sweet corn and snap bean plots should compare published and unpublished OSU recommendations.**
- **Help dairy farmers find new fields (perhaps on neighboring farms) on which to spread manure. Provide technical and financial help to safely and economically transport manure to distant fields.**

## Potash (K<sub>2</sub>O) Application

Generally, strawberry and winter wheat growers applied K<sub>2</sub>O (commercial fertilizer plus manure) as per OSU recommendations. Growers often exceeded K<sub>2</sub>O recommendations on blueberries, sweet corn and silage corn. The highest applications of potash to silage corn were via dairy manure. Recommended actions:

- **Conduct research or demonstration plots for K<sub>2</sub>O on blueberries and sweet corn.**
- **Help dairy farmers safely and economically transport manure to appropriate fields.**

## Irrigation

We compared what growers told us about their irrigation practices with estimates of crop water needs based on average climatic data from the Tualatin River Basin. These analyses must be interpreted cautiously because growers may have had difficulty in estimating average irrigation rates.

Strawberries, black raspberries, sweet corn and silage corn in the Tualatin Basin often received less irrigation water than estimated needs. For strawberries and black raspberries, soil moisture deficiency following harvest is part of normal farming practices and may not affect yields in the following year. Soil moisture deficits in sweet corn and silage corn, however, may cause yield losses. Some snap bean and blueberry fields received significantly less water than estimated crop need and other fields received significantly more water. For all crops, the total amount of irrigation water reported per season varied widely between growers.

At the time of this survey, a neutron probe was available to monitor soil moisture, but most irrigators were not using this neutron probe (or any other soil moisture monitoring technology). The year after the survey was completed, the neutron probe became unavailable and many of the farmers who had used it switched to modified gypsum block technology. The surveyed growers who used the neutron probe did not appear to apply significantly different irrigation amounts than other growers. Growers reported irrigation water runoff on 12 percent of the surveyed fields. This runoff occurred on strawberries, black raspberries and sweet corn. Recommended actions:

- **Determine why many farmers appear to under-irrigate sweet corn and silage corn, whether this causes significant yield loss and (if so) what alternatives exist to solve these problems.**
- **Help blueberry growers use soil moisture monitoring devices to their fullest potential.**
- **Investigate irrigation runoff, especially on strawberries, black raspberries and sweet corn. This runoff could carry phosphorus into the Tualatin River and its tributaries during summer months when prime temperature and sunlight conditions occur for growth of algae. If necessary, develop and implement conservation systems to reduce this runoff.**

## **Tillage and Cover Crops**

Residue management (leaving moderate to high levels of plant residue on the soil surface to reduce erosion) is widely used for wheat rotations on hillsides, but not for other crops grown in valley and floodplain locations. Cover crops do not seem to be widely used with suitable crops, such as silage corn, strawberries, black raspberries and blueberries. Recommended actions:

- **Determine the obstacles to residue management and cover crops, especially on valley bottom and floodplain fields.**

## **Farmer Decision Making Process**

This survey did not formally address the reasons why some growers apply more nutrients than OSU recommends. However, some farmers explained that blueberries, sweet corn, black raspberries and strawberries are high-value crops and additional fertilizer ensures against yield loss. Some growers are skeptical of OSU recommendations for blueberries and caneberries, believing OSU research isn't relevant to our area or to new high-yielding varieties and methods. Some farmers believe that heavy application of phosphate on strawberries helps prevent winter injury to the plants. Others believe soil phosphorus (P) is not available to crops because of cold soil and/or low soil pH. Still others are reluctant to change a farming system that has worked for many years. Manure applications are sometimes seen more as manure disposal than as fertilization. Farmers often rely on advisors who work for food processors, farm supply businesses or independent consulting

companies. Often, these advisors share many of the same beliefs as farmers concerning OSU recommendations. Recommended actions:

- **Invite farmers and their consultants to comment on the results of this survey, especially regarding the situations where nutrient and irrigation applications are significantly different from OSU recommendations. Focus groups may be a useful format for these discussions.**

## **Voluntary Farmer Efforts**

Tualatin Basin farmers participated voluntarily in this survey. They were open, honest and patient in answering our questions. The survey revealed that farmers have adopted many best management practices to protect water quality, including:

- Good N management on snap beans, sweet corn, strawberries, silage corn and winter wheat.
- Good P<sub>2</sub>O<sub>5</sub> management on winter wheat.
- Good K<sub>2</sub>O management on strawberries and winter wheat.
- Low irrigation water use on sweet corn, silage corn, strawberries and black raspberries.
- Good use of residue management (conservation tillage) for wheat grown on hillsides.

Recommended actions:

- **Farmers should be publicly congratulated for their voluntary efforts. Also, data in this survey that indicate room for improvement should be interpreted as a call for farmers, their private consultants and their public servants to work together in search of solutions.**

# FORWARD

By Cal Krahmer  
Retired Farmer

*Note: Cal Krahmer was hired by the Washington County Soil and Water Conservation District to conduct the surveys which form the basis of this project. Cal's observations of the farms and farm families he visited follow.*

Following are some observations I made while doing my job of interviewing farmers and investigating fields for the Tualatin Basin Farm Practices project with the Washington County Soil and Water Conservation District.

I interviewed 90 farmers and did about 111 different surveys. There were four people who refused to be surveyed. The age of those interviewed was between 24 and 70 years. Most of those under 40 years of age were college educated, but education seemed to be no prerequisite to success or status with farming. Eighty per cent of the farms had some degree of computer capability.

The farmers interviewed farmed from 35 to over 2,000 acres. To guess an average size is very difficult in this valley because of the great opportunity to diversify. It seemed 400-500 acres was the goal of most farmers. Fruit and vegetable growers were the best managers of nutrients, water, labor and time. All dairy farmers understood animals and about half of them were good managers of water and land. Nursery farmers were the best at marketing their products.

I saw fields of 20 percent to 30 percent slope planted to vetch with no gully erosion and other fields of 2 percent to 3 percent slope planted to crimson clover with gully erosion. Those who farm steep slopes work very hard to control erosion and those on relatively flat land did nothing to control erosion. This was not a year to document soil erosion caused by sprayer tracks because they didn't get in the fields to spray until spring. This cause of erosion has been observed in the past.

The change from moldboard plowing to chisel plows is at a rate of about 5 percent per year. I could tell which farmers sub-soiled on a regular basis when I soil sampled because those fields had more deep soil moisture. Cover crops were almost non-existent. I never observed an orchard in cover crop like the Soil and Water Conservation District had promoted several years ago.

Where sweet corn stubble had been plowed down by a moldboard plow, there was excessive erosion compared to where the stubble had only been disked. In December, January and February, almost every winter wheat field I walked into had geese feeding. Some of those fields



were damaged permanently. Fields in the Gales Creek-Banks area had elk damage. Elk damaged all crops, not just wheat like the geese.

The Tualatin Basin climate and abundance of water has some very distinct advantages for water quality. Water conservation is quite easy compared to standards set in other areas for conservation. Water spreading, which is illegal by state and federal law, could have a real positive effect on water quality. Putting two inches of water on some fall-seeded crops to get early germination in September would have a real plus for water quality by obtaining adequate ground cover to protect the land.

The blueberry growers have some unique practices that need to be researched and addressed. Their use of irrigation water varied from 22 to 42 inches. Amounts of water put on at one time were very low.

Some water quality needs:

The management of nutrients from animal waste could be improved. The addition of supplemental nutrients to animal waste may make it more productive. The livestock industry needs to manage surface water better both in the winter and summer.

Row crop producers and nursery farmers need improved irrigation management. This wouldn't help water quality but would improve production. Many row croppers and nursery farmers are not taking advantage of improving their soils by growing cover crops. Cover crops will control erosion and utilize waste nutrients better than any other best management practice.

The economy of contour farming is generally not understood by agriculture. Technicians talk about it but few have ever put themselves in a tractor seat and done it. Those farmers who need contour farming should develop the art and make the technique known to others.

## Project Objectives

In 1987, the State of Oregon listed the Tualatin River as water quality limited for ammonia and phosphorus. "Water quality limited" is a legal term meaning the river was officially considered to be polluted with these nutrients. Excessive phosphorus in the river encourages the growth of algae, causing wide fluctuations in dissolved oxygen and pH (acidity), ultimately hurting fish and other aquatic organisms.

The water quality limited status generated efforts by the urban, agricultural and forestry sectors to reduce the discharge of ammonia and phosphorus to the river. This document pertains to agricultural lands. We direct readers to the Unified Sewerage Agency for information on Tualatin River Basin urban lands and to the Oregon Department of Forestry for forestry issues.

In 1991, the United States Department of Agriculture (USDA) significantly increased its level of assistance to the Tualatin Basin by funding a Hydrologic Unit Area in Washington County. This effort incorporated three USDA agencies: Natural Resources Conservation Service, Farm Services Agency, and Oregon State University Extension Service. These agencies, in cooperation with the Washington County Soil and Water Conservation District, worked to reduce agricultural erosion and the runoff of nutrients to the Tualatin River. Since the problem of ammonia was largely solved by facility upgrades at the Unified Sewerage Agency's wastewater treatment plants, the USDA project focused its attention on phosphorus.

Between 1991 and 1994, USDA invested in technical, educational and cost-sharing assistance to Tualatin River Basin farmers. At first, efforts centered on helping farmers manage irrigation applications, build facilities to store manure over winter, test their soils for nutrients and reduce erosion.

However, by 1994, the goals for low levels of phosphorus in the Tualatin River had not been achieved. Consequently, the Soil and Water Conservation District planned the *Farm Effects on Runoff Quality in Oregon's Tualatin River Basin* project to gather more information about how local farm practices affect phosphorus runoff and erosion. The results of this project are reported in two parts. Part I, the *Farm Survey*, comprises this document. Part II, *Runoff Model Predictions*, will be published separately.

The objectives of the project are:

1. **Include A Cross-Section of Farmers.** USDA planners had already collected information from the growers participating in USDA programs. These growers, however, were a select group of the most progressive farmers in the Basin. We felt a survey was key to obtaining accurate information on practices used by a broad cross-section of farmers. This objective is addressed in Part I (i.e. this document).

2. **Document Voluntary Efforts by Farmers.** At a series of Grower Focus Groups held in early 1994, farmers repeatedly said that clean water in the Tualatin River and its tributaries was important to them. Many of these farmers stated that Tualatin Basin agriculture was already working hard to reduce phosphorus in the river. The Conservation District wanted to help document those voluntary efforts. This objective is addressed in both Parts I and II.
3. **Use Taxpayer Money Efficiently.** Conservation practices differ both in cost and effectiveness. Investing USDA cost-share funds in those practices that provide the most effective conservation per dollar spent saves taxpayer money. Both Parts I and II of the project are being used for this purpose.
4. **Assist Agribusiness in Protecting Water Quality.** Both the survey and the EPIC model provide insight into fertilizer use, irrigation management and crop yields. This information can assist consultants and fertilizer dealers in their efforts to improve water quality in the Tualatin River Basin while maintaining high yields for their clients. Both Parts I and II of the project apply to this objective.
5. **Include Economic Impacts.** During the Grower Focus Groups, farmers stressed the difficult financial conditions they face. Any systems of practices that do not allow reasonable farm profit will never be adopted. This objective is addressed in Parts I and II.
6. **Estimate Effectiveness of Best Management Practices.** The farmers in the Focus Groups were skeptical about some of the practices that USDA was promoting. The farmers said that, before investing large sums of money in new systems, they wanted proof that the practices would actually help improve water quality. Runoff studies are very expensive and often take years to complete. We could not, in a timely manner, measure the effects from the wide range of practices being promoted on the many diverse crops of the Tualatin Basin. This problem was confounded by our suspicions that some practices interacted with each other synergistically. Because we wanted to investigate systems of practices and not just one practice at a time, we decided to use a nationally recognized computer model, EPIC, to predict the effects of various systems of farm practices on erosion and phosphorus runoff. This objective is addressed in Part II.

In short, the *Farm Effects on Runoff Quality in Oregon's Tualatin River Basin* project seeks to provide information to farmers and their consultants, invest tax dollars wisely, aid in the design of profitable farming systems and document the conservation efforts farmers are already taking in the Tualatin River Basin. The overall goal is to improve water quality in a manner that is economically feasible for farmers.

## Methodology

The survey involved in-depth interviews with growers of seven important Tualatin Basin crops: snap beans, blueberries, sweet corn, black raspberries, strawberries, silage corn, and winter wheat. Sample survey questionnaires were drafted and circulated to the participating agencies for comment. Several revisions recommended by the Scientific Research Center at Oregon State University (OSU) were incorporated. Cal Krahmer, the interviewer, tested the drafts with seven farmers. The questionnaires were then finalized after minor revisions.

The boundaries of the Tualatin Basin are essentially the same as the boundaries of Washington County. Consequently, we assembled our farmer lists from USDA and sweet corn processor county records. The populations were screened for ownership duplications and acreage thresholds were determined to eliminate non-commercial growers.

We surveyed 40 percent to 100 percent of the farmers on each crop list. Table 1 displays the acreage threshold, commercial population and survey sample data. The best sources available were used to assemble the lists, which can be assumed to represent most, if not all, of the commercial growers in Washington County. Some farmers appeared on more than one list (e.g. many snap bean growers also grow sweet corn). In general, we eliminated those farmers who had already been interviewed for a previous crop and then randomly chose interviewees from the remaining farmers on the lists.

**TABLE 1. Commercial acreage threshold, population size of Washington County commercial growers and sample size for seven crops.**

Crops	Acreage Threshold	Commercial Population	Number Surveyed	% Surveyed
Snap beans	>20	8	8	100
Sweet corn	>20	38	28	74
Black raspberries	>10	9	8	89
Blueberries	>10	14	11	78
Strawberries	>10	25	10	40
Silage corn	>20	23	16	70
Winter wheat	>40	114	68	60

A letter was sent to each selected farmer, explaining the survey and requesting an interview. Each letter was followed by a phone call to set up an appointment. Most growers completed one survey, but some completed two. Before the letters were sent, any surveys already completed for that crop were counted toward meeting the sample size. A total of 94 letters were sent, resulting in 90 farm visits. Four farmers refused to participate.

Our interviewer, Cal Krahmer, began each survey by asking farmers to choose a typical field where they grew the crop in question in 1994. Cal then spent one to two hours asking the farmers detailed questions about their farming practices on that field. After the interview, Cal visited each surveyed field and took soil samples to be analyzed by the Central Analytical Laboratory in the Crop and Soil Science Department at OSU. He also used the Soil Survey of Washington County, Oregon (USDA-SCS, 1982) to identify each field's soil series, elevation and watershed. Cal completed surveys for 111 fields on 90 farms between January and May 1995. A copy of the survey document is included in Appendix A.

# Farm and Field Characteristics

## Subsurface Drains and Irrigation Systems

Questions about drainage and irrigation systems pertained only to the specific field chosen by the farmer. The figures given below are percentages of fields surveyed. Since field size in the Tualatin Basin varies widely, we would expect percentages by acreage to be different from these values.

