Cropping Sequences on Grey-Wooded Soils

S.A.Brandt

Introduction

The influence that grain or forage crops exert on yields of succeeding grain crops has been studies at a number of locations in the past. Such test were conducted in conjunction with rotation studies in an effort to develop rotations suited to regional soil and climatic conditions.

In tests conducted on brown and dark brown soils the results indicated that wheat yields were influenced mainly by the effect of the preceeding crop on soil moisture levels and weed populations. Results of studies conducted on a black loam soil at Lacombe indicated that weed populations played a major role in determining the effect of preceeding crops on the yield of the wheat crop that followed. Due to more favorable moisture conditions at this location, the wheat was better able to utilize residual nitrogen produced by a preceeding legume crop.

On grey-wooded soils, moisture conditions are generally more favorable for crop production than on the brown and dark brown soils. However, the physical and chemical properties of these soils are a more crucial factor in determining crop yields. This test was initiated to determine the effect that cropping sequences have on yields of succeeding crops and on improving some of the undesireable properties of these soils.

Materials and methods

This study was conducted at Loon Lake on a grey-wooded soil classed as Loon River Loam. The soil at this site is typically low in organic matter, in the range of 2 to 3 percent in the 0 - 15 cm soil profile. The soil density is relatively high ranging from 1.51 to 1.81 grams per cm^3 in the 0 to 90 cm soil profile. By contrast, the Elstow Loam soil at Scott has an organic matter content over 4 percent and soil density ranges from 0.85 to 1.25 grams per cm^3 in similar soil profiles.

This soil is prone to surface crusting, which may limit crop production, particularly if it occurrs between seeding and crop emergence. Levels of available sulfur in this soil are also low.

This test was set up in a four-year rotation, with four blocks of land, one for each year. Each block of land is divided into six replicates with nine preceeding crops (wheat, oats, barley, flax, rapeseed, summerfallow, alfalfa, brome, brome and alfalfa mix) grown on each replicate. The following year, three test crops (wheat, barley, rapeseed) are seeded lengthwise across the replicates to give a total of 27 sequences. These are the crops from which most of the data has been collected.

The following year oats is seeded over the complete block and the preceeding alfalfa, brome and brome-alfalfa plots are underseeded. The remainder of the block is underseeded to sweetclover. In the final year of the rotation the sweetclover hay is removed and the sweetclover plots plowed. The other forage crop plots are hayed and remain in production into the following year which becomes year one of the rotation.

Yields were determined on the preceeding crops and on the succeeding crops but not on the oats or hay crops from years three and four. Protein contents, test weights and 1000 kernel weights were determined for the succeeding wheat and barley crops.

Soil moisture levels were determined prior to seeding and following harvest on cores removed from the 0 to 90 cm profile of soil. Moisture determinations were made on a main plot basis in years 1, 3 and 4 of the rotation and on a sub-plot basis in year 2 of the rotation.

Chemical fertilizers were not applied at any time during the course of the test.

Results and discussion

Average yields of wheat and barley were highest on summerfallow over the 14 years of testing. Wheat grown following alfalfa yielded 92% of summerfallow yields (table 1), and equalled or exceeded summerfallow yields in 7 of the 14 years. Barley yields following alfalfa were 90% of summerfallow yields. Yields of wheat or barley following rapeseed have been higher than following other grain crops. Yields of the preceeding rapeseed crops have been low and this may account, at least in part, for the better performance of the succeeding wheat and barley crops.

Table 1

Average (14yrs) yield of wheat and barley following several crops on a grey-wooded soil

	Wheat		Barley	
Preceeding crop	kg/ha*	% of fallow yield	kg/ha	% of fallow yield
summerfallow	2381^{a}	100	2933^{a}	100
alfalfa	2179^{a}	92	2631^{b}	90
brome	1614^{c}	68	2093^{c}	71
brome & alfalfa	1782^{bc}	75	2206^{c}	75
wheat	1655^{c}	70	2050^{c}	70
oats	1722^{bc}	72	2050^{c}	70
barley	1843^{bc}	77	2050^{c}	70
flax	1789^{bc}	75	2093^{c}	71
rapeseed	1937^{b}	81	2292^{c}	78

* Yields do not differ at the 5% level of significance when followed by the same letter. (D.N.M.R.).

