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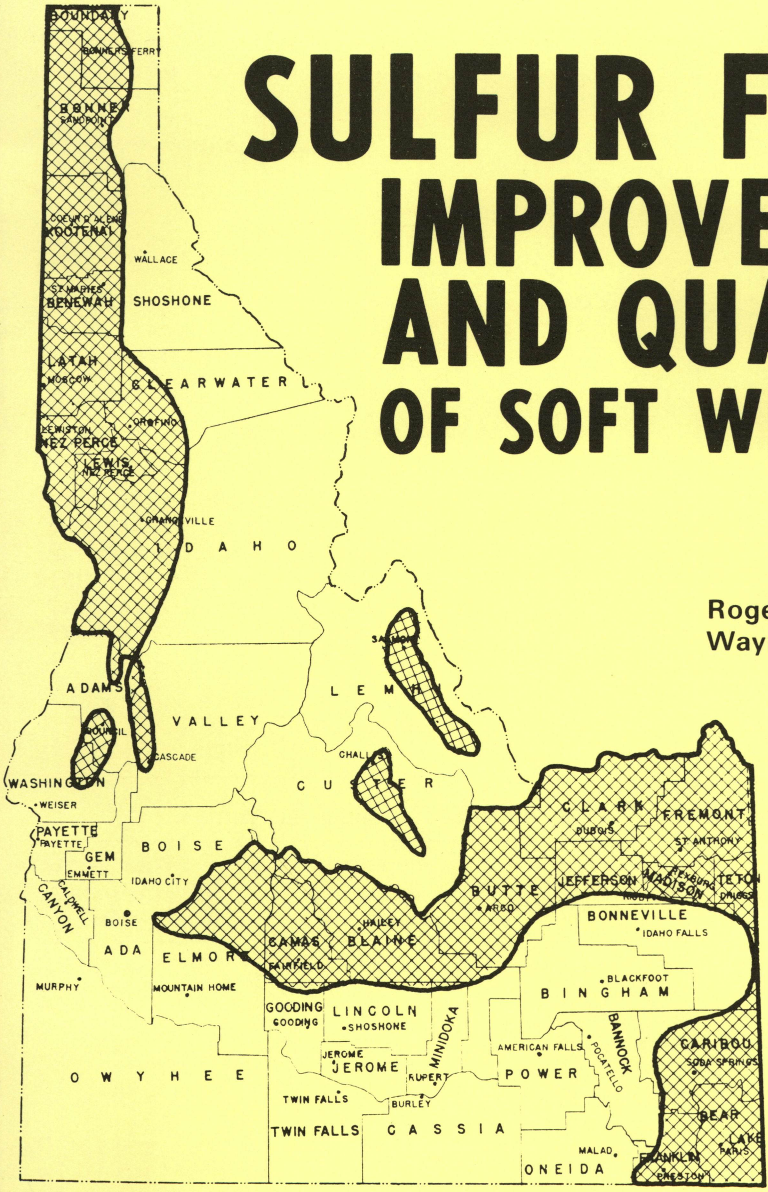
SULFUR FERTILIZER IMPROVES YIELD AND QUALITY OF SOFT WHITE WINTER WHEAT



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Sulfur Deficient

Generalized map of sulfur-deficient areas in Idaho compiled from sulfur analyses of soil test samples. Prepared in cooperation with Franklin Parks, University of Idaho Soil Testing Laboratory.

Sulfur has been known, since 1922, to be deficient in northern Idaho soils for the growth of legumes. Consequently, the use of gypsum fertilizer for preplant application has been widely used throughout the area. Visual observations of responses to sulfur fertilization during the early stages of growth of cereal crops were reported as early as 1953, but yield responses were rare and generally non-significant.

However, in 1957, a series of plots of soft white winter wheat, not treated with sulfur fertilizer, showed severe sulfur deficiencies and highly significant yield increases were found on plots treated with sulfur fertilizer. Numerous soil areas deficient in sulfur for cereal production were subsequently found and experiments with sulfur fertilizers were expanded.

