

# TECHNICAL NOTES

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## MANAGEMENT OF RESIDUAL NITROGEN WITH COVER CROPS

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Nitrogen (N) is applied to millions of acres of cropland in the Pacific Northwest each year. Most of the applied nitrogen is converted to nitrate ( $\text{NO}_3^-$ ) in the soil and readily taken up by the crop. Unfortunately, nitrate-N is mobile in the soil and can escape below the root zone of the crop and potentially contaminate groundwater.

Pacific Northwest farmers use a variety of techniques tailored to their soil conditions and farming operations to obtain maximum uptake & benefit of applied fertilizer. Split applications of nitrogen, fertigation, and crop rotations are common techniques used to ensure maximum use of nitrogen and minimal escape of nitrates. Fall cover cropping, a conservation practice widely used to reduce wind erosion, has been shown to be an excellent nitrate-N management tool in the Pacific Northwest.

Results of studies conducted in the Columbia Basin show:

- Residual nitrogen is subject to deep leaching throughout the winter months.
- Fall cover crops must be seeded early enough in the fall to develop a root system capable of extracting nitrate deep in the soil profile.
- Fall cover crops that over-winter retain much of the nitrogen in the foliage and should be incorporated into the soil 2-3 weeks before seeding the spring cash crop.
- Fall cover crops that do not over-winter breakdown in the soil and nitrogen is released over the winter and spring.
- Spring oats seeded in the fall grew very rapidly but did not over-winter.
- Cereal rye has been one of the best fall cover crops in 3 years of testing in Washington.
- Winter wheat, white mustard and canola are also good cover crop options.
- Sudangrass is an excellent cover crop but requires an early planting date.

### Nitrogen in the Soil-

Nitrogen is applied to fields in various forms such as anhydrous ammonia, ammonium nitrate, urea, ammonium sulfate, and others. These nitrogen based fertilizers undergo reactions in the soil and plants take up the nitrogen in the form of ammonium ( $\text{NH}_4^+$ ) or nitrate ( $\text{NO}_3^-$ ). While ammonium can be taken

up by plants, much of it undergoes nitrification in the soil to produce nitrate. Nitrate does not bind to clay particles and is mobile in the soil. Mobility is both an asset and a detriment for producers. The benefit of high mobility of nitrate is that it readily diffuses through the soil so plant roots do not have to actually intercept it in the soil. Plants thus expend far less energy developing roots to meet their nitrogen needs. The disadvantage of high mobility is that nitrate can move with soil moisture beyond the rooting zone of the crop. Once the nitrate is beyond the rooting zone, it is subject to further deep leaching and can contaminate ground water.

The U.S. Geological Survey (USGS) conducted a survey of 573 wells in the Columbia Basin to assess water quality. Nitrate concentrations exceeded the EPA maximum contaminant level for drinking water of 10 mg/L in 19% of the 573 wells (Ryker and Jones, 1995). The occurrence of high nitrate in shallow wells coincided with areas that receive high amounts of nitrogen fertilizer (>100 lbs/acre). The report also indicated that nitrate concentrations in groundwater have increased since the 1950s which is prior to intensive, large-scale, irrigated agriculture.

A study of domestic water wells in six vegetable growing areas of central Wisconsin showed that between 10 and 44% of the water wells of the six areas had nitrate levels exceeding the EPA maximum contaminant level for drinking water (Kraft and Stites, 1994). Nitrate levels in fallow fields were monitored for one year beginning in March in an associated study. In March, nitrate levels were concentrated in the upper soil profile and low in the deeper profile. As the season progressed the high nitrate concentration moved deeper into the profile. By November the highest concentration of nitrate was located well beyond the effective rooting depth of any crop. A similar response occurs in the Pacific Northwest but high concentrations of nitrates generally occur near the soil surface in the fall because most nitrogen-rich crop residues occur at or near the soil surface. Since much of the Pacific Northwest precipitation is received in the winter and uptake of nitrogen by plants is minimal during the winter, nitrate concentrations tend to be deep in the soil profile in the spring.

#### **Fall Seeded Cover Crops-**

An important benefit of cover crops is their ability to recycle nitrogen and reduce leaching losses. Wagger and Mengel (1988) reported that wheat or rye cover crops following corn generally retained 10 to 90 lbs/ac of soil nitrogen that would otherwise be available for leaching. Shipley et al. (1992) reported that 10 to 45% of the nitrogen fertilizer was retained in rye, annual ryegrass, and hairy vetch cover crops which were planted following harvest of corn. Furthermore, these three cover crops were more efficient than resident weeds at uptaking nitrogen. While fall cover crops generally reduce nitrate leaching, cover crop residues can increase nitrate leaching if decomposition of cover residues is rapid and coupled with excessive rainfall or over-irrigation (Miller et al., 1994).

Fall cover crops have been used in California to improve the nitrogen supply in soil. Annual legumes seeded in October have contributed in excess of 200 lbs N/ac/yr. by March in an ongoing study conducted at Davis, CA (Miller, 1990). The accumulated nitrogen is largely held in the top growth and released after plow down. Annual legumes will utilize residual nitrogen as well as fix nitrogen and may be an excellent EARLY fall cover crop for the Pacific Northwest. Most annual legumes have exhibited slow growth in cool temperatures in trials conducted in the Pacific Northwest.

