PRODUCTIVITY STUDIES ON SOLONETZIC SOILS IN THE WEYBURN AREA - A PROGRESS REPORT

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INTRODUCTION

The Saskatchewan Institute of Pedology is currently re-surveying the soils of the Weyburn and Virden map areas in southeastern Saskatchewan. To assess the significance of the greater detail, finer separations and longer time inputs of the new maps a study comparing productivity levels of various soil series and map units was begun. This study included Solonetzic and Chernozemic soils, the most commonly occurring soils over much of this area. Additional objectives of this study were to assess the practicability of extending crop rotations on these Dark Brown soils and to gather basic data on soil properties and yield that could be used in the development of predictive models of crop production.

This study was initiated in 1975, when 5 sites were selected, experimental plots established and soil, weather and yield data gathered. The first year's results were for wheat grown on fallow and indicated that yields were greatest on Orthic Dark Brown and intergrade Solonetzic or Solodic Dark Brown soils at 2312 Kg/ha. Almost equivalent yields of 1981 Kg/ha were observed for Dark Brown Solod soils. Yields on Dark Brown Solonetz and Dark Brown Solodized-Solonetz profiles were less, at 1750 Kg/ha and 1297 Kg/ha respectively (Anderson and Wilkinson, 1976). Yields were significantly correlated with soil factors indicative of Solonetzic qualities, for example yield and soluble sodium levels of Bnt horizon had a correlation coefficient of -0.53. Surprisingly, yield was negatively correlated with nitrate nitrogen in the 0-60 cm depth, demonstrating the importance of other factors in determining yield.

MATERIALS AND METHODS

The experimental design was described in an earlier report (Anderson and Wilkinson, 1976). In summary, representative fields were selected, transects established across them and plots selected along the transects. Plots, replicated 3 to 5 times were selected on the 3 or 4 most commonly occurring series or subgroup profiles. At seeding, pH, salinity and nutrient levels were measured at each site. Soil moisture levels were measured at seeding and during the season using the neutron moisture probe. Crop growth was monitored. At harvest, square meter estimates of yields were obtained and soil profiles described.

Soil analyses were by current techniques of the Saskatchewan Soil Testing Laboratory and included measurement of pH and conductivity on 1:1 soil-water suspensions.

Table 1. The subgroup profiles or series included in the study.

Symbol	Association	Subgroup
AMA	Amulet	Orthic Dark Brown
BKW	Brooking	Solonetzic Dark Brown
BKY	Brooking	Solodic Dark Brown
TCS	Trossachs	Dark Brown Solonetz
TCT	Trossachs	Dark Brown Solodized-Solonetz
TCU	Trossachs	Dark Brown Solod

The 1976 data was for wheat grown on land cropped to wheat in 1975 and summerfallowed in 1974. Fertilizer was applied according to soil test recommendations except for one site where additional N was supplied. Except for the Schnell site good control of weeds was accomplished.

RESULTS AND DISCUSSIONS

Yields - The yields of the 1976 wheat crop, grown on stubble, ranged from 1254 to 1984 Kg/ha and were 54% to 212% of the 1975 yields on fallow (Table 2). The three normal fields, not subject to drought in 1975 or a severe weed problem in 1976 yielded about 82% of the 1975 fallow yield. Nitrate - N levels in the 0-60 cm depth decreased steadily to levels where substantial N inputs are required, except at the Flaten site where available N levels appear adequate, although a significant proportion of the N is in the subsoil, often in association with soluble salts.

Yields were lowest on Dark Brown Solonetz (TCS) profiles at 1385 Kg/ha (Table 3). Somewhat higher yields of 1397 to 1525 Kg/ha were observed for the Chernozemic and intergrade profiles, the AMA, BKW and BKY soils. The best yields were realized on the deep Dark Brown Solod (TCU) profiles at a mean of 2052 Kg/ha, with the Solodized-Solonetz profiles (TCT) at 1916 Kg/ha. The good yields on the TCT soils were surprising, but perhaps explained by the fact that deep TCT soils with thick Ap and Ae horizons were selected and these soils generally had high NO_3-N levels. The relatively poor yields of the Chernozemic (AMA, BKY, BKW) soils may be explained by the low levels of N as compared to the Solonetzic soils although other factors may be involved. Six of the eight AMA profiles were at the Schnell site where weed problems reduced yield (Table 4).

Table 2. Yields and available N levels, 1975 and 1976 crop years.

Co-operator	1975 Yield Kg/ha	1976 Yield Kg/ha	NO_3-N 0-60 cm May, 75 Kg/ha	NO_3-N 0-60 cm May, 76 Kg/ha	NO_3-N 0-60 cm Oct. 76 Kg/ha	Growing Season rainfall, 1976 (mm)
Flaten	935	1984	128	170	111	229
Halvorson	2177	1800	121	65	29	220
Lievaart	2016	1691	110	78	29	180
Memory	1982	1603	104	78	60	196
Schnell	2331	1254	87	60	25	177

Table 3. A comparison of mean yields on various profiles, 1976.