Over the term of the test the trend has been for the yield of wheat following alfalfa to increase relative to summerfallow yields (figure 1). A similar trend occurred where wheat followed a brome or brome-alfalfa mix hay crop except that the yields from these sequences were very low initially and rose to levels similar to the cereal and oilseed sequences in the later years of the test. Yields of wheat following the cereal crops varied, but did not show any clear trend. Where the wheat crop followed an oilseed crop (rapeseed or flax) there did not appear to be any clear yield trend over time. For the purpose of preparing figure 1 yield data from 1963 to 1966 were included in calculating the sliding average yields. This data was not included in table 1 as it was collected during the period when the four-year rotation was being established.

FIGURE I

Wheat yields following several crops as a %.of summerfallow yields

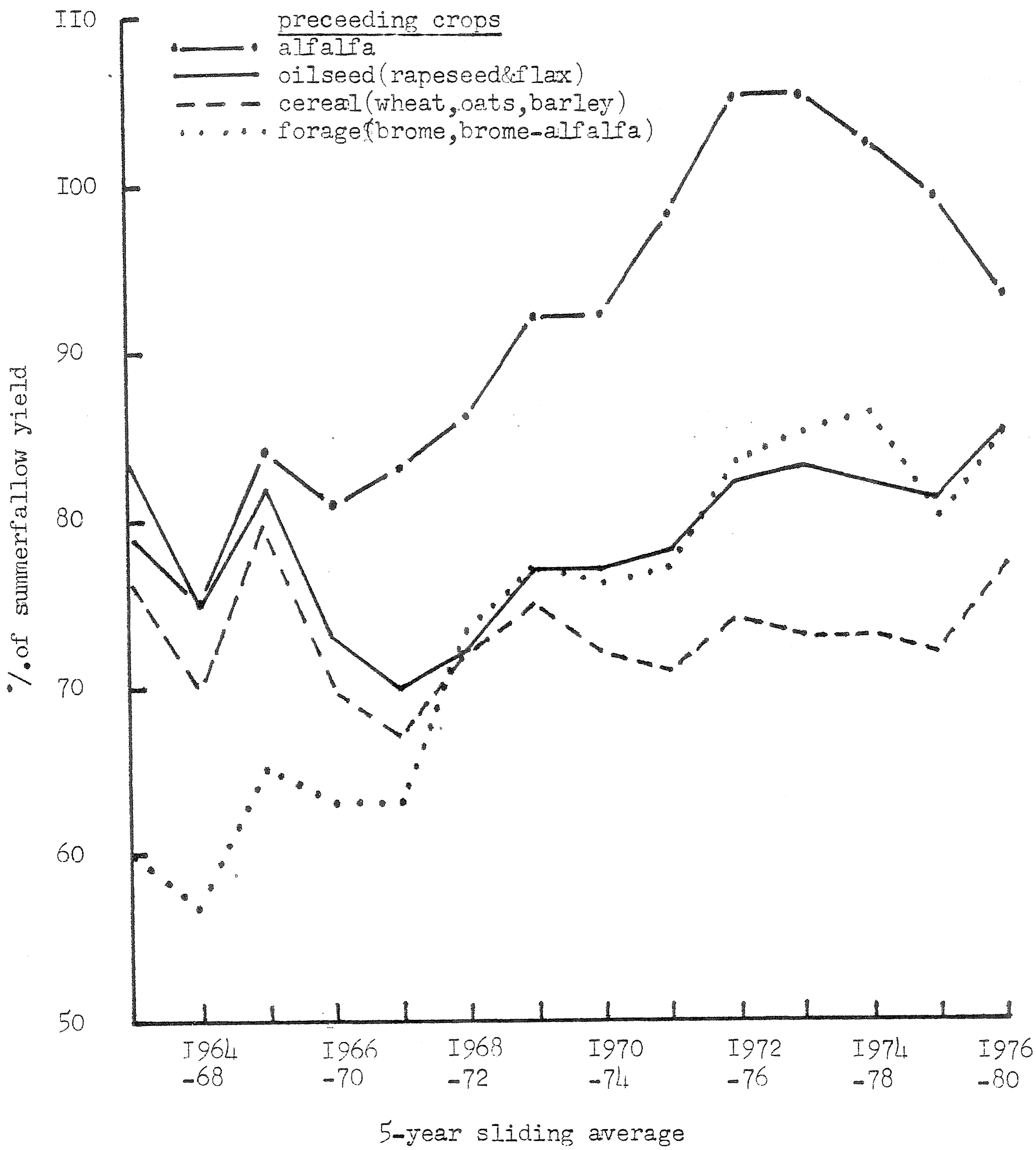


FIGURE 2

Available moisture

