INTRODUCTION

Napa, Sonoma, Mendocino, Lake and Contra Costa counties are important agricultural areas in northern coastal California. The major deciduous crops are wine grapes, pears, apples, peaches, nectarines, and cherries with smaller plantings of prunes, walnuts, and other fruits. Also under production in the area are field and feed crops, nurseries and livestock. Production of these agricultural commodities relies on fertilizers to improve growth and yield, and to replace nutrients removed by crops.

European wine producers have spent hundreds of years defining and promoting quality in their product. The sensory experience of wine tasting encompasses general appearance, color, bouquet and flavor. The general consensus is that quality lies in the fruit. The interaction of the soil with the climate, cultivar, and cultural practices is described by the French as *terroir.* This project is an attempt to improve the education of agricultural consultants and managers. I have combined my professional experience in northern California tree fruit and vine production with many contributions of the scientific literature into a concise account of how to achieve optimum *terroir* through nutritional management. Quality and health in fruit production through a positive soil building program is the goal - and good yields of high quality fruit will follow.

I first started working in the field of agriculture in 1973, providing pest and disease technical services for crops in this area. We began offering soil testing services at that time, sending samples to a mid-Western laboratory for analysis. They returned reports with recommendations for lime requirement, building potash and phosphorus reserves, and other fertilization methods not often practiced in northern California. We passed the recommendations on to our growers, but they usually preferred to apply only nitrogen. Leaf or petiole tests

often showed excess nitrogen and sometimes deficiencies of other nutrients. Unless symptoms of excesses or deficiencies actually showed up in the field, or yield suffered, growers were not concerned with plant nutrition. They always gave priority to pest control and yields. Grape and pear growers faced several serious pests and diseases, with potential to cause serious economic damage in the absence of treatments. Our work was to minimize damage with better timing and lowered use of pesticides.

About 1977 I began to study soil fertility and its relation to pest and disease problems. In 1979 I started working for a company with expertise in soil fertility. As district manager for New Era Farm Service, I used soil and tissue testing to formulate advanced fertilization programs. We introduced compost to the agricultural industry, sold fertilizers appropriate to local crops and soils, and used foliar fertilization as a tool to improve tree and vine production while soil building was underway. As we worked in the area and accumulated soil testing data and results of our fertilization programs, I investigated the relationship of plant nutrition and pests and diseases. I noticed trends between the fertilization practices common to this area and pest and disease problems. In 1983 I started my own fertilizer company, Y & B Agricultural Services, and worked with a wider variety of crops. In 1988 I addressed a conference in which I called for the integration of the disciplines of soils and plant nutrition, entomology, and plant pathology (Young, 1988). Now my favorite professional activity is helping growers with their pest, disease, and quality management strategies. Teaching and leading others towards increased productivity with fewer and safer pesticides has been my life's work - and this project is an exciting culmination of my goals.

Problem Statement

Careful examination of the fertilizer industry, the purchase and use of fertilizers, local soil types, and the crops grown, reveals a gap between the amounts and types of fertilizers used in the area, and the appropriate needs based on soil types and crop requirements. As an agronomist practicing in the area for over 20 years, with involvement in both the fertilizer industry and education, I have identified three major deficiencies of knowledge: basic soil science, the nature of our local soils, and which fertilizers are appropriate for the area. Most of my efforts working in the industry have been directed at filling this gap.

I define improper fertilization as higher or lower amounts of applied nutrients, reliance on some nutrients over others, poor uptake of applied nutrients or long term declines in productivity. I know that improper fertilization is common in Northern California through my involvement in agriculture in the area. I will document each of these problems, many of which are common.

There are several reasons for the trends in fertilizer use in the area - and they mostly involve lack of knowledge. Farmers, fertilizer dealers and consultants often do not use soil or tissue testing as tools to prescribe fertilizers. Interpretation of test results is often done by lab technicians who are unfamiliar with local crops and soils. Published technical information often is generic and does not address local needs. Common practices are repeated year after year; growers are often reluctant to change if results seem satisfactory. Economic considerations can also limit attention to soil fertility and nutrient maintenance.

