The Nitrogen Supplying Power of Alfalfa in Irrigated Crop Rotations

by

J.L. Henry and D.J. Tomasiewicz

Soil Science Department
University of Saskatchewan
Saskatoon, Saskatchewan

1. Introduction

The rising costs of energy and the resultant large increase in the costs of nitrogen fertilizers based on natural gas reserves has stimulated an increase in interest in legume crops in rotation with cereals and oilseeds. The nitrogen supplying power of these legumes is of primary importance. It is well known and documented that perennial legume crops such as alfalfa can fix large quantities of nitrogen and can essentially meet the nitrogen needs of that legume crop.

The beneficial effect of legume crops in rotations is also well documented in at least a qualitative sense and in many cases in a quantitative sense in terms of yields of subsequent crops. Less well documented is the affect of a legume on the nitrogen requirements and in particular on the nitrogen soil test benchmarks of subsequent cereals and oilseeds. Provincial Soil Testing Laboratories on the prairie provinces do not at this time take previous legume crops into account in interpretation of the nitrate soil test.

In the South Saskatchewan River Irrigation Project at Outlook, alfalfa is a stable crop in the rotations and much of it is marketed through a cubing operation. Recommendations for breaking alfalfa prior to planting cereals and oilseeds have suggested that even under irrigation it would be necessary to take only one cut in the previous year and to break in early July and have a partial summerfallow to effect the mineralization and thus meet the nitrogen needs of the subsequent crop. General farm practice in the Outlook area in recent years, however, involved breaking of alfalfa stands in late fall or in some cases even in the spring of the year in which the subsequent crop is planted. General observations indicated that rather large and rapid releases of nitrate were taking place but no data were available to confirm these observations.

In light of the information supplied above, the objectives of this study were: 1) to determine the nitrogen fertilizer requirements of cereals planted on alfalfa breaking, 2) to modify nitrogen soil test correlations for crops following alfalfa.

2. Experimental Methods

Field experiments were laid down on farmers fields within the South

Saskatchewan River Irrigation Project during the 1977, 1978 and 1979 growing seasons. There were five experiments with hard red spring wheat, one with utility wheat and one with barley. Seeding and seedplaced phosphate applications were as conducted by the cooperating farmer. Phosphate rates were 30-40 kg P_2O_5 per hectare with two exceptions. On one wheat experiment in 1978 and in 1979 no seedplaced phosphate application were made.

Plot size was 1.5 x 6.1 m and the treatments included nitrogen rates 0, 28, 56, 84, 112, 168 and 224 kg N per hectare as surface broadcast ammonium nitrate. The broadcast applications were made immediately after seeding. Irrigation was by the border dyke method as practiced by the cooperating farmers.

All experiments were on fields that had been in alfalfa for four or more years. With one exception, the breaking was done in the spring prior to planting. For the one exception, breaking was done in mid-October of the year prior to planting. On that experiment prior estimates of the nitrogen supplying power were available. An identical experiment had been conducted on the same boarder strip in 1972. In 1973 the field was planted to wheat and under seeded to alfalfa and alfalfa was then grown and two cuts per year taken during the years 1973 to 1978. Following mid-October breaking, wheat was planted in late May of 1979.

Just prior to swathing by the farmer cooperator yield samples of 2 m^2 were taken from each of the treatments in each of the six replicates of the randomized complete block experiments. Samples were cut by hand at the soil surface and total weights were taken prior to thrashing. Straw weights were calculated by difference between the total and grain weights. During the thrashing operation a composite sample of the six reps for each treatment was gathered and ground with a Wiley mill. Grain samples were retained for protein analysis.

3. Results and Discussion

The mean data for four wheat experiments after alfalfa is presented in Figure 1. The N uptake in the above ground plant parts in relation to the applied nitrogen for the experiments after alfalfa is compared to an experiment in the same area and with a similar level of soil nitrate nitrogen. From this data it can be seen that the alfalfa as a previous crop resulted in an above ground nitrogen uptake equivalent to the application of approximately 100 kg N per hectare.

Figure 2 shows similar data from one location where the nitrogen supplying power had been obtained in 1972 prior to the establishment of alfalfa. The barley crop in 1972 had only about 15 kg N per hectare in the above ground parts. The five intervening years of full alfalfa production essentially raised the nitrogen supplying power of that soil to a value of approximately 90 kg N per hectare, which was measured in the 1979 wheat crop. Prior to alfalfa a nitrogen fertilizer application of approximately 170 kg N per hectare was required to provide a nitrogen uptake of 90 kg N per hectare.