The percentage of fields drained by subsurface ("tile") drains:

- 39 percent of the fields surveyed had subsurface drains installed *throughout* the field.
- 46 percent of the fields had *some* subsurface drains installed.
- 15 percent of the fields had no subsurface drains.

The depth of subsurface drain installation:

- In most (76 percent) of drained fields, drains were installed at an average depth of 4 feet.
- The shallowest average depth was 2 feet.
- The deepest average depth was 5 feet.

Of the survey respondents with irrigation systems on the field chosen for the survey:

- 53 percent used a big-gun system.
- 50 percent used hand move or wheel line sprinklers.
- 10 percent irrigated with permanent position sprinklers.
- Since some respondents used a combination of irrigation systems, the sum totals more than 100 percent.

## Livestock

Survey respondents were asked what type of livestock they owned:

- 68 percent owned no livestock.
- 17 percent owned beef cattle.
- 16 percent owned dairy cattle.
- 7 percent owned swine.
- Since some farmers owned more than one type of livestock, the sum totals more than 100 percent.

## Soil Types, Landscape and Watershed Location

The soil type, landscape and watershed location were determined for each field chosen for the survey, using the Soil Survey of Washington County, Oregon. Table 2 illustrates that most (68 percent) of the fields were silt loam soils, while 24 percent were silty clay loams. Landscape positions for each soil are also given. Table 3 identifies landscape positions by crop. The most common landscape position surveyed was valley (or terrace), and the second most common landscape was floodplain. Landscape positions were assigned based on soil type, however, and not all of the fields technically identified as floodplain soils were frequently flooded. Table 4 illustrates that 40 percent of the fields are in the Dairy Creek sub-watershed and 27 percent drain directly to the Tualatin River.

**TABLE 2. Soil series of surveyed fields.**

Soil Series	% of Fields	Landscape Position
Woodburn silt loam	39	Valley
Helvetia silt loam	9	Valley
McBee silty clay loam	9	Floodplain
Aloha silt loam	7	Valley
Chehalis silty clay loam	5	Floodplain
Quatama loam	5	Valley
Wapato silty clay loam	5	Floodplain
Willamette silt loam	5	Valley
Laurelwood silt loam	3	Hill
Other	15	

**TABLE 3. Landscape position of crops surveyed.**

Crop	Floodplain	Valley	Hillside
	----- % of Fields -----		
Snap Beans	38	62	0
Sweet Corn	25	75	0
Black Raspberries	13	87	0
Blueberries	20	80	0
Strawberries	10	80	10
Silage Corn	35	65	0
Winter Wheat	18	70	12

**TABLE 4. Sub-watersheds of surveyed fields.**

Sub-watershed	% of Fields
West Fork Dairy Creek	23
East Fork Dairy Creek	17
Tualatin River, above Dairy Creek	15
Tualatin River, below Dairy Creek	12
McKay Creek	9
Council Creek	6
Other	17

### pH, Phosphorus (P), and Potassium (K)

Soil samples were taken from each of the selected fields and analyzed by the Central Analytical Laboratory in the OSU Crop and Soil Science Department for pH, P, and K levels (Table 5). P was extracted with Bray P1 solution and K extraction was with ammonium acetate. Most crops need little or no P fertilizer when soil test P is over 50 parts per million (ppm). Most crops need little or no K fertilizer when soil test values exceed 200 ppm K. In the following pages, soil test values for individual crops are rated low, medium, high or excessive according to OSU's *Soil Test Interpretation Guide* (Marx *et al.*, 1996).

**Table 5. Soil test pH, phosphorus (P) and potassium (K) values.**

Parameter	Minimum	Maximum	Average
pH (0-14 scale)	4.1	6.7	5.6
P (ppm)	10	405	111
K (ppm)	66	818	227

### Economic Analyses

Where information is given on fertilizer costs, nitrogen (N) is valued at 30 cents per lb, phosphate ( $P_2O_5$ ) at 26 cents per lb and potash ( $K_2O$ ) at 15 cents per lb. These amounts are approximate average Washington County bulk retail values for January, 1999. Cost-savings information does not include application machinery or labor because reducing fertilizer rates does not tend to reduce application costs.



## A Note on the Data

Data shown in tables throughout this document are based on the fields selected for the survey, not acres. For example, in Table 5 above, the average soil test P of all *fields* surveyed was 113 ppm. In calculating this value, a 10 acre blueberry field counted as much as an 80 acre wheat field. We reported data in this way because this study is concerned with practices used by individual farmers.

If the data were weighted by acreage, a few large fields would skew those data, resulting in less meaningful information about how many farmers have adopted conservation practices. For a summary of statistical techniques used, please see Appendix B.

# Snap Beans (Bush Beans)

## Landscape, Yield and Previous Crops

Eight snap bean growers were surveyed. Three of the surveyed fields were on floodplain soils and the other five were on valley soils. No fields were on hillsides. Snap beans followed winter wheat on seven of the fields and row crops on one of the fields. Reported yields (fresh weight as harvested) ranged from 5-10 tons/ac and averaged 7.5 tons/ac.

## Nutrient Management

Table 6a summarizes soil test results from surveyed snap bean fields. The average soil test P was excessive at 107 ppm. Average soil test K was medium at 174 ppm and pH was moderately acid at 5.6. The OSU *Fertilizer Guide-Bush Beans* (Mansour *et al.*, 1983) recommends lime at pH 5.5 or below and two of the eight bean fields were below this value. Soil tests above the "critical values" for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely.

Table 6b summarizes nutrient application data and Figures 1a-c chart reported yield versus fertilizer rates. Each point on a chart represents one field on one farm. Over the range of N,  $P_2O_5$ , and  $K_2O$  applied on these farms, there was no significant correlation of fertilizer rate to yield ( $p = 0.10$ ).

Only one of the eight surveyed snap bean growers exceeded OSU recommendations for N, but three exceeded published OSU recommendations for  $P_2O_5$  and six exceeded unpublished<sup>1</sup> OSU recommendations for  $P_2O_5$ . The unpublished OSU information (Hart, 1993) recommends reducing snap bean  $P_2O_5$  rates to 0-60 lb/ac for fields with a soil test P greater than 50 ppm. This would allow surveyed farmers to reduce  $P_2O_5$  applications by an average of 48-71 lb/ac (worth about \$12-18/ac). According to soil test results, four of the eight growers exceeded OSU recommendations for  $K_2O$ . These growers could have reduced their average  $K_2O$  applications by 43 lb/ac, or roughly \$6/ac.

Half of the surveyed snap bean growers broadcast N and  $K_2O$  before planting. All of the growers banded a blended fertilizer at planting. Each grower applied a different blend, but most of the blends were predominately N and  $P_2O_5$ . Only one of the growers top-dressed N on the growing crop.

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<sup>1</sup> The unpublished OSU  $P_2O_5$  recommendations for the Tualatin River Basin were conveyed in a letter from Professor John Hart to USDA-NRCS. Figure 1b groups growers according to published recommendations.

**TABLE 6a. Soil test data for surveyed snap bean fields.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

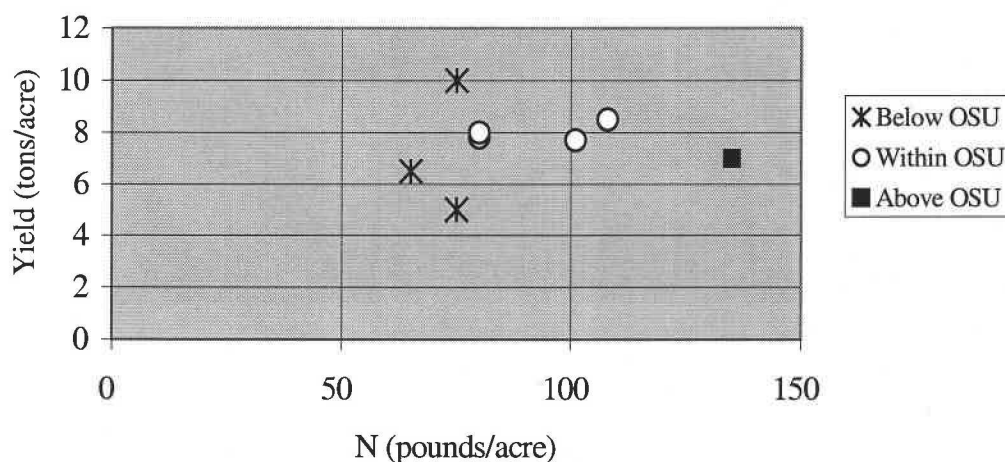
Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	18	250	107	100 <sup>1</sup>
Potassium (K) (ppm)	140	230	174	200
pH	5.3	5.8	5.6	5.5

<sup>1</sup> Application of some phosphate fertilizer in a band at planting may be beneficial for early plantings, even at high soil test P values.

**TABLE 6b. Nutrient management data for surveyed snap bean fields.** Appendix D explains calculations used in this table.

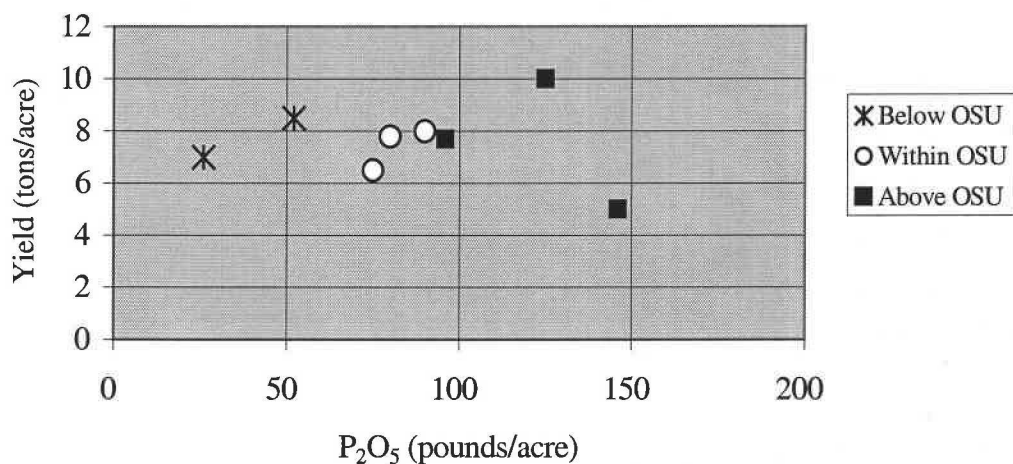
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
-----lbs / ac -----				
Nitrogen	65	135	90	76-106
Phosphate (P <sub>2</sub> O <sub>5</sub> )	26	146	86	68-98
Potash (K <sub>2</sub> O)	28	80	59	33-49

### Bean Yield vs. Nitrogen Fertilizer



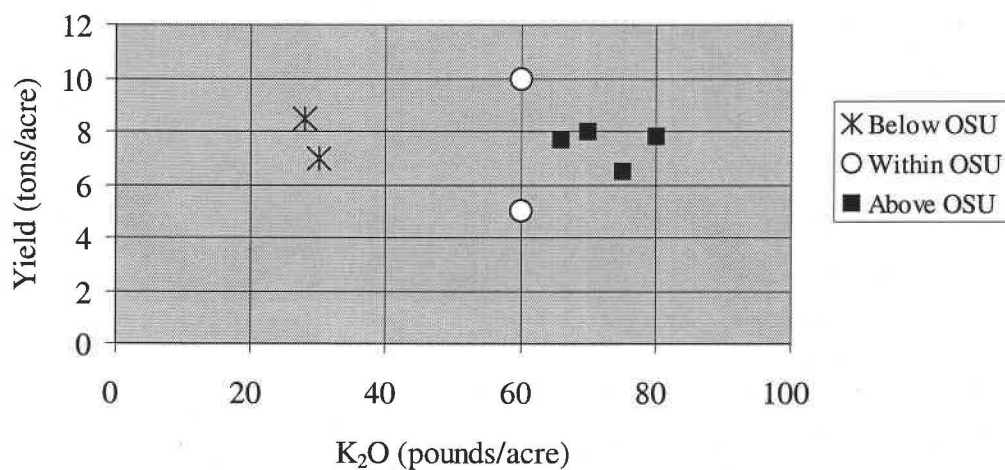
**FIGURE 1a. NITROGEN (N) FERTILIZER.** 88% of surveyed growers applied N within or below OSU recommendations. Reported bean yield was not correlated to fertilizer N ( $r = 0.06$ ,  $p = 0.10$ ) over this fertilizer range.

## Bean Yield vs. Phosphate Fertilizer



**FIGURE 1b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** The fields in this chart are grouped ("below, within, above OSU recommends") according to published OSU recommendations. 38% of surveyed growers exceeded published OSU recommendations and 75% exceeded unpublished OSU recommendations. Reported yield was not correlated to P<sub>2</sub>O<sub>5</sub> ( $r = -0.11$ ,  $p = 0.10$ ) over this fertilizer range.

## Bean Yield vs. Potash Fertilizer



**FIGURE 1c. POTASH (K<sub>2</sub>O) FERTILIZER.** 50% of surveyed growers exceeded OSU K<sub>2</sub>O recommendations, based on soil tests. Reported yield was not correlated to K<sub>2</sub>O rate ( $r = -0.10$ ,  $p = 0.10$ ) over this fertilizer range.

## Irrigation Management

Table 6c summarizes irrigation data for eight surveyed snap bean growers during an average year. The growers generally irrigated five to nine times per season, using wheel line or hand-move systems. The average application varied considerably between farms. One grower reported only 4.1 inches per season and another reported over 13 inches. The estimated difference in irrigation need between early and late season beans is 2.8 inches, so variability seems more due to management than planting date. Three of the eight surveyed bean growers reported average seasonal irrigation close ( $\pm 2.0$  inches) to the estimated crop water use of 7.8 inches, but two of the growers reported under 6.0 inches and three of the growers reported over 10.0 inches of average seasonal irrigation. Only one of the eight growers used a soil moisture monitoring device to schedule irrigation, and this grower applied 9.4 inches of irrigation in an average season. No growers reported irrigation runoff.

**TABLE 6c. Gross irrigation application to snap beans in an average year.** Appendix C explains calculations made in this table.

Water Applied	Minimum Applied	Maximum Applied	Average Applied	Estimated Crop Need
	----- inches -----			
Per irrigation	0.75	2.0	1.3	N/A
Per season	4.1	13.1	9.1	7.8

## Tillage and Cover Crops

Three of the eight bean growers used a chisel plow for primary tillage, one used a disk and the other four moldboard-plowed. None of the growers used a cover crop before or after snap beans, but the winter wheat often planted after snap beans provides many of the benefits of a cover crop.