The prevalence of sulfur deficient soils and the needs for sulfur fertilization of cereals can be attributed to (a) a decline in soil organic matter levels and therefore a reduction in soil sulfur reserves, (b) fertilizers such as ammonium nitrate, aqua ammonia and anhydrous ammonia containing no sulfur that came into widespread use for cereal fertilization, and (c) the use of higher nitrogen rates and higher yield varieties that increased the drain on available and reserve soil sulfur.

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EFFECT OF SULFUR ON YIELD

The first phase of sulfur research and the effects of sulfur fertilization on cereal production involved a study of rates, the influence of various sulfur carriers, and the effect on grain yields. The conclusion was reached that little difference in yield occurred among the commonly used carriers ordinarily found on the market.

It was also concluded that the application of 10 to 12 pounds of sulfur was sufficient for maximum wheat production since no significant differences in yields were found when higher rates of sulfur were used. Consequently, it is recommended that 10 to 12 pounds of sulfur per acre be applied in liquid or dry forms for cereal production in northern Idaho. Application should be made preferably in fall for winter grains and in spring for spring grains. Rates higher than 12 pounds of sulfur can be used if desired without any harmful effect on yields or quality.

Many of the farmers in northern Idaho have been applying gypsum to their soil during seedbed preparation for legume crops. When deficiencies of sulfur for the production of cereals were identified in 1957, many of the farmers changed their former practice of applying sulfur to the legume crops and began to apply it to the cereal crop preceeding the legume. Enough extra sulfur was added, above the recommended 10 to 12 pounds for grain, to carry over from one growing season to the next. This insured a highly adequate level for wheat, their best cash crop, and at the same time provided an adequate level for the legume crop the following year. Sulfur rates of 25 to 35 pounds of sulfur per acre should be adequate under this type of management system.

Yields obtained with sulfur from a representative experiment are shown in Figure. I.

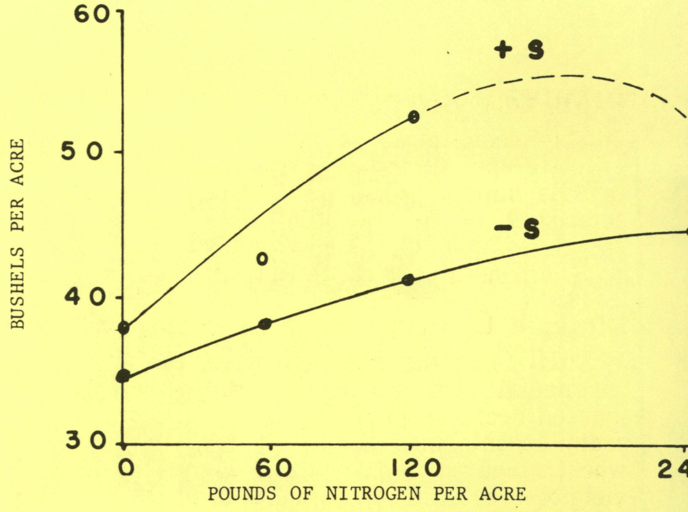

Figure 1

The influence of sulfur fertilization upon yield of Gaines soft white winter wheat.

TABLE 1
Yield, nitrogen and sulfur content of Gaines wheat grain as influenced by sulfur fertilization.

Lbs. S/A[1]	Lbs. N/A		Grain yield bu/A	Total Nitrogen in grain %*	Total sulfur in grain ppm*
0	0		34.1	1.65	875
	60		38.3	1.83	875
	120		41.3	2.08	900
	240		44.1	2.28	805
		Avg.	39.5	1.96	864
10	0		37.4	1.65	1015
	60		42.5	1.67	1015
	120		51.2	1.82	1025
	240		48.7	2.01	975
		Avg.	45.0	1.79	1007
20	0		37.0	1.57	1035
	60		47.8	1.54	1040
	120		56.0	1.74	1005
	240		59.3	2.03	1220
		Avg.	50.0	1.74	1075
40	0		38.6	1.71	1055
	60		50.6	1.63	1120
	120		52.1	1.79	1220
	240		45.4	1.99	1110
		Avg.	46.7	1.78	1126

[1]Sulfur gave significant yield increase, but no significant difference was found between rates of sulfur.

*Oven-dry basis.