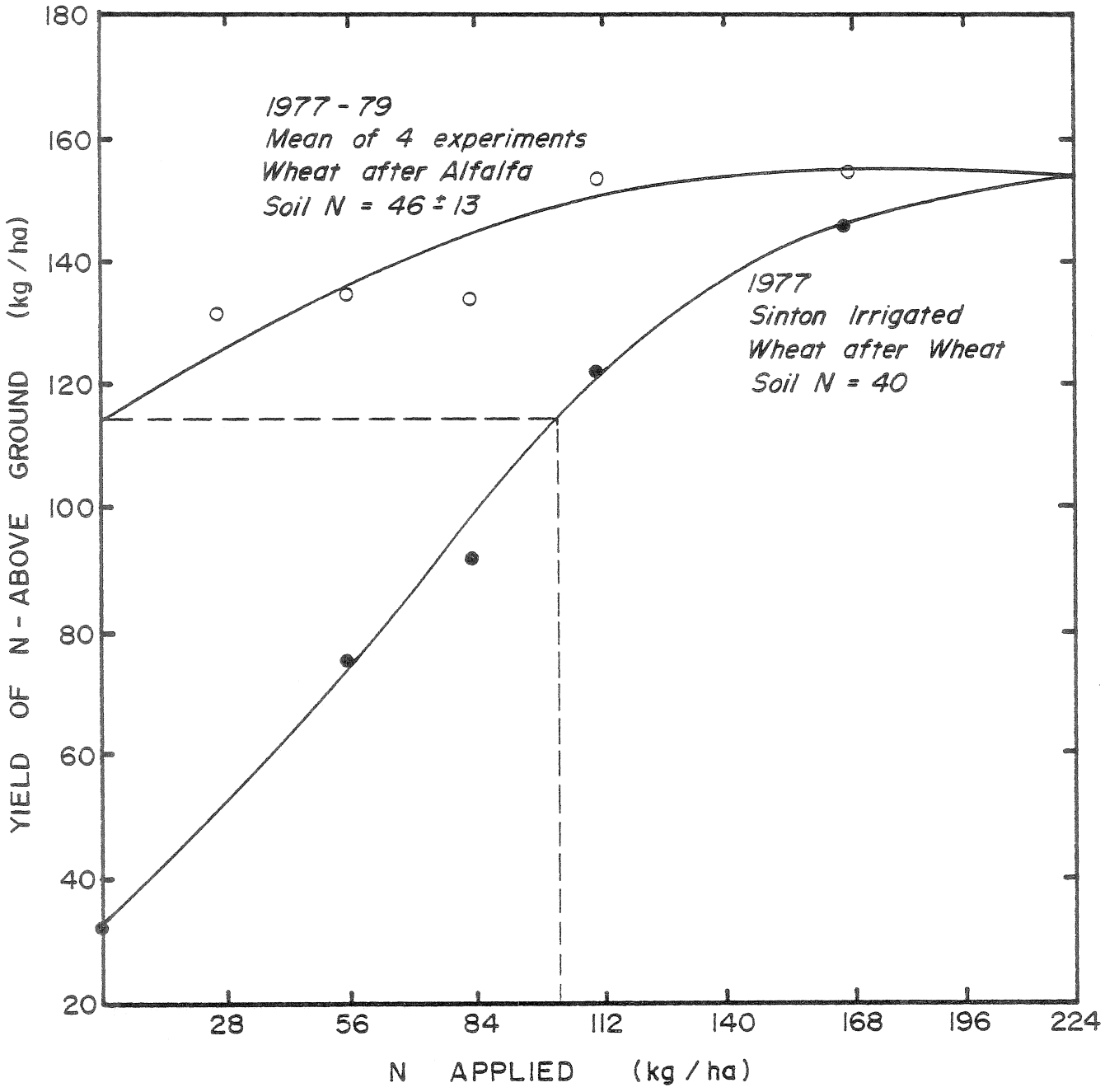

Figure 1. N uptake of wheat after wheat and wheat after alfalfa.

