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FINAL REPORT

Progress Report on Site Specific Management of Potatoes

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In 1999 the precision agriculture experiment was repeated for the fourth year on the same two fields near Hays and Fincastle that it was on in the first year (1996).

In 1999 CASI Imagery was obtained by Itres from a flight on July 28. Detailed analysis of this imagery will be done during the summer of 2000. This will involve comparing the imagery to ground data on tissue nitrogen content, yield, irrigation, distribution, weeds, soil texture and soil fertility.

Unique Observations in 1999

The Fincastle field had received in the fall of 1997 an application of hog manure on the southern 2/3 of the field. This raised the available P level from 9 to 29 ppm to 33 to 65 ppm. The area that had been treated with manure had tissue P levels which remained adequate or high throughout the growing season. The remaining area had adequate tissue P levels early in the season on July 9 and some deficient areas on July 28 and August 13.

For the first time detailed calcium carbonate analysis was completed on both fields. The $CaCO_3$ level for 0.0-.30 m was below 2% on 37 of 51 sites at Fincastle and below 1.2% on 47 of 53 sites at Hays. These calcium carbonate levels should not be high enough to tie up a lot of phosphorus and are lower than what is encountered in Idaho where high rates of phosphorus are recommended.

Clay contents on both fields in 1999 were quite variable with 60% of the Hays samples for 0-0.6 m below 15% clay and 11% above 25% clay. The Fincastle field has a similar range of textures with 55% below 15% clay and 10% above 25% clay. Deficient tissue P levels late in the season were more severe in the areas with high clay content, but also occurred on areas with low clay content.

Disease counts and the effects of phosphorus, manure and compost were made at 12 row x 400 m long strips at Hays in 1999. The treatments had no significant effects on yield or disease visible on tuber surface. The number of plants which were showing visible disease on the tops was significantly lower on the compost and high rates of manure treatments than on the low rates of manure and phosphorus fertilizer treatments (Table 1).

Table 1. Effect of P, compost and manure on tuber yield and size and disease incidence of potatoes - Hays, 1999

Treatments	P_2O_5 (kg/ha)	Total tuber wt (t/ha)	Medium tubers (t/ha)	Tubers* /1.2 m	% surface infected on 160 tubers		Disease %* on 600 m row
					Rhizoctonia	Scab	
Low P	45	34.6	30.2	65	0.68	0.75	9
High P	134	36.5	32.5	70	0.32	0.88	7.1
Low compost 8.7 t/ha	101	40.0	33.3	95	0.82	1.2	6.6
High compost 17.5 t/ha	188	38.7	35.2	82	0.36	0.57	5.9
Low manure 12.3 t/ha	87	37.2	34	81	0.68	0.57	7.6
High manure 24.7 t/ha	182	39.8	36.2	75	0.86	0.73	6.1

* significant at 5% level

Results from Data Analysis to the End of 1999

Using USA standards as adequate, levels of the tissue nutrient levels in petioles were evaluated. These USA standards were developed in warmer climates than Alberta and were developed at a time when surface and groundwater quality were not considered important factors.

Nitrogen

Despite high application rates of soil plus fertilizer N, much of the fields showed deficient levels of tissue nitrogen. Eg., Hays 1998 - soil + fertilizer N 305 kg/ha and 96% of the samples deficient on July 6 declining to 46% on August 10. This field received 45 kg/ha as fertigation. Fincastle - soil + fertilizer N 310 kg/ha and 76% of samples deficient - July 7 declining to 21% deficient on August 11. In 1999 despite high applications of nitrogen, most of both fields were deficient throughout the season.

Field fertilizer tests in 1997 and 1998 indicated the farmer's rates of N are close to optimum for total yield. Groundwater measurements indicate losses of N are occurring at current application rates.

Phosphorus

In all the years at the Hays site, phosphorus in petioles was adequate at the first week of July and declined later in the season so much of the field was deficient. This occurred despite fertilizer

applications of as high as 134 kg/ha P_2O_5. The Fincastle sites in some cases had received manure applications as well as P fertilizer applications. Those parts of the field that had received manure in previous years did not develop P deficiency.

A question remains. Does root or soil-born diseases on fields which have frequently grown potatoes restrict the uptake of P? In 1999 on fields which had not grown potatoes, tissue P deficiency did not develop even when little or no P fertilizer was applied.