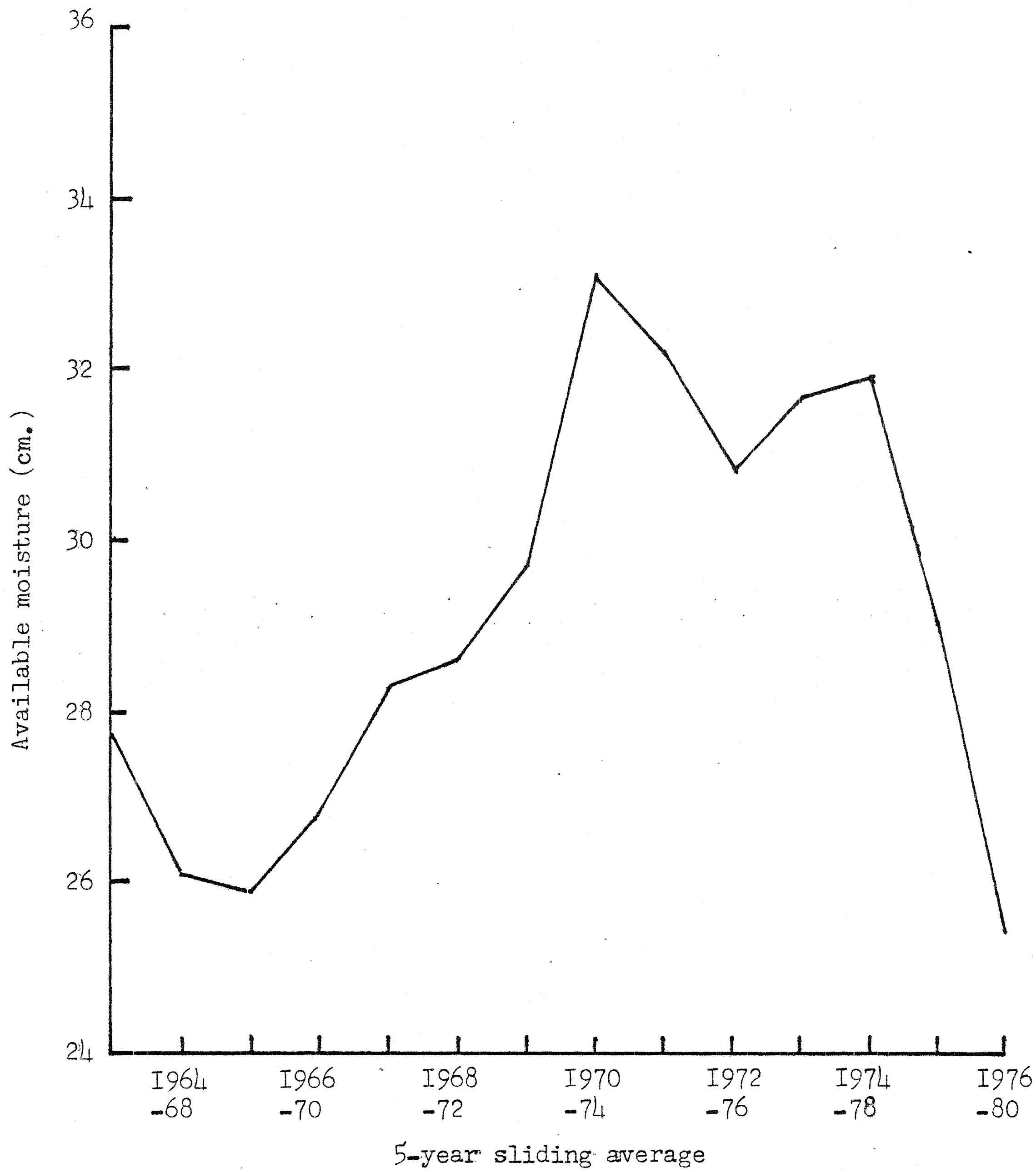


Figure 2 shows the 5-year sliding average of moisture available to grow the succeeding crop. This is the sum of available soil moisture prior to seeding plus precipitation received from seeding until July 31. During the period when relative yields of wheat following alfalfa were highest, the moisture levels also tended to be above average. This would account in part for the higher relative yields during this period. However, at the end of the test, moisture levels were the lowest during the course of the test, yet relative yields were considerably higher than at the beginning of the test. The brome or brome-alfalfa sequence showed a similar trend. This suggests that the forage crops had a cumulative affect on the soil, resulting in improved yields over time.

Barley yields showed similar trends over the course of the test (figure 3). Relative yields following alfalfa showed a steady increase until the mid 1970's and then began to decline slowly. Relative yields following the oilseed crops remained quite stable throughout the test. Where the barley crop was preceeded by the cereal crops there was a slight tendency for yields to increase. The brome or brome-alfalfa sequences led to a similar trend to that noted where alfalfa was used as the preceeding crop.

During the nine-year period where rapeseed was used as an indicator crop, rapeseed yields were low from all sequences (table 2). Plant densities have generally been low and seed-set has been poor. The poor performance of rapeseed may be due to low levels of soil sulfur. Large increases in yields of alfalfa in response to sulfate fertilizers have been obtained at this site in the past. This may also explain the very poor performance of rapeseed following alfalfa since both crops have relatively high requirements for this element. Rapeseed performed better following bromegrass than any of the other crops. The preceeding bromegrass crop has a lower sulfur requirement than the other preceeding crops except for flax.