## Summary

Snap beans generally follow wheat in crop rotations. Only one out of eight surveyed bean growers exceeded OSU N recommendations, but three exceeded published  $P_2O_5$  recommendations and four exceeded  $K_2O$  recommendations. Unpublished OSU information indicates that the published recommendations for  $P_2O_5$  may be too high and six out of eight bean growers exceeded these unpublished recommendations. Soil test P was excessive, K was medium and pH was moderately acid. Few growers used soil moisture monitoring technology to schedule irrigation and irrigation rates varied considerably from farm to farm. Practices likely to conserve resources and increase snap bean profits are reducing  $P_2O_5$  and  $K_2O$ , applying lime, using soil moisture measurements to schedule irrigation and leaving more crop residue on the soil surface. Growers did a good job managing N and controlling irrigation runoff.

# Sweet Corn

## Landscape, Yield and Previous Crops

Of the 28 surveyed sweet corn fields, 75 percent were on valley soils and 25 percent were on floodplain soils. No fields were on hillside soils. Sweet corn followed grain or grass seed on 77 percent, row crops on 19 percent and legumes on 4 percent of the fields. Reported yields (fresh weight as harvested) ranged from 8-13 tons/ac and averaged 10.3 tons/ac.

## Nutrient Management

Table 7a summarizes soil test results from the surveyed sweet corn fields. The average soil test P was high at 85 ppm. Average soil test K was medium at 213 ppm and pH was moderately acid at 5.6. The *OSU Fertilizer Guide – Sweet Corn* (Jackson *et al.*, 1983) recommends lime below pH 5.8 and 61 percent of the surveyed sweet corn fields were below this value, indicating widespread inadequate liming on this crop. Soil tests above the “critical values” for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely.

Table 7b summarizes nutrient application data and Figures 2a–c chart reported yield versus fertilizer rates. Each point represents one field on one farm. Over the range of N,  $P_2O_5$ , and  $K_2O$  applied on these farms, there was no significant correlation of fertilizer rate to yield ( $p = 0.10$ ).

Eighteen percent of the sweet corn growers applied more N than OSU recommends, while 82 percent applied N within or below OSU recommendations. Some growers are concerned that high N applications can cause sweet corn plants to lodge, making harvesting difficult. Most (71 percent) of the growers applied  $P_2O_5$  at rates higher than published recommendations. Unpublished<sup>2</sup> OSU information (Hart, 1993) recommends reducing  $P_2O_5$  rates for sweet corn to 0-60 lb/ac for fields with a soil test P greater than 50 ppm. This would allow surveyed farmers to reduce  $P_2O_5$  applications by an average of 34–93 lb/ac, reducing costs by \$9-24/ac. According to soil test results, 46 percent of the sweet corn growers applied an average of 87 lb  $K_2O$ /ac more than OSU recommendations, which is equivalent to \$13/ac. Also, 25 percent of the sweet corn growers applied 5-50 lb  $K_2O$ /ac less than OSU recommendations.

Most (90 percent) of the sweet corn growers broadcast fertilizer before planting. This was usually a blend of N and  $K_2O$ , such as 30-0-22, although some growers broadcast N only. Every surveyed grower banded a fertilizer blend at planting. The common blends were 13-39-0 (granular) and 10-34-0 (liquid). About half of the growers top-dressed N on the growing corn. The common top-dress fertilizer was 32-0-0 (liquid).

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<sup>2</sup> The unpublished OSU  $P_2O_5$  recommendations for the Tualatin River Basin were conveyed in a letter from Professor John Hart to USDA-NRCS. Figure 2b groups growers according to published recommendations.

**TABLE 7a. Soil test data for sweet corn.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

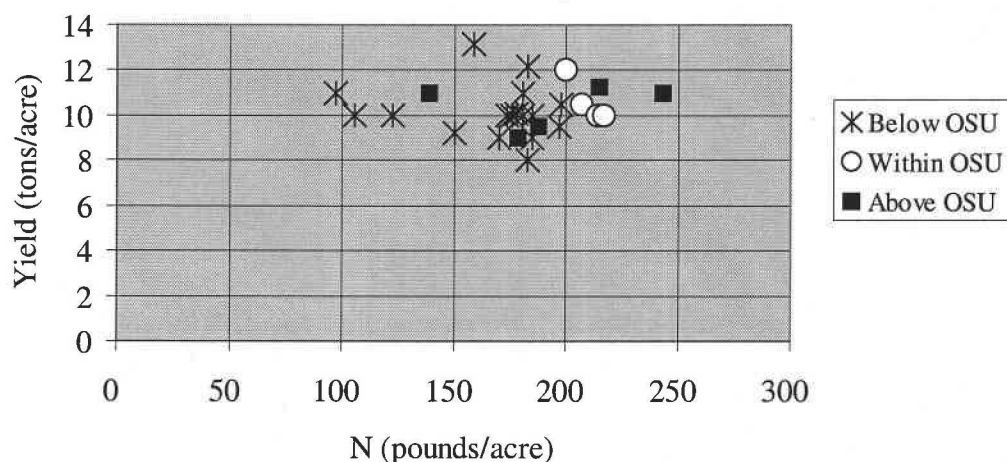
Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	10	187	85	100 <sup>1</sup>
Potassium (K) (ppm)	109	741	213	200
pH	4.9	6.1	5.6	5.7

<sup>1</sup> Application of some phosphate fertilizer in a band at planting may be beneficial for early plantings, even at high soil test P values.

**TABLE 7b. Nutrient management data for sweet corn.** Appendix D explains calculations used in this table.

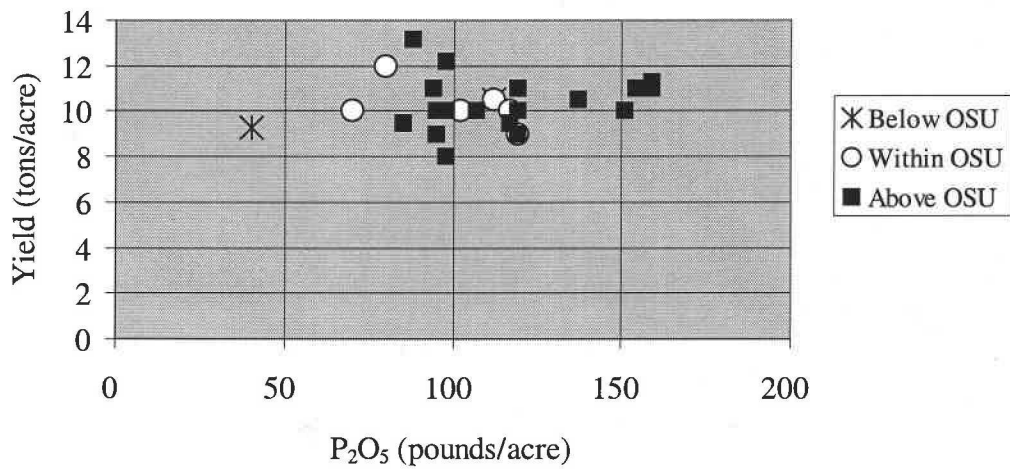
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	97	243	179	184-209
Phosphate (P <sub>2</sub> O <sub>5</sub> )	40	159	108	14-73
Potash (K <sub>2</sub> O)	0	111	64	26-52

### Sweet Corn Yield vs. Nitrogen Fertilizer



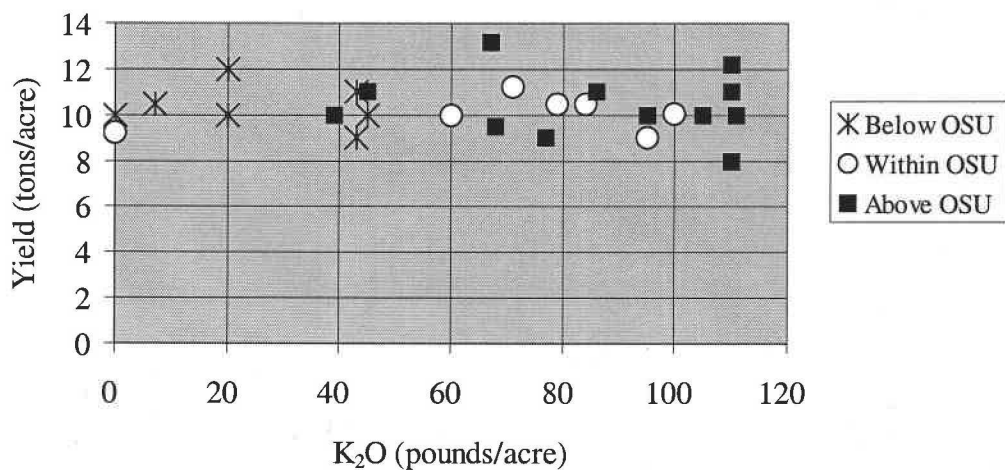
**FIGURE 2a. NITROGEN (N) FERTILIZER.** 68% of surveyed sweet corn growers applied less N than OSU recommendations. Reported yield and N rate were not correlated ( $r = 0.02$ ,  $p = 0.10$ ) over this fertilizer range.

## Sweet Corn Yield vs. Phosphate Fertilizer



**FIGURE 2b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** 71% of surveyed sweet corn growers exceeded published OSU recommendations for P<sub>2</sub>O<sub>5</sub>. Reported yield and P<sub>2</sub>O<sub>5</sub> rate were not correlated over this fertilizer range ( $r = 0.11$ ,  $p = 0.10$ ).

## Sweet Corn Yield vs. Potash Fertilizer



**FIGURE 2c. POTASH (K<sub>2</sub>O) FERTILIZER.** 46% of surveyed sweet corn growers exceeded OSU recommendations for K<sub>2</sub>O. Reported yield and K<sub>2</sub>O rate were not correlated over this fertilizer range ( $r = 0.05$ ,  $p = 0.10$ ).



## Irrigation Management

Table 7c summarizes irrigation data for 28 surveyed sweet corn growers during an average year. Sweet corn growers irrigated four to nine times in a season, using big gun systems. The growing season application varied considerably between farms, with one grower averaging only 4.1 inches per season and another averaging over 18.0 inches.

Only 11 percent of the sweet corn growers reported average seasonal irrigation within 2.0 inches of the estimated crop water use of 16.5 inches. The other 89 percent of growers used less water. Twenty-five percent of the growers used a soil moisture monitoring device to schedule irrigation and these growers averaged 11.3 inches of irrigation in an average season. The discrepancy between actual irrigation and estimated crop needs may be due to chronic under-irrigation of sweet corn, utilization of more stored soil moisture than we estimated<sup>3</sup> or calculated ET values that are not well calibrated to the Tualatin Basin. Eighteen percent of the growers reported irrigation runoff once or twice during an average growing season.

**TABLE 7c. Gross irrigation application to sweet corn in an average year.** Appendix C explains calculations made in this table.

<b>Water Applied</b>	<b>Minimum Applied</b>	<b>Maximum Applied</b>	<b>Average Applied</b>	<b>Estimated Crop Need</b>
	inches			
Per irrigation	0.75	3.0	1.8	N/A
Per season	4.1	18.0	10.8	16.5

## Tillage and Cover Crops

For primary tillage, about 30 percent of the sweet corn growers used a moldboard plow, 30 percent used a disk and the remaining 40 percent used a chisel plow. Only one grower reported growing annual cover crops in conjunction with sweet corn. Often, however, winter wheat is planted after sweet corn and this provides many of the benefits of a cover crop.

<sup>3</sup> We based our calculations on an estimated effective rooting depth of 24 inches (Smesrud *et al.*, 1998), but sweet corn roots may be tapping into deeper soil moisture than this in Tualatin Basin soils.

## Summary

Sweet corn generally follows wheat in crop rotations. Only 18 percent of sweet corn growers exceeded OSU N recommendations, but 71 percent exceeded published  $P_2O_5$  recommendations and 46 percent exceeded  $K_2O$  recommendations. Unpublished information indicates that the published OSU recommendations for  $P_2O_5$  may be too high for the Tualatin River Basin. Average soil test P was excessive, K was medium and pH was moderately acid. Few growers used soil moisture monitoring technology to schedule irrigation on sweet corn. Irrigation rates varied considerably from farm to farm and were often lower than estimated crop need. Practices likely to conserve resources and/or increase farm profits are reducing  $P_2O_5$  and  $K_2O$  fertilizer, applying lime and monitoring soil moisture during the irrigation season. Most sweet corn growers did a good job managing N and controlling irrigation water runoff.

# Black Raspberries

## Landscape, Yield and Previous Crops

Eight growers of black raspberries were surveyed. Seven of the surveyed fields were on valley soils, one field was on a floodplain soil (but the field itself was not commonly flooded) and no fields were on hillsides. Reported yields (fresh weight as harvested) ranged from 1.3-4.5 tons/ac and averaged 2.1 tons/ac.

## Nutrient Management

Table 8a summarizes soil test results from surveyed black raspberry fields. The average soil test P was excessive at 186 ppm. Average soil test K was high at 262 ppm and pH was moderately acid at 5.5. The OSU *Fertilizer Guide – Caneberries* (Hart *et al.*, 1992) recommends lime at pH 5.5 or below and half of the eight black raspberry fields were below this value, indicating a widespread problem of inadequate liming. Soil tests above the “critical values” for P, K and pH indicate yield response from  $P_2O_5$ ,  $K_2O$  and lime are unlikely. Some growers of black raspberries base fertilizer rates on leaf tissue analyses, but these analyses were not completed as part of the survey.

Table 8b summarizes black raspberry nutrient application data and Figures 3a–c chart reported yield versus fertilizer rates. Each point on a chart represents one field on one farm. Over the range applied on these farms, there was no significant correlation of N or  $P_2O_5$  to yield, but  $K_2O$  rate was positively correlated to yield ( $p = 0.10$ ).

Each of the surveyed growers applied more N than the 40-60 lb/ac recommended by Oregon State University (OSU), with one grower applying 218 lb/ac. The average amount of N applied in excess of general OSU recommendations was 73-93 lb/ac or approximately \$22-28/ac. Since OSU recommends that N applications to black raspberries be based in part on leaf tissue and cane vigor, it is incorrect to conclude from these data that the growers were over-applying N. Growers often comment that the general OSU recommendation of 40-60 lb N/ac does not result in vigorous cane growth.

Because of the high soil test P values, OSU would recommend no  $P_2O_5$  on these fields. All but one grower, however, applied  $P_2O_5$  and the grower with the highest soil test P (380 ppm) applied the most. The average application of 45 lb  $P_2O_5$  /ac is equivalent to \$12/ac. Four of the eight growers applied  $K_2O$  within or below OSU recommendations and the other four applied  $K_2O$  at rates slightly higher than OSU recommends. Over the range of rates reported in this survey,  $K_2O$  applications were correlated to higher yields ( $r = 0.65$ ,  $p = 0.10$ ). This, along with the fact that two of the eight growers applied less  $K_2O$  than OSU recommends, suggests that some growers could benefit from modestly higher  $K_2O$  applications.

