REEVALUATION OF ALFALFA SULFUR TISSUE TESTS

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Perhaps it is best to begin our discussion of plant tissue tests with an introduction of what is involved in the basic principles of plant analysis. In many respects the growth and chemical composition of a plant is a result of numerous factors and their interaction, some of which are light, moisture, temperature and nutrient supplies available to the plant. Understanding the relationships between nutrient levels in plant tissue and crop yields hopefully will permit us to diagnose plant disorders and infer which nutrient is most limiting plant growth. Figure 1 gives the relationship of mineral composition of tissue to the growth or yield of plants. As is indicated by the figure, there are several ranges of concentrations which relate to various yield levels. The range indicated for A and B relate to a very low yield as well as rather low concentrations in the plant. The C portion of the curve is defined as a moderate deficiency where yield levels can range from 50 to

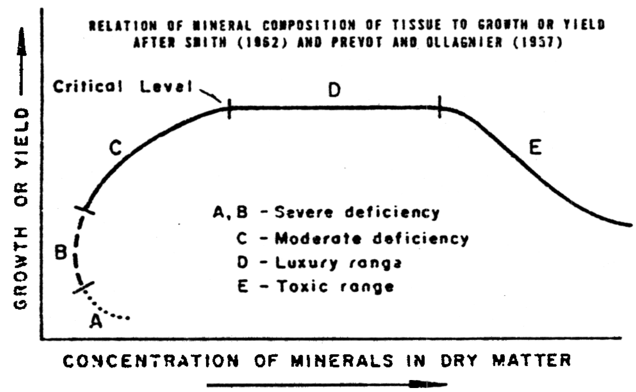

Figure 1. Relation of mineral composition of tissue to growth or yield after Smith (1962) and Prevot and Ollagnier (1957)

perhaps 90-95% of the maximum growth of the plant. The level portion of the curve marked D where maximum yields are achieved is considered to be the adequate or luxury range in concentration of the nutrient. In some plants, certain nutrients reach concentrations whereby they become toxic and reduce plant growth, and this relates to the position of the curve marked E.

One of the limitations that must be kept in mind when examining plant analyses is that only the most limiting nutrient can be evaluated. Nothing can be inferred about other nutrients which may be somewhat high or low. After adequate amounts of the limiting nutrient have been made available to the plant, then resampling and testing will reveal the next most limiting nutrient. An example of this situation might be where phosphorus levels are extremely low in plants as determined by a tissue test and after additions of phosphorus fertilizer, sulfur may then become the most eliminating growth factor as indicated by a second plant tissue analysis.

Other factors which affect the nutrient levels in plants are: 1) the plant part used for analysis, 2) the stage of maturity of the plant, and 3) the chemical fraction determined. As plants begin to grow the nutrient uptake occurs first, followed by the accumulation of structural and fiber portions of the plant. This results in rather high concentrations of nutrients in the very early stages of plant growth. As the plant matures the concentrations of nutrients will usually decline and the dry matter portion increases. In the development of a plant tissue testing technique it is desirable to select a plant part which is easy to identify and collect. The field sampling process should provide a stable plant material that can be shipped by mail to the testing laboratory. It should be a plant part which has a wide range of concentration from adequacy to deficiency and for which the nutrient in question decreases into a deficiency range prior to a substantial reduction in growth and the development of symptoms. Since the stage of maturity affects nutrient concentrations, it is extremely important that the proper stage of growth can be defined so that users will have little difficulty in identification when obtaining the sample. Some misunderstanding has resulted in the current procedure for alfalfa since the traditional sampling has been related to the 1/10 bloom stage. Alfalfa exhibits some early blooming when plants are under some stress, particularly if they are limited by insufficient moisture. A less sensitive indicator of plant stress and therefore a more desirable plant part is the regrowth at the crown. Collecting should be performed when the regrowth is 1/2 to 2 inches in length from 30 to 50 plants randomly selected from the area of the field to be evaluated. In the case of sulfur, both the sulfate and total sulfur chemical fractions have been used by a number of researchers and laboratories. Each provides its advantages and disadvantages depending on the designs of the laboratory and other elements to be considered in the evaluation of the plant sample.