EFFECT ON PROPERTIES OF WHEAT

The second phase of the study began in 1963 to evaluate the influence of sulfur fertilization upon (a) the milling properties of wheat and the characteristics of the resulting flour and its baking properties, and (b) changes which may occur in the organic constituents within the wheat grain.

Nitrogen Content

Analysis of the wheat grain (Table I) from experimental plots fertilized with sulfur showed a marked decrease in percent of total nitrogen in the grain accompanied by an increase in total sulfur when compared to non-sulfur fertilized grain. Grain yields increased as the amount of sulfur in the soil available for plant growth was increased. This was accompanied by a decrease in percent total nitrogen in both grain and straw.

Apparently a more efficient use was made of the nitrogen by the plant through an increased rate of conversion of nitrates to protein within the grain as sulfur uptake by the plant increased. Conversely under sulfur deficient conditions there was an apparent decrease in the ability of the plant to efficiently convert nitrates to protein, consequently total nitrogen increased in the wheat grain because of an increase in stored nitrates. Nitrate nitrogen represents a reserve of unassimulated nitrogen in the plant, which has not been converted to protein.

Flour Quality

When comparisons of flour quality were made on the grain from sulfur-fertilized and non-fertilized plots (Table II) it was found that high rates of nitrogen without adequate sulfur decreased total and patent flour (premium grade flour) yields but increased flour ash. Normally, as flour ash increases, flour yields also increase because of an increase in seed coat and bran contamination. The ash content of flour milled from Golden wheat usually runs about 0.44 percent. The high ash content of the sulfur-deficient flour reduced the sedimentation and viscosity values as shown in Table II. However, to some extent the low values obtained may have been because of reduced flour strength through some change in gluten content and character.

The ash was chemically analyzed to determine why there was an unusually high ash content. It was found that calcium, magnesium, sodium and phosphorus contents were higher in both grain and the flour ash from the sulfur-deficient grain. Potassium and the micro-nutrients appeared to be normal in content. It was concluded that some of the increase in ash was due to a change in chemical composition, rather than increased bran and seed coat contamination during milling.

Flour yield from sulfur deficient grain, as shown in Table II, was as low as 65 percent, while grain adequately supplied with sulfur produced up to 71 percent yield of flour. A good flour yield is considered to be about 72 percent of the grain weight. Long patent flour, which is a premium flour and brings a premium price, yielded an average of 56 and 62 percent respectively for sulfur-deficient and adequately sulfur-fertilized grain.

Wheat of poor milling quality was produced from sulfur deficient plots and improved on plots which received sulfur fertilizer. Mill feed rates were reduced as a result of the poor sifting properties of the flour from sulfur deficient wheat. High feed rates are desirable because they indicate maximum economic production rates when wheat is milled on a commercial scale.

Milling Score

The milling score of the wheat receiving sulfur fertilizer was significantly increased in all experiments. The milling score is a method of evaluating wheat milling quality and considers the factors of flour yield, flour ash percentage, milling time, percent patent yield and tempering moisture level.

Most of these factors were influenced by sulfur fertilization. Consequently, the milling score was also significantly influenced. The higher the milling score for any particular wheat, the more acceptable the wheat is to the miller for flour production. The milling score for Golden wheat which was fertilized with seventy pounds of nitrogen with no sulfur was 61.3 but increased to 77.1 with wheat harvested

TABLE 2

Influence of sulfur fertilization on quality of Golden soft white winter wheat.

Lbs. S/A	Lbs. N/A		Flour yield	Patent yield	Flour Protein	Flour ash	Milling score	Viscosity[1] °Mac
0	70		65.6	55.0	10.4	.61	57.4	11
0	70		66.0	56,2	11.0	.63	59.1	13
0	70		67.2	58.4	9.2	.51	60.6	30
0	70		65.4	55.2	11.0	.61	60.1	10
		Avg.	66.1	56.2	10.4	.59	61.3	16
20	70		71.1	62.0	6.7	.44	78.4	21
20	70		71.0	62.1	8.2	.44	77.9	34
20	70		70.6	62.0	7.2	.45	76.4	24
20	70		70.0	61.0	7.1	.45	75.6	26
		Avg.	71.4	61.9	7.3	.45	77.1	26

[1]Unit used to measure viscosity.

from plots to which 20 pounds of sulfur had been applied (Table II).