All growers applied their fertilizer in a broad band on the soil surface within the crop row. Each grower applied a blended fertilizer, such as 16-16-16, in March or April. One grower applied no additional N after the blended fertilizer. The other seven growers applied additional N one to three times between April and June, using 34-0-0 (solid) or 32-0-0 (liquid) formulations. Two growers applied blended fertilizers in the late summer.

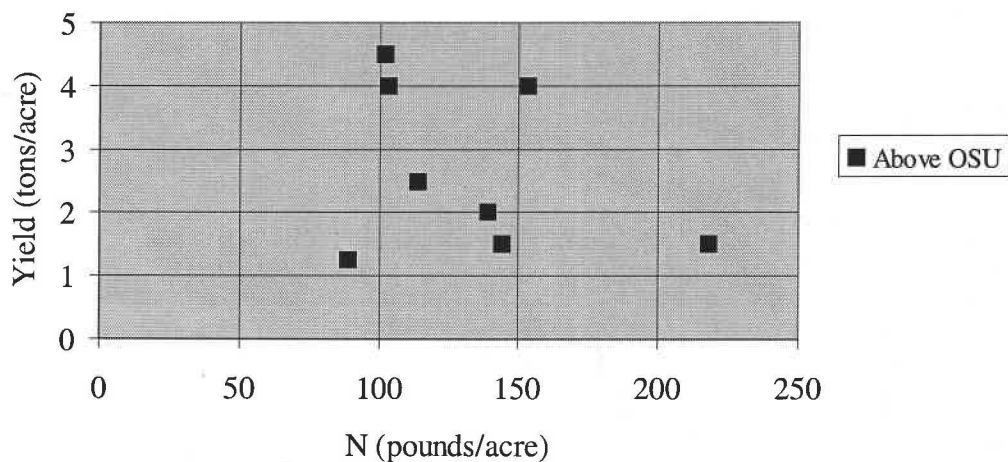
**TABLE 8a. Soil test data for surveyed black raspberry fields.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	55	380	186	40
Potassium (K) (ppm)	140	390	262	350
pH	4.6	6.6	5.5	5.5

**TABLE 8b. Nutrient management data for surveyed black raspberry fields.** Appendix D explains calculations used in this table.

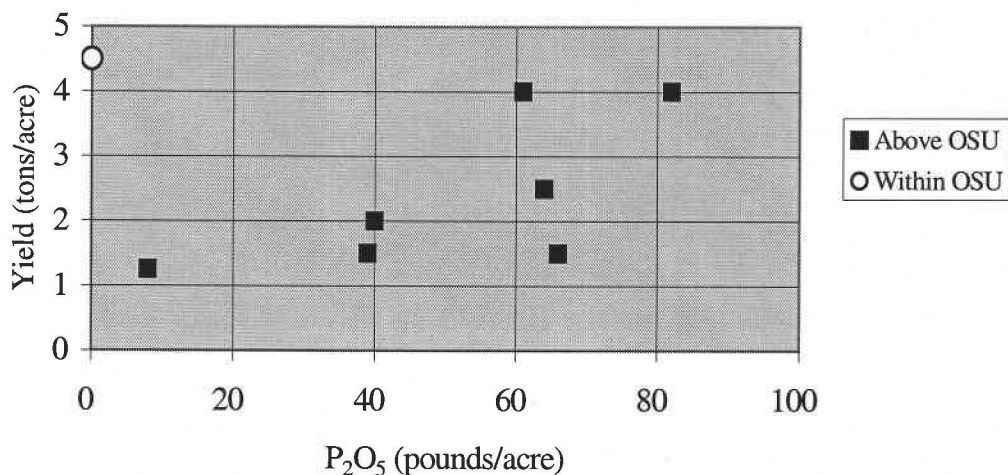
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	89	218	133	40-60
Phosphate (P <sub>2</sub> O <sub>5</sub> )	0	82	45	0
Potash (K <sub>2</sub> O)	15	82	49	35-55

## Black Raspberry Yield vs. Nitrogen Fertilizer



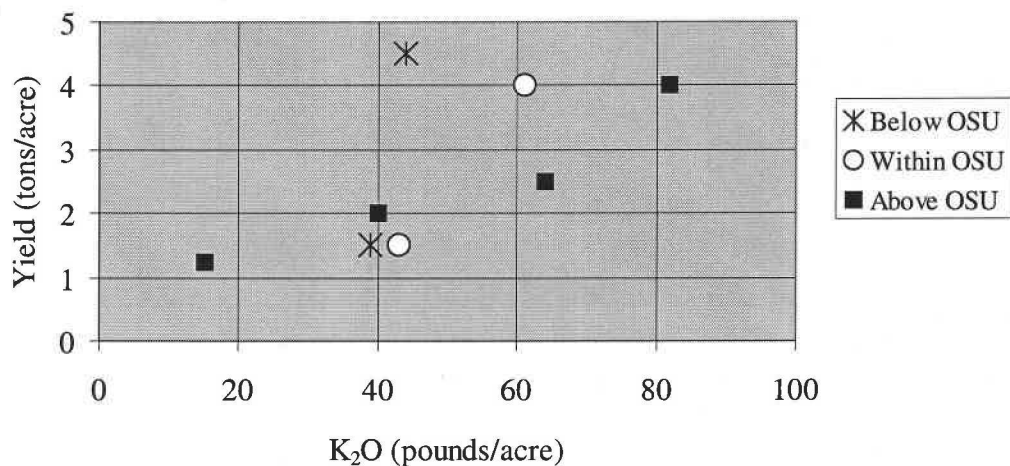
**FIGURE 3a. NITROGEN FERTILIZER.** Every surveyed grower of black raspberries exceeded OSU recommendations for N. Reported yield and N rate were not correlated over this fertilizer range ( $r = -0.32$ ,  $p = 0.10$ ).

## Black Raspberry Yield vs. Phosphate Fertilizer



**FIGURE 3b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** 88% of surveyed growers of black raspberries exceeded P<sub>2</sub>O<sub>5</sub> recommendations. Reported yield and P<sub>2</sub>O<sub>5</sub> rate were not correlated over this fertilizer range ( $r = 0.09$ ,  $p = 0.10$ ).

## Black Raspberry Yield vs. Potash Fertilizer



**FIGURE 3c. POTASH (K<sub>2</sub>O) FERTILIZER.** 50% of the surveyed growers exceeded OSU recommendations for K<sub>2</sub>O. Reported yield and K<sub>2</sub>O rate were positively correlated over this fertilizer range ( $r = 0.65$ ,  $p = 0.10$ ).

## Irrigation Management

Table 8c summarizes irrigation data for eight surveyed growers during an average year. Black raspberry crops received an average of 3–10 irrigations per season, from big gun systems. The average seasonal application varied considerably between farms, with one grower applying only 5.5 inches and another applying 18.0 inches. Each of the surveyed growers reported average seasonal irrigation substantially under the estimated crop water use of 30.8 inches. Growers commonly allow black raspberries to experience some stress due to low soil moisture after harvest. Four of the eight growers used a soil moisture monitoring device to schedule irrigation and these growers averaged 10.9 inches of irrigation per season. Two growers reported irrigation water runoff once or twice per season.

**TABLE 8c. Gross irrigation application to black raspberries in an average year.** Appendix C explains calculations made in this table.

Water Applied	Minimum Applied	Maximum Applied	Average Applied	Estimated Crop Need
	inches			
Per irrigation	1.0	2.5	1.8	N/A
Per season	5.5	18.0	10.8	30.8

## **Cover Crops**

Two of the eight surveyed raspberry growers used cover crops.

## **Summary**

Many growers applied more N and  $P_2O_5$  than OSU recommendations. Average soil test P was excessive, K was high and pH was moderately acid. Half of the surveyed growers used soil moisture monitoring technology to schedule irrigation. Irrigation rates varied considerably from farm to farm and were lower than estimated crop need. Practices likely to conserve resources and/or increase farm profits are reducing N and  $P_2O_5$  fertilizer, applying lime and planting cover crops. Growers of black raspberries conserved irrigation water well.

# Blueberries

## Landscape, Yield and Previous Crops

Eleven blueberry growers were surveyed. Nine of the surveyed fields were on valley soils and the other two were on floodplain soils. Blueberries do not reach full production until they are six to eight years old, according to OSU's *Highbush Blueberry Production* (PNW 215). Only 5 of the 11 growers surveyed had fields at mature, full production and the data reported here pertain only to those five fields that were eight or more years old. Reported yields (fresh weight as harvested) ranged from 5-12 tons/ac and averaged 9 tons/ac. Many factors influence blueberry yield, including variety and whether the crop was harvested by hand or machine.

## Nutrient Management

Table 9a summarizes soil test results from surveyed blueberry fields. The average soil test P was excessive at 315 ppm. Average soil test K was high at 259 ppm and pH was strongly acid at 4.5. The OSU *Fertilizer Guide – Blueberries* (Strik and Hart, 1997) recommends lime at pH below 4.5 and two of the five mature blueberry fields were below this value. Soil tests above the “critical values” for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely. Some growers base fertilizer rates on leaf tissue analyses, but these analyses were not completed as part of the survey.

Table 9b summarizes nutrient application data and Figures 4a-c chart reported yield versus fertilizer rates. Each point on a chart represents one field on one farm. Over the range of N,  $P_2O_5$ , and  $K_2O$  applied on these farms, there was no significant correlation of fertilizer rate to yield ( $p = 0.10$ ).

The one grower who applied N within OSU recommendations had the lowest reported yield, but the data are insufficient to determine if this yield loss was due to the lower N rate. The other growers exceeded OSU recommendations for N by between 48-184 lb, which is roughly equivalent to \$14-55/ac. The growers exceeded OSU *Fertilizer Guide* recommendations for  $P_2O_5$  by 39-108 lb/ac, which is equivalent to \$10-28/ac. According to soil test results, none of the five growers needed to apply  $K_2O$ . The four growers who did apply  $K_2O$  used 39-108 lb/ac, roughly equivalent to \$6-16/ac.

Each of the five growers applied a blended fertilizer, such as 16-16-16, in March or April. Each grower applied additional N, after the initial blended fertilizer, in one to six applications between April and September. The growers used 34-0-0 (solid), 32-0-0 (liquid), or 46-0-0 (solid) formulations for these additional N applications. Three growers applied blended fertilizer again in September or October. The OSU *Fertilizer Guide* recommends that no N be applied after July 1.



**TABLE 9a. Soil test data for surveyed blueberry fields.** When soil test values are above the critical value, yield response to phosphate or potash application is unlikely.

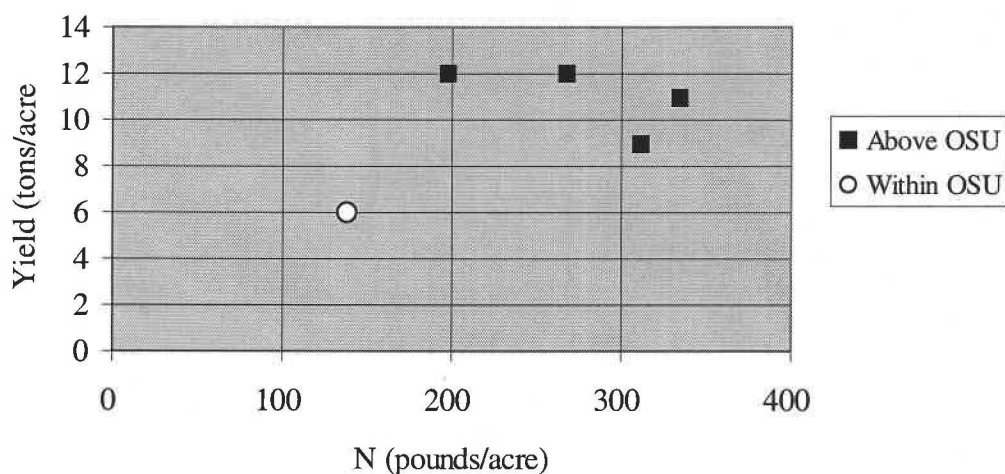
Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	56	405	315	50
Potassium (K) (ppm)	195	343	259	200
pH	4.1	4.9	4.5	4.5-5.5 <sup>1</sup>

<sup>1</sup> When pH is below 4.5, lime applications are needed and when pH is above 5.5, sulfur is recommended.

**TABLE 9b. Nutrient management data for surveyed blueberry fields.** Appendix D explains calculations used in this table.

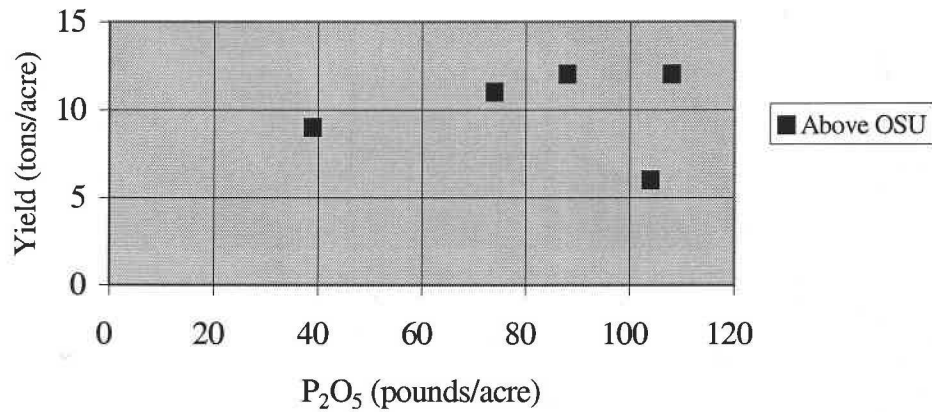
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	138	334	250	90-150
Phosphate (P <sub>2</sub> O <sub>5</sub> )	39	108	83	0
Potash (K <sub>2</sub> O)	0	108	62	0

### Blueberry Yield vs. Nitrogen Fertilizer



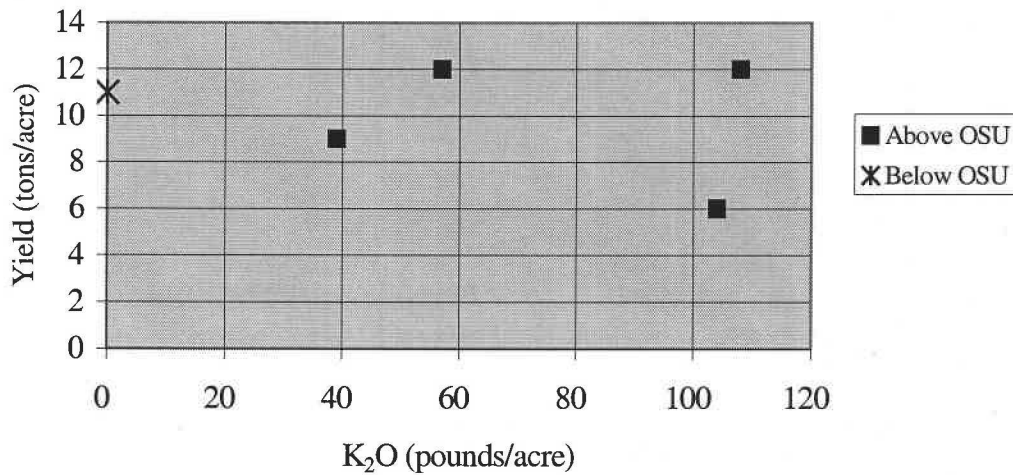
**FIGURE 4a. NITROGEN (N) FERTILIZER.** 80% of surveyed blueberry growers exceeded OSU recommendations for N. Reported yield and N rate were not correlated ( $r = 0.49$ ,  $p = 0.10$ ) over this fertilizer range.

