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Managing Nitrogen During the Crop Rotation to Increase Income and Protect the Environment

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National concern about nitrate contamination of groundwater is raising many questions about the use of nitrogen fertilizer to grow high-quality crops. Some extremists are suggesting that commercial inorganic nitrogen fertilization should not be permitted. Such a limitation would seriously reduce crop productivity and farming profitability. We hope that it does not occur. However, the farming industry has become somewhat careless in nitrogen management because nitrogen fertilizer has been relatively cheap for the past couple of decades. Commonly, *a little extra nitrogen* has been applied to assure against a deficiency and less than maximum yield. In recent years, sugar beet growers have learned that such a practice can be costly because high soil nitrate the latter part of the season can cause low sugar percentage and high Brei nitrate leading to low sugar recovery from the sugar beets. We can and should do a better job of managing both applied and symbiotically fixed nitrogen in the soil to diminish the potential for groundwater contamination and to provide the right amount of nitrate in the soil at the right time for the crop being grown.

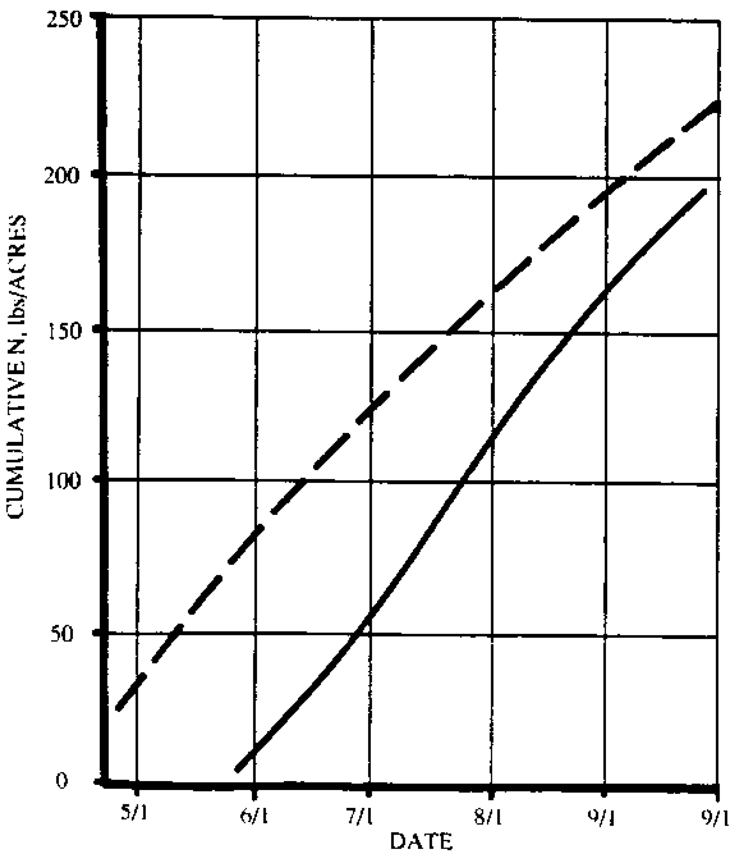
Nitrogen management is best accomplished by considering all nitrogen sources and potential losses during the entire crop rotation being followed. To best utilize nitrogen available and to decrease potential nitrogen leaching, changes in the cropping sequence may be required. Many sugar beet growers as well as other irrigated land farmers grow alfalfa in their crop rotation. Some also produce dry beans and some produce dry peas. These three leguminous crops are infected by nitrogen-fixing bacteria causing nodules to develop on their roots. These nodules provide a home where nitrogen-fixing bacteria can grow and multiply. These nodules are also mini nitrogen-fixing factories. The bacteria feed on sugars and other materials obtained from the leguminous plant as a result of the root infection. To be able to utilize these materials from the plant, the bacteria requires a nitrogen source. That source is N2 or nitrogen gas, from the atmosphere. The organisms have the ability to break apart N2 molecules and assimilate the nitrogen atoms into ammonium, amine and other nitrogen-containing compounds. The leguminous plants benefit because this nitrogen-fixing process provides nitrogen for the plants to grow; therefore, both the bacteria and the plants benefit. Such processes where the coexistence of two organisms occur and both benefit are called symbiotic.

