
SUMMARY OF PRECISION FARMING RESEARCH IN THE DEPARTMENT OF SOIL SCIENCE

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Abstract

A three-year field study was initiated in 1996 to measure the inherent fertility variations in typical Saskatchewan landscapes and to determine the different yield responses of wheat and canola to fertilizer rates in these landscapes. Our objective was to assess the agronomic and economic feasibility of variable rate fertilizer (VRF) application for wheat and canola. Results suggest that the response of canola to fertilizer application was strongly tied to spring moisture availability which, in turn, was directly related to landscape position. Because canola yield responses were relatively consistent (and thus predictable) from year to year (although the overall mean varied depending on spring soil moisture), we concluded that canola appears to be an excellent crop choice for VRF. In contrast, wheat did not respond consistently to fertilizer N application from year to year, limiting the potential for VRF in wheat.

Introduction

Predictable soil variability may translate into predictable differences in both nutrient and moisture availability and, thus, productivity potential. Understanding these relationships is critical to developing appropriate precision farming strategies. Our experience has shown that the relationship to moisture is clear – soil conditions are driest on the knolls, increase through the midslope areas and are wettest in the lower slope positions. These differences are, for the most part, unmanageable at a practical level. In contrast, fertility variations can be managed and thus are the focus of much of the current precision farming research and technology.

Nitrogen levels are known to differ in fields and, at least in the broadest sense, these differences are well understood. The largest pool of N in the soil occurs in the organic matter. Breakdown, or “mineralization” of organic N depends on a number of factors, but a recent summary suggests that between 5 and 15% of the organic N can be mineralized in a given year (Campbell et al. 1994). Hence, at the simplest level, the amount and quality of organic matter in the soil controls the potentially available N, and the moisture and temperature conditions in a given year will determine the fraction of the potentially available N that is mineralized.

Materials and Methods

The study site was located on a glacial till landscape (loam to clay loam) in Saskatchewan, Canada. Soils at the site were dominantly Chernozemic (Udic Borall) with significant Gleysolic (Typic Aquoll) soils in the depressional areas. Slope gradients at the site range from 5 to 10%. Two research experiments (i.e., wheat and canola) were established, each covering an area 250 m

by 300 m. Each site encompassed several cycles within the knoll and depression landscape. Analysis of aerial photographs was used to develop maps comprising three management units: 1) upper slope; 2) midslope; and 3) lower-slopes (McCann et al., 1996).

A series of replicated (6 replicates) treatments were imposed across complete landform cycles within the study site. Nitrogen was applied as sidebanded urea (46-0-0) at 5 rates (0, 0.5, 1.0, 1.5 and 2.0 times the recommended rate) and P was applied in the seedrow as monoammonium phosphate (11-55-0) at 3 rates (0, 1.0 and 2.0 times the recommended rate for wheat and 0, 0.5 and 1.0 times the recommended rate for canola). For the purposes of this paper, only the N fertilizer treatments will be discussed. The recommended fertilizer rates were based on fall soil analysis of composite soil samples from midslope positions (Enviro-Test Labs, Saskatoon). Treatments were seeded using a modified Morris air seeder (2.13m width, 30 cm row spacing) and were harvested using a small plot harvester (10m within each management unit).

Results

Management units developed on the basis of black and white aerial photographs were agronomically meaningful, i.e., different management units represented areas with different soil properties. For example, plant available spring soil moisture was strongly related to the management unit – overall means increased from the upper slope through to the lower slope positions (Fig. 1). Although overall soil moisture declined over the three years of the study, the landscape pattern of moisture distribution persisted. Crop productivity similarly was influenced by landscape position. The mean canola and wheat yields on upper slope were consistently less than yields achieved on lower slope units, regardless of N fertilizer rate (Fig. 2 and 3).

