Northwest

Phosphorus and Sulfur Support Nitrogen in Intensified Cereal Production

By Paul E. Rasmussen

Studies on the Columbia Plateau near Pendleton, OR, emphasize the importance of providing adequate phosphorus (P) and sulfur (S) nutrition to supplement the traditional nitrogen (N) program in no-till and intensified dryland cereal production systems.

EFFICIENT FERTILIZER USE is a prerequisite for achieving optimum crop yield while avoiding adverse environmental impacts. Generally, nutrient deficiencies are greater under annual cropping than in cereal/fallow rotations because of the extra time in the latter for mineralization of available nutrients.

Nitrogen and S deficiencies are likely to be more severe in conservation tillage than in conventional tillage systems because these nutrients are derived primarily from the organic fraction of soil. It is the decomposition of this fraction that is most altered by a change in tillage. Phosphorus can be similarly affected. Nutrient deficiencies tend to be more severe in no-till because of cooler, wetter soil conditions that impair early crop growth and root development. This is especially significant relative to early season availability of P.

Six-Year Field Study

Cereal grain was grown over a 6-year period in an experiment with three rotation-tillage treatments and four levels of fertility on a Walla Walla silt loam. Crop rotation consisted of winter wheat/fallow and annual cropping (winter wheat/spring cereal). Tillage treatments, applied to annual cropping only, were no-till and conventional-till. Fertilizer treatments were (a) none, (b) N only, (c) N + S, and (d) N + P + S. Fertilizer amounts varied slightly with year, averaging 97 lb/A N, 22 lb/A P_2O_5, and 16 lb/A S. Soil tests prior to planting indicated that the soil (0-1 foot) was low in available S . . . 3 parts per million (ppm) . . . and medium in available P (11 ppm $NaHCO_3$ extractable) for dryland wheat production.

Table 1. Winter wheat grain yield and relative-yield ratio as affected by tillage and fertilization.

	-------- Yield, lb/A --------			
Fertilization	NT	CT	3-yr Avg.	NT/CT ratio
None	1,060	1,850	1,460	0.57
N	2,300	2,980	2,640	0.77
NS	3,260	3,680	3,470	0.89
NPS	3,550	4,200	3,880	0.85

NT = No-till, CT = Conventional-till.

Fertilizer Response

Rates of N, P and S were adjusted annually depending on soil water storage, cereal variety, seeding data, and previous experience. Cereals responded to each nutrient in all years at a statistical probability of 0.10. The marginal P responses (statistical probability between 0.05 and 0.10) tended to occur in years of low precipitation (years 3 and 6) while marginal S responses did not. Yields for all cereals,

Table 2. Spring cereal grain yield and relative-yield ratio as affected by tillage and fertilization.

	-------- Yield, lb/A --------			
Fertilization	NT	CT	3-yr Avg.	NT/CT ratio
None	1,380	2,220	1,800	0.62
N	2,200	3,010	2,610	0.73
NS	3,380	3,460	3,420	0.98
NPS	3,980	3,730	3,860	1.07

NT = No-till, CT = Conventional-till.
Barley planted in year 2 and year 4; spring wheat planted in year 6.

Dr. Rasmussen is Soil Scientist with USDA-ARS, Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97801.

Table 3. Winter wheat yield in annual cropping and wheat/fallow rotation as affected by fertilization. (2-year average)

Fertilization	------ Yield, lb/A ------ Annual crop (AC)	Wheat-fallow (WF)	AC/WF ratio
None	1,630	3,170	0.52
N	2,260	3,380	0.67
NS	3,390	3,810	0.89
NPS	3,890	4,330	0.90

cropping systems, and tillage systems (**Tables 1-3**) were greatest for the NPS combination in which there was never any visual or analytical evidence that nutrients were deficient when applied at the rates indicated. Yields progressively increased from none<N<NS<NPS, indicating that the application of all three nutrients was necessary to maximize yields. Six-year yield averages were 1,620, 2,620, 3,450 and 3,870 lb/A, respectively, for these nutrient combinations.

Conventional-till (CT) vs. No-till (NT)

Winter and spring cereals responded about equally to N, P, and S in both no-till and conventional-till, with one distinction. Winter wheat yield (**Table 1**) in no-till was always less than conventional-till regardless of fertility, whereas spring cereal no-till yield (**Table 2**) equaled conventional-till when NS and NPS were applied.

The NT/CT yield ratio was lowest with no nutrient application and progressively improved when N and S were applied for both tillage systems. An increase towards unity in the NT/CT ratio with N and S addition indicates that the deficiency of these nutrients was more severe in no-till. The NT/CT yield ratio also increased for P addition in spring cereals, but not in winter wheat. This indicates P deficiency was similar in both no-till and conventional-till for winter wheat. The NT/CT ratio >1.0 for spring wheat reveals the importance of P for spring planting when cold, wet soil conditions limit P availability.

Annual Cropping vs. Wheat/Fallow

When grown without fertilizer, winter wheat in annual cropping yielded 52 percent of wheat following fallow (**Table 3**), reflecting the substantial contribution of a year of fallow to the nutrition of the following crop. When fertilized with N, P and S, annual crop winter wheat yielded 90 percent of wheat after fallow. Total production over two years would be up to 80 percent greater with annual cropping than with wheat/fallow, but with higher production costs to be considered in the final analysis.

The AC/WF (annual crop/wheat-fallow) yield ratio increased with N and S application, indicating these nutrients were more deficient under annual cropping. The ratio did not increase with P addition, indicating that response was similar in both cropping systems.

SUPPLYING adequate P advances heading and maturity of spring grains by as much as 5 to 7 days. This can improve water use efficiency and avoid late-season drought stress. In the photo, barley plot at left received N and S, while plot at right received P in addition to N and S.

Summary

Cereal grains responded strongly to application of N, P and S. Both N and S were more deficient in no-till than conventional-till. Deficiency was also greater when soils were cropped annually rather than in wheat/fallow rotation. These responses occur because the amount of N and S that native soil organic matter can supply decreases with less-intensive tillage and with less time between cropping. Phosphorus availability, which is governed to a greater degree by the mineral fraction of soil, was only minimally affected by either cropping intensity or type of tillage.

Adequate fertility is a prime prerequisite for efficient yield in all cropping systems, but more so in no-till systems and intensive cropping. ■