		Total Yield Kg/ha	Grain Yield Kg/ha	NO_3-N 0-24
TCS	13	4971 $\pm$ 183	1385 $\pm$ 70	87 $\pm$ 12
TCU	13	6786 $\pm$ 341	2052 $\pm$ 110	92 $\pm$ 17
TCT	22	6447 $\pm$ 268	1916 $\pm$ 105	104 $\pm$ 14
BKW	11	5242 $\pm$ 169	1397 $\pm$ 80	62 $\pm$ 4
BKY	10	6122 $\pm$ 440	1525 $\pm$ 206	66 $\pm$ 7
AMA	8	5492 $\pm$ 256	1439 $\pm$ 114	53 $\pm$ 3

<u>Correlations between yield and soil properties</u> - The strongest correlations between yield and soil properties were between yield and depth of friable A horizon (Ap + Ae + AB horizon thickness, $r = 0.37$) and depth to lime carbonate ($r = 0.40$, Table 5). This was expected in that it has generally been recognized that the thickness of soil above the tough Solonetzic B was important in determining yield, and that deep soils occur in sites where moisture and nutrient supply are relatively favorable and natural productivity is high. NO_3-N levels in the 0-90 or 0-120 cm depths were correlated with yield, although R^2 values were quite low. The only significant correlation between yeild and properties related to the salt or sodium content of the soils was between yield and the salinity level of the 0-15 cm depth. This is in contrast to 1975 data where strong correlations between yield and soluble and exchangeable sodium percentages were noted. However, the relatively good yields on the sodium affected TCU and TCT profiles in 1976 disrupted this relationship.

Available N supplies in the 0-15, 0-60 and 0-90 cm depths were strongly correlated with the protein content of the grain, with best correlations obtained with NO_3-N in the 0-90 cm depth. This indicates the importance of subsoil N in determining protein content of grain. Somewhat poorer correlations were noted between protein yield and NO_3-N reflecting the poor correlation between NO_3-N and grain yield and inverse yield-protein relationships.

<u>Multiple regression equations</u> - Stepwise multiple regression between yield and soil properties yielded the following regression equation,

Grain yield (g/m^2) = 112 + 2.53 (Ap + Ae + AB cm) with a R^2 value of 22.2%.

Additional soil properties which were added to the equation step-wise but did not make a statistically significant contribution were:

Depth to $CaCO_3$ - 4% increase in R^2
Phosphorus, 0-15 cm - 1.8%increase in R^2
NO_3-N, 0-120 cm - 0.9% increase in R^2.

Relationships between protein yield and soil properties were described by the equation,

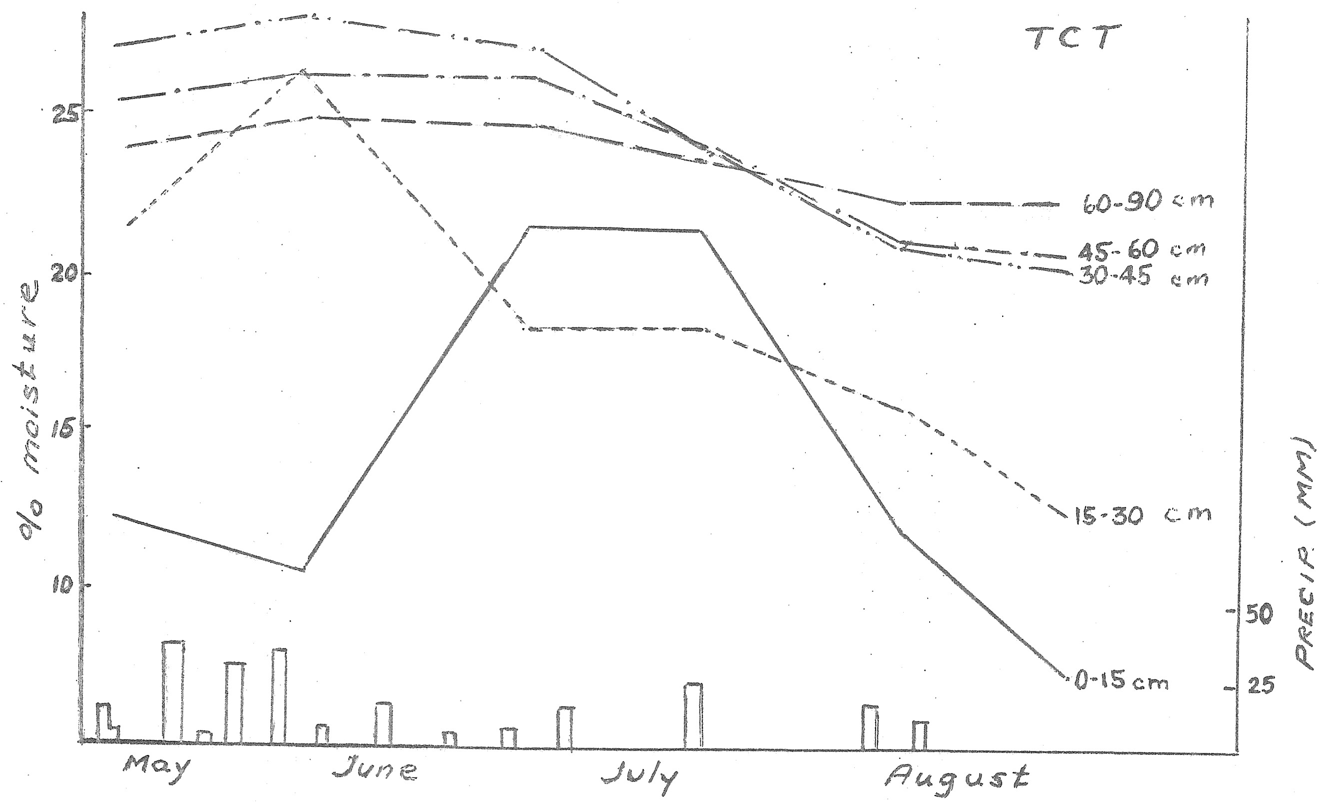
Protein yield (g/m^2) = 77.0 + 0.054 (NO_3-N, 0-120 cm) + 0.59 (Depth to $CaCO_3$) · (R^2=36.5%)