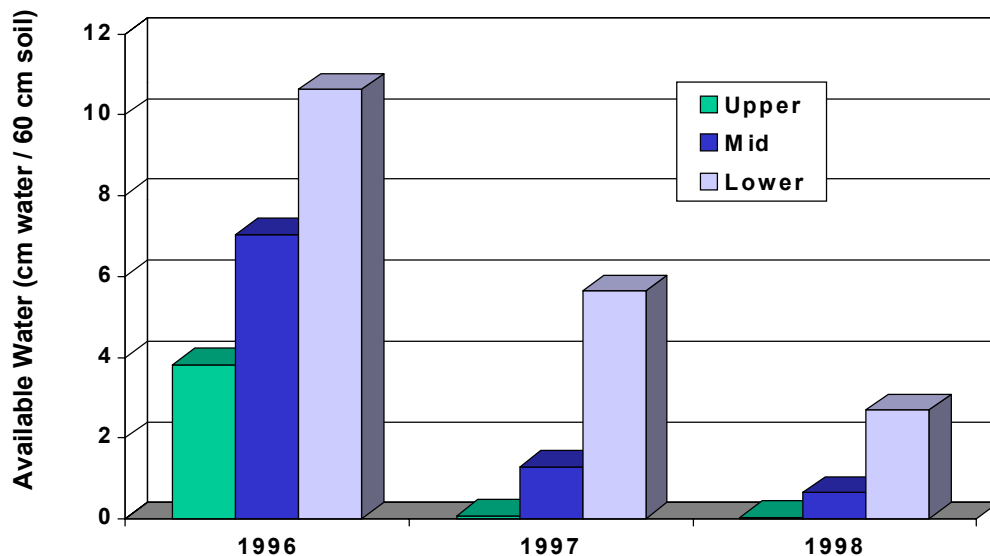


Figure 1. Available spring soil moisture at the Hepburn canola site.

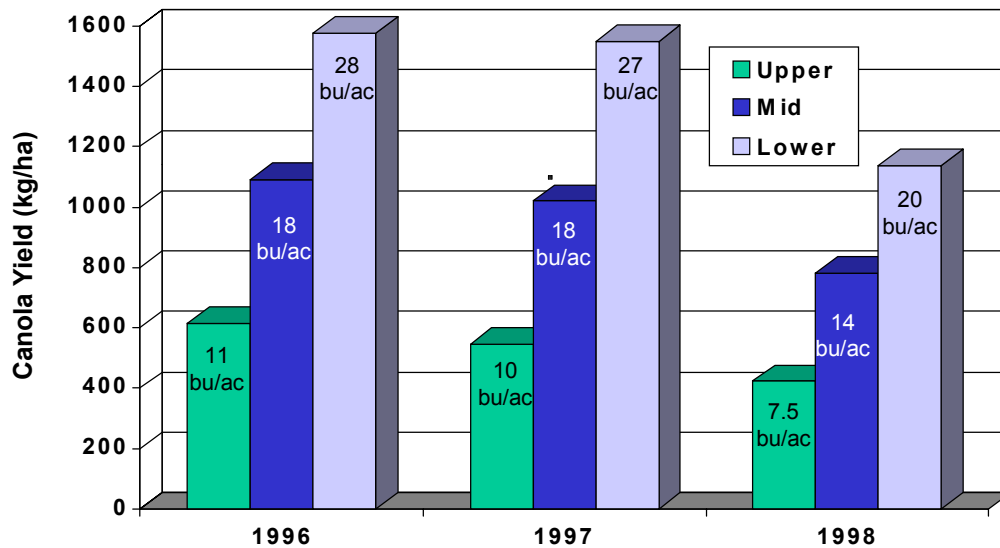


Figure 2. Mean yield of canola (averaged over all N treatments).

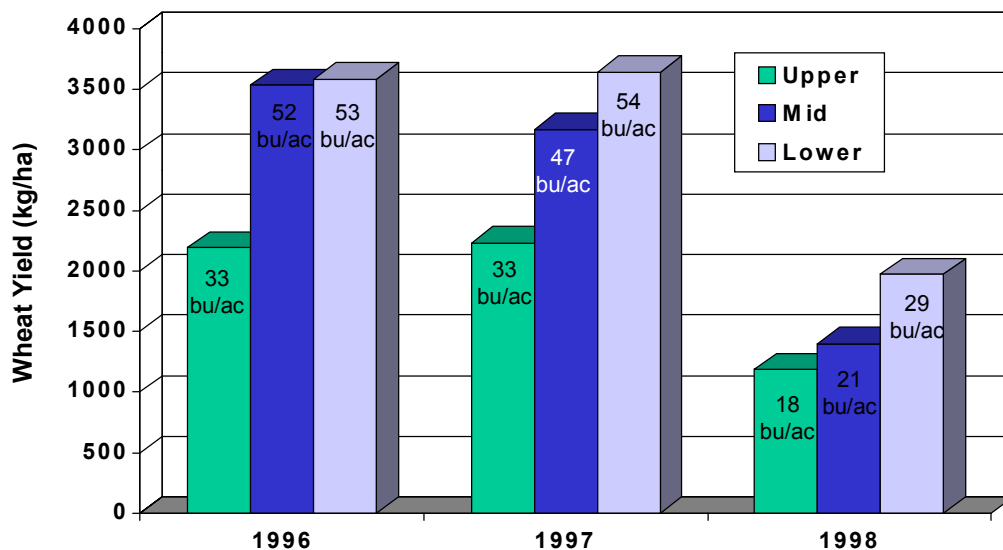


Figure 3. Mean yield of wheat (averaged over all N treatments).

