ASSESSMENT OF VARIABLE SUBSOIL REPLACEMENT DEPTHS FOR RECLAMATION OF SOILS AFTER SURFACE MINING (BRSRP)

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ABSTRACT

The Battle River Soil Reconstruction Project (BRSRP) was established in 1979 to determine the most effective methods of reclaiming lands disturbed by surface mining of coal in the Battle River Coal Fields. The project is located 150 km southeast of Edmonton in a region dominated by Dark Brown Chernozemic and Solonetzic soils used for agriculture. Subsurface till materials are moderately saline and sodic but deeper mine spoils consist of unconsolidated bedrock that is weakly saline but highly sodic.

Results from the Subsoil Depth Experiment (one of the four experiments established) are addressed in this paper. The objective of the Subsoil Depth Experiment is to determine the optimum thickness of replacement subsoil over sodic minespoil. The thickness of subsoil replaced under 15 cm of topsoil ranged from 0 cm (Treatment 1) to 335 cm (Treatment 6).

Results from the Subsoil Depth Experiment indicate that forage, but not cereal, yields increase with increasing subsoil thickness. Data are presented that indicate these responses are primarily related to soil moisture regime rather than to soil chemistry. Further, data are presented to suggest that the different crops, cereals versus forage, have different and very important effects on soil chemistry and this is related to their influence on soil water status.

The combination of yield, soil moisture and soil salinity monitoring over a period of years provides extremely important insights into soil forming processes. This understanding is essential to establishing the sustainability of soil quality after mining and has very important implications to agricultural use of undisturbed lands.

INTRODUCTION

The Battle River Soil Reconstruction Project (BRSRP), featuring four experiments, was established in 1979. Objectives were to determine the most effective methods of reclaiming lands disturbed by surface mining of coal in the Battle River Coal Fields. This paper focuses on the Subsoil Depth Experiment which was designed to determine the optimum depth of replacement subsoil over sodic mine spoil required to sustain agricultural production. Results of four years of data collection are presented and discussed. The findings and opinions expressed in this paper are those of the authors, and not of the Alberta Ministry of Environment or any of its representatives.

SITE DESCRIPTION

The BRSRP is located about 20 km north of Halkirk on lands transferred from Manalta Coal Ltd. to the County of Paintearth. The dominant soils of the area before mining ranged from Dark Brown Solonetz to Orthic Dark Brown Chernozems developed on till deposits overlying the Horseshoe Canyon Formation which consists mainly of non-marine Cretaceous clayey sandstone, bentonitic mudstone and carbonaceous shale. Climate is continental with a frost-free period of approximately 100 days and an average annual precipitation of approximately 400 mm, 60% of which falls as rain during May through August.

Production of cereal crops and livestock are the major agricultural industries in the region.

METHODS

Experimental Design

Plots were established in 1980 using a randomized complete block design (Figure 1). Six treatments were established where the thickness of subsoil replaced over spoil increases from Treatment 1 to Treatment 6 (no subsoil, 25, 65, 135, 165, and 335 cm, respectively). A 15 cm layer of topsoil was replaced on the surface of all treatments. Topsoil and subsoil materials were obtained locally from an area of Orthic Dark Brown Chernozemic and Dark Brown Solod soils. Plots were constructed using mine machinery (dozers and scrapers) simulating the "take and put" system of mine reclamation (Parker, 1981). Crop type (forage, cereal) was crossed with the 6 treatments to produce 12 plots within each block which constitutes one of three experimental replicates (Figure 1).

Plot Monitoring

Each year soil and crop husbandry was practiced in a manner similar to that employed by local farmers. Soil parameters, crop yields and rainfall were monitored during each growing season.

In 1980 grab samples of construction materials were taken and analyzed to establish baseline conditions (Table 1). In subsequent years soil sampling was conducted in autumn. Two

Figure 1: Plot Layout for the Subsoil Depth Experiment

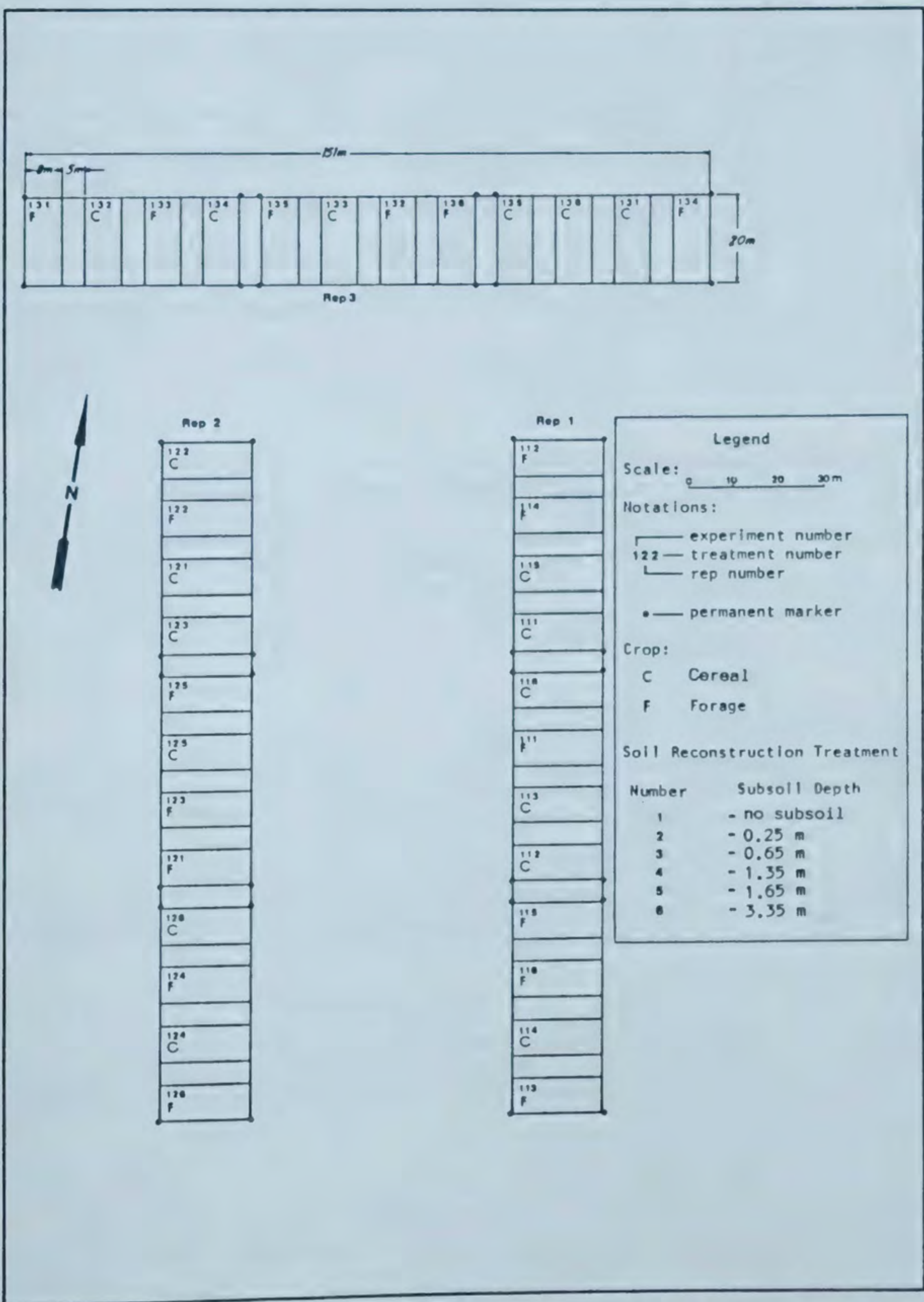


Table 1: Chemical Analyses of Materials Used in Plot Construction (Baseline Conditions).

Material[1]	EC (mS/cm)[2]		Na (meq/L)		SAR		Reclamation Suitability Rating[3]
	X	s.d.	X	s.d.	X	s.d.	
Topsoil	3.6	0.5	14.2	3.6	3.5	0.8	F (EC)
Subsoil	5.8	0.7	37.4	8.6	8.4	1.6	F-P(EC:SAR)
Spoil	2.9	1.0	27.2	9.0	23.9	2.7	U (SAR)

[1] Topsoil: Loam to clay loam textured A horizon removed from native soils before mining.

Subsoil: B and C horizons plus underlying material that has chemical and physical properties suitable for sustaining vegetative growth.

Spoil: Sodic bedrock materials of the Horseshoe Canyon Formation.

[2] EC: electrical conductivity
Na: sodium
SAR: sodium adsorption ratio

[3] Proposed Alberta Soil Quality Criteria (A.S.A.C., 1981):

Ratings	Constraints
F - fair	EC - high electrical conductivity (salinity)
P - poor	SAR - high sodium adsorption ratio (sodicity)
U - unsuitable	

samples within each plot were taken at 15 cm depth intervals to at least 50 cm into the underlying spoil. Chemical analyses which have been conducted by Norwest Labs using standard analytical procedures (McKeague, 1978) include pH, saturation percentage, SAR (sodium adsorption ratio), EC (electrical conductivity), and soluble Ca^{++}, Mg^{++}, Na^{+}, K^{+}, $SO_4^{=}$ and Cl^{-} in the saturated paste extract. Neutron probe access tubes were installed in all plots in 1982 to facilitate measurement of soil moisture and bulk density. Soil moisture measurements have been taken on a monthly basis (May to September) at 15-30 cm intervals using a Campbell Scientific Subsoil Moisture Gauge (Model #503). Soil bulk density measurements were taken using a Campbell Scientific soil moisture/density probe (Model #501), in fall 1983 and in spring 1985, at the same depth intervals where soil moisture readings were taken.

Each April, soil samples were taken to determine fertilizer application rates for both cereal and forage crops. Cereal crops were seeded in May and harvested in mid-August of every year. Forage crops were established with a companion wheat crop in 1982. Forage crops were harvested in late July of every year: a second harvest was made only in September 1983. For further details regarding crop husbandry practices see Pedology Consultants (1983, 1984, 1985, 1986).

Forage and cereal yields are expressed on a dry weight basis (T/ha) calculated from entire plot fresh weights measured in the field and subsamples dried to a constant weight (forage) for 24 hours (cereal), at $60^{\circ}C$.