## Blueberry Yield vs. Phosphate Fertilizer



**FIGURE 4b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** All surveyed blueberry growers exceeded OSU recommendations for P<sub>2</sub>O<sub>5</sub>. Reported yield and P<sub>2</sub>O<sub>5</sub> rate were not correlated ( $r = 0.03$ ,  $p = 0.10$ ) over this fertilizer range.

## Blueberry Yield vs. Potash Fertilizer



**FIGURE 4c. POTASH (K<sub>2</sub>O) FERTILIZER.** 80% of surveyed blueberry growers exceeded OSU recommendations for K<sub>2</sub>O. Reported yield and K<sub>2</sub>O rate were not correlated ( $r = -0.27$ ,  $p = 0.10$ ) over this fertilizer range.

## Irrigation Management

Table 9c summarizes irrigation data for five blueberry growers during an average year. Blueberry growers irrigated from 21–36 times per average season, using solid set systems. The average seasonal application varied considerably between farms, with one grower applying 25.5 inches per season and another applying 51.0 inches. Two of the growers used a soil moisture monitoring device to schedule irrigation; one of these growers applied 50.6 inches of water and one applied 29.0 inches per season. No growers reported irrigation water runoff.

**TABLE 9c. Gross irrigation application to blueberries in an average year.** Appendix C explains calculations made in this table.

<b>Water Applied</b>	<b>Minimum Applied</b>	<b>Maximum Applied</b>	<b>Average Applied</b>	<b>Estimated Crop Need</b>
	----- inches -----			
Per irrigation	1.0	2.0	1.3	N/A
Per season	25.5	51.0	37.3	35.4

## Cover Crops

None of the surveyed blueberry fields had cover crops, although some of the growers had cover crops in other blueberry fields on their farm.

## Summary

Many blueberry growers applied more N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O than OSU recommendations. Average soil test P was excessive, K was high and soil pH was strongly acid. Two of the five surveyed growers used soil moisture monitoring technology to schedule irrigation. Irrigation rates varied considerably from farm to farm and were often higher than estimated crop need. Practices likely to conserve resources and/or increase farm profits are reducing N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O fertilizer, liming, planting cover crops, and scheduling irrigation based on soil moisture measurements. All surveyed blueberry growers did a good job controlling irrigation water runoff.

# Strawberries

## Landscape, Yield and Previous Crops

Ten strawberry growers were surveyed. Eight of the surveyed fields were on valley soils, one was on hillside soils and one was on floodplain soils. The field on floodplain soils was not frequently flooded. Because strawberries are a perennial crop, rotation data were not collected. Reported yields (fresh weight as harvested) ranged from 4.5-10.5 tons/ac and averaged 8.9 tons/ac. Strawberries are not harvested in the year they are planted. Growers fertilize established fields differently than newly planted strawberries and the results shown here pertain only to established fields that growers planned to keep in production the following year.

## Nutrient Management

Table 10a summarizes soil test results from surveyed strawberry fields. The average soil test P was excessive at 123 ppm. Average soil test K was medium at 217 ppm and pH was moderately acid at 5.7. The *OSU Fertilizer Guide – Strawberries (Western Oregon – West of the Cascades)* (Hart *et al.*, 2000b) recommends lime at pH 5.3 or below and 2 of the 10 strawberry fields were below this value. Soil tests above the “critical values” for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely. Table 10b summarizes nutrient application data and Figures 5a-c chart reported yield versus fertilizer rates. Each point represents one field on one farm.

Seven of the 10 strawberry growers applied N according to OSU recommendations and the remaining 3 growers applied N at rates slightly below OSU recommendations. Three of the 10 growers applied  $P_2O_5$  according to OSU recommendations and the other 7 growers exceeded OSU recommendations by 20-200 lb, or about \$5-52 / ac. For these 10 fields, yield was negatively correlated to  $P_2O_5$  rate ( $r = -0.62$ ,  $p = 0.10$ ). These rates of  $P_2O_5$  should not be toxic to crops and it seems unlikely that the  $P_2O_5$  is *causing* decreased yields. Many growers believe  $P_2O_5$  can reduce the severity of strawberry root diseases. Some of the surveyed growers may have applied higher rates of  $P_2O_5$  because their fields had disease problems. Thus, perhaps the high  $P_2O_5$  applications were actually *caused by* decreased yields (diseased fields). One strawberry grower relates an anecdote of how one of his fields was mistakenly over-fertilized with  $P_2O_5$  one year. The following year, that field yielded better than other fields and word spread that high  $P_2O_5$  rates were beneficial.

Seven of the strawberry growers applied  $K_2O$  according to OSU recommendations, while one grower applied slightly less than recommended and two growers applied slightly more. Over this range of applications, strawberry yield was positively correlated to  $K_2O$  rate ( $r = 0.67$ ,  $p = 0.10$ ). All of the surveyed strawberry growers applied a blended fertilizer in August. Common formulations were 10-20-20 and 11-52-0. Half of the growers applied 0-0-22 in March.

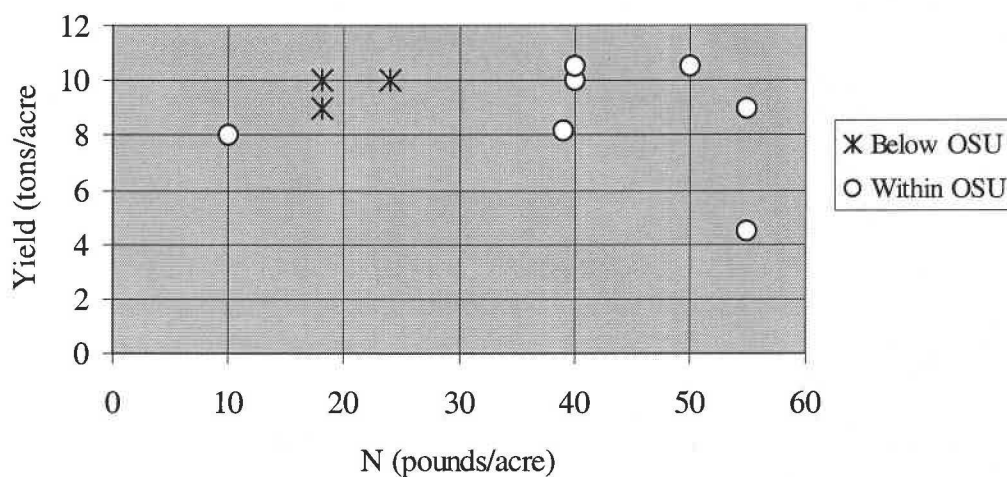
**TABLE 10a. Soil test data for surveyed strawberry fields.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	48	278	123	45
Potassium (K) (ppm)	136	358	217	175
pH	5.2	6.3	5.7	5.3

**TABLE 10b. Nutrient management data for surveyed strawberry fields.** Appendix D explains calculations used in this table.

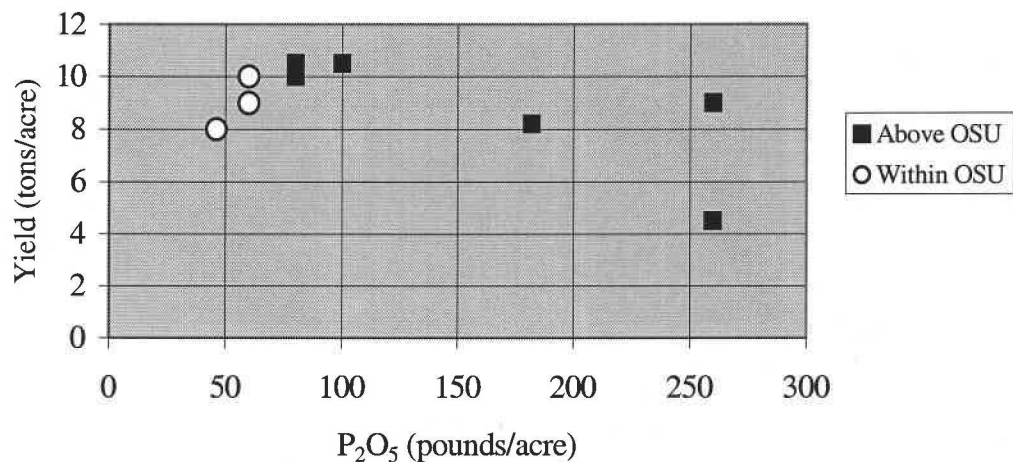
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	18	55	39	25-70
Phosphate (P <sub>2</sub> O <sub>5</sub> )	46	260	121	0-60
Potash (K <sub>2</sub> O)	0	100	58	32-88

### Strawberry Yield vs. Nitrogen Fertilizer



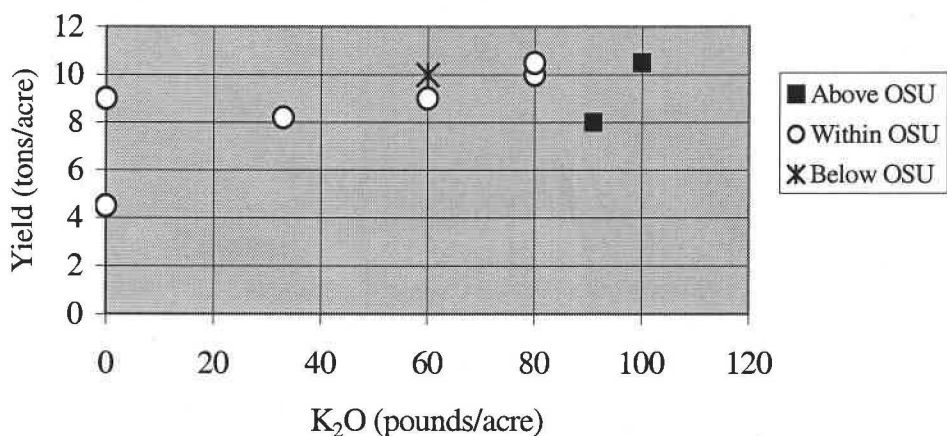
**FIGURE 5a. NITROGEN (N) FERTILIZER.** All surveyed strawberry growers applied N within or below OSU recommendations. Reported yield and N rate were not correlated ( $r = -0.42$ ,  $p = 0.10$ ) over this fertilizer range.

## Strawberry Yield vs. Phosphate Fertilizer



**FIGURE 5b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** 70% of surveyed strawberry growers exceeded OSU P<sub>2</sub>O<sub>5</sub> recommendations. Reported yield and P<sub>2</sub>O<sub>5</sub> rate were negatively correlated ( $r = -0.62$ ,  $p = 0.10$ ) over this fertilizer range.

## Strawberry Yield vs. Potash Fertilizer



**FIGURE 5c. POTASH (K<sub>2</sub>O) FERTILIZER.** 70% of surveyed strawberry growers followed OSU Fertilizer Guide recommendation of 0-120 pounds K<sub>2</sub>O / acre, based on soil test potassium levels. Strawberry yields and K<sub>2</sub>O rates were positively correlated over this fertilizer range ( $r = 0.67$ ,  $p = 0.10$ ).

## Irrigation Management

Table 10c summarizes irrigation data for 10 surveyed strawberry growers during an average year. Strawberry growers averaged from 2–7 irrigations per season, using hand-move systems. The average seasonal application varied considerably between farms, with one grower applying 3.5 inches per season and another applying 16.3 inches. Each of the growers applied much less irrigation in an average season than the estimated crop need. Strawberries, like black raspberries, are allowed to experience stress due to low soil moisture after the crop is harvested. Four of the 10 growers used a soil moisture monitoring device to schedule irrigation; these growers averaged 9.6 inches of water per season. Three of the growers reported irrigation water runoff once or twice per season.

**TABLE 10c. Gross irrigation application to strawberries in an average year.** Appendix C explains calculations made in this table.

Water Applied	Minimum Applied	Maximum Applied	Average Applied	Estimated Crop Need
	----- inches -----			
Per irrigation	1.0	3.0	1.9	N/A
Per season	3.5	16.3	8.1	26.4

## Cover Crops

Only one grower reported using a cover crop in strawberries.

## Summary

A strawberry planting takes one year to come into production and then is usually harvested for two to four years before being tilled under. Some growers rotate fields into other crops for many years to avoid disease; others plant right back to strawberries. The data shown above are for production year strawberries. First year plantings are fertilized differently and this report doesn't present those data. Many strawberry growers applied more  $P_2O_5$  and  $K_2O$  than OSU recommendations. Average soil test P was excessive, K was medium and soil pH was moderately acid. Four of the 10 surveyed growers used soil moisture monitoring technology to schedule irrigation. Irrigation rates varied considerably from farm to farm and were often lower than estimated crop need. Practices likely to conserve resources and/or increase farm profits are reducing  $P_2O_5$  fertilizer, planting cover crops, and controlling irrigation water runoff. All surveyed strawberry growers did a good job managing N and  $K_2O$  fertilizer and most maintained a suitable soil pH.



# Silage Corn

## Landscape, Yield and Previous Crops

Of the 16 silage corn fields surveyed, 65 percent were on valley soils and the other 35 percent were on floodplain soils. No fields were on hillsides. Silage corn followed a row crop on 35 percent of the fields, a legume on 29 percent and small grain or grass seed on 18 percent of the fields. For 18 percent of the surveyed fields, the farmer could not identify the preceding crop because another farmer had leased the field the year before. Reported yields (fresh weight as harvested) ranged from 23-38 tons/ac and averaged 27 tons/ac. Yield data for silage corn may not be as accurate as yield data for other crops presented in this report. Often, growers do not have an accurate means of measuring corn tonnage produced from individual fields. Many of the farms that produce silage corn are dairies.

## Nutrient Management

Table 11a summarizes soil test results for surveyed silage corn fields. The average soil test P was high at 98 ppm. Average soil test K was high at 335 ppm, reflecting the fact that many of these fields received dairy manure. Soil test pH was moderately acid at 5.8. The OSU *Fertilizer Guide – Field Corn (Western Oregon – West of the Cascades)* (Gardner and Jackson, 1983) recommends lime at pH 5.5 or below, but none of the corn silage fields were below this value. Soil tests above the “critical values” for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely.

Table 11b summarizes nutrient application data and Figures 6a-c chart reported yield versus fertilizer rates. Each point represents one field on one farm. Over the range of N,  $P_2O_5$ , and  $K_2O$  applied on these farms, there was no significant correlation of fertilizer rate to yield ( $p = 0.10$ ). The amount of nutrients applied includes both commercial fertilizer and manure. Before determining fertilizer credits from manure, nutrient losses in storage and application were subtracted. See Appendix E for details.