Table 1 lists the concentrations of several nutrients indicated in the University of California Soil and Plant Tissue Testing Bulletin #1879. I would like to draw your attention to the levels indicated for sulfur which are the levels given for the leaves from the midstem section of the alfalfa plant. Phosphorus and potassium are evaluated utilizing the mid section (middle 1/3) of the plant and using only the stem from this middle section of the plant. The leaves are removed from this midstem portion and utilized for sulfur determinations. The top 1/3 of the plant is utilized for molybdenum and boron evaluations.

TABLE 1. Nutrient Concentrations in Alfalfa at Different Response Levels

Response Category	Midstems		Leaves	Top 1/3 of Plant	
	Total K	PO_4-P	SO_4-S	Total Mo	Total B
	(%)			(ppm)	(ppm)
Deficient	.40- .65	300- 500	<80	<.3	<15
Critical	.65- .80	500- 800	80-150	.3-.9	15-20
Adequate	.80- 5	800-1500	150-500	1-5	20-40
High	1.5+	1500+	500+	5-10*	200**

Forage containing more than 10 ppm of Mo may produce "Molybdenosis" in ruminant animals.

** Boron concentrations in alfalfa greater than 200 ppm are associated with reduced growth and vigor.

<u>A Reevaluation Study</u>. Several years ago we had the fortune to locate an alfalfa fertility trial on a site which proved to be very responsive to sulfur. One of the first steps which is essential to develop the relationship between plant nutrient tissue concentrations and yield is that the area in the field be uniformly deficient. A rather small uniform area which had shown severe deficiency symptoms was selected for evaluation to apply sulfate sulfur as gypsum and elemental sulfur. The high rates that had been used in the early fertility trial to study the longevity of several sources resulted in no differences, thus

the lower rates of 25, 50 and 100 lbs S/A were utilized in the experiment in the small area. With the current practice of dividing the alfalfa plant into 3 separate portions for evaluating different nutrients, it seemed desirable to begin to look at the possibilities of taking a single plant part to evaluate several nutrients. Thus the top 1/3, the midstems as well as the leaves from the midstems were the 3 plant parts sampled.

Large increases in yield following the application of the 3 rates of gypsum were noted and are indicated in Table 2. A smaller but significant increase in yield was also observed from the application of elemental sulfur. I might say at this point, that these two sulfur sources are particularly valuable in an alfalfa management program because of the characteristics of the materials. Gypsum gives a very rapid plant response after application because the sulfur is in the sulfate form, whereas somewhat larger quantities of elemental sulfur are necessary to attain adequate yields as bacterial oxidation is necessary before plant use. However, the long lasting effect that elemental sources with larger particles provide is very desirable in that it eliminates the need to apply fertilizer sulfur annually. An application of gypsum as well as the incorporation of 200 to 300 lbs S/A of elemental sulfur before planting will provide an adequate supply of sulfur for 4 to 6 years.

TABLE 2. Alfalfa Yields in 1979 Following the Application of Sulfur Treatments on February 12, 1979.

	Treatment		Yield, Tons DM/A				
			5/23	7/10	8/13	9/28	Total
	Control		0.68	1.22	1.19	.77	3.86
2.	Gypsum	25 lbs S/A	2.16	2.84	1.93	1.26	8.19
3.	Gypsum	50 lbs S/A	2.35	3.21	2.07	1.54	9.17
4.	Gypsum	100 lbs S/A	2.15	2.87	.78	1.59	8.39
5.	Elemental Sulfur	25 lbs S/A	76	.27	1.30	90	4.23
6.	Elemental Sulfur	50 lbs S/A	.83	.45	1.43	.06	4.77
7.	Elemental Sulfur	100 lbs S/A	.85	1.77	1.60	.35	5.57