In 1983 the Alberta Research Council installed a rain gauge in the BRSRP compound to continually monitor precipitation (mm) from early May to late October.

Statistical Analyses

Statistical analyses were performed on yield data (forage and cereal separately) and on soil chemical data. The effects of factors in soil chemical properties were determined at four profile locations:

1. Topsoil (ts) above topsoil/subsoil interface
2. Upper subsoil (ss1) below topsoil/subsoil interface
3. Lower subsoil (ss2) above subsoil/spoil interface
4. Lower spoil (sp)

as well as for differences between the two subsoil layers (Diff 1 =ss2 - ss1) and between the spoil and lower subsoil layer (Diff 2 = sp - ss2). The purpose of the latter procedure was to identify differential salt movement across treatments while avoiding the problem of heterogeneity of variance and co-variance across depths.

Within Years

The Subsoil Depth Experiment was analyzed as a randomized complete block design. Conceptually, treatment and crop were fixed factors, replicate was treated as a random factor. The treatment main effect was decomposed into linear, quadratic and deviation planned comparison. For the planned comparison, homogeneity of variance was tested with Bartlett's test and Hartley's test at $p \leq 0.05$ (Winer, 1971). Tukey's HSD test at $p = 0.05$ was used for post-hoc tests. Statistical analyses (ANOVA's, homogeneity testing) were conducted using BMDP statistical packages on the AMDAHL mainframe at the University of Alberta. Means testing was conducted on the mainframe utilizing a custom program.

Across Years

Trends in soil chemistry since 1982 were analyzed using a split-plot design with years being within plot. Unless "year" interacted with any of the other factors, the trend across years was tested as the main effect and was decomposed into planned linear and deviation comparisons.

If "year" interacted significantly with Treatment and/or Crop, a planned comparison was performed at each factor level ($p=0.05$) (Myers, 1979). Tukey's HSD test at $p = 0.05$ was used for post-hoc tests.

RESULTS

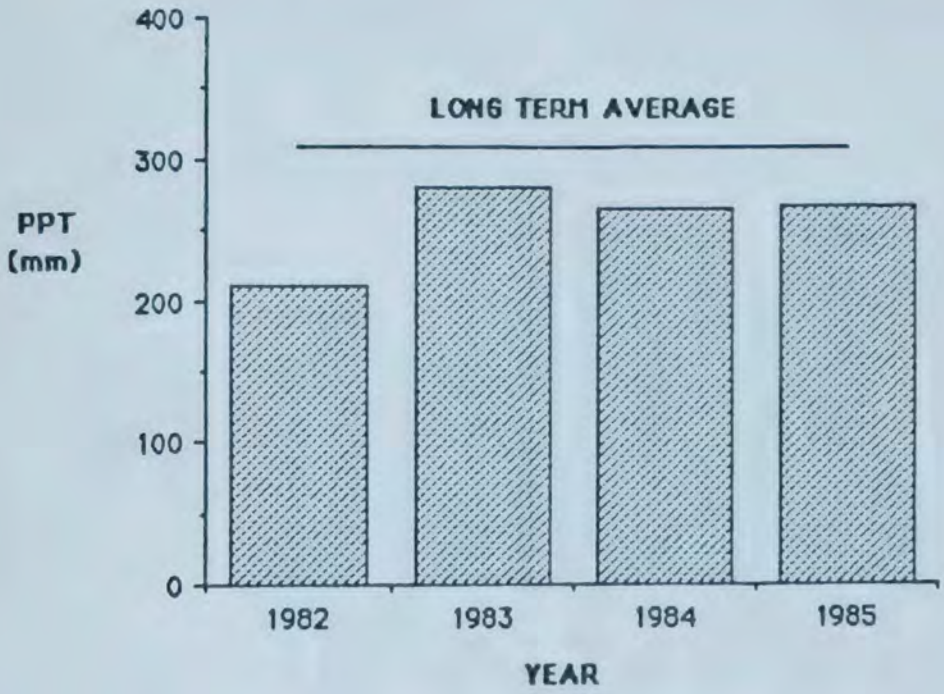
Rainfall monitoring results are summarized in Figure 2. Cereal and forage yield data for all years by treatment are shown in Figure 3 and long term average yields for both crops are shown in Figure 4. Examples of soil moisture (volumetric) distribution with depth under the two crops are shown in Figures 5-7.

Annual comparisons of soil chemical data are presented in Figures 8-10. Important crop effects on soil chemical properties are illustrated in Figures 11, 12 and 15. Treatment effects on soil chemical properties are presented in Figure 16.

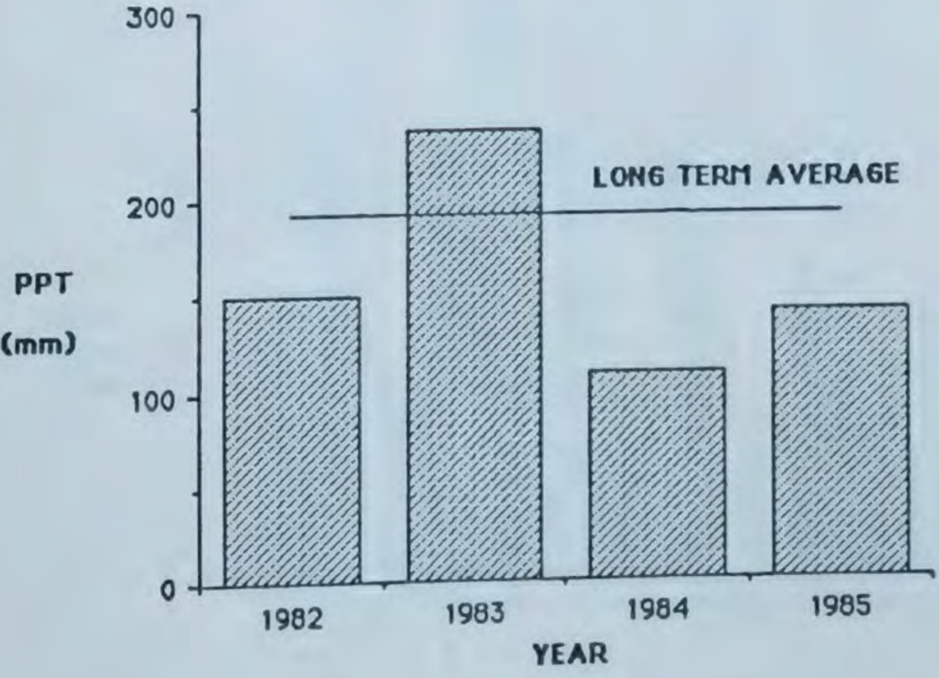
To summarize the large volume of soil moisture data collected, soil moisture classes were developed and their monthly frequency of occurrence tabulated (Figures 13 and 14). The data represent five monthly readings at several depths in each of three field seasons (1983-1985, total of 15 months) and two treatments (3 and 6) crossed with two crops (cereal, forage). The three classes at 0-5%, 6-10% and 11-20% above wilting point permit segregation of the less (0-5%) and readily (11-20%) available water. The percentage frequency distributions represent (for each depth) the number of months out of 15 which fell into each class. Results from the trend analyses of saturation % are shown in Figure 17 and associated regression analyses are found in Table 2.

In order to facilitate a comparison of treatment and crop effects on salinity in the rooting zone over the years, a mass balance approach was used. This approach eliminates some of the problems encountered when comparing profiles of such diverse and variable composition (e.g. Treatment 1-6). For each depth interval sampled (at the sample and replicate level) total salts (T/ha) were calculated as follows:

Figure 2: Total Precipitation at the BRSRP Compound (1982-1985)

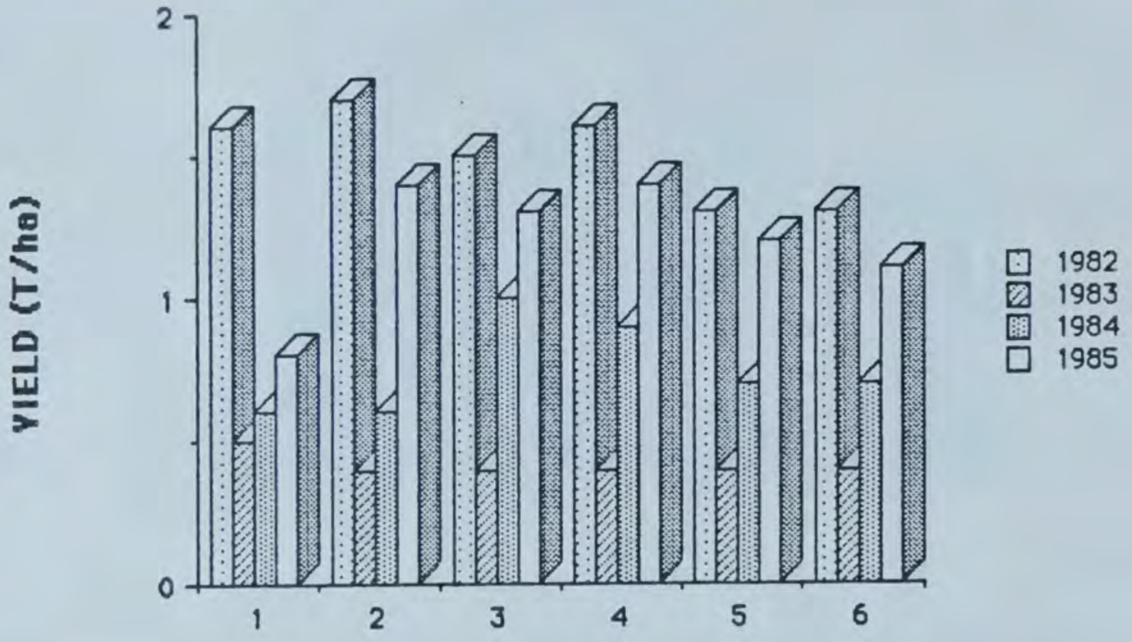


2a. Total precipitation (mm) from May 1 to Oct. 31.