I will show that proper fertilization can make an important impact on local crop production in several facets: yield, quality, and pest or disease resistance. Soil testing and proper interpretation can be a tool in achieving this. The main

obstacle is the gap in knowledge by those involved in the industry. Improving the understanding of soil science is an important step in changing fertilizer practices in the area. The reasons for this project are to: 1) to document the gap in education and knowledge of soil science, 2) to develop a training program for people involved in sales, advising, or use of fertilizers in Northern California, and 3) to teach others the importance of proper soil fertility management through the use of applied soil science.

Significance of the Project

There are several short and long term consequences of improper fertilization. Declining or erratic yields, poor crop quality, increased pest and disease problems, greater risk of crop failure, and environmental problems are all possible results. Better fertilization practices can ameliorate problems and have positive effects on economic and environmental aspects of agriculture. I have already seen improvements in yields and quality, and reductions in pesticide use in this region due to better fertilization. A well formulated, multi-disciplinary approach to crop production is needed; this training program is unusual in this regard.

Why Do This Project?

The need for a training program for the local fertilizer industry will be demonstrated from several angles; see methodology. The importance of the project for me is production of the curriculum: the training program. Because the clientele involved are familiar or well versed in soil science, the program will concentrate on the gaps in knowledge.

The foundation of soil analysis interpretation will focus on the work of William Albrecht (1888 -1974), professor and chairman of the Department of Soils at University of Missouri College of Agriculture. Dr. Albrecht studied soils

from the Mid-West to the East, Europe, and Australia, and published over 725 papers in three languages in scientific journals and farm magazines from 1918-1957. His work was featured in the most prestigious journals of his time, including 52 articles in The Journal of the American Society of Agronomy , Proceedings of the Soil Science Society, Soil Science, American Journal of Botany, Plant & Soil, The Scientific Monthly, Agronomy Journal and Plant Physiology. He authored 25 bulletins for the Missouri and Mississippi Agricultural Research Services on subjects from soil science to animal nutrition.

Albrecht studied soils in relation to productivity, yields, and quality, and later insect and disease resistance. He took earlier work in nutrient delivery to plants, classification of soils, and fertilizer technology and developed generalizations for mineral balance which are in use by many soil laboratories today. This theory of optimum soil nutrient balance for best productivity will be the basis for soil analysis interpretation and fertilizer recommendations used in this project. I have personally used Albrecht's system for over 20 years, and know several colleagues in other areas of California who also use the system. Neal Kinsey, a former student of Albrecht's, works with over a million acres around the world. In his book Hands On Agronomy (Kinsey & Walters, 1995) he described his practical experience using Albrecht's soil balancing principles to advise farmers around the world. Here I hope to add my practical experience in northern California to the scientific evidence for Albrecht's system of describing natural systems, the soil, and crop production.

Albrecht's knowledge and foresight to look beyond yields alone in agronomic research resulted in theories on the rise of human civilizations, distribution of natural animal populations, and animal and human nutrition. His publications in Journal of Applied Nutrition, Journal of the American Academy of

Applied Nutrition, American Journal of Orthodontics & Oral Surgery, American Dietetic Association, Journal of Osteopathy, and Oral Surgery. Oral Medicine and Oral Pathology Journal attest to his important contribution to the field of plant, animal, and human nutrition.

Albrecht's theories will be historically and critically examined from the literature and as applied in the field. Critics and the work of those who ignored his research will be addressed. I will build a substantial case for the simplicity and applicability of his system of soil classification and analysis interpretation. The goal of this project is the formulation of a training program, utilizing the Albrecht system and my own experience in northern California agriculture.

