MILLING WHEAT FERTILITY MANAGEMENT

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ABSTRACT

Growing a successful crop of milling wheat that meets the yield goal and protein target is a challenge, particularly when the high cost of nitrogen and phosphorus are considered. The most efficient and least cost system is desirable; however, not attaining sufficient yield to maximize profit per acre is a lost opportunity. The profit is further reduced if the grower does not attain the protein standard and is docked for every ton that does not make 13 percent protein. Strategic planning in growing the wheat crop can help strengthen procedures that can promote higher yields and help meet protein standards. Accumulating a history of yield and protein performance by field with soil sampling history sets a baseline for the future. The most important step will be to set yield and protein goals for the future. Fertilizer rates can then be put in to a program of split applications coinciding with critical growth stages. The monitoring of critical growth stages with tissue testing for nitrogen, phosphorus and sulfur is indispensable for good plant growth and protein formation. Planning for the correct formulation of the fertilizer element for the cool soil conditions of winter and spring will help make sure that plant growth is not limited.

Key Words: Wheat, Triticum aesetivum, nitrogen, phosphorus, sulfur, management

Establishing a Yield and Protein Goal. Having a firm assessment of the farm and field conditions is a starting point in the development of a strategic plan for reaching profitability goals based upon yield and quality. Building a base line of performance for each field is the first step. This will help guide and realistically establish the number of pounds of nitrogen, phosphorus and sulfate required to achieve yield and quality averages. Input costs have to be realistic, fertilizer inputs must targeted above the actual performance in order to fully take advantage of the genetic lead that is in newly developed wheat cultivars Dahnke et al. (1983) state that choosing a yield goal is one of the most important decisions farmers can make. If he aims for the average he may miss yield and quality potential that is built into the crop. Aiming above average builds in a safety margin when considering the variables of annual climatic conditions and crop use efficiencies.

Reaching quality targets has been a very important factor in maintaining local markets for milling wheat. Wheat that is too low in protein to make satisfactory human consumption products such as bread and bagels must be sold for animal feed. The resulting dockage is profit limiting for the farmer as well as the grain handlers, millers and bakers. When there is not

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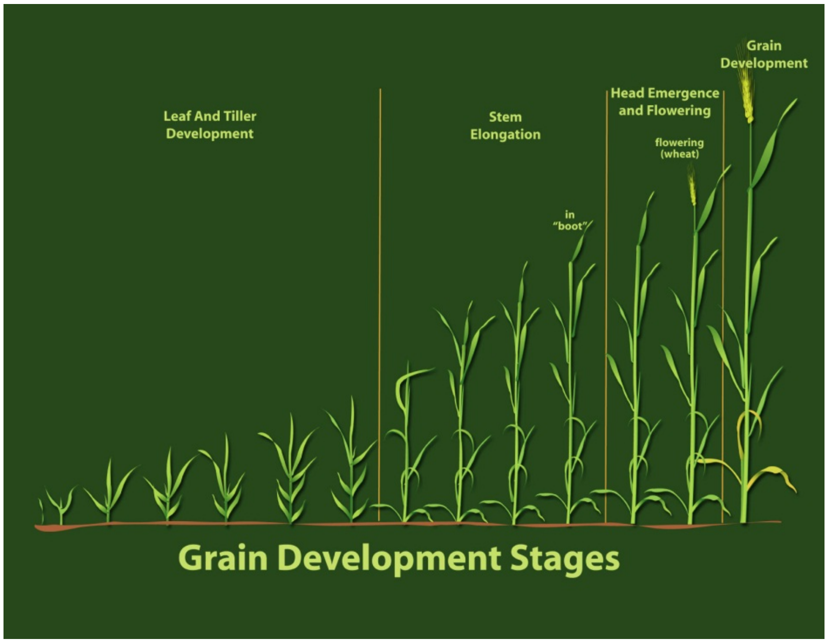
enough local wheat of sufficient quality the mills must purchase outside the area. This is a loss for all allied industries involved in the wheat growing region.