Table 2

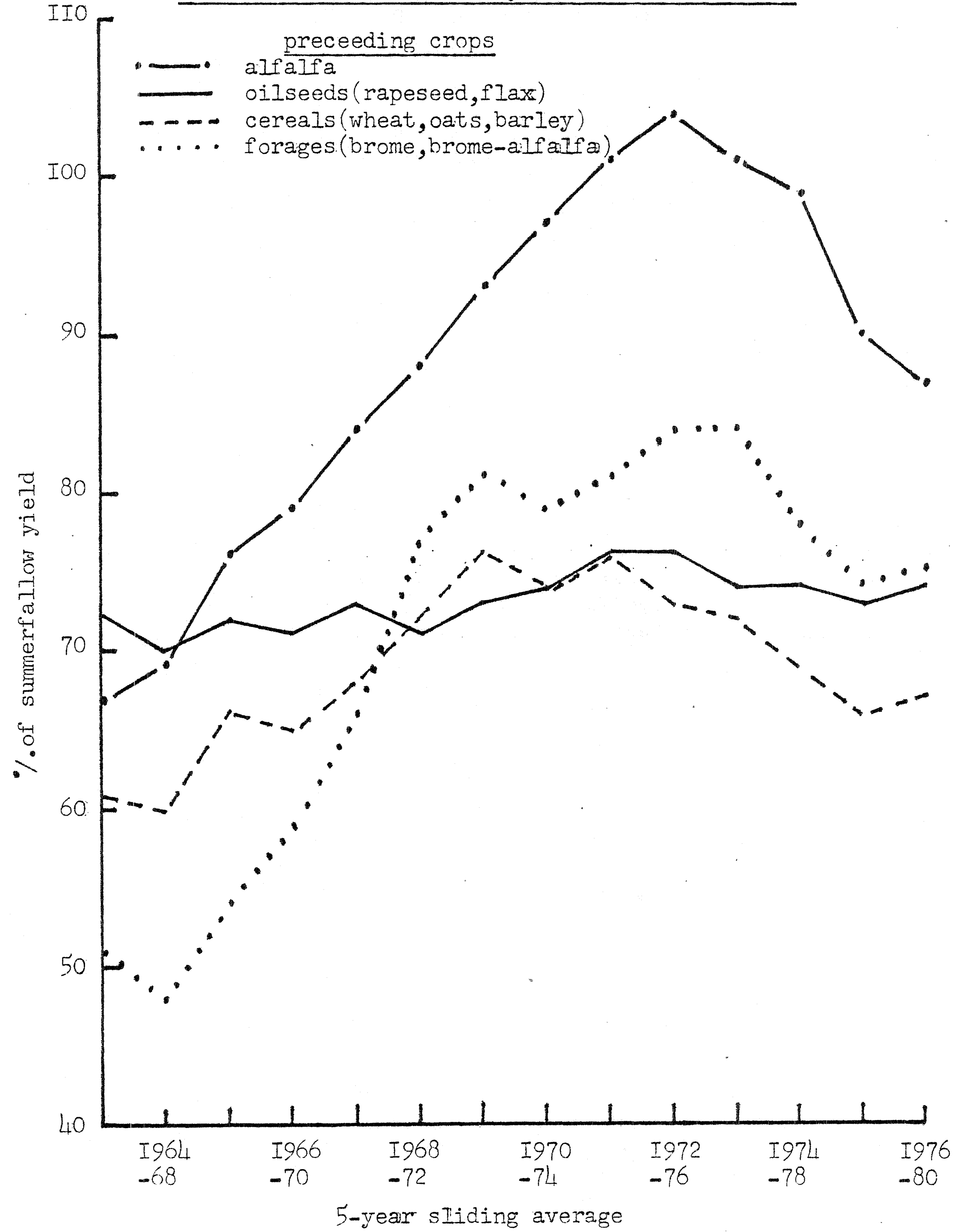
Average (9yr) yield of rapeseed following several crops on a grey-wooded soil

preceeding crop	kg/ha	% of fallow yield
summerfallow	726	100
alfalfa	468	64
brome	536	74
brome & alfalfa	487	67
wheat	458	63
oats	405	56
barley	456	63
flax	409	56
rapeseed	424	58

Heavier infestations of Canada thistle (Cirsium arvense L.) and Perennial Sow-thistle (Sonchus arvensis L.) have been noted in the flax-rapeseed and rapeseed-rapeseed sequences than in other sequences.

FIGURE 3

Barley yields following several crops as a %.of summerfallow yields



The residual N fixed by the preceeding alfalfa crop has maintained the protein content of the succeeding wheat or barley crops at levels near that of wheat or barley produced on summerfallow (table 3). This effect also shows up in the brome-alfalfa sequence, where the average protein content is higher than from the bromegrass or grain crop sequence-es. Protein levels were similar for the remaining six sequences, which were approximately 2% lower than the wheat and barley crops produced on summerfallow.