Quality considerations such as flavor, sweetness, and sugar/acid ratios are not often important to production agriculture. Pears, apples, peaches & nectarines are often harvested and packed according to size, firmness, skin color, and lack of cosmetic defects. Yields and appearance are the most important factors. Winemakers on the other hand, encourage reducing yields to enhance quality; premium prices are paid to growers who cooperate. Great grapes make great wines; flavor is the number one goal.

Robert Benson (1977) interviewed 28 of California's top winemakers of the time, seeking keys to quality wine production. Of the 21 growers specifically asked about soil and grape quality, 18 replied it was important; 2 felt it may be; 1 said it was not. Of those who related soil conditions to grape quality, most used terms describing geography (hillside, valley, bench land, alluvial,) depth of soil (deep, shallow, rich, thin, well drained), or textural observations (gravelly, clay, rocky, loamy). Often colors are mentioned (red, brown, black), or comparisons to regions of France with similar looking soils. Occasionally references to nutrients (limey, chalky) are given - sometimes mistakenly.

No one gave any specific nutritional characteristics or trends - they just

knew that soil types affect grape and wine quality.

The importance of a reliable system of interpreting soil characteristics does not end with quality. The importance of fertility and pest & disease relations becomes crucial each year as more pesticides fail to control target organisms. Presently, worldwide over 600 insects, weeds and diseases have become resistant (immune) to pesticides (Whalon, Bush, Maredia, 1996). The term "resistance management" - the delay or prevention of pest adaption to protection mechanisms - is used commonly in the agriculture trade journals. The development of "resistance breaking" viruses, bacteria, fungi, nematodes, insects and mites, in crops formally protected through genetic breeding, calls for a truly integrated approach to agronomy. I will show that well balanced soils result in healthier plants more resistant to pests and diseases. Although this is concept is generally accepted, the vast majority of studies in the field of pest management, and even many in fertilization and nutrition, do not even do a basic soil analysis.

Assumptions

Considerable debate over Albrecht's principles has occurred; presently both the use of his principles and the debate are being revived. A generalized system of interpretation of all soils for all crops will always have some detractors. I know of many who use the system; I know many who criticize the system. I have never met, nor reviewed the writings of any who both used the system and did not find it valuable - except for those dealing with yields only. Any generic system for dealing with the world will have exemptions, exceptions, and anomalies. Albrecht's system does need fine tuning anywhere it is applied. The extension of scientific theory to practice is my specialty, and this system has been valuable for my clients

Having worked in the fertilizer industry for 25 years, I have been a part of the changes during that period. The gap between soil and crop needs and actual practices will be easy to demonstrate. However, whether the industry wants additional training and will attend workshops depends on their perceptions and the marketing of the program.

Soil science is a very complex subject involving several disciplines. Over simplification could be subject to criticism. Practitioners are using simple systems now; this project will modify, clarify, and augment the knowledge presently being used. The methods produced by this project will be valuable for a wide range of agriculturalists such as farm managers, field persons, industry representatives, consultants and winemakers. In addition, researchers in plant pathology, entomology, and related disciplines will find a concise model for soil analysis interpretation valuable as they integrate their work with soil fertility.

Limitations

The application of this project will be limited to medium to high rainfall soils and deciduous tree fruits and vines worldwide. Albrecht's method of soil analysis interpretation is also presently being applied to low rainfall and desert agriculture; these conditions do not occur in northern California and will not be emphasized.

California Department of Food and Agriculture fertilizer sales records show general trends in use in the area; however they are compiled by industry-submitted figures and may contain some inaccuracies. The dealer survey was limited by the willingness of participants and accuracy of their own records or recollections. I have contacted every fertilizer dealer in the study area in an attempt to accurately assess educational needs in the industry.

Review of the literature will always be limited to those researchers who managed to achieve publication. Published research can sometimes have a lag time of years between completion of the research and its publication. Many problems and scientific questions are simply not high enough on priority lists to be researched. Finally, many leading practitioners who are in the field do not publish their knowledge nor conduct formal research. They do, however, help grow our food supply, and their knowledge cannot be underestimated.