The color of the flour produced from sulfur deficient grains from some of the experimental plots was also adversely influenced. The Pekar color test showed that all of the high ash flours (obtained from the zero sulfur treatments) were darker in color than the samples with the same nitrogen treatment but with added sulfur. Application of sulfur at all nitrogen levels reduced the grayness. Gray color in flour is objectionable because the miller is unable to remove it by bleaching. Consumers prefer a pure white flour.

Baking Characteristics

Of interest to the baking industry is the size of cookie which a given flour will produce. Generally a small increase in cookie diameters occurred when flour from the sulfur treated plots was compared to flour from plots receiving no sulfur (Figure II). But this effect was not consistent. The influence of sulfur on cookie diameter was not present in all plot locations and may be due to differences in the variety of grain grown. Different varieties of grain may respond with different degrees to sulfur additions. It may, however, be due to the degree of the sulfur deficiency which occurred in different locations, or to other environmental factors.

Another factor which interests the miller, the baker, and the consumer is the appearance of the finished product. In Figure II it is obvious that the surface and color characteristics of the cookie would play an important role in consumer preference. The six cookies shown were all baked with equal amounts of dough, all of which had been prepared in the same manner and baked at the same time in the same oven. Each cookie represents flour made from wheat from different plots. All plots had 80 pounds of nitrogen per acre applied; three of them were treated with 20 pounds of sulfur per acre, using gypsum as the sulfur carrier. Some variation in cookie quality occurred within treatments, but cookie quality was considerably better when made from wheat flour obtained from the sulfur treated plots.

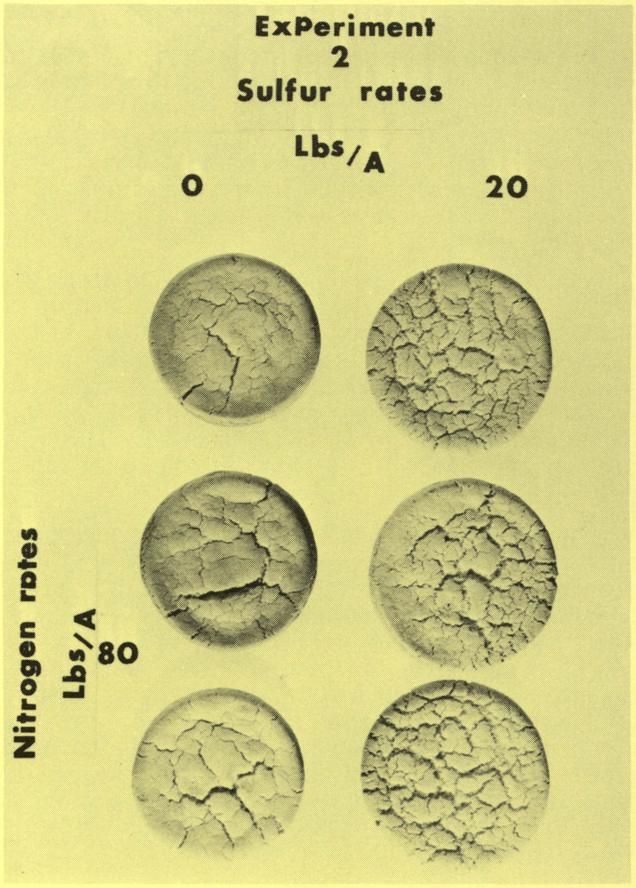

Figure 2

Quality of cookies as influenced by sulfur-fertilized Gaines wheat.

SUMMARY

The conclusion reached at this point in the research on sulfur fertilization is that under conditions of sulfur deficiency a low yielding crop of wheat of inferior quality is produced. Both of these factors can be improved readily by adding sulfur, providing no other essential element or environmental condition is limiting.

The authors wish to express their appreciation for the cooperation and assistance received from the staff of the Western Wheat Quality Laboratory for their analysis of the wheat for milling and baking characteristics.

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James E. Kraus, *Director*