Because the yield responses are dramatic in the case of the gypsum rates and gradually increasing throughout the season with the elemental source they would seemingly demonstrate several situations to evaluate plant tissue concentrations of sulfur. Analyses of the 3 plant parts i.e. the midstem, the leaves from the midstem, and the top 1/3 of the plant for each of the 4 cuttings harvested in 1979 indicated in general that the 3 plant parts for the first harvest could easily be used in indicating that the low nutrient level concentrations would relate to a rather low yield. Either the total sulfur or the sulfate sulfur chemical fractions could be analyzed and results used for indicating whether or not the nutrient was deficient to the point of reducing plant growth. Figure 2 indicates a desirable relationship between plant yield and tissue concentrations wherein the midstem leaf tissue is analyzed and indicates from 0-400 ppm of sulfate sulfur is associated with lower yields. Concentrations in the 400-600 ppm range indicates yields could be in the 1 ton up to the 2 ton range. Plants having a concentration of 800 ppm or higher are associated with yields of 2 tons per acre or higher. Figure 3 gives the relationship of total sulfur and yield for the same plant part and harvest date. Chemical analysis of the three plant fractions utilizing both the total sulfur and sulfate sulfur determinations revealed that the most consistent plant part was the leaves from midstem portions and the sulfate sulfur determinations revealed a much better relationship to plant yield level.

Figure 2. Alfalfa yield on May 23, 1979 as related to sulfate sulfur in midstem-leaf tissue as effected by sulfur applied Feb. 12, 1979 as gypsum [+] and elemental sulfur [0].

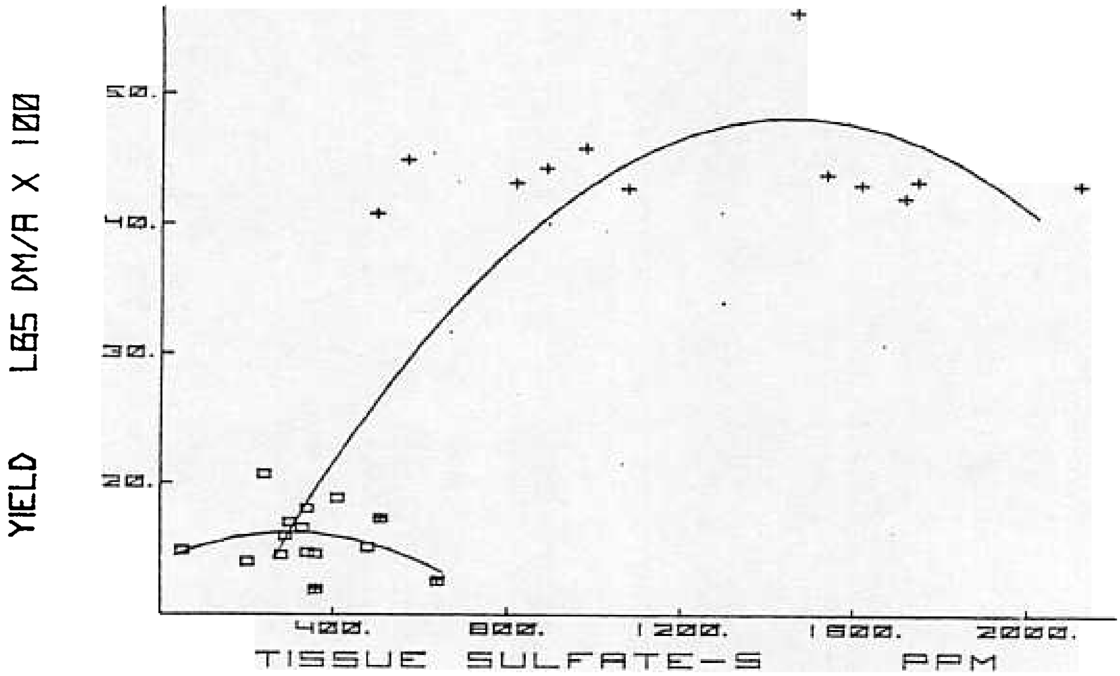

Figure 3. Alfalfa yield on May 23, 1979 as related to total sulfur in midstem-leaf tissue as effected by sulfur applied Feb. 12, 1979 as gypsum [+] and elemental sulfur [0].