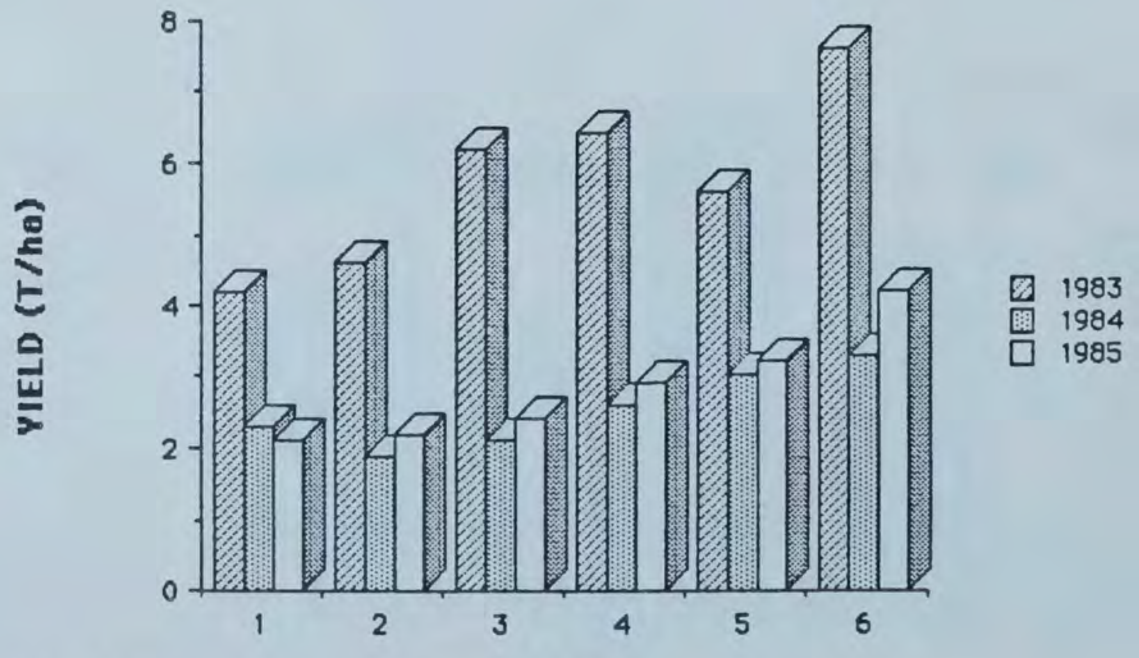


2b. Total precipitation (mm) from May 1 to July 31.

Figure 3: Mean Yields (T/ha) of Forage and Cereal Crops from 1982 to 1985.



3a. Cereal TREATMENT



3b. Forage TREATMENT

Figure 4: Long-term Yields (T/ha, 4-year average) of Cereal and Forage Crops for Six Treatments.

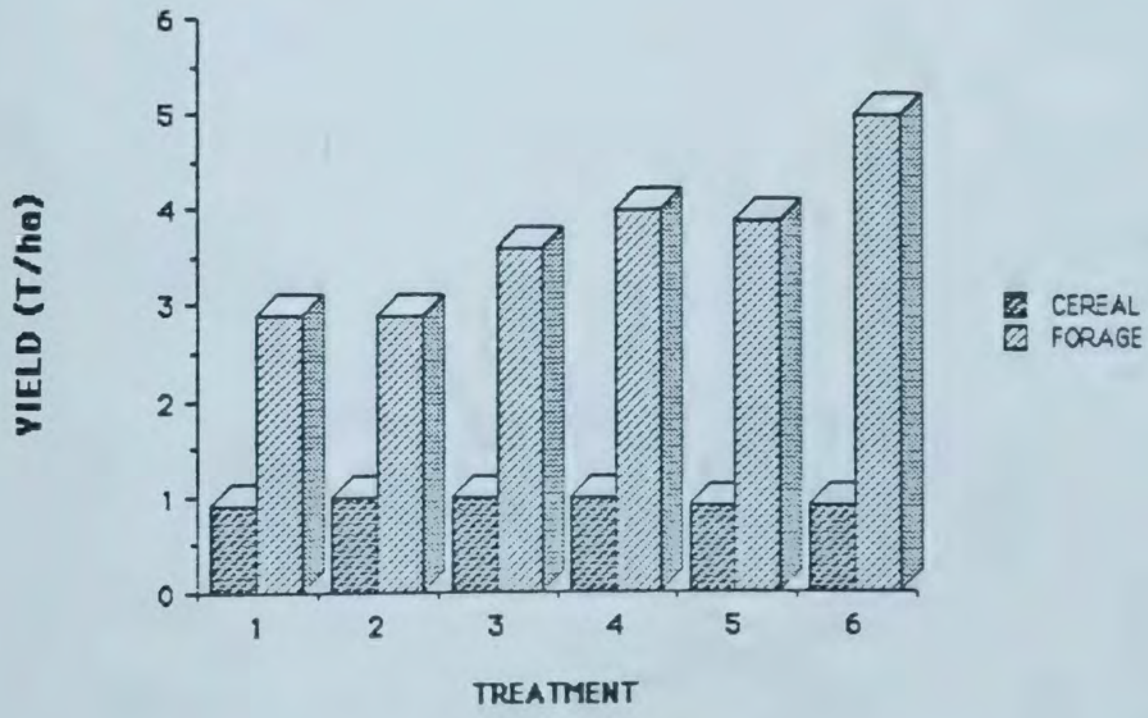
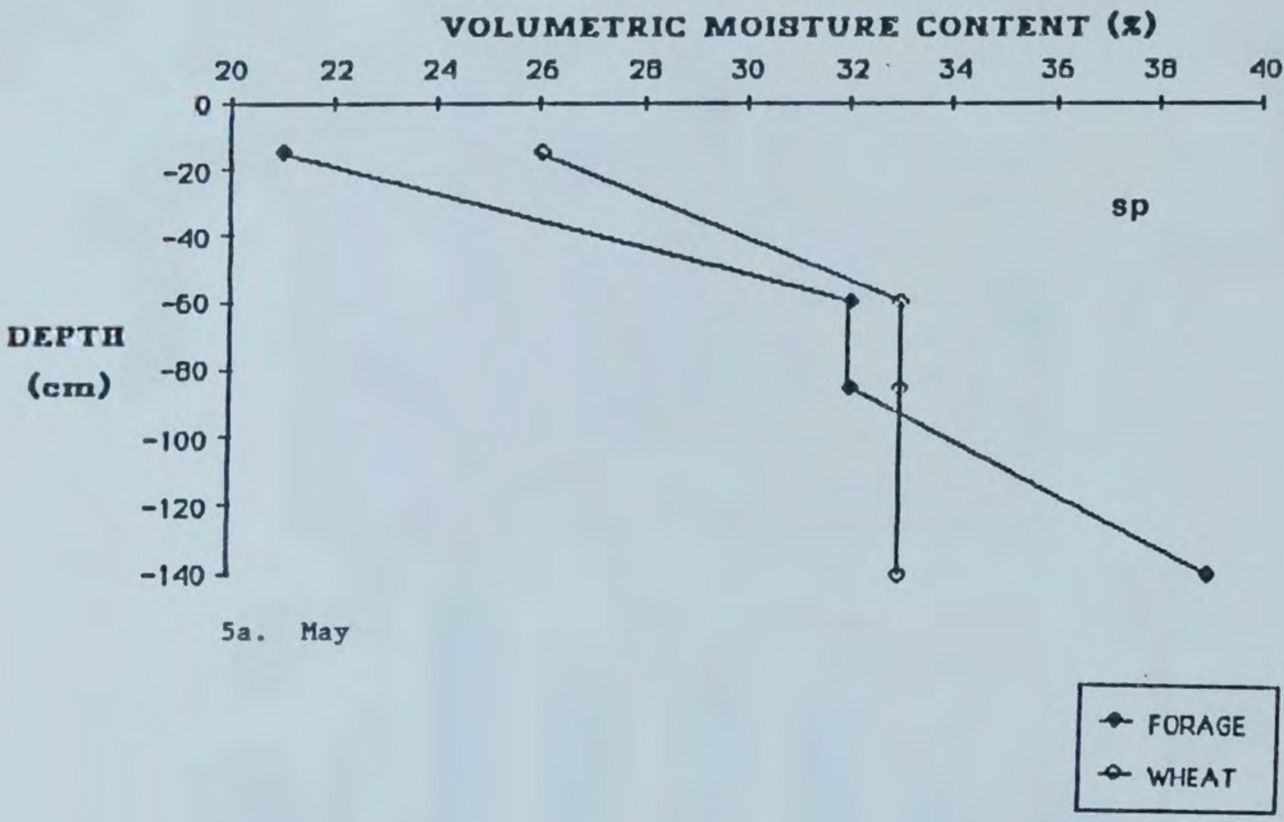
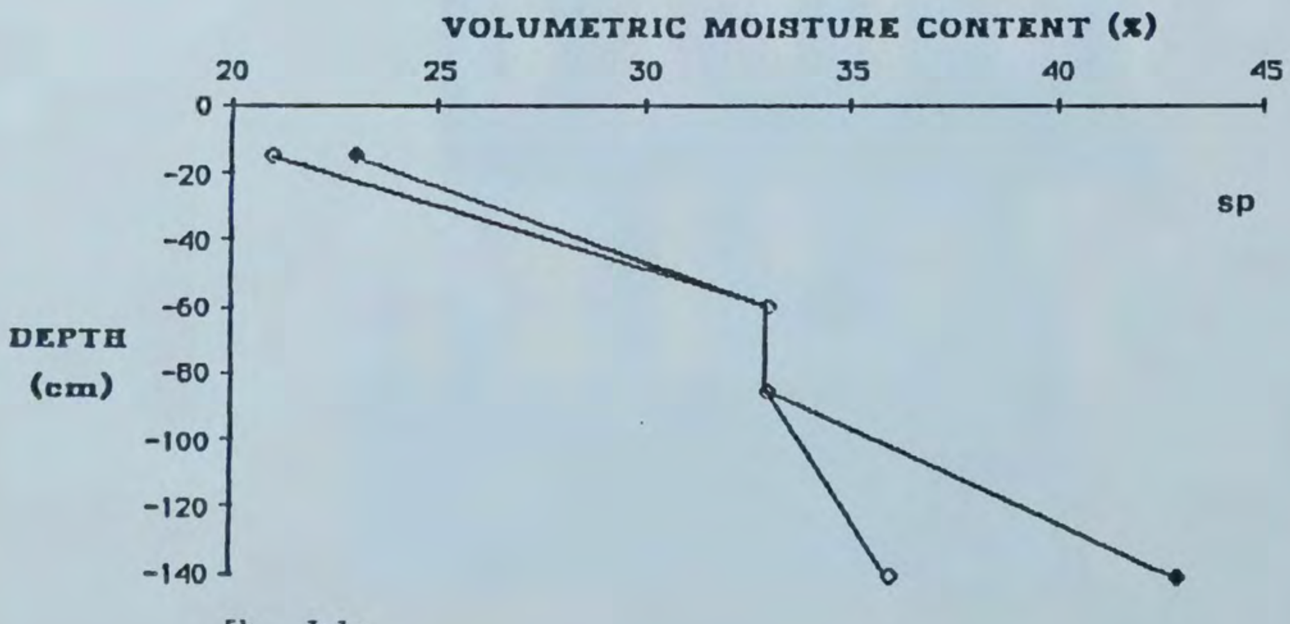


Figure 5: Distribution of Soil Moisture (% v/v) with Depth in May and July Under Cereal and Forage - Treatment 1 (1985).