Potassium

In 1996, 1997 and 1998, both fields showed low levels of tissue K in early July and adequate or high tissue K later in the season. In 1999 tissue K levels were adequate or high throughout the season.

Water

Uniformity of water applications was a problem in all the years on all fields. Problems occur with pivots equipped with a corner arm not applying sufficient water on the corners. In 1996 one set of pivots was underpressured and did not provide sufficient water at the outer end. Later the pivot were redesigned and then provided excess water at the outer end. One farmer frequently applied excess water which pooled in low or poorly drained areas causing loss of yield. The other farm frequently encountered some deficiency of water applications.

Quality

Tuber quality as measured by size and specific gravity was associated with water applications. Areas such as under an end gun which had received insufficient water had high average tuber size and a lower specific gravity than the remainder of the field.

French fry and chipping scores were not related to the characteristics of the field.

Site Specific Management of Potatoes

AB-14

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Abstract

The objective of this project was to determine how site variability and management influenced uniformity of yield and quality of irrigated potatoes. The environmental impact of nitrogen (N) fertilizer management was measured. Two varieties of potatoes were monitored for four years. Yield was measured with a harvester equipped with a yield monitor and with hand dug grid samples of tubers. Grid sampling was also done to determine soil texture, soil fertility, available soil moisture and tissue nutrient levels. Aerial multispectral imagery was collected and compared to ground data.

The results indicate that N fertilizer rates of about 300 kg/ha N available soil and fertilizer provided maximum yields but caused losses of N to groundwater. Tissue phosphorus (P) was usually adequate in early July but frequently by late July and August became deficient when compared to NW USA standards. This occurred despite applications of 110 to 130 kg/ha P_2O_5 fertilizers. Irrigation water applications were found to be uneven and this influenced size and numbers of tubers produced.

Introduction

Potatoes are a high value crop requiring high inputs. Excess nitrogen will delay maturity, reduce the quality of potatoes in storage, contribute to ground water contamination and increase the cost of production, while insufficient nitrogen will reduce yield and increase the severity of early blight. Phosphorus fertilizer applications are higher on potatoes than on other crops and may contribute to surface water contamination. Potatoes are often grown on coarse textured soils which have low water and nutrient holding capacity and high field variability. Uniformity of quality is an important factor when potatoes are grown for processors. Traditional research under small plot conditions does not describe this field variability and current management systems do not account for it.

The objectives of this project were to: measure the variability of yield within a field using a yield monitor and global positioning technology; determine the effects of soil type, landscape position, nutrient level, fertility treatments, irrigation, diseases and weeds on the yield and quality of potatoes; evaluate remote sensing and digital image analysis to detect nutrient deficiencies and diseases of potatoes and measure the financial and environmental benefits of site specific management of potatoes.

Methods and Materials

A potato field on each of two farms was monitored each year for four years from 1996-1999. The fields were each from 26 to 30 ha and were half of a center pivot irrigated field. The farmers used a 3-year rotation, so in 1999 the same fields were monitored as in 1996. At 7 of the 8 fields from 47 to 54 sites in each field were monitored in detail to measure soil fertility, soil moisture and rainfall plus irrigation. In the first year only, 8 points were sampled on one field. Tissue nutrient samples were taken 3 times each year at each sampling site.

At each monitoring point yield samples were dug and graded for size. Specific gravity and chipping or french fry scores were determined on these samples. Yield on the entire field was monitored with a yield monitor and differential global positioning and a topographic map was made.

In 1997 and 1999 remote sensing multi spectral imagery was obtained on the fields. Fertilizer strips were applied to the fields with rates of N in 1997, N and P in addition to the farmers rate in 1998 and P, compost and manure in 1999.

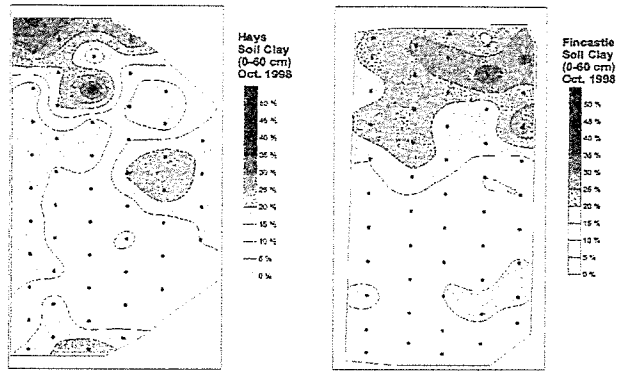
Results and Discussion

Soil texture (Table 1, Figure 1) was variable. This influenced water holding capacity and caused water tables to accumulate in parts of all fields. The amount of soil that accumulated on the harvester belt and was weighed by the yield monitor was influenced by the per cent clay.