Sixty-three percent of the growers applied N at rates within or below OSU recommendations, but only 6 percent of the surveyed growers applied  $P_2O_5$  according to OSU recommendations. The other 94 percent of the growers exceeded OSU recommendations by up to 365 lb  $P_2O_5$  /ac. Most of these excessive  $P_2O_5$  applications were via dairy manure. Sixty-nine percent of the growers exceeded OSU recommendations for  $K_2O$ . These high  $K_2O$  applications were via dairy manure. One grower applied 675 lb of  $K_2O$ /ac on a field that, according to soil test results needed no additional  $K_2O$ . The relative concentrations of N,  $P_2O_5$  and  $K_2O$  in manure often result in applications aimed at supplying a crop's N requirements but grossly exceeding the crop's  $P_2O_5$  and  $K_2O$  needs (Sharpley *et al.*, 1996).



It is difficult to estimate an economic cost to over-applying nutrients via manure. Often, the only alternative to over-applying manure is to haul the manure to other fields. The reduced fertilizer costs on those fields is often at least partially offset by the increased labor and machinery costs in hauling.

Eighty percent of the growers broadcast fertilizer before planting. Most used a blend of N and K<sub>2</sub>O, but two growers broadcast a complete N-P-K formulation. Also, 80 percent of the growers applied a banded fertilizer blend at planting. The most common blend used was 13-39-0, but some used 16-20-0, 10-34-0, or some other blend. Only one surveyed grower top-dressed N to the growing corn crop. He used a 32-0-0 liquid solution.

Five of the growers applied solid manure in the spring before planting corn silage, tilling this manure into the soil an average of 14 days after application. Two of the growers applied solid manure throughout the winter and one grower applied solid manure in the previous fall. The fall and winter manure was not incorporated until spring. The reported amount of solid manure ranged from 16-50 tons/ac (wet weight), but two of the growers did not know how much they applied. Three growers applied liquid manure in the spring before planting corn and they incorporated this manure within 7-21 days. Two growers applied liquid manure to the growing corn crop during the summer. Liquid manure applications ranged from 0.7-3.0 acre-inches per acre per year.

**TABLE 11a. Soil test data for surveyed silage corn fields.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

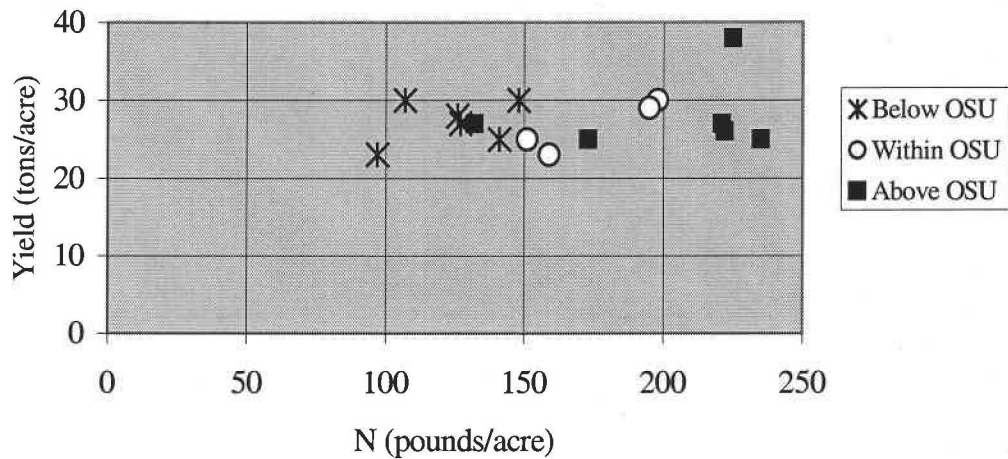
Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	17	206	98	30 <sup>1</sup>
Potassium (K) (ppm)	97	818	335	150
pH	5.6	6.1	5.8	5.5

<sup>1</sup> Application of some phosphate fertilizer in a band at planting may be beneficial for early plantings, even at high soil test P values.

**TABLE 11b. Nutrient management data for surveyed silage corn fields.** Appendix D explains calculations used in this table.

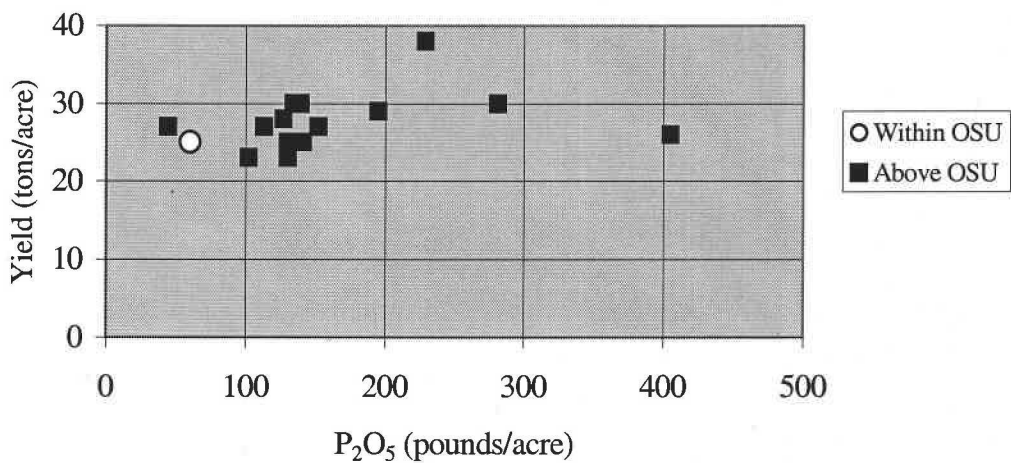
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	97	235	166	141-188
Phosphate (P <sub>2</sub> O <sub>5</sub> )	44	405	157	33-45
Potash (K <sub>2</sub> O)	0	675	208	9-14

## Corn Silage Yield vs. Nitrogen Fertilizer



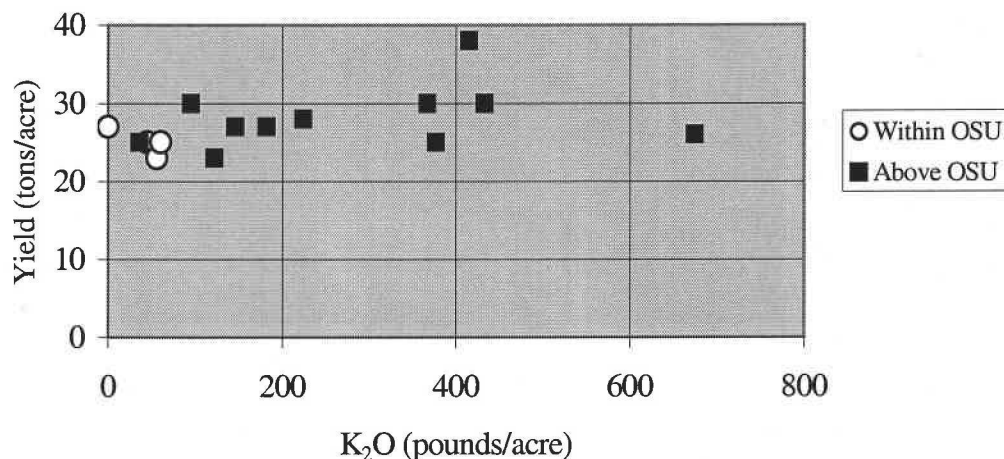
**FIGURE 6a. NITROGEN (N) FERTILIZER.** 63% of surveyed silage corn growers applied N at rates within or below OSU recommendations. Reported yield and N rate were not correlated ( $r = 0.29$ ,  $p = 0.10$ ) over this fertilizer range.

## Corn Silage Yield vs. Phosphate Fertilizer



**FIGURE 6b. PHOSPHATE ( $P_2O_5$ ) FERTILIZER.** 94% of surveyed silage corn growers exceeded OSU  $P_2O_5$  recommendations. Reported yield and  $P_2O_5$  rate were not correlated ( $r = 0.31$ ,  $p = 0.10$ ) over this fertilizer range.

## Corn Silage Yield vs. Potash Fertilizer



**FIGURE 6c. POTASH (K<sub>2</sub>O) FERTILIZER.** 69% of surveyed silage corn growers exceeded OSU K<sub>2</sub>O recommendations. Reported yield and K<sub>2</sub>O rate were not correlated ( $r = 0.38$ ,  $p = 0.10$ ) over this fertilizer range.

## Irrigation Management

Table 11c summarizes irrigation data for silage corn during an average year. Silage corn growers average from two to five irrigations per season, using big gun systems. The seasonal application varied considerably between farms, with one grower reporting only 3.0 inches per average season and another reporting 18.4 inches.

Of the 16 surveyed growers, 15 applied much less irrigation in an average season than the estimated crop need. Silage corn is a low value crop and many growers explain that they can't afford to invest in enough irrigation system capacity to adequately irrigate the crop during heat waves. Only 1 of the 15 growers used a soil moisture monitoring device to schedule irrigation. Some growers remark that they don't need a monitoring device to tell them their corn is wilting. Without enough irrigation system capacity, it is understandable that they see no reason to monitor soil moisture. No growers reported irrigation water runoff.

**TABLE 11c. Gross irrigation application to silage corn in an average year.** Appendix C explains calculations made in this table.

<b>Water Applied</b>	<b>Minimum Applied</b>	<b>Maximum Applied</b>	<b>Average Applied</b>	<b>Estimated Crop Need</b>
	----- inches -----			
Per irrigation	1.0	3.5	2.0	N/A
Per season	3.0	18.4	7.0	16.0

## Tillage and Cover Crops

Half of the surveyed growers moldboard plowed before planting corn. 30 percent of the growers used a disk for primary tillage, and 20 percent used a chisel plow. None of the surveyed growers planted a cover crop in conjunction with the corn. Winter wheat, however, is sometimes planted after silage corn and this provides many of the benefits of a cover crop.

## Summary

The survey indicates that silage corn generally follows clover or a row crop in the rotation. Many silage corn growers applied more  $P_2O_5$  and  $K_2O$  than OSU recommendations. Often, the excessive applications were due to manure. Average soil test P and K values were high. One of the 16 surveyed growers used soil moisture monitoring technology to schedule irrigation. Irrigation rates varied considerably from farm to farm and were often lower than estimated crop need. Practices likely to conserve resources and/or increase farm profits are reducing  $P_2O_5$  and  $K_2O$  rates (manure plus fertilizer) and planting cover crops. Investing in additional irrigation system capacity may improve yields, but it is beyond the scope of this document to evaluate whether the costs involved are justified. Many surveyed silage corn growers did a good job managing N fertilizer and maintaining a suitable soil pH for corn silage.

# Winter Wheat

## Landscape, Yield and Previous Crops

Of the 68 surveyed winter wheat fields, 70 percent were on valley soils, 12 percent were on hillside soils and 18 percent were on floodplain soils (but not in active floodplains). Winter wheat followed a good crop of perennial legumes on 8 percent of the fields, row crops or a below average crop of legumes on 81 percent of the fields and small grain or grass seed on 12 percent. Reported yields (as harvested) ranged from 60-140 bushels/ac and averaged 106 bushels/ac. The winter wheat data presented here include dryland wheat farms, but many of the wheat data were collected in conjunction with surveying sweet corn, snap beans and silage corn growers. Consequently, the data as a whole are skewed toward wheat grown in rotation with irrigated crops. It is likely that these data show higher soil test values for P and K than would be expected from dryland fields.

## Nutrient Management

Table 12a summarizes soil test results from surveyed winter wheat fields. The average soil test P was high at 93 ppm. Average soil test K was medium at 200 ppm and pH was moderately acid at 5.7. The *OSU Fertilizer Guide – Winter Wheat (Western Oregon – West of the Cascades)* (Hart *et al.*, 2000a) recommends lime at pH 5.7 or below and 35 percent of the wheat fields were below this value. Soil tests above the “critical values” for P, K and pH indicate yield response from application of  $P_2O_5$ ,  $K_2O$  and lime, respectively, are unlikely.

Table 12b summarizes nutrient application data and Figures 7a-c chart reported yield versus fertilizer rates. Each point represents one field on one farm. Over the range of N,  $P_2O_5$ , and  $K_2O$  applied on these fields, there was no significant correlation of fertilizer rate to wheat yield ( $p = 0.10$ ).

Sixty-nine percent of growers applied N according to OSU recommendations, while 12 percent applied less N than recommended and 18 percent applied more. OSU bases N recommendations on the previous crop. For winter wheat following a good crop of clover or alfalfa, 60-100 lb N / ac is recommended. Following row crops, vetch, peas or a poor crop of perennial legumes, OSU recommends 100-140 lb N / ac. Following grain or grass seed crops, OSU recommends 140-180 lb N / ac. Winter wheat followed a good crop of clover or alfalfa on 8 percent of the surveyed fields and each of these was fertilized with more N than OSU recommends. Growers seem reluctant to trust the previous legume crop to supply as much N as OSU indicates. If the wheat fields following a good crop of perennial legumes had been fertilized with 100 lb N / ac rather than the 134 lb they actually averaged, these growers could have reduced costs by approximately \$10 / ac.

Over 90 percent of the surveyed growers applied no  $P_2O_5$ , as per OSU recommendations. Five growers applied 10-30 lb  $P_2O_5$  / ac at planting time. One grower applied 105 lb  $P_2O_5$  / ac in the

form of liquid manure in late September just before planting. Only three of the surveyed wheat growers applied  $K_2O$  and one of these applications was due to manure. According to soil test results, four of the growers should have applied some  $K_2O$  to their wheat crop but did not.

Only 10 percent of the growers applied a blended fertilizer at planting and most of these applied 16-20-0 through the grain drill. One grower broadcast 10-20-20 before planting. 48 percent of the wheat growers top-dressed N fertilizer in split applications around February 29 and March 29. The other 52 percent top-dressed N once around March 11. Common formulations were 40-0-0 and 46-0-0 dry fertilizer and 32-0-0 liquid.

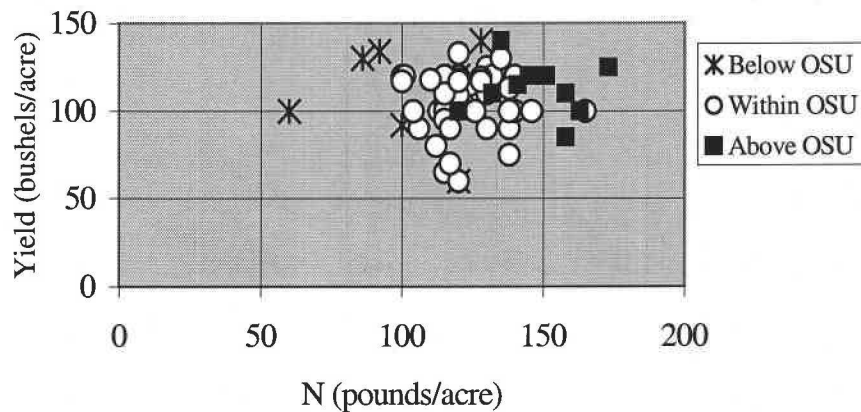
**TABLE 12a. Soil test data for surveyed winter wheat fields.** When soil test values are above the critical value, yield response to phosphate, potash or lime application is unlikely.