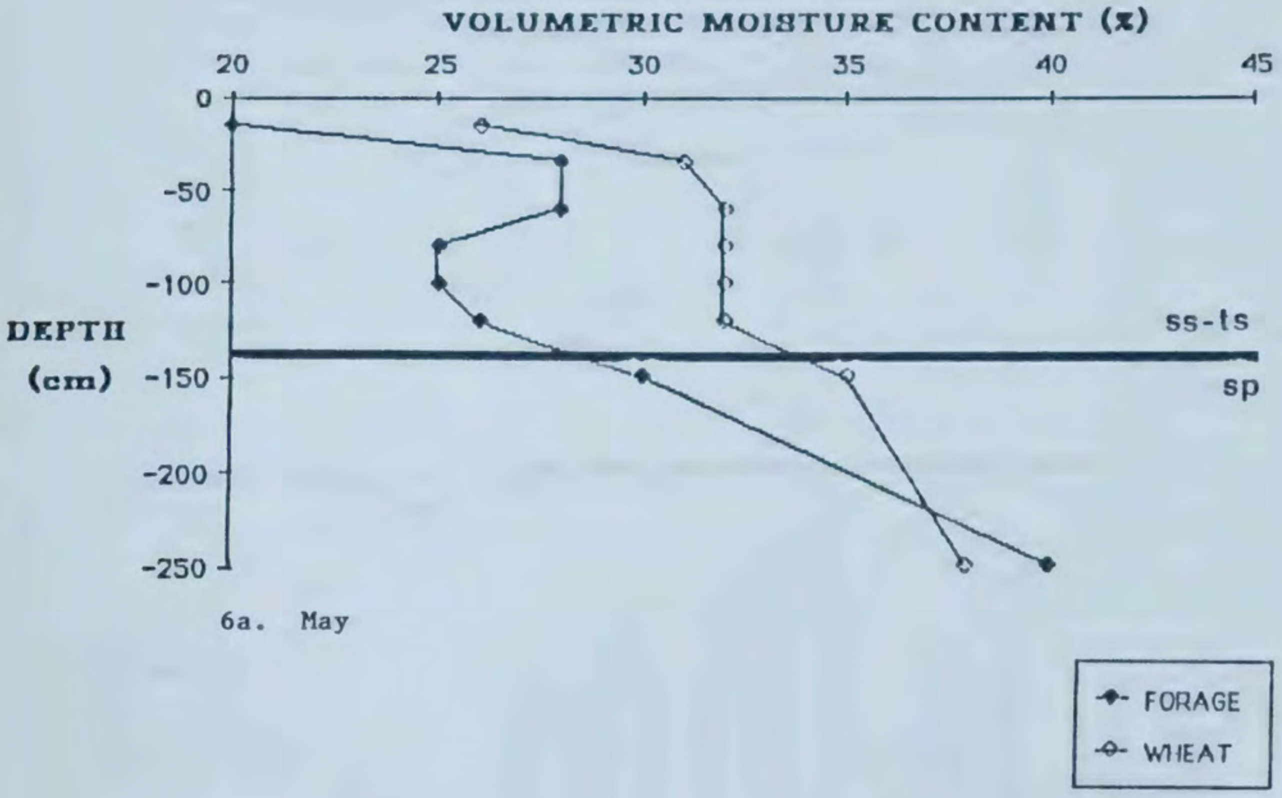


5a. May

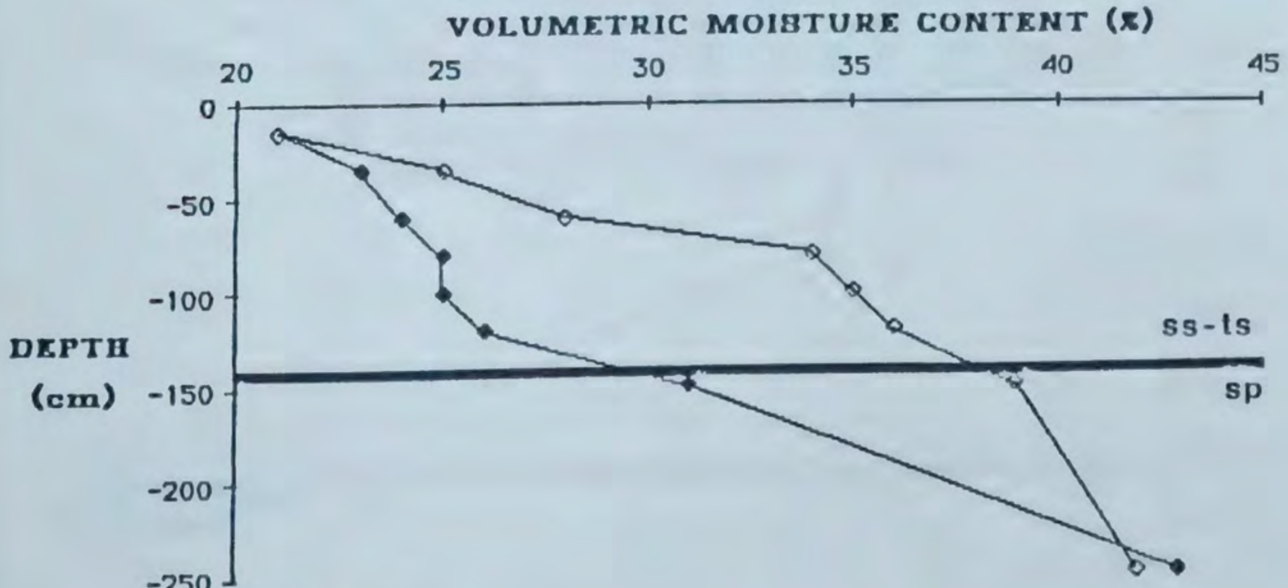


5b. July

Figure 6: Distribution of Soil Moisture (% v/v) with Depth in May and July Under Cereal and Forage - Treatment 4 (1985).

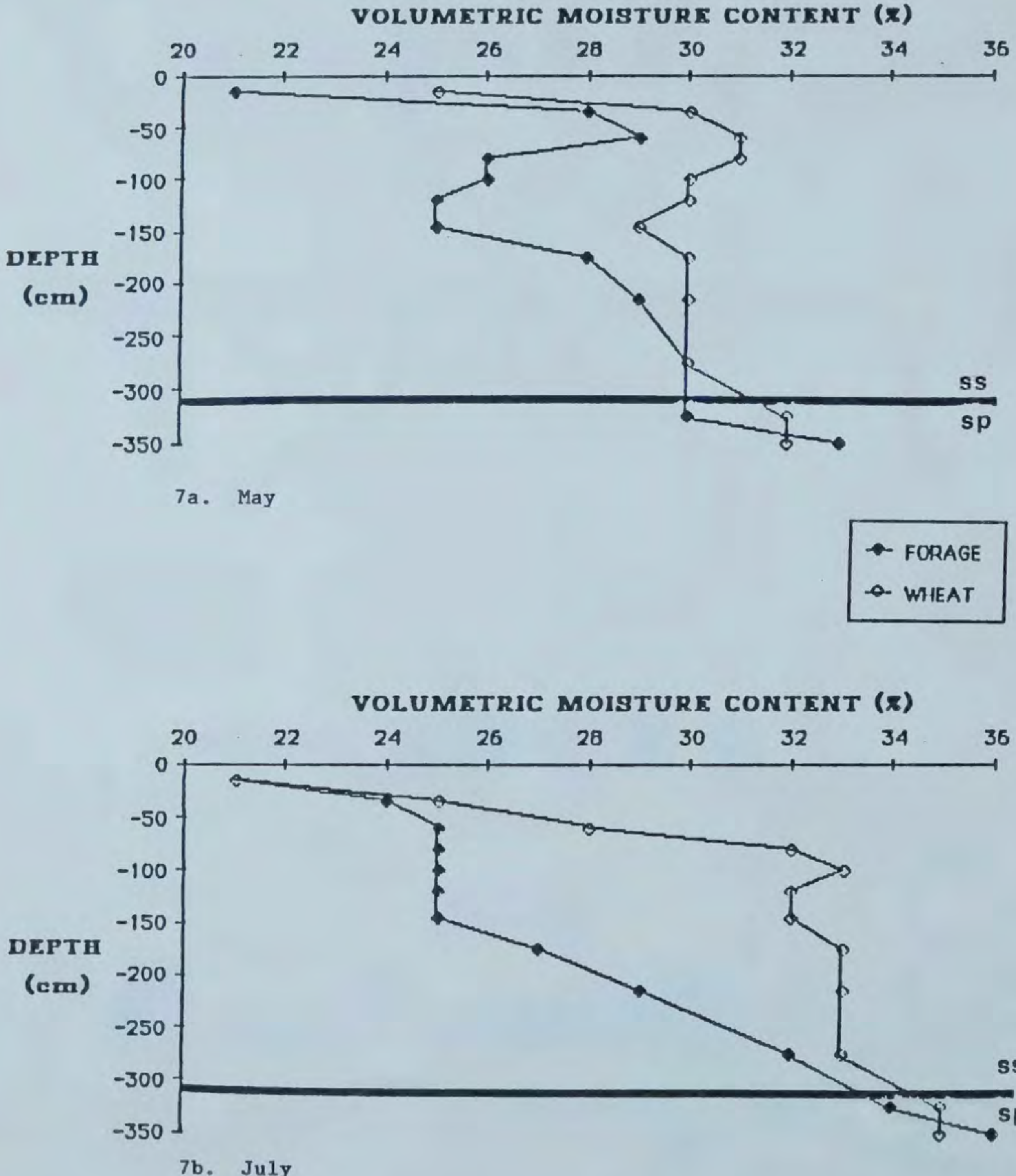


6a. May



6b. July

Figure 7: Distribution of Soil Moisture (% v/v) with Depth in May and July Under Cereal and Forage - Treatment 6 (1985).*



* Values within materials not accompanied by the same letter are significantly different (p = 0.05).