Table 1.Clay % for 3 years at 2 sites each year for about 50 sample sites per field.

	Hays 0.0-0.60 m	Fincastle 0.0-0.60m
1997	5-35%	5-25%
1998	5-30%	5-25%
1999	5-40%	5-35%

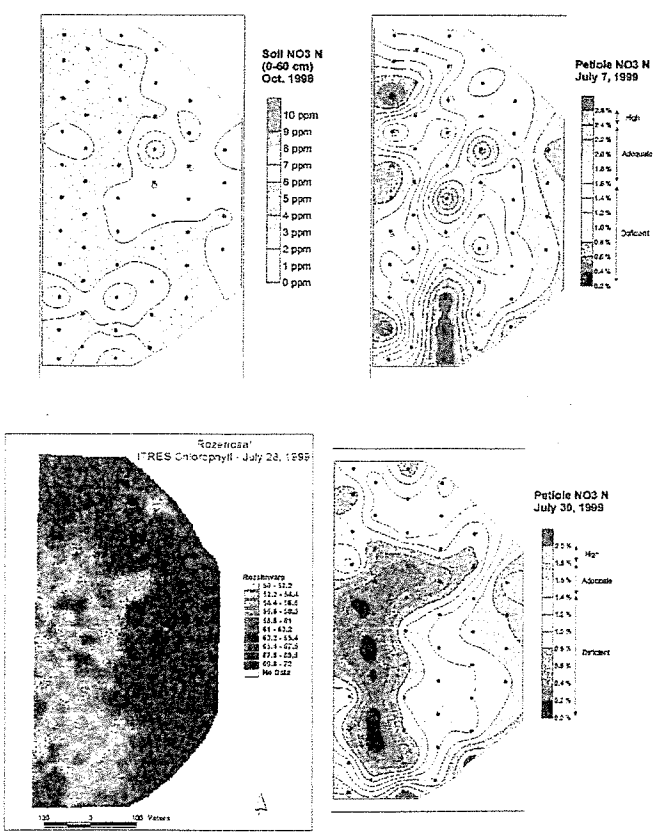
Figure 1. Soil textural variability 1998



Soil nitrogen was determined at all sites in 1997, 1998 and 1999, tissue petiole nitrogen was determined in all four years. On July 28, 1999, hyperspectral contact airborne spectrographic imager (CASI) imagery of the potato fields was obtained. A correlation between Hays leaf chlorophyll content determined by CASI imagery on July 28 and tissue N on July 30 gave a r^2 of 0.42. Three weeks earlier on July 7 the correlation between the July 28 CASI imagery on tissue N the r^2 was only 0.004 (Figure 2). Remote sensing imagery deserves consideration as a basis for applying nitrogen fertilizer.

In 1998, addition of 67 kg/ha N to fields which had a total of soil and fertilizer N at Hays of 305 kg/ha and 310 kg/ha at Fincastle resulted in reductions in yields of 5% at Hays and 7.5% at Fincastle. When this N was combined with extra phosphorus an increase in yield of 1.8% occurred at Hays and at Fincastle. Nitrate accumulations in the groundwater at these sites exceeded Canadian drinking water guidelines.