Large amounts of nitrogen are fixed and assimilated into leguminous plant roots, nodules and tops. This process is active while the plants are living, but, after plants die or are killed, the symbiotic nitrogen fixation process ceases and decomposition processes begin. This decomposition and subsequent nitrification release previously symbiotically fixed nitrogen into the soil and convert it to nitrate. The following table gives approximate ranges of the amount of nitrate that can be expected to be formed in the soil following the killing of the three common legumes grown on irrigated land in the West. This nitrate does not appear all at once, but accumulates gradually as the season progresses, and the decomposition and nitrification processes proceed. The amount formed following alfalfa is adequate to supply the nitrogen requirements of most other crops.

Symbiotically fixed nitrogen appearing in the soil as nitrate following different crops

Crop	First Season	Total for Three Years
	lbs/acre	
Alfalfa	250-300	350-450
Dry beans	50-100	0-150
Dry peas	30-50	40-70

Nitrate in the soil is readily leached below the root zone if too much irrigation water is applied or if rainfall is excessive. It is also readily absorbed by plant roots if it is in the root zone of growing plants. Crops such as corn and cereals are the best to follow alfalfa because these crops have extensive fibrous rooting systems to effectively absorb nitrate from the soil. Dry beans, a traditional crop following alfalfa, is a poor choice because this crop also symbiotically fixes nitrogen and requires frequent irrigation leading to considerable nitrate leaching. Sugar beets are also a poor choice because the nitrate concentrations in the soil arising from the decomposition and nitrification processes near the end of the growing season can result in both low sugar percentage and high Brei nitrate, causing low sugar recovery. The sugar beet grower who also grows corn and cereal can wisely grow corn without tillage following alfalfa. This can be accomplished by killing the alfalfa with herbicide in the fall or the spring, then seeding corn directly into the killed alfalfa stubble. Corn seeders with cutting coulters or bull tongue shanks ahead of the seeders can be used. Irrigation furrows used to irrigate the alfalfa can be cleaned and used to irrigate the corn. The following figure illustrates how the nitrogen requirements for the corn can be supplied by the nitrate being formed from decomposition of alfalfa roots and nodules, and subsequent nitrification processes.



The dashed line represents the amount of nitrogen in the nitrate form that accumulates in the soil as the season progresses. The solid line represents the progressive nitrogen uptake requirements by corn as the crop develops and matures. The supply line is always higher than the solid line. This means that the corn crop will be adequately supplied with nitrogen, without any supplemental nitrogen fertilizer being applied. Also, the absorption of the nitrate as it becomes available by the growing corn will reduce the potential for nitrate leaching.

Cereal can be grown without tillage following the corn the next season. This is done by seeding cereal, preferably winter wheat, following the corn harvest. The cereal is seeded parallel to the irrigation furrows with a conventional drill. The furrows are cleaned and used for irrigating the cereal. Nitrate that continues to be formed from the symbiotic sources after the corn matures will supply the nitrogen requirements for the cereal in the fall and may provide most of the nitrogen needed by the cereal. A soil test for available nitrogen in the spring should be made to help the grower determine how much additional nitrogen may be needed. Following this two-crop sequence will maximize removal of nitrate arising from the alfalfa, thereby minimizing nitrate leaching. The no-tillage practice essentially eliminates furrow erosion, thereby conserving soil resources. Five years of research by the Agricultural Research Service at Kimberly, Idaho, has shown that corn and wheat yields grown without tillage in this sequence are equal to yields grown with traditional tillage. Without tillage costs and with minimal nitrogen fertilizer costs, significantly higher net farmer income is realized than when growing the same crops with traditional tillage.

Sugar beets or dry beans can be grown the third season. The cereal stubble can be disked in the fall and left to partially decompose over winter. The following spring, the land can be disked once or twice, herbicide applied and incorporated by roller harrowing, and the crop seeded. If sugar beets are grown, nitrogen should be supplied by following recommended seasonal fertilization practice. If dry beans are grown the third season, sugar beets can be grown following the dry beans with only three or four tillage operations. Sugar beets plus one or two crops of dry beans can be grown before growing spring cereal or dry peas as a companion crop to a new seeding of alfalfa to begin the crop rotation a second time.

Following the cropping sequence and tillage practices discussed has many advantages compared to the traditional sequence of alfalfa, beans, sugar beets, corn and back to alfalfa. Five years of research has shown that net farmer income can be as much as $400 per acre greater over five years following the suggested cropping sequence and practices than from the traditional sequence using traditional tillage practices. Part of this higher net income results from utilizing nitrate arising from symbiotically fixed nitrogen to produce high nitrogen-requiring crops. This saves nitrogen fertilizer costs, reduces the potential for nitrate leaching and saves operational costs.