Interestingly, application of fertilizer N did not overcome the impact of slope position on crop yield, particularly for canola grown on upper slopes, suggesting that factors other than N fertility, such as soil moisture availability, limited yields (Fig. 4). Typically, the seed yield response of canola to N application was curvilinear on both the upper- and mid-slope positions. In the lower slope positions, however, seed yield responses to N tended to be linear, indicating that yield maximums were not achieved, even at the 2 × the recommended N rate. These results suggest that producers wanting to implement variable rate fertilizer application for canola should consider increasing fertilizer inputs in the most responsive areas of the field; namely the lower slope positions.

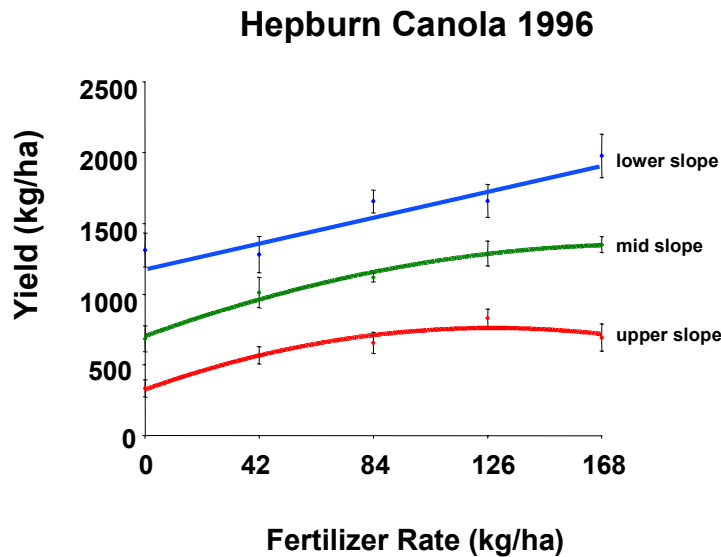


Figure 4. Response of canola (1996) to N fertilizer on upper, mid and lower slope units. The recommended rate of N fertilizer in 1996 was 84 kg N/ha.

Wheat yield responses to fertilizer N differed between years although wheat grain yields typically were lower on the upper slope units as compared to lower slope units (e.g., Fig. 6 and 7). The unpredictable nature of the wheat N response curves limited the potential for developing a successful variable rate N fertilizer strategy for this location. Clearly, the success of variable rate fertilizer application depends on our ability to predict crop response to inputs.

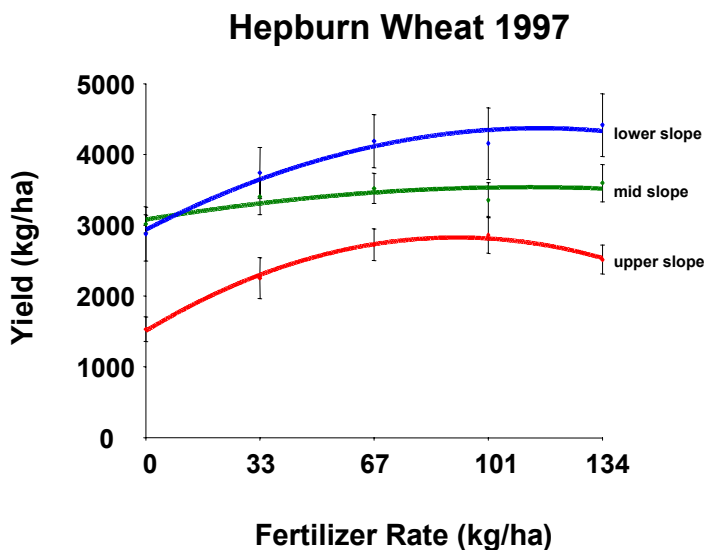


Figure 7. Response of wheat, grown in 1997 at Hepburn, SK, to N fertilizer on upper, mid and lower slope units. The recommended rate of N fertilizer in 1997 was 67 kg/ha.

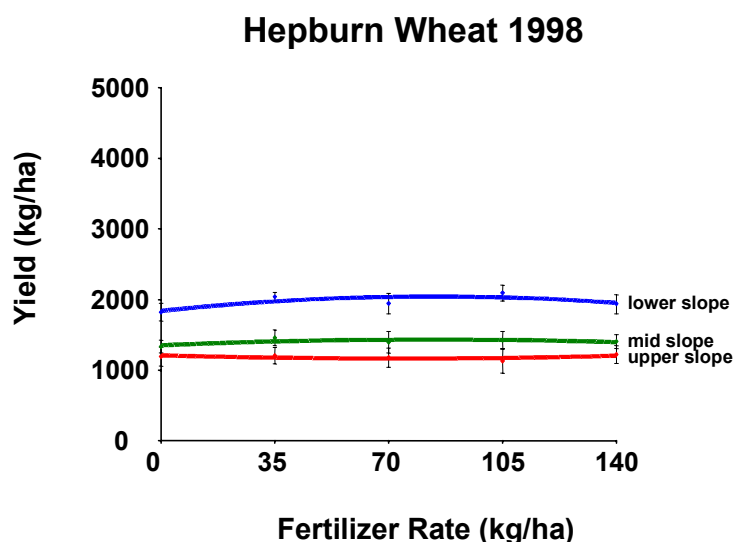


Figure 8. Response of wheat, grown in 1998 at Hepburn, SK, to N fertilizer on upper, mid and lower slope units. The recommended rate of N fertilizer in 1998 was 70 kg N/ha.