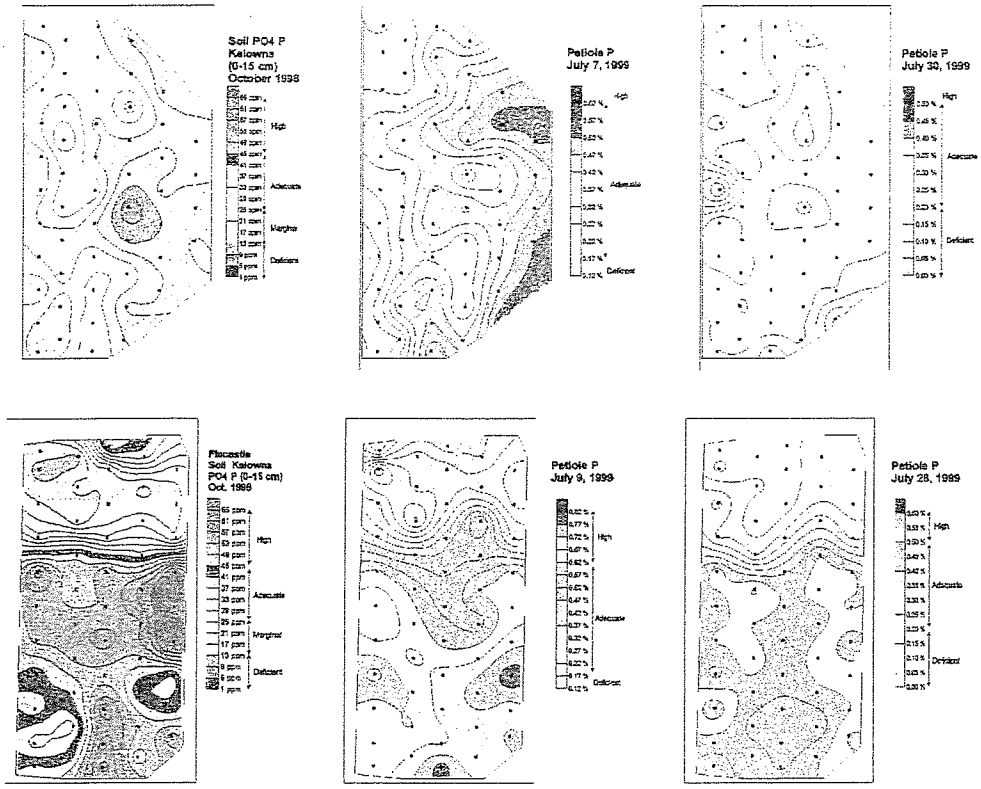
Figure 2. Hays 1999 Snowden potatoes soil and tissue N and remote sensed chlorophyll



1. AAFRD, Crop Diversification Centre South, Brooks
2. AAFRD, Conservation and Development, Edmonton
3. AAFRD, Agriculture Centre, Lethbridge
4. AAFRD, Provincial Building, Brooks

Petiole P content on the 8 fields studied was found to decline abruptly after the first sampling in early July (Figure 3). The farmers were applying about 60-80 kg/ha P. Only those soils which had high levels (above 4.5 ppm P in 0-.15 m layer) did tissue P not usually become deficient. Strip trials with P fertilizers and compost showed no increase in yield as compared to the farmer's rates of fertilizers. It is not known if the standards used for levels of tissue P are adequate for Alberta growing conditions. For the 0-0.30 m layer soil $CaCO_3$ content was usually below 2% and soil pH was usually between 7 and 8. These factors should not be of major importance in reducing the availability of P.

Figure 3. Two sites soil P and potato petiole P for two dates.



On two other experiments, where rates of P were applied to potatoes grown on fields which had not been previously used for potatoes, tissue P did not abruptly decline and P fertilizers did not increase yield of tubers. This leaves the possibility that soil born diseases may be reducing the uptake of phosphorus.

Irrigation applications by the center pivot irrigation systems were not uniform. In one case a pivot was operated below optimum pressure and insufficient water was applied to the outer part of the circle. End guns and corner arms usually applied less water than the remainder of the pivot. Differences in soil texture caused some areas of the fields to accumulate excess water. Water influenced quality. Areas which received inadequate water produced tubers with a lower specific gravity and larger average size than areas which received more water. At Fincastle in 1998 correlation between consumptive use and specific gravity gave an r^2 of 0.16 (Figures 4 and 5). Some areas of the fields which had excess water had loss of tubers due to soft rots.

Conclusions

Variation in water supply and retention influenced tuber quality factors such as average tuber size, specific gravity and presence of disease. Irrigation water applications were not uniform.

Soil fertility and tissue nutrient status were variable. CASI imagery was significantly correlated with the level of tissue nitrogen. Additional fertilizer and soil N above 300 kg/ha N will have little effect on yield and will contribute to additional N losses to groundwater.

Tissue phosphorus was found to decline rapidly during the growing season on soils that tested low in soil phosphorus. Yield responses were not obtained with additional phosphorus fertilizers.

Field scale precision agriculture projects provide a useful research tool to identify problems in potato production.