Parameter	Minimum	Maximum	Average	Critical Value
Phosphorus (P) (ppm)	10	250	93	30
Potassium (K) (ppm)	66	546	200	100
pH	5.1	6.7	5.7	5.7

**TABLE 12b. Nutrient management data for surveyed winter wheat fields.** Appendix D explains calculations used in this table.

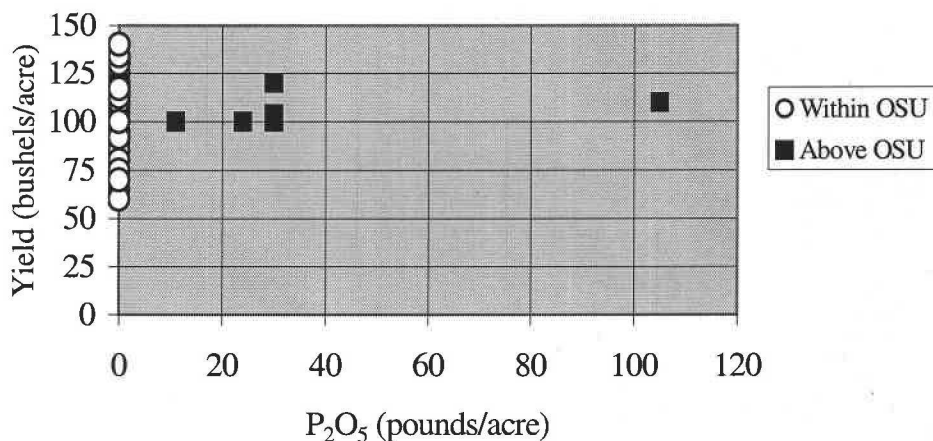
Nutrient	Minimum Applied	Maximum Applied	Average Applied	Average OSU Recommends
----- lbs / ac -----				
Nitrogen	60	173	125	105-145
Phosphate ( $P_2O_5$ )	0	105	3	4-5
Potash ( $K_2O$ )	0	182	4	3-5

## Wheat Yield vs. Nitrogen Fertilizer



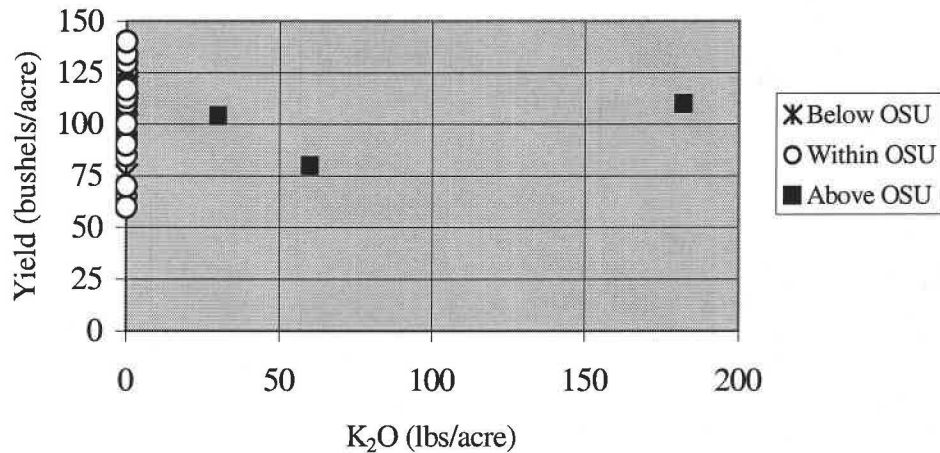
**FIGURE 7a. NITROGEN (N) FERTILIZER.** 69% of surveyed wheat growers applied N according to OSU recommendations. Many of the growers who exceeded N recommendations appeared to not take credit for N supplied by a previous legume crop. Reported yield and N rate were not correlated ( $r = 0.05$ ,  $p = 0.10$ ) over this fertilizer range.

## Wheat Yield vs. Phosphate Fertilizer



**FIGURE 7b. PHOSPHATE (P<sub>2</sub>O<sub>5</sub>) FERTILIZER.** Over 90% of surveyed winter wheat growers followed OSU P<sub>2</sub>O<sub>5</sub> recommendations. Reported yield and P<sub>2</sub>O<sub>5</sub> rate were not correlated ( $r = 0.03$ ,  $p = 0.10$ ) over this fertilizer range.

## Wheat Yield vs. Potash Fertilizer



**FIGURE 7d. POTASH (K<sub>2</sub>O) FERTILIZER.** 90% of wheat growers followed OSU recommendations for K<sub>2</sub>O. Reported yield and K<sub>2</sub>O rate were not correlated ( $r = -0.03$ ,  $p = 0.10$ ) over this fertilizer range.

## Irrigation Management and Tillage

Winter wheat is usually not irrigated in the Tualatin Basin. 60 percent of the growers on valley and floodplain locations used a moldboard plow as their primary tillage tool. Two of the hillside winter wheat growers used a moldboard plow. One grower planted wheat no-till. Six of the 10 hillside wheat growers reported planting across the slope, roughly following the contour.

## Summary

Winter wheat is rotated with a variety of crops. Most growers applied N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O according to OSU recommendations. Average soil test P values were high, K values were medium and soil pH was moderately acid. Practices likely to conserve resources and/or increase farm profits are leaving more crop residue on the soil surface on valley soils, reducing N applications on wheat following legume crops, and applying lime when needed. Most surveyed winter wheat growers, however, did a good job managing N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O fertilizer.



## APPENDIX A: Survey Document

The survey instrument used in this project is reproduced on the following eight pages. When beginning a survey, farmers were asked to choose a typical field where they grew the crop in question during 1994.

The first four pages (numbered 1-4) are designed to record physical information about this field in particular and the farm in general. Specifically, pages 1-2 contain questions about crop rotations, drainage and irrigation systems on the selected field. Page 3 contains questions about livestock and manure management on the entire farm. Page 4 was completed after our interviewer visited the selected field. Generally, each farmer was interviewed about only one field and completed only one set of pages 1-4.

The next four pages (numbered A-D) are designed to record detailed information about each crop in the rotation on the selected field. These pages contain questions about yield, tillage, fertilizer, manure and irrigation practices. Generally, each farmer completed several sets of pages A-D.

For example, a sweet corn farmer who was interviewed chose a field with a sweet corn – winter wheat – snap bean – winter wheat rotation. This farmer was asked to complete pages 1-4 and then complete three sets of pages A-D (one for sweet corn, one for snap beans and one for winter wheat).

Code = \_\_\_\_\_

**PAGE 1: CROP**

1. This survey focuses on the following crop: \_\_\_\_\_
2. How many total acres of this crop did you raise in 1994? \_\_\_\_\_

**FIELD DESCRIPTION**

*Please think about a typical field of this crop in 1994.*

1. Landscape (circle one): Floodplain Valley Upland hillside
2. Locate this field on the soil survey map.
3. Size of this field? \_\_\_\_\_ acres
4. Rotation:

<u>Year</u>	<u>Crop</u>	<u>cross- slope farming</u>	<u>pre- side dress N test</u>	<u>filter strip/ cover crop*</u>
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O
_____	_____	O	O	O

\* Please describe your filter strips and cover crops:

## PAGE 2: DRAINAGE AND IRRIGATION

*These questions pertain to the field identified on page 1.*

### 1. Drainage:

- a. How much of this field is drained by tile drainage? \_\_\_\_\_ %
- b. What is the average depth of the tile? \_\_\_\_\_ ft

### 2. Irrigation system in this field (check one):

- |   |   |
|---|---|
| <input type="radio"/> none                | <input type="radio"/> big gun                 |
| <input type="radio"/> solid set sprinkler | <input type="radio"/> other movable sprinkler |
| <input type="radio"/> drip                |   |

## LIME

*These questions also pertain to the field identified on page 1.*

1. When do you apply lime? pH \_\_\_\_\_ or below.
2. Before what crop do you usually apply lime? \_\_\_\_\_

**PAGE 3: LIVESTOCK**

*These questions pertain to the entire farm.*

**1. At any one average time in 1994, how many animals did you have?**

**a. Dairy**

\_\_\_\_\_ milking cows

\_\_\_\_\_ dry cows

\_\_\_\_\_ heifers

\_\_\_\_\_ calves

\_\_\_\_\_ bulls

**b. Beef**

\_\_\_\_\_ cows

\_\_\_\_\_ yearlings (450-750 lbs)

\_\_\_\_\_ feeders (750-1100 lbs)

\_\_\_\_\_ bulls

**c. Swine**

\_\_\_\_\_ sows

\_\_\_\_\_ pigs under 40 lbs

\_\_\_\_\_ pigs 40 - 220 lbs

\_\_\_\_\_ boars

**d. Poultry**

\_\_\_\_\_ layers

\_\_\_\_\_ pullets

\_\_\_\_\_ broilers

**e. Other**

\_\_\_\_\_ please describe:

**2. In 1994, on how many total acres did you spread manure? \_\_\_\_\_ acres**

**3. Manure storage.** What are your main methods of storing manure? Disregard storage systems for small amounts of manure, like calf pens. Check all others that apply:

☐ Stack, no roof.

☐ Stack with roof.

☐ Separator, no roof.

☐ Separator with roof.

☐ Tank, no separator.

☐ Tank with separator.

☐ Pond, no separator.

☐ Pond with separator.

☐ Slurrystore.

## PAGE 4: FIELD INVESTIGATION

*This information collected by surveyor in the field.*

### 1. Field slope:

length = \_\_\_\_\_ ft

steepness = \_\_\_\_\_ %

### 2. Main channel through field:

#### a. Type:

- ☐ field depression (farmed across).
- ☐ grassed waterway (seeded to perennial grass).
- ☐ drainage ditch (man-made, not farmed across).
- ☐ eroded gully (not farmed across).

#### b. Visible gully erosion (the worst place in field):

\_\_\_\_\_ inches deep.

\_\_\_\_\_ inches wide.

## FIELD INVESTIGATION

### 1. Soil & topography

soil number = \_\_\_\_\_ (e.g. 45B)

soil name = \_\_\_\_\_ (e.g. Woodburn silt loam)

average elevation = \_\_\_\_\_ feet above sea level

### 2. Watershed (check one):

- |   |   |
|---|---|
| <input type="radio"/> Tualatin, above Dairy Cr. | <input type="radio"/> McKay Creek       |
| <input type="radio"/> Tualatin, below Dairy Cr. | <input type="radio"/> Gales Creek       |
| <input type="radio"/> Rock Creek                | <input type="radio"/> E. Fork Dairy Cr. |
| <input type="radio"/> Scoggins Creek            | <input type="radio"/> W. Fork Dairy Cr. |
| <input type="radio"/> Other (list):             | <input type="radio"/> Patton Valley     |

# **PAGE A: YEARLY PRACTICE DESCRIPTION**

Crop = \_\_\_\_\_ Code = \_\_\_\_\_  
 Year = \_\_\_\_\_

*This information collected for each crop in the rotation on Page 1.*

*Please record a history of the following farming practices for the year shown above.*

- tillage & cultivation
- fertilizer
- planting
- harvest

*Estimate when needed.*

## **1. 5-YEAR AVERAGE YIELD FOR THIS CROP ON THIS FIELD = \_\_\_\_\_**

Month	Day	Operation	Fertilizer Analysis	Rate* (lbs/acre)	Fertilizer Depth (in)	BC/SD/FG**	Notes***

\* RATE = for liquid fertilizer, note if rate is in gallons or pounds per acre.

\*\* BC/SD/FG = BC is broadcast, SD is sidedress, FG is fertigate.

\*\*\* NOTES = please include row spacing. For berries, include plant spacing.

[illegible]

## PAGE C: IRRIGATION

*Please think about how you irrigated the crop identified on page A during the period 1989 - 1994. Base all answers on the field identified in the beginning of this survey.*

### 1. Irrigation season:

a. date of first irrigation = \_\_\_\_/\_\_\_\_

b. date of last irrigation = \_\_\_\_/\_\_\_\_

### 2. Amount of water:

a. maximum you apply in 1 irrigation = \_\_\_\_\_ inches

b. minimum you apply in 1 irrigation = \_\_\_\_\_ inches

c. average you apply in 1 irrigation = \_\_\_\_\_ inches

### 3. Irrigations per month. Report as a range of irrigations. For example, if you irrigate this crop 2 times in a wet July and 4 times in a dry July, report "2 - 4."

a. May: \_\_\_\_\_

d. August: \_\_\_\_\_

b. June: \_\_\_\_\_

e. September: \_\_\_\_\_

c. July: \_\_\_\_\_

### 4. Do you use any tools to determine when to irrigate?

☐ none

☐ tensiometer

☐ neutron probe

☐ other (describe): \_\_\_\_\_

### 5. How often does irrigation water run off in an average year?

☐ never

☐ once or twice per year

☐ more than twice per year



## PAGE D: MANURE APPLICATION

*Now we want to ask about manure applications to this field during the year shown on Page A.*

### 1. Solid Manure:

- a. amount applied = \_\_\_\_\_ tons/acre
- b. days between spreading and incorporation = \_\_\_\_\_
- c. depth of incorporation = \_\_\_\_\_ inches
- e. date you started spreading on this field = \_\_\_\_/\_\_\_\_
- f. date you finished spreading on this field = \_\_\_\_/\_\_\_\_

### 2. Liquid Manure:

- a. amount applied = \_\_\_\_\_ gals/acre      inches      (circle one)
- b. time between spreading and incorporation = \_\_\_\_\_ days
- c. depth of incorporation = \_\_\_\_\_ inches
- d. date you started spreading on this field = \_\_\_\_/\_\_\_\_
- e. date you finished spreading on this field = \_\_\_\_/\_\_\_\_

## APPENDIX B: Statistical Functions

In an effort to make the graphical data presented in this document more meaningful, we calculated Pearson correlation coefficient (  $r$  ) values to measure the association between yields and application rates of N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O. We also performed a Student's two-tailed  $t$  test on these  $r$  values at the  $\alpha = 0.10$  level (Mendenhall and Sincich, 1995). These statistical measures were based on all of the data in each chart and not calculated separately for the three groups of growers (i.e. below, within and above OSU recommendations).

It is important to note that the data collected in our surveys were not from controlled experiments. The statistics comparing reported strawberry yield to P<sub>2</sub>O<sub>5</sub> application rate, for example, include fields with different varieties, different harvest methods, different soils and different irrigation systems. Given the high variability in these other factors and the limited number of surveys completed on each crop, it is not surprising that most of the calculated  $r$  values are low.