The strategic fertility management plan begins with soil testing the fields that will be planted to milling wheat. Soil tests reveal the status of the soil reveling limitations that would prevent a successful crop. On the positive side, soil tests can indicate useable reserves of nutrients that will augment planned crop nutrient applications. Water testing is also very important because minerals salts and pH level can have an undesirable effect on the present crop and the long term fertility of the soil. The analysis of minerals and elements along with status of soil structure must be interpreted and applied to the crop to be grown. For example, high soil saturation percentages would be indicative of heavy soils that can become saturated during the winter causing denitrification. Lighter soils with a medium to low saturation percentage may be low in sulfate resulting in low protein grain even though nitrogen is adequate. The leaching of valuable nitrogen out of the root zone reduces crop yield and quality if not replaced with additional fertilizer. Nitrate nitrogen is mobile in the soil and can leach into the ground water if not managed properly.

When considering the total crop growth strategy, from preplant fertility to maturity, N P K and S must be thought of in terms of plant uptake throughout the season (table 1). Nutrients are taken up by the plant as needed. Early development stages, from seedling to boot require less total nutrients during the cool winter season. However, the plant cannot make adequate yield determining growth without available N P K and S during these early stages. In fact the cold winter soils make the availability of P and S critical. Both nutrients are needed for energy transfer systems at the cellular level in the plant. Adequate plant growth during the period between seedling and tillering sets the ultimate number of spikes and kernels which will determine the potential for yield. From tillering to boot there is a dramatic increase in plant nutrient uptake. The powerful surge of growth that is in preparation for the coming reproductive stages creates a big demand for N P K and S. By milk stage all reproductive structures are formed and kernel fill is taking place. Inadiquate nutrient availability from milk stage on will result in reduction in quality. The protein starch matrix in the endosperm cannot be completed if there is reduced availability of nitrogen and sulfur for the formation of gluten.



(Table 1) Nutrient Uptake of Wheat by Growth Stage
Washington. Source: Koehler, 1985

Growth Stage
Kg ha^{-1}

	Tillering	Boot	Milk	Mature †	Total
Nutrient	(0-30 days)	(31-73 days)	(74-93 days)	(94-114 days)	Accumulation
					For season
N	42	78	56	-19	176
P	7	23	17	-3	47
K	18	100	15	-36	133
S	1	7	3	0	11
Dry Matter	885	6238	5029	2005	14157
Percent of Maximum Uptake					
N	24%	68%	100%	89%	
P	15	65	100	94	
K	14	89	100	73	
S	10	60	100	100	
Dry Matter					

†Shows net loss of N, P, and K due to leaf drop

From Table 1 it becomes clear that split applications are the best approach to matching nitrogen supply with the right amount of nitrogen for plant growth. Applying heavy rates of nitrogen at preplant risks loss of nitrogen during the winter if soils become water logged and denitrification occurs. If the wheat crop is grown on light textured soils early applications of nitrogen are subject to leaching. For irrigated production, three applications are a very practical way of supplying the right amount of nitrogen when the plant can use it for production. This is important in production field where high yields are expected. Making 3 or more applications for a total 280 to 300 pounds of nitrogen applied throughout the season is a reasonable approach. Particularly when the crop is expected to yield four to 4 and 4.5 tons per acre as new varieties of wheat are capable of doing.

Knowledge of historical field performance levels for yield and protein is necessary for planning nitrogen needs. The specific requirements for nitrogen in the mature plant at harvest can be determined from Table 2. Using the historical yield and protein levels provides a nitrogen use efficiency level for the present program and specific field. The strategic plan is to project the highest realistic profitable yield and protein level. The information in Table 2 will indicate the needed nitrogen to achieve the profitable production goal at harvest. Fertilizer inefficiencies under field conditions are not considered in the table, making it necessary to add additional nitrogen. According to Wuest and Casman (1992) early season applied nitrogen is about 70 percent effective whereas nitrogen applied at anthesis is 98 percent effective in raising grain protein.