This equation includes the effect of A horizon thickness on yield and NO_3-N supplies in percent protein.

Table 4. Yields of subgroup profiles at each site.

Co-operator	Series	No. of replicates	Total yield Kg/ha	Grain Yield Kg/ha
Halvorson	TCS	1	520	1705
	TCU	5	6865 ± 671	2022 ± 233
	TCT	4	6436 ± 995	1776 ± 400
	BKY	2	7705 ± 505	1885 ± 35
	BKW	2	5320 ± 211	1438 ± 87
Flaten	TCS	3	5257 ± 498	1542 ± 167
	TCU	4	6906 ± 710	2039 ± 199
	TCT	10	6676 ± 380	2096 ± 134
Lievaart	AMA	2	5368 ± 18	1533 ± 173
	BKW	2	5205 ± 280	1583 ± 123
	TCS	5	5000 ± 355	1368 ± 100
	TCU	2	6643 ± 408	2068 ± 88
	TCT	4	6893 ± 401	2040 ± 152
Memory	BKW	2	4845 ± 895	1365 ± 280
	BKY	4	5851 ± 904	1911 ± 366
	TCS	4	4650 ± 193	1210 ± 93
	TCU	2	6495 ± 1100	2138 ± 368
	TCT	3	5173 ± 7515	1518 ± 58
Schnell	AMA	6	5534 ± 347	1408 ± 347
	BKY	4	5400 ± 236	1290 ± 173
	BKW	4	5601 ± 240	958 ± 87
	TCT	1	6225	1380

Soil Moisture - Soils were generally moist at seeding, a consequence of the relatively wet 1976 fall and average snowfall. Timely June and July rains maintained adequate soil moisture levels through the early growing season (Figure 1). Of particular interest were the high moisture levels of the 0-15 cm through July, partly a consequence of the measurement dates following rains but reflecting the cool July temperatures and lower evapotranspiration rates. Many local farmers attributed their excellent yields with modest amounts of mid to late growing season rainfall to the cooler than average temperatures of July. Depths of moisture extraction were generally greater on the Chernozemic soils than on the Solonetzic soils with their dense Bnt horizons. However, signficant amounts of moisture were removed from the 45-60 cm depth of Solodized-Solonetz soils, indicating that roots were able to extend into and through the tough B horizons. This is consistent with the observations as to the importance of subsoil NO_3-N in contribution to yield and, to greater degree, protein content of the grain.