Figure 8: Mean EC (mS/cm) of Four Materials from 1982 to 1985. Values within materials not accompanied by the same letter are significantly different (p = 0.05).

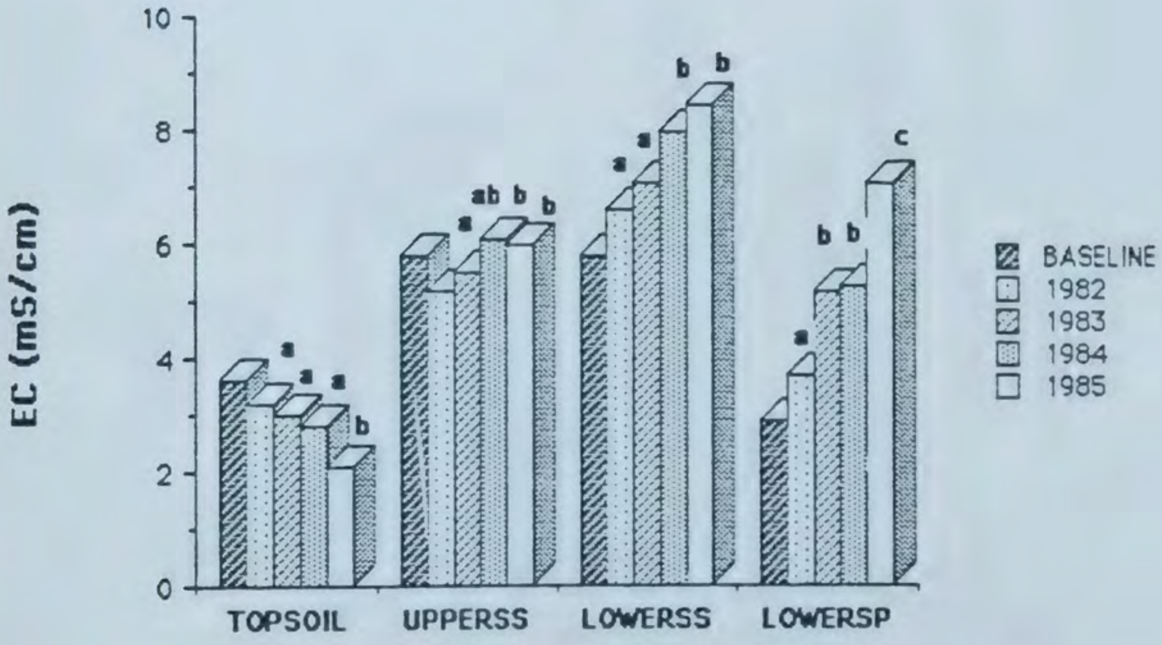


Figure 9: Mean SAR of Four Materials from 1982 to 1985. Values within materials not accompanied by the same letter are significantly different (p=0.05).

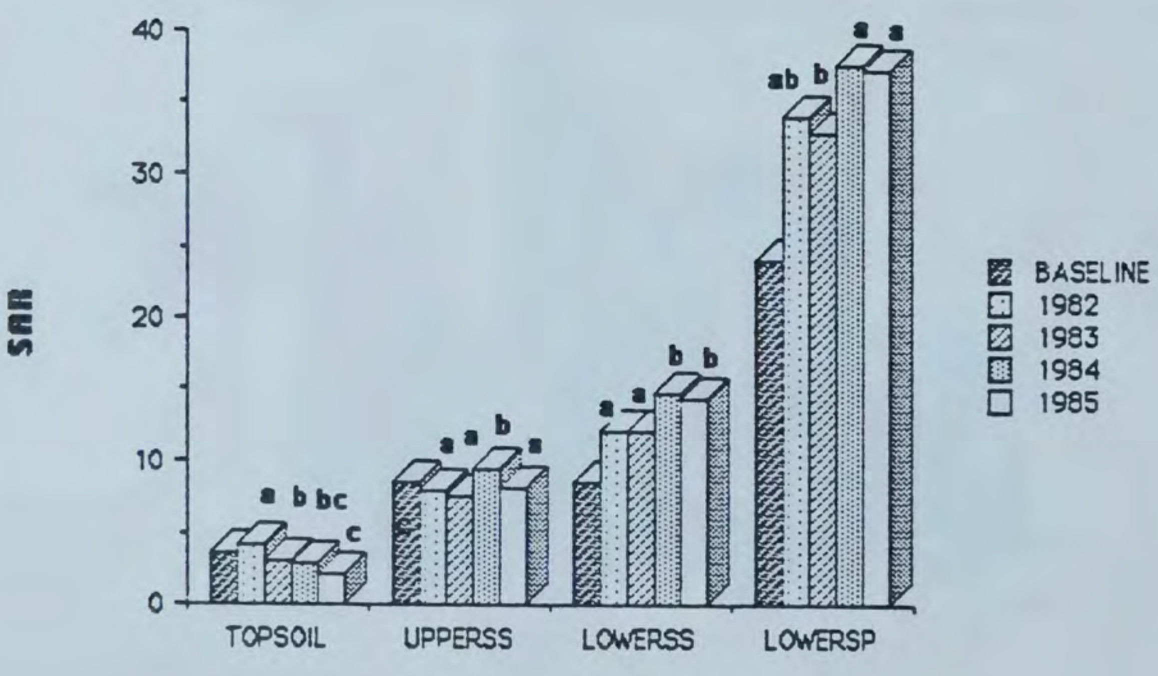


Figure 10: Mean Na Concentration (meq/L) of Four Materials From 1982 to 1985.

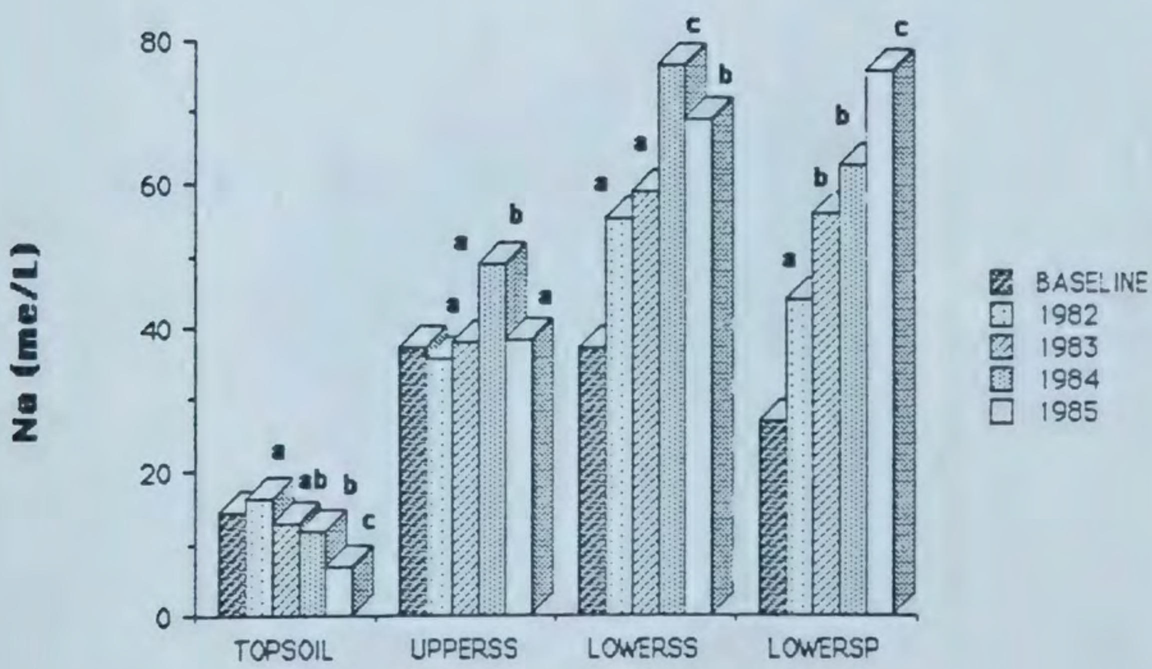
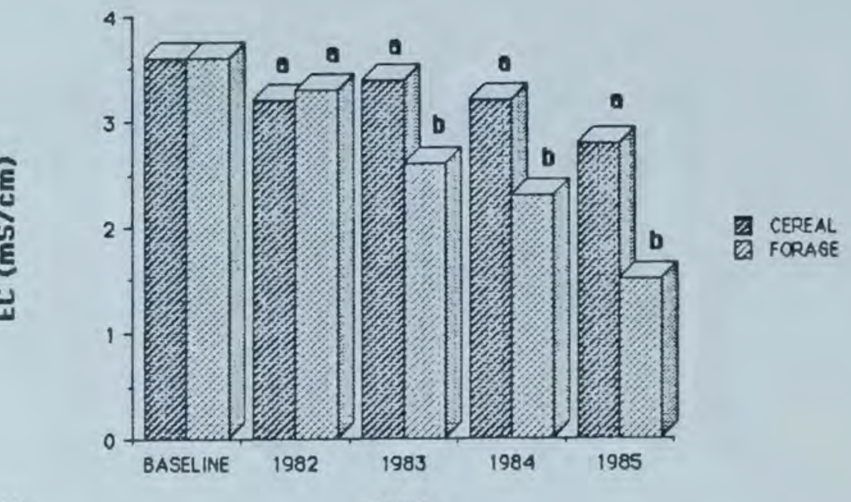
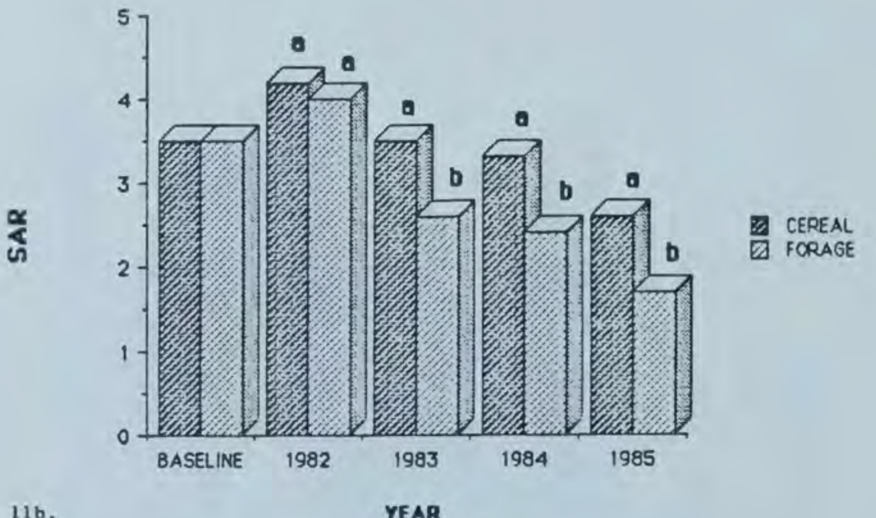