Discussion

We developed the management units used in this study on the basis of landscape position. Clearly, this approach to variable rate fertilization is only applicable to fields that have recognizable knolls and depressions and thus is well suited to landscapes developed on glacial till deposits. Results from this study indicate that the different management units were agronomically meaningful for both wheat and canola production. Moreover, these management units were strongly tied to landscape position and were predictable, and recognizable.

Of particular importance was the observation that mean yields on upperslope units were consistently less than yields achieved on lowerslope units. Moreover, the greatest limitation to yield on the upperslope position was moisture. As a consequence, yield response to increasing rates of fertilizer N on the upperslope positions, in particular, tended to be curvilinear. Interestingly, canola, in particular, continued to respond to increasing increments of fertilizer N on lowerslopes which suggests that maximum response to fertilizer application was not achieved, even when fertilizer N was applied at 2 X the recommended rate of application. Thus, producers wanting to implement VRF should consider increasing fertilizer inputs in the most responsive areas of the field; namely the lowerslope positions.

Generally speaking, the response of canola to fertilizer N was strongly tied to spring moisture availability which, in turn, was directly related to landscape position. This observation suggests that the success of variable rate fertilizer application in any given year likely is dependent, to a large degree, on the overall levels of soil moisture and the differences in soil moisture between landscape position. Furthermore, because yield responses were relatively consistent (and thus predictable) from year to year (although the overall mean varied depending on spring soil moisture), canola appears to be an excellent crop for producers interested in implementing VRF.

Wheat, in contrast, did not respond consistently to fertilizer N application from year to year nor was the response of wheat predictable on the basis of spring soil moisture. We believe that the

unpredictable nature of the response of wheat to fertilizer N as compared to the relatively predictable canola response reflects basic differences in the physiology of these two crops. In particular, the yield potential of wheat is known to be set relatively early in the growing season and is strongly influenced by early spring soil moisture availability (Johnston and Fowler, 1992). In addition, the response of wheat to N fertilizer additions includes both a yield component and a protein component – both of which are strongly influenced by available soil moisture. Thus, we were unable to predict the impact of N fertilizer on wheat yield in the various landscape positions from year to year whereas canola yield responses were more consistent and predictable. Clearly the success of a VRF program rests on the ability to predict crop response to added inputs. On the basis of our observations, we concluded that wheat is not as well-suited as canola to VRF due to the unpredictable nature of the wheat yield response in the different landscape positions.

A simple economic analysis revealed that increased economic returns were associated with the variable rate scenario developed for canola as compared to a blanket application of the recommended rate of N fertilizer (data not shown). However, it is important to note that a significant improvement in economic returns is required to cover the expenses associated with full implementation of variable rate fertilizer application. The variability in the wheat yield responses to fertilizer N limited the potential for developing a variable rate scenario and data suggest that implementation of a variable rate scenario at Hepburn according to our “prescription” would have resulted in a net loss in returns as compared to the blanket application of the recommended rate of N fertilizer.

Many factors determine overall crop productivity in a given year. The variability of nutrients other than N, such as P, K and S or various micronutrients can be critical for certain crops; competition from weeds may be greatest in the lower slope positions; or in a wet year, problems with water-logging or root rot in lower slope positions may lower the yields. Through a combination of research trials on non-level fields and producer trials of different fertility/weed control scenarios, a more complete understanding of the management of variable productivity conditions will emerge.

Acknowledgments

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Literature Cited

- Campbell, C.A., D.A. Rennie, L.D. Bailey. 1994. Nitrogen, phosphorus, potassium, sulphur. Answers to your questions. Agriculture and Agrifood Canada Publication, Swift Current.
- ERDAS, Inc. 1991. Field Guide. ERDAS, Inc., Atlanta, Georgia.
- Johnston, A.M. and D.B. Fowler. 1992. Response of no-till winter wheat to nitrogen fertilization and drought stress. *Can. J. Plant Sci.* 72:1075-1089.
- McCann, B.L., D.J. Pennock C. van Kessel and F.L. Walley. 1996. The Development of management units for site-specific farming. Proceedings of the 3rd International Conference on Precision Agriculture. Minneapolis, MN. June 23-26. ASA/CSSA/SSSA.