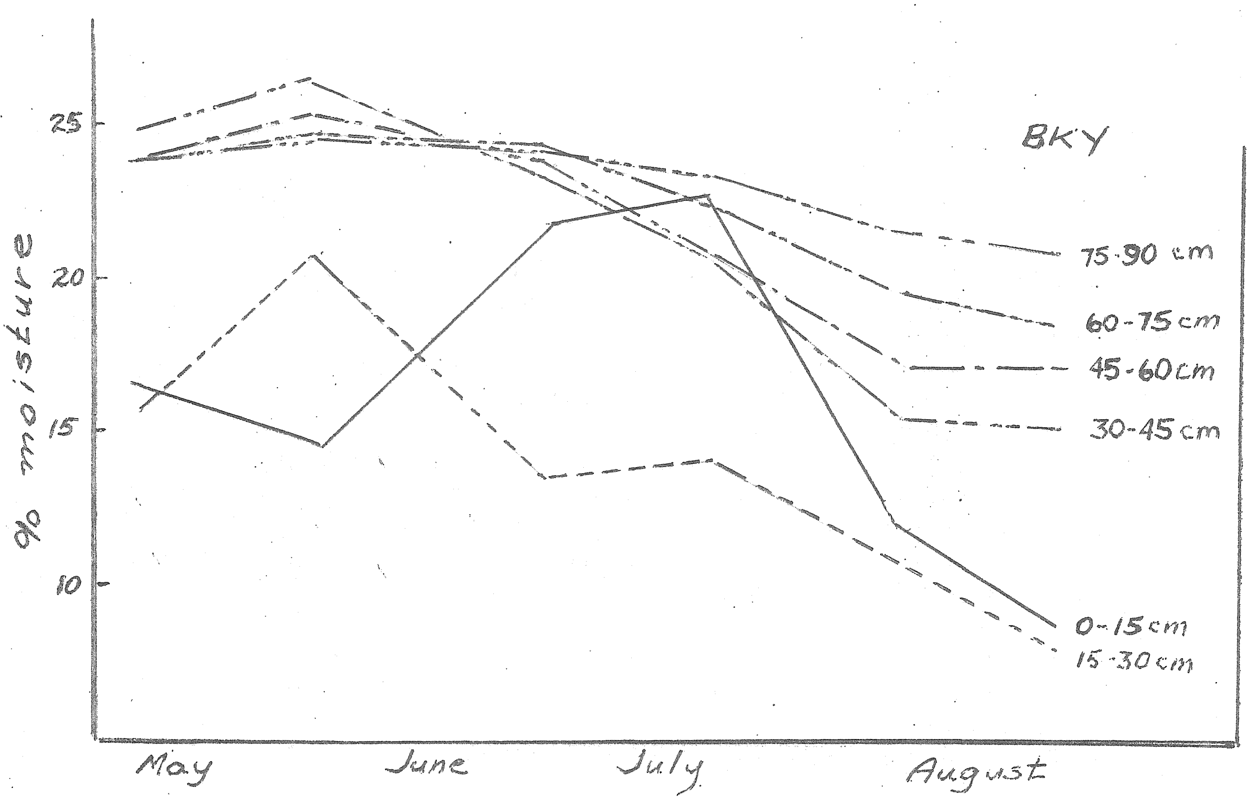


Figure 1. Moisture content and rainfall at TCT and BKY profiles at the Memory site.

Table 5. Simple correlation coefficients between soil properties and yield, protein content and protein yield.

Soil Property	Grain Yield Kg/ha	Protein (%)	Protein Yield Kg/ha
NO_3-N, 0-15 cm	0.14	0.56	0.34
NO_3-N, 0-60 cm	0.18	0.72	0.46
NO_3-N, 0-90 cm	0.24	0.78	0.53
NO_3-N, 0-120 cm	0.27	0.78	0.55
Salinity, 0-15 cm	-0.29		
Ap + Ae + AB thickness	0.37		
Depth to $CaCO_3$, cm	0.40		

Significance levels, 5% level, r = 0.22, 1% level, r = 0.29.
Only most significant correlations shown.

SUMMARY

On fields not subject to unusual conditions grain yields of wheat on stubble were 82% of the previous years summerfallow-seeded crop. Yields were greatest for Dark Brown Solod soils at 2052 Kg/ha, slightly less at 1916 Kg/ha for Dark Brown Solodized Solonetz (TCT) soils, 1525 to 1397 Kg/ha for Chernozemic profiles and lowest for the Dark Brown Solonetz soils at 1385 Kg/ha. The surprisingly high yields for TCT soils are difficult to explain, but are probably related to several factors. The thick A horizons encountered were of some importance, as well as the considerable amount of available N. In contrast to 1975 the 1976 crops on TCT soils appear to have been able to utilize the NO_3-N of the subsoil. It is interesting to speculate that the cool July with timely rainfall allowed the plants the time to produce the energy required to grow the roots that were able to exploit the moisture and nutrients of the subsoil. During 1975, hotter temperatures in July, with slightly less rainfall, resulted in moisture stresses, reducing the photosynthetic capacity of the plants and not allowing the energy or the time required for extending root systems into the subsoil. These considerations are speculative, but point to the complexity of the soil-plant-climate system, not only in terms of their properties and magnitudes, but the interaction of properties over time.

LITERATURE CITED

Anderson, D.W. and D.B. Wilkinson. 1976. Productivity studies in the Weyburn map area. Proc. of the 1976 Soil Fertility Workshop. Ext. Publ. 244, University of Saskatchewan, Saskatoon.