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VARIABLE RATE FERTILIZER APPLICATION IN A THIN BLACK SOIL¹

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ABSTRACT

A broad association between landform and distinctive pedological regimes, as influenced by the hydrological pattern of the hillslope, exists in glacial till landscapes of southern Saskatchewan, Canada. Image analysis of aerial photographs was used to delineate different pedological regimes within a typical glacial till field characterized by knolls and depressions. Three distinctive areas (upper, mid, and lower slope) were identified as “management units”. Fertility trials (N and P) with wheat and canola indicated that these management units are agronomically meaningful and can be used in the development of variable rate fertilizer management strategies.

INTRODUCTION

On the rolling plains of the western Canadian prairies, crop productivity can be highly variable within a field. The most pronounced variability usually occurs on hummocky or rolling terrain where upper slope positions are characterized by reduced crop yields as compared to lower slope positions. The productivity gradient has been attributed to loss and redistribution of topsoil (Gregorich and Anderson 1985; Pennock and de Jong 1990; McConkey et al. 1997) and moisture (Verity and Anderson 1990) from upper to lower slope positions. The challenge for implementing precision farming is to determine the specific pedological and hydrological factors that are responsible for productivity gradients and develop appropriate management strategies.

In 1996, we initiated a study 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.

MATERIALS AND METHODS

The study site is located 40 km north of Saskatoon, SK, Canada near the community of Hepburn (SW 7-40-5-W3 or 52°25'N, 106°41'W). The site is situated on a glacial till landscape (loam to clay loam) that is part of the Oxbow soil association (Acton and Ellis 1978). Soils at the site are dominantly Chernozemic (Udic Boroll) with significant Gleysolic soils (Typic Aquoll) in the depressional areas. Slope gradients at the site range from 5 to 10%. Surface drainage at the site is local.

¹ Presented at the 1998 Great Plains Soil Fertility Conference, Denver, CO.

Two research experiments (i.e., wheat and canola) were established, each covering an area 250 m by 300 m. The sites encompassed several cycles within the knoll and depression landscape – one cycle extending from one knoll down into a depression and then to the top of the next knoll. The sites were extensively surveyed using a Total Station and 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). Soils from within each landscape position were sampled (15 cm increments to 60 cm) and were subjected to a series of analytical procedures to determine characteristics including mineral N, total carbon, organic carbon, pH, electrical conductivity and moisture content.

A series of replicated (6 replicates) fertility treatments were imposed across a complete landform cycle within the study site. Nitrogen was applied as urea (46-O-O) at 5 rates (0, 0.5, 1.0, 1.5 and 2.0 times the recommended rate) and phosphorus was applied as monoammonium phosphate (11-55-O) at 3 rates (0, 1.0 and 2.0 times the recommended application rate for wheat and 0, 0.5 and 1.0 times the recommended rate for canola). The recommended fertilizer rates were based on fall soil analysis (Enviro-Test Labs, Saskatoon). Fertilizer treatments were seeded using a modified Morris air seeder (2.13m width with 30 cm row spacing). Fertilizer N was side-banded whereas P was placed in the seed furrow. Treatments were harvested using a small plot harvester (10m sections were harvested within each of the management units).

RESULTS AND DISCUSSION

In both study years, available soil moisture was related to the management units and increased downslope (data not shown). Surprisingly, however, differences in spring available soil nitrate N were not detected (data not shown). Others similarly have reported variability in soil nitrates with no significant effect of slope position (McConkey et al. 1997).

In both 1996 (data not shown) and 1997, yields of wheat (Fig. 1) and canola (data not shown) were strongly influenced by landscape position. Moreover, response to N applications differed in the different landscape positions. These results indicate that the management units delineated using image analysis of aerial photographs were agronomically meaningful.

At the wheat site, yield responses to fertilizer N in the upper and midslope positions were similar in both 1996 (data not shown) and 1997 (Fig. 1). Generally the yields were lower on the upper slope units and the N response was curvilinear- the maximum yields were observed at the 1X rate. The response to N treatments was relatively flat at the mid slope units. In the lower slope positions, no response to fertilizer N was detected in 1996 whereas a strong response to N fertilizer occurred in the lower slope units in 1997 (Fig. 2). Clearly, the success of variable rate fertilizer application depends on our ability to predict crop response to inputs. A clear wheat protein response to the N treatments was detected in 1996 (data not shown). The increase in protein in the N treatments was greatest in the upper slope units, but a consistent response also occurred in the mid and lower slope units.

A very strong management unit effect was detected at the canola site in both 1996 and 1997 (data not shown) – the overall means increased from the upper slope through the mid slope to the lower slope. As was observed for wheat, the upper slope units were characterized by a curvilinear N response – the yields flattened or declined slightly after the 1X N rate. A

small but progressive increase in yield occurred in the mid slope units. The canola yield increase in the lower slope was from approximately 22 bu/ac at the OX N treatment through to 36 bu/ac at the 2X N rate. Given the economics of N costs and the price of canola, this likely represents a major economic benefit.

Wheat yields were enhanced by the addition of P fertilizer at the recommended rate, but no apparent benefit was achieved by increasing P fertilization to the 2X rate (Fig. 3). In the case of the upper slope units, the 2X P rate decreased yield. As was observed for wheat, the apparent response of canola to fertilizer P additions differed between management units (data not shown).