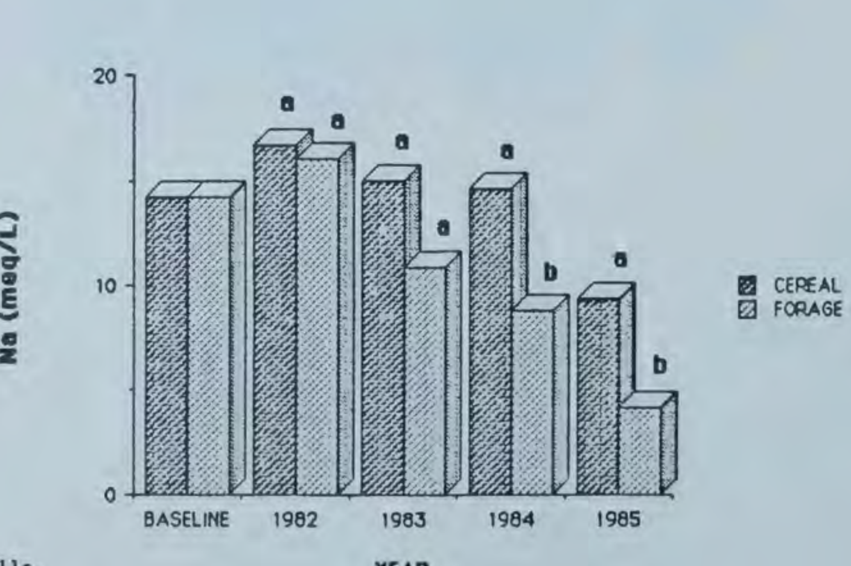
Figure 11: Annual Comparison of Topsoil Chemistry Under Cereal and Forage (1982-1985). Values within years not accompanied by the same letter are significantly different (p = 0.05).



11a.



11b.



11c.

Figure 12: Mean EC (mS/cm) of the Upper and Lower Subsoil Under Cereal and Forage Crops (1985).

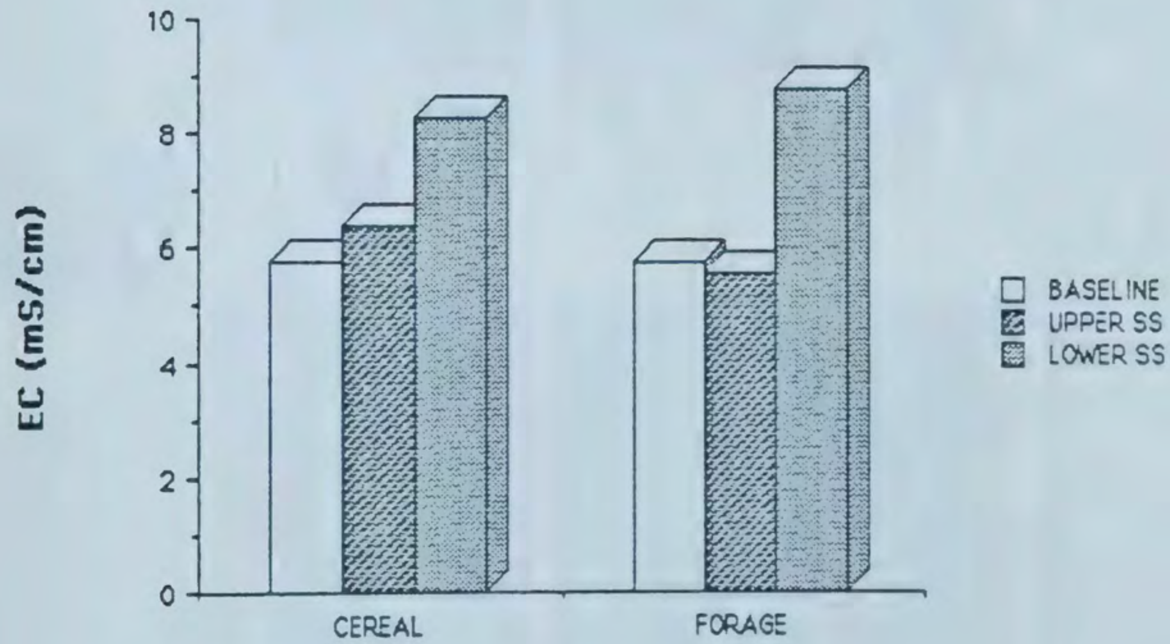
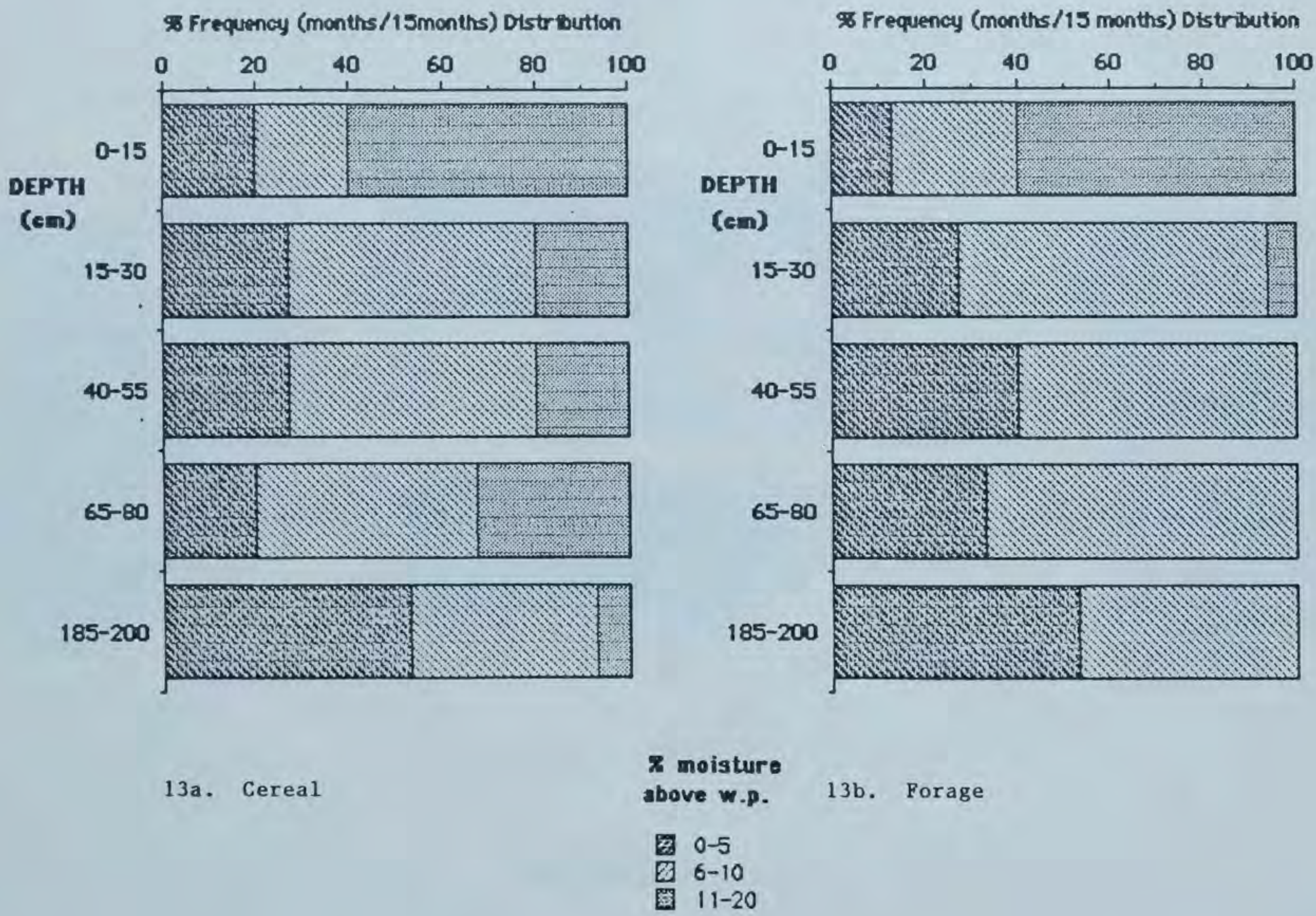