(Table 2) Pounds of Nitrogen Needed in the
Wheat Plant at Harvest

Grain Protein Percent

Grain/Acre	11	12.5	13	13.5	14
3	165	188	195	203	210
3.25	179	203	211	219	228
3.5	193	219	228	236	245
3.75	206	234	244	253	263
4	220	250	260	270	280
4.25	234	266	276	287	298
4.5	248	281	293	304	315
4.75	261	297	309	321	333
5	275	313	325	338	350

Formula from CWC Pamphlet protein is 17.5% nitrogen

Monitoring Crop Fertility. Tissue testing prior to critical plant stages in order to make adjustments in fertility is an excellent strategic practice. Making use of tissue tests during the tillering stage helps the grower gain a real time a picture of the nutrient status of plants in the field. At this stage there is still time to make adjustments in fertility. Tillering is a critical stage because it is at this time that the plant is developing the number of tillers, spikes and kernels on each head. Boot stage can be another opportunity to test for adequate nitrogen and sulfur levels. Typically irrigations are going on at flowering so this is a good adjustments in nitrogen fertility. The wheat plant growing in the field is a perfect source for information on a range of nutrient availability issues. The availability of nutrients from the soil can be restricted by unbalanced soil chemistry not permitting adequate extraction by the plant. At this time it is best to assess the broad range of nutrients rather than just nitrate. Phosphorus and sulfur should be included in in the lab tissue test. The test results will indicate how effective the plant is at extracting these important nutrients from the soil. With the tissue tests being done in the spring it is too late to make an adjustment in the phosphate level in the soil. It is possible to increase the sulfate in the soil if the nitrogen-sulfur ratio is more than 15:1. The tissue tests can serve as a valuable reference when the specific field is prepared for planting next time. Then deficiencies can be addressed with applications of phosphate and sulfur prior to planting.

Phosphorus Requirements and application. Phosphorus is associated with energy transfer at the cellular level. The plant must have adequate phosphorus to use the other fertilizer elements, particularly nitrogen. As important as phosphorus is to plant growth it can easily be tied up in calcareous saline soils. California's Central Valley soils tend to be calcareous with the ability to lock up phosphorus before the plant is able to extract the element from the soil. The winter growth period for cereals compounds the problem of availability with low soil temperatures during the first half of the growth period. The practice of drilling seed and 11-52-0 fertilizer at 50 to 100 lbs. per acre would be beneficial. The small amount of nitrogen in the starter formulation reflects the need to keep ammoniacal nitrogen below 22 pounds per acre because of potential damage to the seed at higher rates The Total preplant nitrogen requirements are not met by the starter fertilizer so an additional 80 to 100 pounds must be applied preplant. Phosphorus is very important to plant energy transfer from the leaves to the developing kernel. High test weight grain that meets the protein standards comes from first making phosphorus available in the soil.

Sulfur Recommendations. The amino acids cysteine, methionine and cystine are necessary for the formation of gluten in milling wheat and durum wheat. The quality of products made from wheat flour like protein level, loaf volume and loaf texture are affected by available sulfate in the soil. Sulfate is mobile in the soil and just like nitrate, it can move out of the root zone through leaching. Sulfate becomes available in the soil through the action of soil bacteria on elemental sulfur. This is similar to the action of soil bacteria in the conversion of ammonia to nitrate which can be used by the plant. Both biological conversion systems require time and adequate temperature levels to make these conversions. Wheat grown in California is a cool season crop grown during a time when biological activity is low. It is important to build adequate sulfur levels into the fertility programs so that sulfate is available for winter and spring plant growth. Ammonium sulfate fertilizer, although higher in per unit nitrogen cost than urea, can be an effective way to get nitrogen and sulfate on fields deficient in sulfate.

CONCLUSION

The production of quality milling wheat that meets the standards set by the milling industry need not be a mystery. The procedures and information for developing a strategic plan are available. Gathering field histories of yield and protein performance as well as fertilizer applications required to meet these goals is a crucial starting point in the process. The histories help set the base line for performance at the known levels of fertilizer applied over time to achieve protein and yield by specific fields. Armed with background information realistic projections can be made for yield and protein levels. The most important decision that can be made is to take into account historical production then to determine the amount of fertility and timing of fertility to be applied. Using split applications of nitrogen timed to preplant, tillering and flowering will provide nitrogen to the plant when needed. Using tissue samples to monitor the fertilizer use efficiency of the plant will guide any adjustment that need to be made.

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