Table 3

Average (14yr) protein contents of wheat and barley grown following several crops on a grey-wooded soil

	Protein content (%)	
Preceeding crop	Wheat	Barley
summerfallow	14.5	11.7
alfalfa	14.4	11.3
brome	12.7	9.7
brome & alfalfa	13.3	10.0
wheat	12.4	9.5
oats	12.0	9.3
barley	12.3	9.6
flax	12.6	9.7
rapeseed	12.5	9.8

One thousand kernel weights and test weights were similar where wheat and barley were preceeded by summerfallow or an alfalfa hay crop (table 4). Overall, where the test crops followed wheat, barley, bromegrass or a brome-alfalfa mix, thousand kernel weights and test weights were generally lower than where the preceeding crop was alfalfa or summerfallow.

Table 4

Quality factors of wheat and barley following several crops on grey-wooded soil. (average of 14yr data)

	Weight per 1000 kernels(g)		Test weight (kg/hl)	
Preceeding crop	Wheat	Barley	Wheat	Barley
summerfallow	30.5	35.8	78.1	63.4
alfalfa	31.1	36.0	78.4	63.8
brome	29.5	35.3	77.7	62.7
brome & alfalfa	29.8	35.2	77.8	62.9
wheat	28.6	34.8	77.4	62.9
oats	29.8	34.7	78.3	63.1
barley	29.7	34.2	77.9	63.7
flax	30.4	34.8	78.3	62.1
rapeseed	30.3	35.3	78.6	63.6

Long-term average moisture data showed that in the fall of the preceed-ing crop year the summerfallow contained from 2 to 4.5 cm more moisture than the stubble plots (table 5). Over winter the stubble plots stored more snow-melt moisture and at the time of seeding the summerfallow contained approxi-mately 0.5 to 1.0 cm more moisture.

Table 5

Average (14yr) soil moisture levels following nine preceeding crops and levels the following spring

Preceeding crop	fall soil moisture* (cm)	spring soil moisture***(cm)
summerfallow	21.4	22.3
alfalfa	18.6	21.3
brome	19.7	21.5
brome & alfalfa	19.2	22.1
wheat	17.3	21.0
oats	16.9	21.2
barley	18.3	21.4
flax	17.0	21.2
rapeseed	18.3	21.4

* Moisture in the 0-90 cm profile of soil after harvest of the preceeding crop.

**Moisture in the 0-90 cm profile of soil prior to seeding the succeeding crop.

Summary

The results of this study indicate that moisture levels have been adequate for recropping to wheat or barley every year during this period, and that factors other than soil moisture would determine how frequently summerfallowing would be required. On an individual year basis, wheat yields have exceeded 1000 kg/ha in all cases where the wheat was preceeded by one of the grain crops or alfalfa. In 1967 and 1979 wheat yields were below this level when the preceeding crop was brome or a brome-alfalfa hay crop. Barley yields have exceeded 1400 kg/ha in all sequences except in 1967 and 1978 where it was preceeded by brome or a brome alfalfa hay crop.

While the risk of crop failure when growing wheat or barley on stubble in this area is low, it is considerably higher where rapeseed is grown as a stubble crop. Soil samples were collected in 1980 and analysis of these samples should reveal whether or not a deficiency of sulfur exists and the effects of these sequences on levels of this element. If such a deficiency exists, the relative performance of rapeseed on stubble may be improved considerably by addition of sulfate fertilizer.

On grey-wooded soils, which are typically difficult to manage an alfalfa hay crop could be used to advantage to improve soil properties and provide nitrogen to a succeeding wheat or barley crop.

The long-term yield trends from these sequences indicate that cropping sequences have had an effect on the productive capacity of this soil. There is a need to collect additional data on the effects of the sequences on soil chemical and physical properties such as organic matter levels, soil density, water holding capacity and soil crusting.

Some sequences of crops such as: wheat or barley following an alfalfa hay crop or rapeseed or; rapeseed grown on summerfallow or possibly following a bromegrass hay crop would provide higher returns than sequences such-

as; wheat or barley following bromegrass hay or; rapeseed following oats, flax or rapeseed.

Additional research needs to be done to determine how frequently alfalfa should be utilized in rotations in this area, and how long-lasting the residual effects of an alfalfa hay crop is.