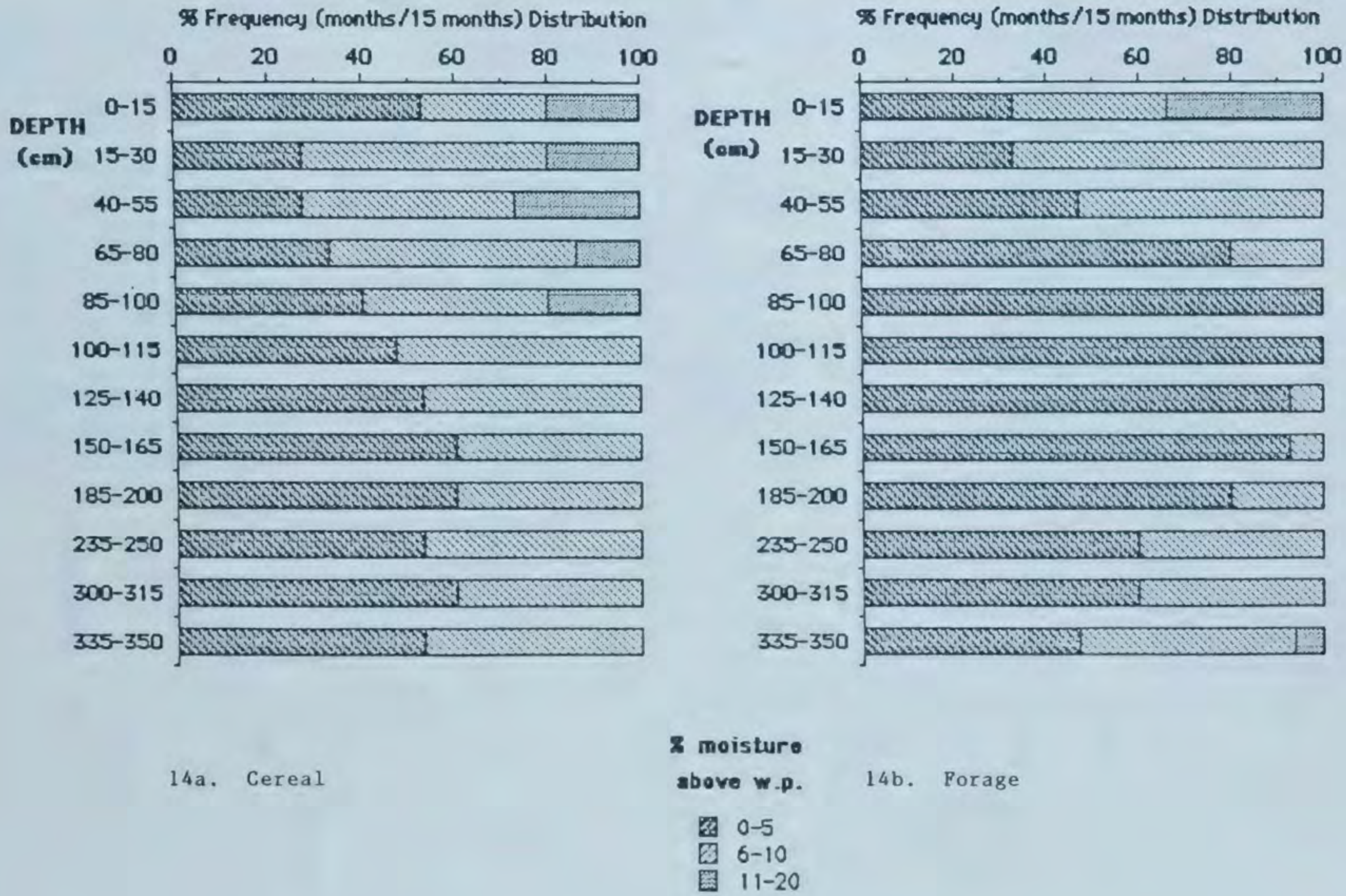
Figure 13: Frequency Distribution of Soil Moisture Under Cereal and Forage Crops - Treatment 3 (1983-1985).



13a. Cereal

13b. Forage

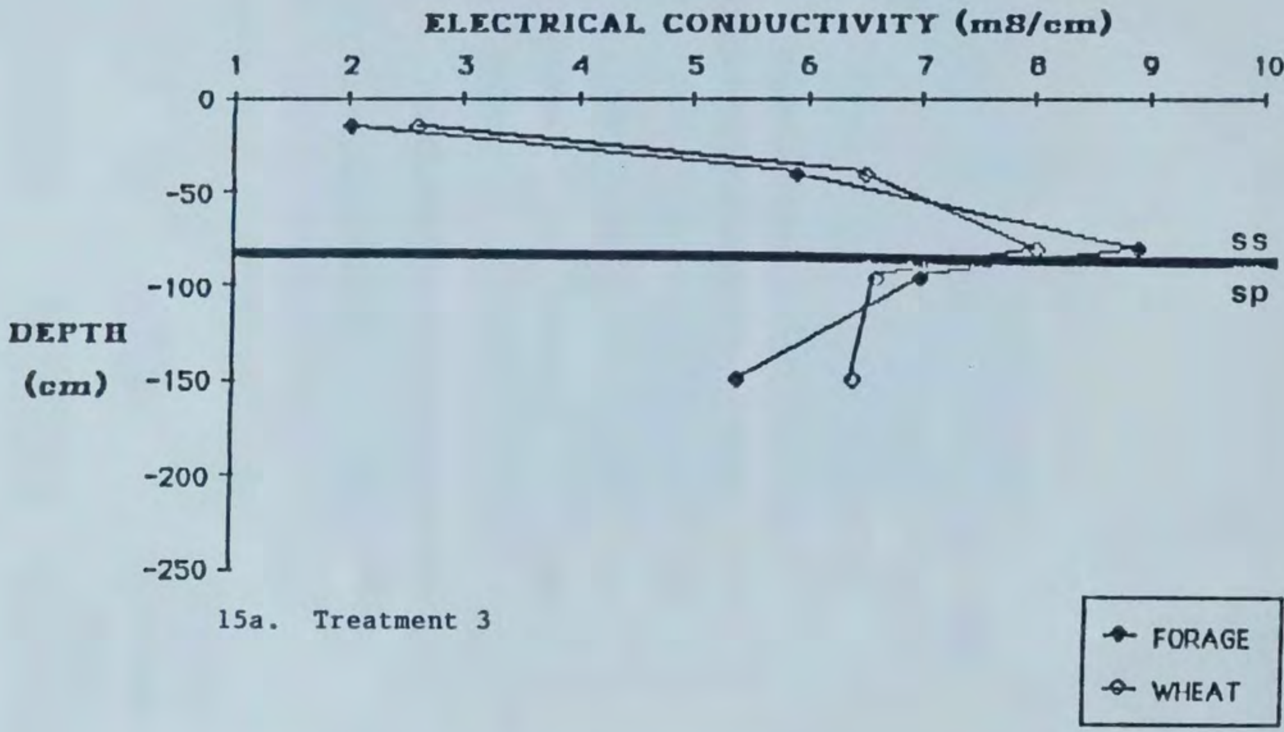
Figure 14: Frequency Distribution of Soil Moisture Under Cereal and Forage Crops - Treatment 6 (1983-1985).



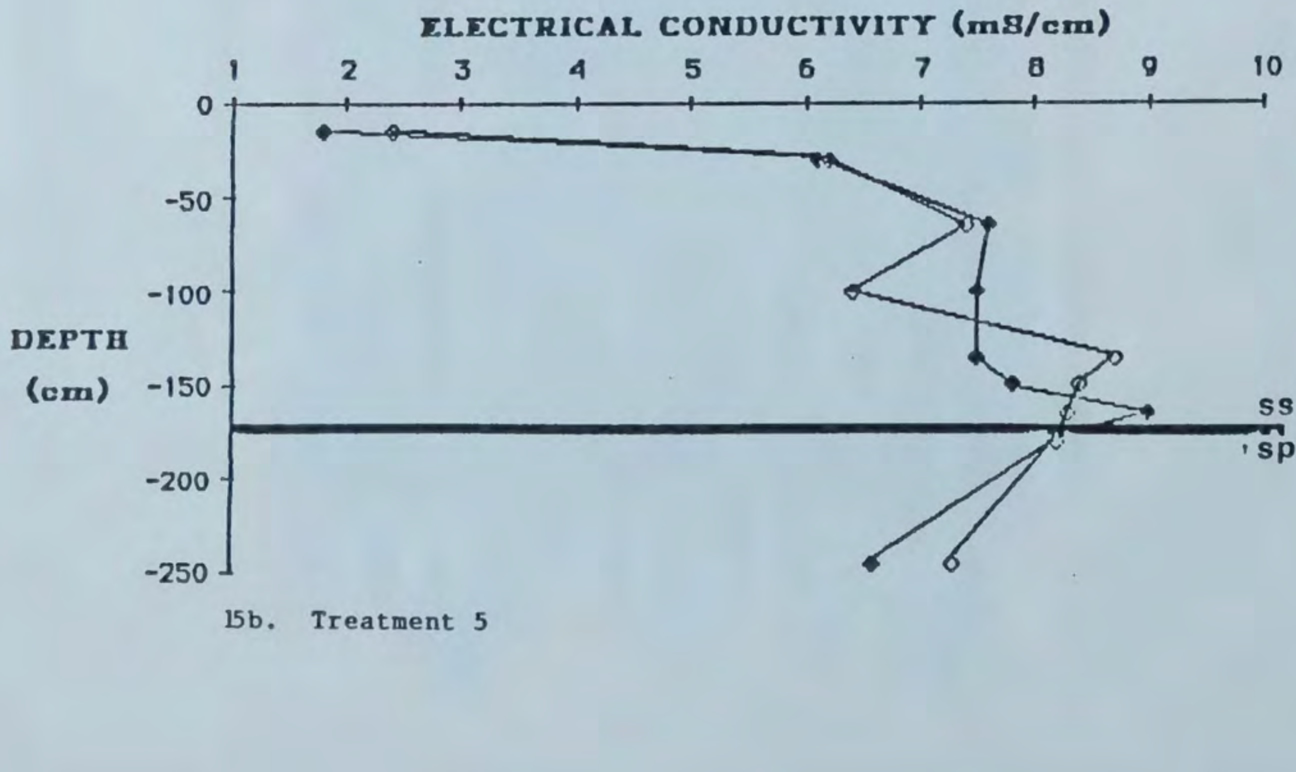
14a. Cereal

14b. Forage

Figure 15: Distribution of Mean EC (mS/cm) with Depth Under Cereal and Forage Crops - Treatment 3 (1985).