Acknowledgments

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Figure 5. Fincastle Potatoes 1998 specific gravity vs irrigation/rainfall and consumptive use

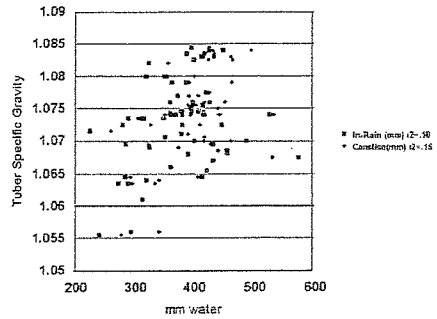
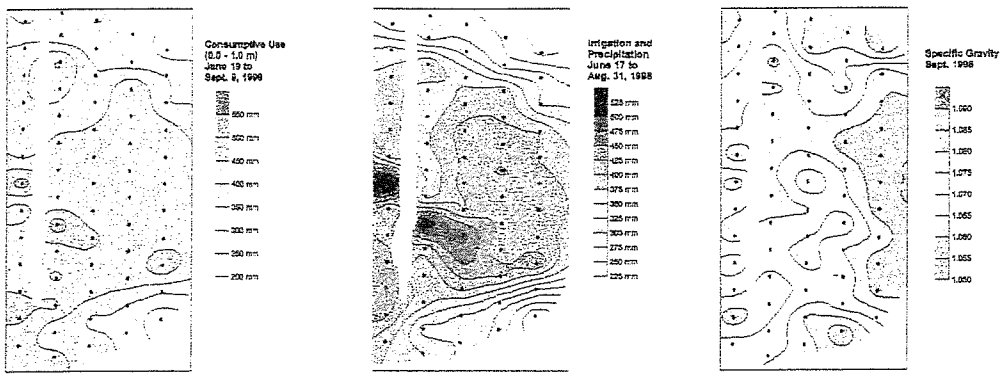


Figure 4. Fincastle Potatoes 1998 consumptive use, precipitation and irrigation and tuber specific gravity



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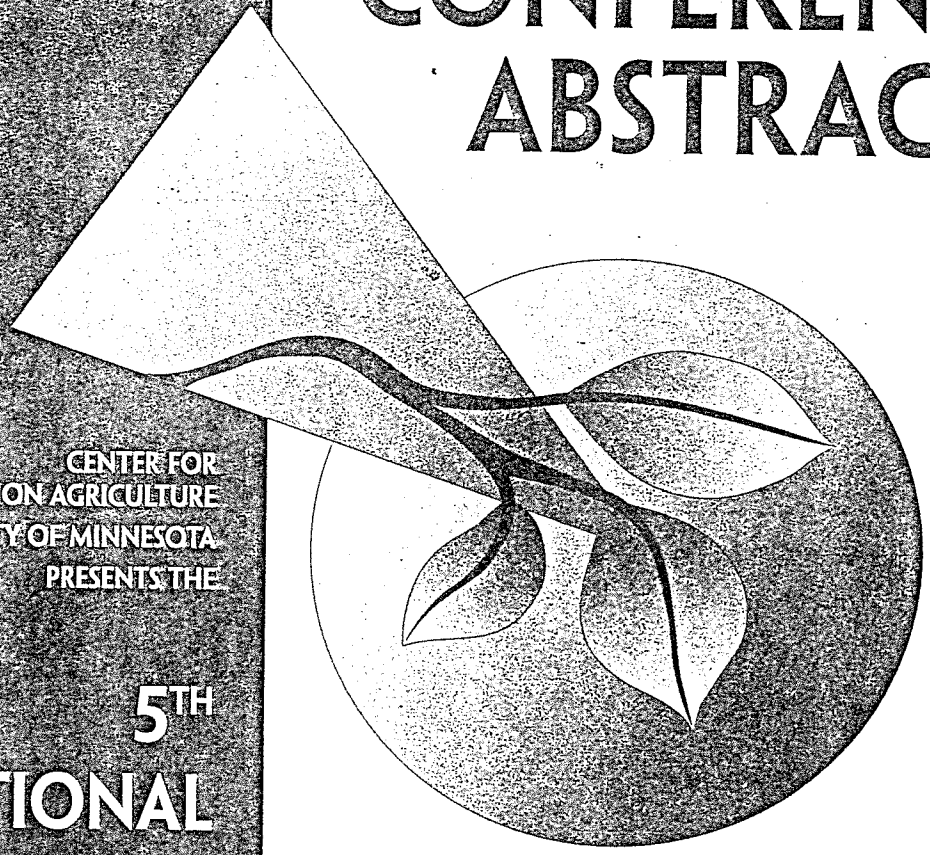

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