Corn and potatoes are two important crops grown in the Pacific Northwest. Neither utilize large amounts of nitrogen late in development (Hammond, 1992; Thornton et al. 1997). Low utilization coupled with decomposition of post-harvest residues can result in a large pool of residual nitrogen remaining in the soil.

A 1993-1994 cover crop study planted near Plymouth, WA following sweet corn showed that the cover crops accumulated 29 to 125 lbs N/ac in the above-ground portion (Weinert et al., 1995). The cover

crops were seeded in late August and were either allowed to over-winter or were incorporated in late fall. Spring incorporated cover crops that over-wintered accumulated between 100 and 125 lbs N/ac. Spring incorporation of the over-wintered cover crop maintained the nitrogen in the upper profile, and nitrogen was released for up to 60 days after incorporation. Nitrate movement below 2 feet was reduced in the soil below over-wintering/spring plowed cover crops, compared to fallow ground and fall incorporated cover. Fall incorporated cover crops fared somewhat poorly and approximately 75 lbs N/ac escaped deep into the soil profile. Postponing fall incorporation would probably reduce decomposition and release of nitrogen into the soil. Potatoes were planted into the field at the end of the study and none of the cover crop treatments effected tuber yield or quality. Seeding potatoes 2-3 weeks after incorporation ensures adequate time for the biomass to begin decomposition. Decomposition is needed to release the nitrogen and prevent difficulties with potato planting operations.

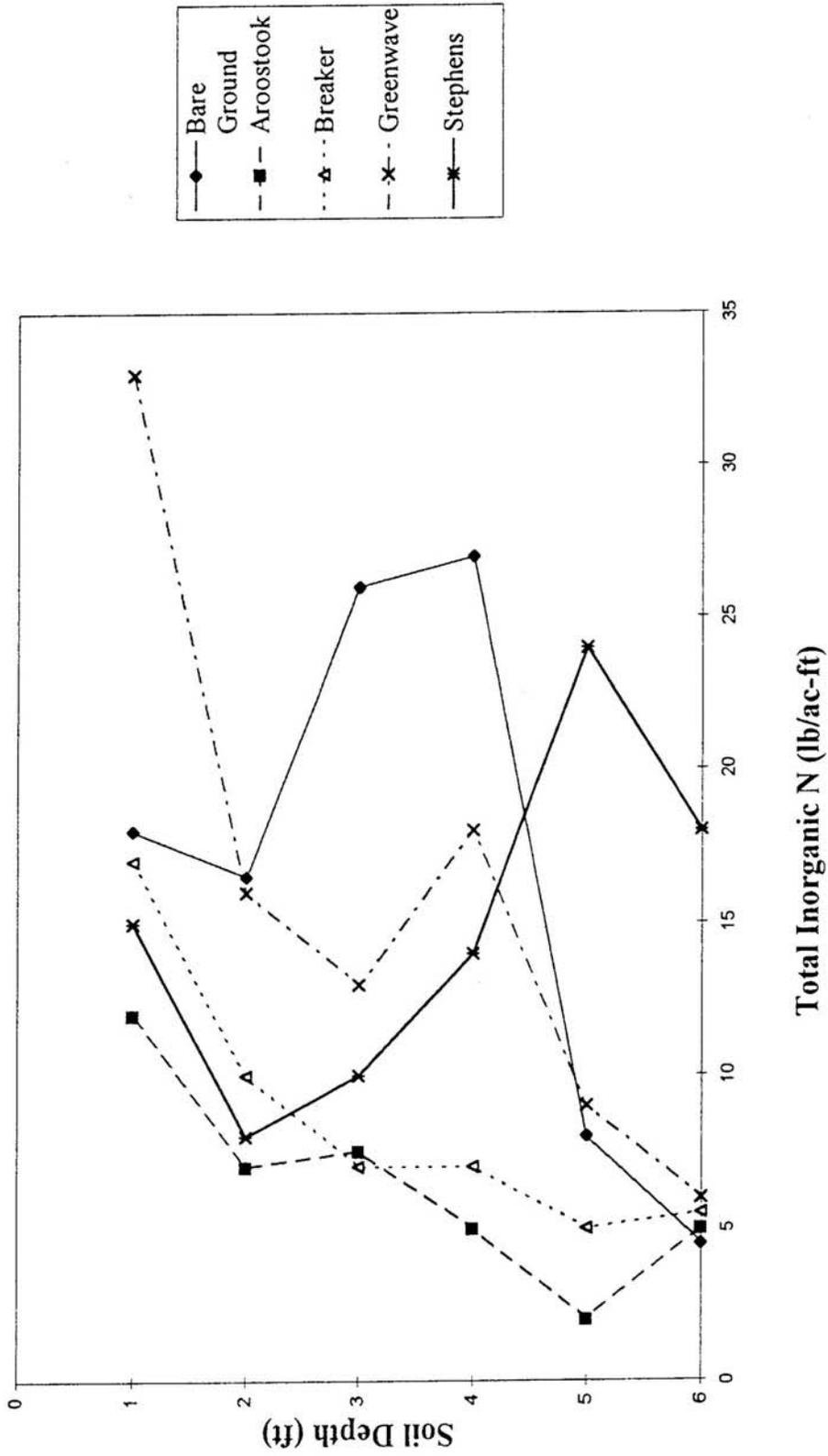
A series of fall cover crop studies conducted near George, WA evaluated growth and nitrogen capture. Results of a planting date study showed that seedings made in the first week of September produced between 0.4 to 2.2 tons dry matter/ac by mid-November (Gillespie et al., 1998). Oats provided the most biomass production and winter-peas provided the least biomass production. Unseeded plots contained 119 lbs N/ac in the top 6 feet of soil. Nitrogen capture ranged from 57 to 91 lbs N/ac in the cover crop plots. In comparison, seedings made in early October produced at most 0.13 tons dry matter/ac on the same sampling date. Nitrogen capture was negligible for the October seeded cover crops because they failed to acquire much growth beyond the 2-leaf stage and root development was minimal. A concurrent study evaluated whether surface applied nitrogen fertilizer would stimulate fall growth and overall plant vigor. Results showed that applying nitrogen did not improve fall above-ground growth (Gillespie et al., 1998). The limiting factor for fall growth was not available nitrogen but rather growing degree days.