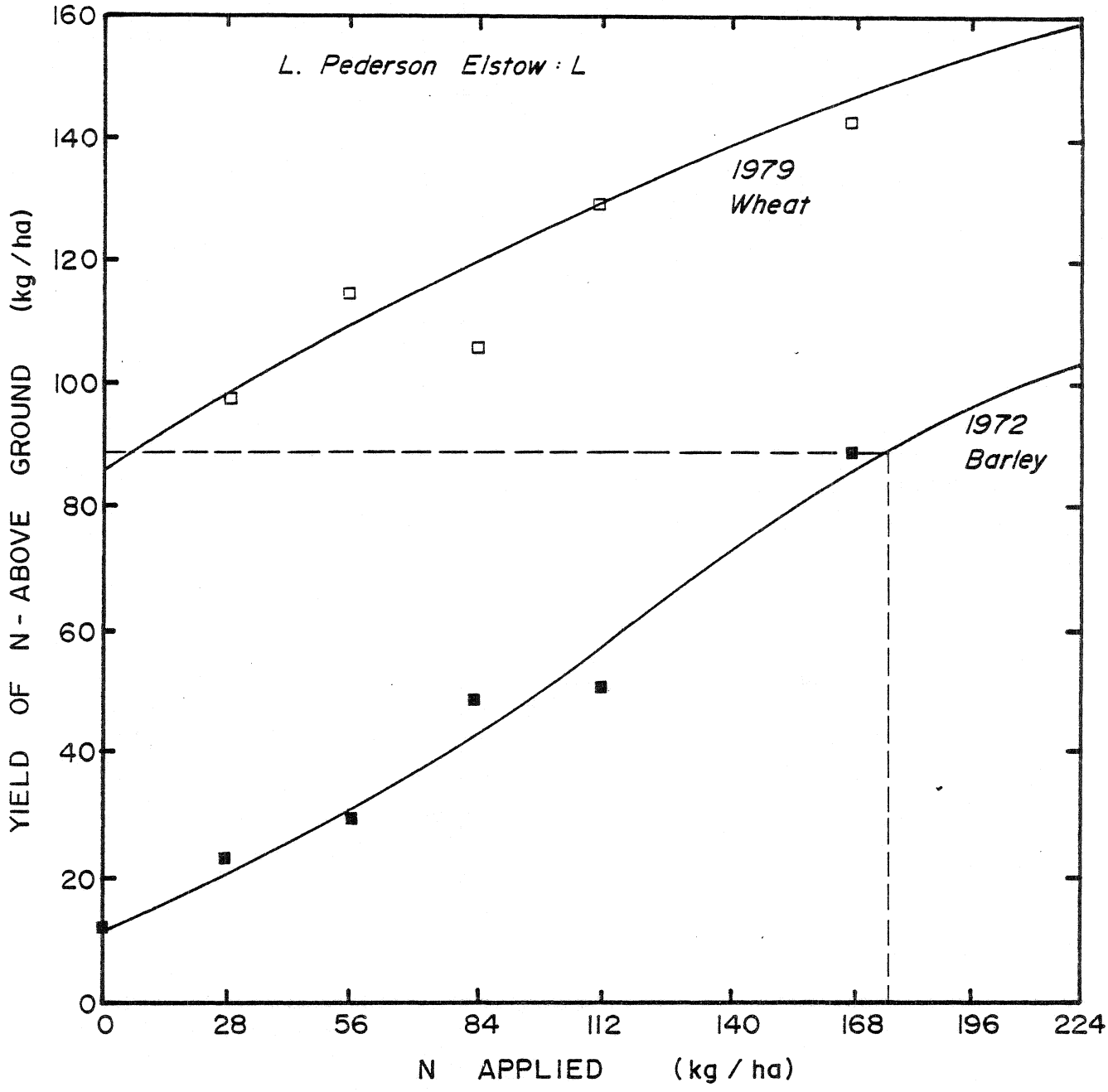

Figure 2. N uptake by wheat after alfalfa in 1979 and barley after wheat in 1972.

Another way to examine the data is to relate the N uptake in the crop to the soil nitrate level at the beginning of the experiment. Table 1 presents such a comparison. These data suggest that in continuous cereal rotations the nitrogen uptake in the above ground portion of the crop would be approximately equal to the nitrogen measured as nitrate to 60 cm at planting time. Where alfalfa was grown this ratio increased to 2.4.

Table 1. N yield in above ground plant parts in relation to soil NO_3^--N.

	Soil NO_3^--N kg/ha to 60 cm	N Uptake kg/ha	Ratio	Difference
Wheat after wheat*	48	48	1.0	0
Wheat after alfalfa**	48	113	2.4	65

* Mean of 3 experiments, 1977-79
** Mean of 4 experiments, 1977-79

An economic analysis was conducted on all experiments to compare the most economic rate of nitrogen to use on the basis of the seven experiments conducted herein in relation to the 1979 benchmarks as utilized by the Saskatchewan Soil Testing Laboratory. The economic analysis was based on nitrogen at 44¢ per kg, wheat at 11¢ per kg and barley at 7¢ per kg and assuming a marginal return to marginal cost ratio of 1.5. On this basis the average reduction in the nitrogen recommendation due to alfalfa was 68 kg N per hectare.

4. Conclusions

1. The data presented here show clearly that soil test recommendations based solely on nitrate concentration to 60 cm depth are not adequate where high producing stands of alfalfa are broken. The data suggest that the nitrogen fertilizer equivalent of first year alfalfa breaking is in the range of about 100 to 170 kg N per hectare.

2. Release of mineral nitrogen in the year of breaking, under irrigated agriculture, is sufficiently rapid to meet at least a major portion of the needs of irrigated cereals.

3. The economic rate of nitrogen is reduced by about 65 kg N per hectare on average following alfalfa. In that there is considerable variation around this mean value the current procedure in Saskatchewan is to subtract about half of that amount from the nitrogen fertilizer recommendation (i.e. 30 kg N per hectare).

4. Experiments similar to the type reported herein must now be reported for annual legume crops.