Many factors determine overall crop productivity in a given year. The variability of nutrients other than N and P, such as 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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Hepburn ADF Wheat Site 1997

N Treatments

1 XN Rate: 55 lbs/ac

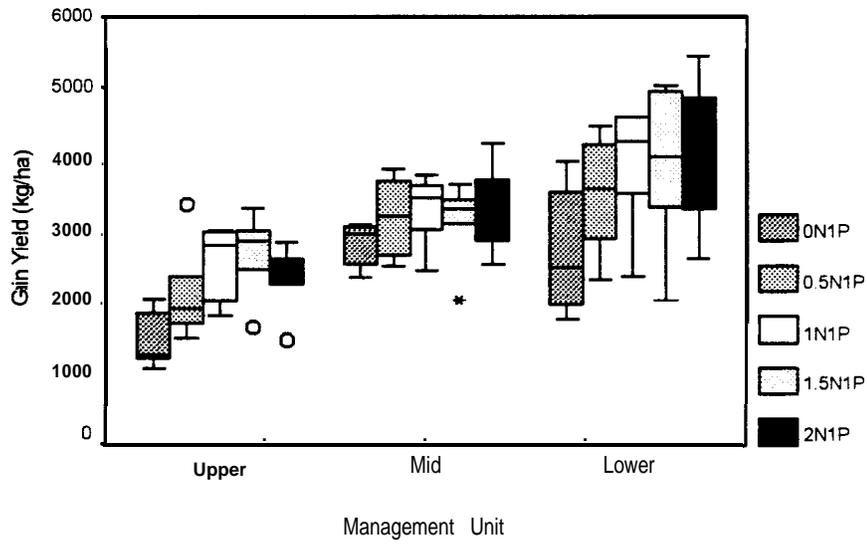


Figure 1. Boxplots for wheat yield response to N treatments at Hepburn, 1997. The line in the middle of the box is the median or the 50th percentile; the box and whiskers extend through the full range of values for the six replicates for the treatment.

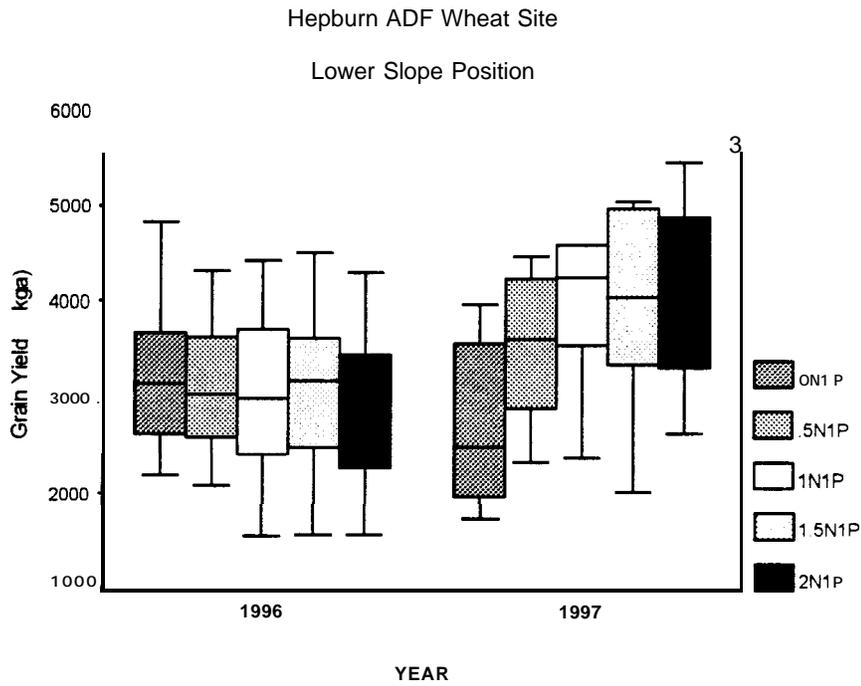


Figure 2. Boxplots for wheat yield response to N treatments in the lower management unit at Hepburn, 1996 and 1997.

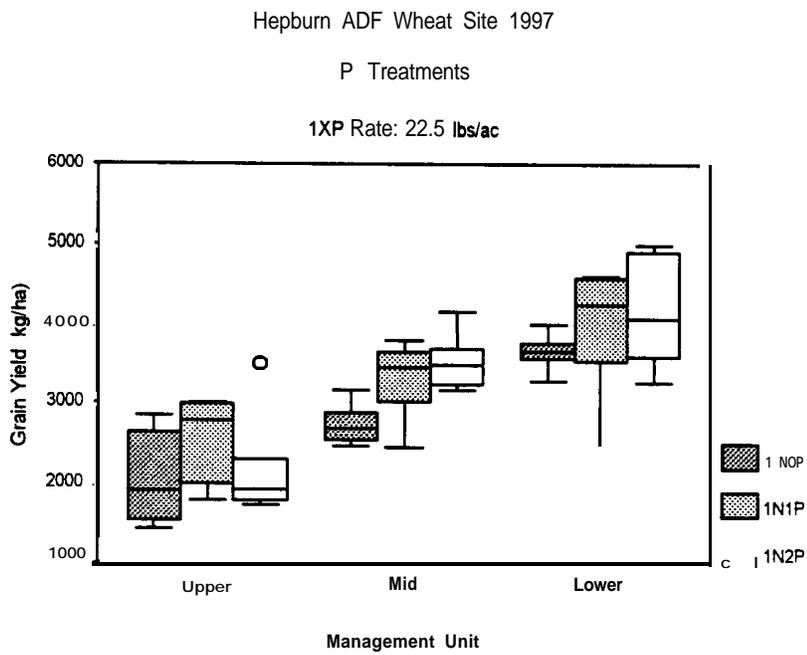


Figure 3. Boxplots for wheat yield response to P treatments at Hepburn, 1997.