Still, each chart in this document presents a great deal of information concerning the range in reported yields and nutrient application rates, the numbers of growers applying nutrients below, within or above OSU recommendations and a measure (however imperfect) of the correlation between application rate and reported yield.

## APPENDIX C: Irrigation Calculations

Surveyed growers were asked a variety of questions about the field they selected for the survey (please see Appendix A). The data were used to estimate the amount of irrigation water each grower applied to a particular crop in an average year. In each crop section of this document we report the lowest, the highest and the average application of water. For example, the lowest average seasonal snap bean irrigation was 4.1 inches. This means one grower reported that, between 1989-1994, he averaged 4.1 inches of water per year applied to his snap beans. During dry years, he applied more water and during wet years he applied less. Likewise, the highest average seasonal snap bean irrigation was 13.1 inches. That grower applied more during dry years and less during wet years, but he averaged 13.1 inches per year during 1989-1994. The average seasonal snap bean irrigation was 9.1 inches, meaning all of the snap bean growers together applied an average of 9.1 inches (more during dry years, less during wet years) between 1989-1994.

We used published data (Smesrud *et al.*, 1998), (Cuenca *et al.*, 1992) to estimate the average monthly evapotranspiration (ET) during the growing season of each surveyed crop. ET values were estimated for average weather conditions (i.e. 5 years out of 10 we would expect ET values to be less than or equal to the estimates used here). Average effective precipitation was calculated from actual Hillsboro weather data (Oregon Climate Service, 1999) on a monthly basis throughout the growing season for each crop from 1985 through 1995, using USDA-NRCS methods (USDA-NRCS, 1993). Effective precipitation is an estimate of the growing season rainfall that is actually available for crop use. We calculated carryover soil moisture by taking 40 percent of the effective root zone's available water holding capacity for each crop, assuming the crop was grown on an average Tualatin Basin silt loam soil. This strategy is also based on USDA-NRCS methods (USDA-NRCS, 1993).

We subtracted effective precipitation and carryover soil moisture from ET for each crop to estimate the net amount of irrigation water needed for that crop in an average growing season. Then, we divided this amount by an efficiency factor (Cuenca *et al.*, 1992) to estimate the gross amount of seasonal irrigation needed in an average season. We chose the highest expected efficiency factors for each system in order to estimate the least amount of gross irrigation that was needed by each crop in an average year. This assumes that it is reasonable for growers to maintain and operate their existing systems to their greatest potential, but it is not reasonable to compare existing practices to what would be possible with new, higher efficiency systems such as drip irrigation.

Tables C1 and C2 provide the values described above. We used these values as practical benchmarks to evaluate irrigation practices as reported in the survey. It is impossible to fully evaluate irrigation management in the Tualatin River Basin based on the limited amount of data collected in this survey. Complete irrigation evaluations can only be made one field at a time and must involve accurate measurements of water applied, distribution patterns, soil moisture, irrigation water needed for cooling high value crops, etc. However, the methods used here allow an initial assessment of irrigation practices for these crops.

**TABLE C1. Irrigation systems commonly used in the Tualatin Basin.** Efficiency values are from (Cuenca *et al.*, 1992). Root zone depths are from (Smesrud *et al.*, 1998).

Crop	Commonly Used Irrigation System	Estimated System Efficiency	Effective Root Zone (inches)
Snap beans	Wheel line	80%	18
Sweet corn	Big gun	70%	24
Black raspberries	Big gun	70%	36
Blueberries	Solid set	75%	18
Strawberries	Hand move	80%	12
Silage corn	Big gun	70%	36

**TABLE C2. Average evapotranspiration data for the Willamette Valley.** Silage corn values are based on (Cuenca *et al.*, 1992); all other crops are based on (Smesrud *et al.*, 1998), adapted to reflect average (50% probability) growing season weather. ET is evapotranspiration, the amount of water that evaporates from the soil surface and transpires from leaf surfaces during the growing season. Effective Precipitation is an estimate of the growing season rainfall that is available for crop growth. Carryover Soil Moisture was calculated at 40% of the available water stored in the root zone from winter precipitation. The figures in the table below have been rounded.  
Net Crop Water Need = ET - Effective Precip. - Carryover Soil Moisture.  
Gross Crop Water Need = Net Crop Water Need / System Efficiency.

Crop	Growing Season ET	Effective Precip.	Carryover Soil Moisture	Net Crop Water Need	Gross Crop Water Need
	-----Inches-----				
Snap beans	9.3	1.6	1.4	6.2	7.8
Sweet corn	15.7	2.2	1.9	11.6	16.5
Black raspberries	27.3	2.9	2.9	21.5	30.8
Blueberries	31.3	3.3	1.4	26.6	35.4
Strawberries	24.5	2.4	1.0	21.1	26.4
Silage corn	17.1	3.0	2.9	11.2	16.0

## APPENDIX D: OSU Fertilizer Recommendations

Oregon State University has published fertilizer guides for each of the crops described in this document. Fertilizer recommendations depend on several factors:

**Nitrogen (N):** Recommendations for N on annual crops like snap beans, wheat, sweet corn and silage corn are based on the previous crop grown in that field. This is because the residue from some crops, such as legumes, will release significant amounts of N to the subsequent crop. N recommendations for perennial crops like blueberries, black raspberries and strawberries are based on the age of the crop and/or on leaf tissue analyses.

**Phosphate ( $P_2O_5$ ) and Potash ( $K_2O$ ):** Recommendations for these nutrients are based on soil test values for phosphorus (P) and potassium (K). Many growers of blueberries and black raspberries use leaf tissue analyses to determine application rates for these nutrients.

**Lime Recommendations:** Soil test pH determines whether lime is recommended.

We calculated the OSU fertilizer recommendation for each surveyed field based on previous crop, perennial crop age, soil test P, soil test K and soil test pH. Our calculated OSU recommendations for blueberry and black raspberry fields may differ from recommendations based on leaf tissue analysis. OSU recommendations are given in ranges, because farmers and their consultants must weigh a variety of factors in addition to soil test results when making fertilizer decisions. Such factors include differences in crop varieties, weather, economics, weed competition and damage from pests. Tables D1 and D2 use snap bean phosphate applications to illustrate the nutrient data analysis employed in this document.

**TABLE D1. Phosphate recommendations for snap beans.** Rates are in lb of phosphate per acre from commercial fertilizer plus manure (Mansour *et al.*, 1983), (Hart, 1993).

Soil Test P (ppm)	Published OSU Recommended $P_2O_5$	Unpublished OSU Recommended $P_2O_5$
	----- lbs. / acre -----	
0 – 15	120-150	120-150
15 – 60	90-120	60-120
60 – 100	60-90	0-60 <sup>1</sup>
over 100	60-90	0 <sup>1</sup>

<sup>1</sup> Application of 60 lbs./acre  $P_2O_5$  fertilizer in a band at planting may be beneficial for early plantings in cold soil, even at high soil test P values.

**TABLE D2. Calculation of OSU phosphate recommendations for snap beans.** Each "Field" is a typical field chosen by a snap bean grower for this survey. Eight snap bean growers were surveyed.

Field	Soil Test P (ppm)	Minimum OSU Recommends	Maximum OSU Recommends	Actually Applied	Relation of Actual to OSU Recommends
----- lbs. P <sub>2</sub> O <sub>5</sub> / acre -----					
1	18	90	120	125	Above
2	119	60	90	26	Below
3	69	60	90	96	Above
4	250	60	90	80	Within
5	137	60	90	52	Below
6	109	60	90	75	Within
7	127	60	90	90	Within
8	23	90	120	146	Above
<b>Average</b>		<b>68</b>	<b>98</b>	<b>86</b>	<b>Within</b>

Table D1 summarizes published (Mansour *et al.*, 1983) and unpublished (Hart, 1993) OSU phosphate recommendations for snap beans in the Tualatin River Basin. Table D2 presents recommendations based on each field's soil test P level and the published recommendations from Table D1. For example, Field 1 had a soil test P value of 18 ppm, which calls for an application of 90-120 lb/ac of P<sub>2</sub>O<sub>5</sub>. Table D2 also illustrates how each field was classified as below, within or above OSU recommendations. For example, Field 1 received 125 lb/ac of P<sub>2</sub>O<sub>5</sub>, which is above the maximum published OSU recommendation of 120 lb/ac, based on the soil test for Field 1. Recommendations and actual application rates are in lb/ac of total P<sub>2</sub>O<sub>5</sub> (commercial fertilizer plus manure).

Average values were calculated as in Table D2 and reported in each crop section of this document. For example, Table 6b of the Snap Bean section reports the average OSU recommendation as 68 to 98 lb/ac P<sub>2</sub>O<sub>5</sub> and the average application as 86 lb/ac P<sub>2</sub>O<sub>5</sub>. Figure 1b of the Snap bean section shows that two of the surveyed fields had P<sub>2</sub>O<sub>5</sub> rates below published OSU recommendations, three had rates within OSU recommendations and three had rates above OSU recommendations. The average amount of P<sub>2</sub>O<sub>5</sub> applied by all surveyed snap bean growers was within the average amount recommended. Nitrogen, phosphate and potash data were analyzed in this manner for each crop.

A suggested way to interpret the nutrient management data presented in this document is as follows:

1. Choose the crop that interests you and examine the tables and charts in that section.
2. Under-application of nutrients is indicated by:
  - The average soil test for P or K is well below the critical value.
  - The “Average Applied” amount of N, P<sub>2</sub>O<sub>5</sub>, or K<sub>2</sub>O is well below the “Average OSU Recommends.”
  - There are many fields below OSU Recommendations in the nutrient/yield charts.
3. Over-application of nutrients is indicated by:
  - The average soil test for P or K is well above the critical value.
  - The “Average Applied” amount of N, P<sub>2</sub>O<sub>5</sub>, or K<sub>2</sub>O is well above the “Average OSU Recommends.”
  - There are many fields above OSU Recommendations in the nutrient/yield charts.

## APPENDIX E: Available Nutrients in Dairy Manure

**TABLE D1. Estimated crop-available nutrients from different forms of dairy manure.**

System	Units	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Dairy solids, no separator	Pounds / ton	3.8	7.3	5.1
Dairy solids, with separator	Pounds / ton	1.9	1.6	1.8
Dairy liquid, from pond	Pounds / acre-inch	71	24	122
Slurry	Pounds / 1,000 gal.	11	7.2	16
Slurry	Pounds / acre-inch	290	200	440

The above figures are estimates of average nutrients available to the crop after spreading various forms of dairy manure. The concentrations of nutrients in the two "Slurry" rows are the same; only the units are different. The assumptions used in preparing Table D1 are:

- 25 percent of the N in solid manure is lost in application.
- 50 percent of the remaining N in solid manure is plant available the first year.
- 25 percent of the N in liquid manure is lost in application.
- 70 percent of the remaining N in liquid manure is available to plants for the first year.
- 10 percent of the P<sub>2</sub>O<sub>5</sub> in all manure is lost in application.
- 90 percent of the remaining P<sub>2</sub>O<sub>5</sub> is plant available the first year.
- 10 percent of the K<sub>2</sub>O in all manure is lost to application.
- 100 percent of the remaining K<sub>2</sub>O is available to plants for the first year.

These estimates were calculated from actual manure tests at Washington County dairies and from published references (Hart *et al.*, 1995), (USDA-NRCS, 1992).



## APPENDIX F: References

- Cuenca, R. H., Nuss, J. L., Martinez-Cob, A., Katul, G. G., and Gonzalez, J. (1992). "Oregon crop water use and irrigation requirements," Rep. No. EM 8530. Oregon State University, Corvallis, Oregon.
- Gardner, E. H., and Jackson, T. L. (1983). "Fertilizer guide - field corn (Western Oregon - west of the Cascades)," Rep. No. FG10. Oregon State University, Corvallis, Oregon.
- Hart, J. (1993). Unpublished OSU recommendations for sweet corn and snap beans.
- Hart, J., Christensen, N. W., Jackson, T. L., Karow, R., and Kronstad, W. E. (2000a). "Fertilizer guide - winter wheat (Western Oregon, west of the Cascades)," Rep. No. FG-9. Oregon State University, Corvallis, Oregon.
- Hart, J., Gangwer, M., Graham, M., and Marx, E. (1995). "Dairy manure as a fertilizer source," Rep. No. EM 8586. Oregon State University, Corvallis, Oregon.
- Hart, J., Righetti, T., Sheets, A., and Martin, L. W. (2000b). "Fertilizer guide - strawberries (Western Oregon - west of the Cascades)," Rep. No. FG 14. Oregon State University, Corvallis, Oregon.
- Hart, J., Strik, B., and Sheets, A. (1992). "Fertilizer guide - caneberries," Rep. No. FG 51. Oregon State University, Corvallis, Oregon.
- Jackson, T. L., Gardner, H., Mansour, N. S., Mack, H. J., and Doerge, T. A. (1983). "Fertilizer guide - sweet corn," Rep. No. FG11. Oregon State University, Corvallis, Oregon.
- Mansour, N. S., Mack, H. J., Gardner, E. H., and Jackson, T. L. (1983). "Fertilizer guide - bush beans," Rep. No. FG 28. Oregon State University, Corvallis, Oregon.
- Marx, E. S., Hart, J., and Stevens, R. G. (1996). "Soil test interpretation guide," Rep. No. EC-1478. Oregon State University, Corvallis, Oregon.
- Mendenhall, W., and Sincich, T. (1995). "Statistics for engineering and the sciences," 4th/Ed. Prentice-Hall, Inc., Upper Saddle River, New Jersey.
- Oregon Climate Service (1999). "Hillsboro Oregon daily precipitation," URL: [http://www.ocs.orst.edu/pub\\_ftp/climate\\_data/daily/prec/prec3908.lf](http://www.ocs.orst.edu/pub_ftp/climate_data/daily/prec/prec3908.lf). Oregon Climate Service, Corvallis, Oregon.

- Sharpley, A., Daniel, T. C., Sims, J. T., and Pote, D. H. (1996). Determining environmentally sound soil phosphorus levels. *Journal of Soil and Water Conservation* **51**, 160-166.
- Smesrud, J., Hess, M., and Selker, J. (1998). "Western Oregon irrigation guides," Rep. No. EM 8713. Oregon State University, Corvallis, Oregon.
- Strik, B., and Hart, J. (1997). "Fertilizer guide - blueberries," Rep. No. FG 78. Oregon State University, Corvallis, Oregon.
- USDA-NRCS (1992). "Agricultural waste management field handbook," United States Department of Agriculture, Washington, D.C.
- USDA-NRCS (1993). Irrigation water requirements. In "National Engineering Handbook", Vol. Chapter 2, pp. 284. USDA-NRCS, Washington, D.C.
- USDA-SCS (1982). "Soil survey of Washington County, Oregon," Soil Conservation Service, Washington, D.C.