Preliminary results of a study conducted by Brunty and Pan at the WSU Othello Agricultural Research and Extension Center showed a large accumulation of nitrogen occurring between 3 and 4 feet in bare ground in the spring (Figure 1). Fall seeded "Aroostook" cereal rye and "Breaker" triticale captured the most nitrogen. "Greenwave" mustard did not over-winter. Much of the captured nitrogen in "Greenwave" was stored in the above-ground tissues. As these tissues decomposed in the spring, the nitrogen was released into the upper soil profile. "Stephens" winter wheat recovered much of the residual nitrogen but not as effectively as the other crops. Sudangrass failed to develop more than 2-leaves because the August 30 seeding date did not provide adequate warm days for growth. However, sudangrass has performed very well in cover crop trials that were seeded the first week of August.

### **Summary**

Contamination of groundwater is a major concern in the Pacific Northwest. Fall cover cropping is an effective means to capture nitrogen that would normally leach deep into the soil profile. The effectiveness of this practice hinges on a few key factors. First, the cover must be seeded as soon as possible after the preceding crop because growing degree days are the most limiting factor for fall cover crop growth. This is especially important for sudangrass. Cereal rye and triticale are among the most tolerant of cool fall temperatures. Second, incorporation of the cover crop should be delayed until spring. Spring incorporation allows over-wintered cover to continue nitrogen capture up until incorporation and prevents loss of nitrogen caused by fall-winter decomposition of the cover crop. Lastly, producers must be made aware of the potential economic benefit of fall cover cropping. The ability to capture as much as 125 lbs-N/acre translates into a fertilizer savings worth roughly \$40.00/acre for the following cash crop.

**Figure 1. Nitrogen Profiles in the Spring 1997 for Several Fall Planted Cover Crops at the WSU Othello Agriculture Research and Experiment Center.**



## References

- Gillespie, R., W. Pan, M. Stannard, J. Brunty. (1998). Evaluating irrigated cover crops in the Columbia Basin. Northwest Columbia Plateau Wind Erosion/Air Quality Project. Semi-Annual Report (Nov. 1997 - May 1998).
- Hammond, M. (1991). Research for reduction of nitrate leaching into Columbia Basin groundwater. Final Report to the Upper Grant Cons. District, Ephrata, WA.
- Kraft, G.J. and W. Stites. (1994). Groundwater impacts of potato and vegetable production. Proc. Wisc. Ann. Potato Conf. 7:-12.
- Miller, M.H., E.G. Beauchamp, J.D. Lauzon. (1994). Leaching of nitrogen and phosphorus from the biomass of three cover crop species. J. Envir. Quality 23:267-272.
- Miller, P.R. (1990). Legume cover crops in annual cropping systems. Proc. Sustainable Agr. Conf., Portland, OR.
- Ryker, S.J. and J.L. Jones. (1995). Nitrate concentrations in Groundwater of the Central Columbia Plateau. U.S. Geological Survey. Open-file report 95-445.
- Shipley, P.R., J.J. Meisinger, A.M. Decker. (1992). Conserving residual corn fertilizer nitrogen with winter cover crops. Agron. J. 84:869-876.
- Thornton, R., S. Victory, M. Hammond. (1997). A comparison of pre-plant nitrogen best management practices on potatoes and their effect on nitrate leaching in the Columbia Basin. Proc. 36th Ann. WA State Potato Conf. & Trade Show.
- Wagger, M.G. and D.B. Mengel. (1988). The role of nonleguminous cover crops in the efficient use of water and nitrogen. ASA Spec. Publ. 51:115-127.
- Weinert, T., W. Pan, M. Moneymaker, G. Santo, and R. Stevens. (1995). Green-manured winter cover crops in irrigated potato rotations. Proc. 34th Washington State Potato Conf. & Trade Show.