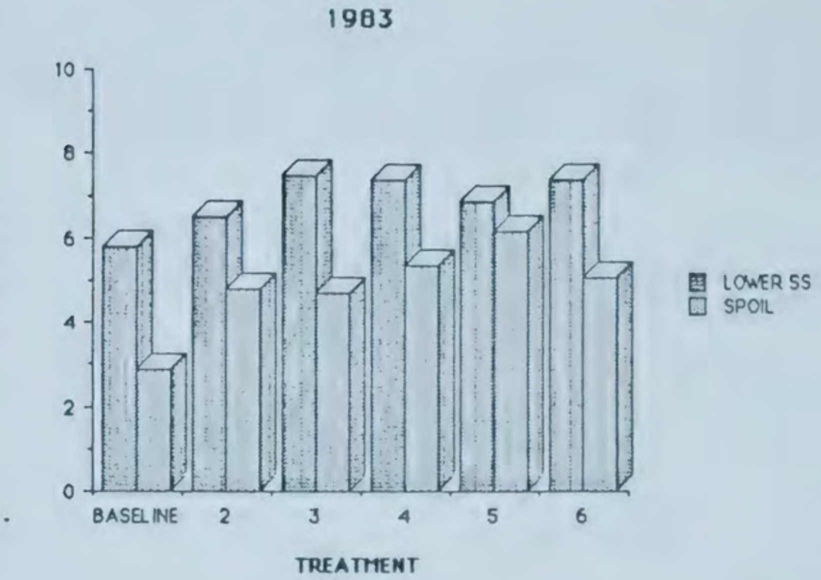


15a. Treatment 3

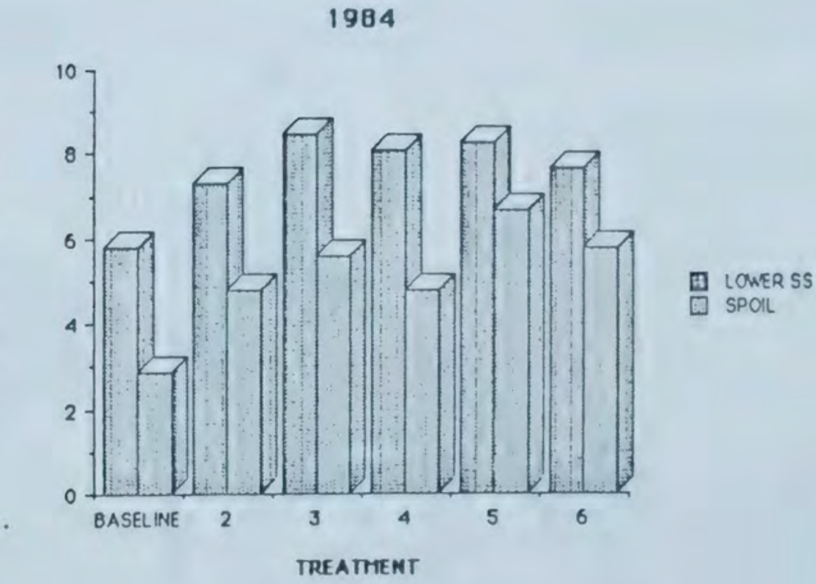


15b. Treatment 5

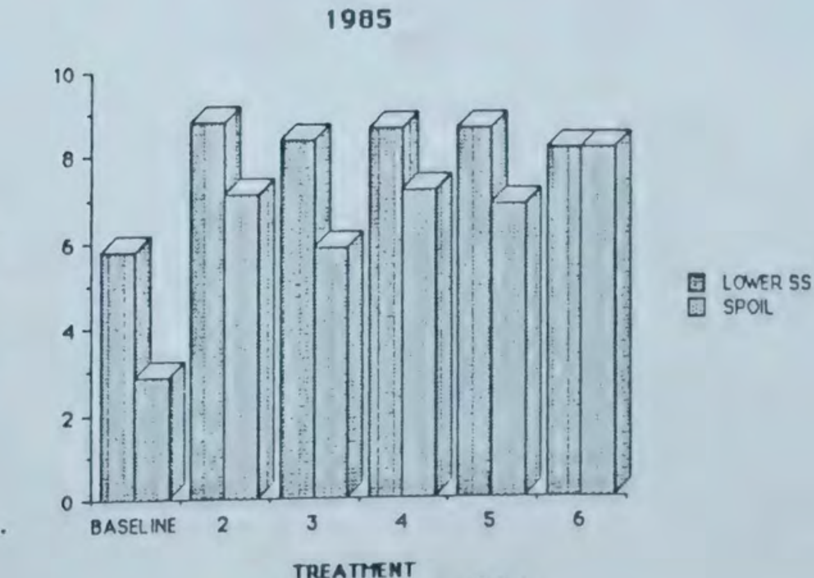
Figure 16: Mean EC (mS/cm) of the Lower Subsoil and Spoil from 1983 to 1985.



16a.



16b.



16c.

Figure 17: Mean Saturation % of Four Materials from 1982 to 1985. Values within materials not accompanied by the same letter are significantly different (p = 0.05).

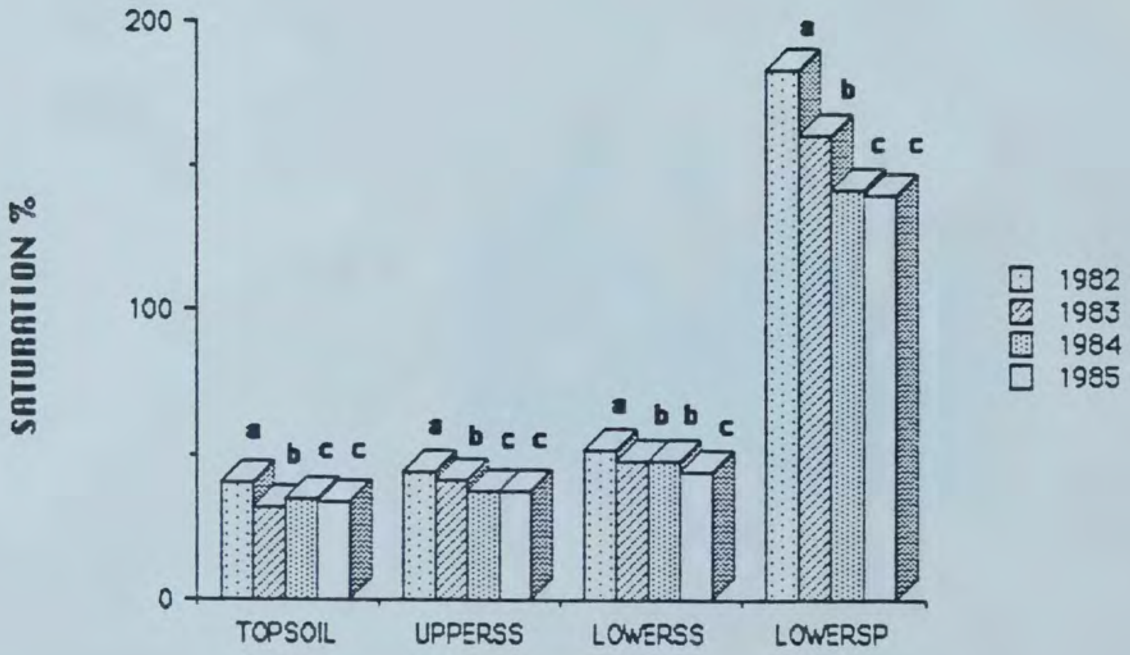


Table 2: Correlation (r^2)* of Saturation % with EC (mS/cm), Na Concentration (meq/L) and SAR for 4 Materials.

Material	EC (mS/cm)	Na (meq/L)	SAR
Topsoil	+ .19	+ .35	+ .57
Upper SS	- .96	- .46	- .35
Lower SS	- .81	- .34	- .40
Spoil	- .75	- .86	- .60

* based on regression of means shown to be significantly different in annual comparisons.

$$\text{EC (mS/cm)} \times 850^{*}\ (\mu g/ml) \times \text{Saturation \% (ml/100g soil)} \times \text{Bulk Density } (g/cm^3) \times \frac{1 \text{ tonne}}{10^{12}\ \mu g} \times \frac{cm}{\text{depth interval}} \times \frac{10^4 cm^2}{m^2} \times \frac{10^4 m^2}{ha}$$

* Source: Stanley/SLN Consulting, 1978.

The appropriate number of depth intervals were summed to 140 cm. Means resulting from these calculated values are presented in Figure 18.

DISCUSSION

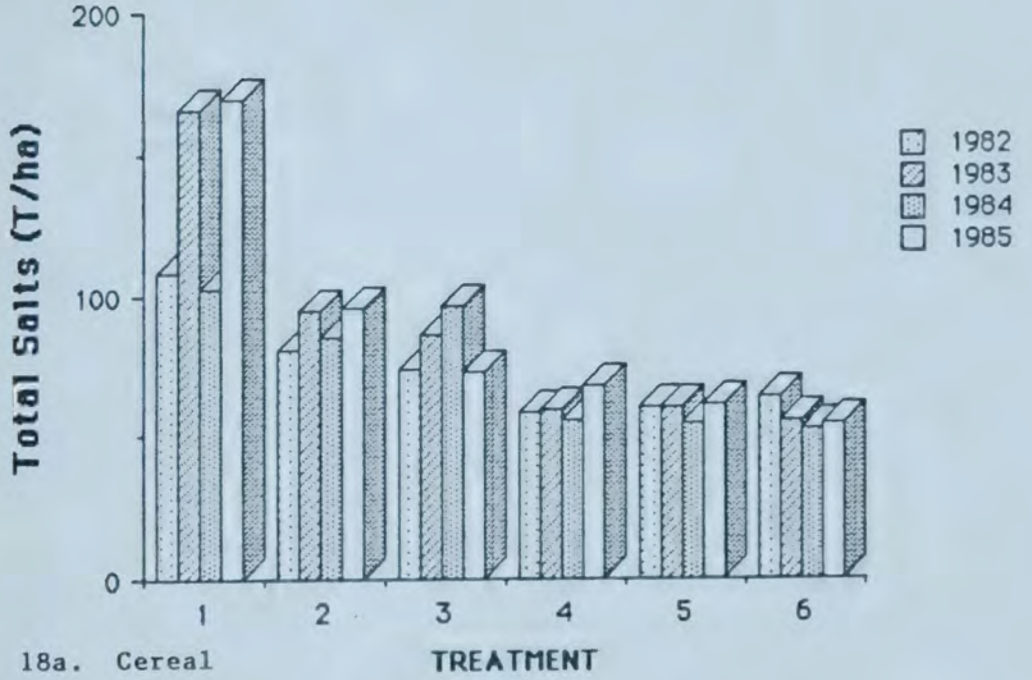
Crop Yields

Results to date suggest that crop yield on the reconstruction site is more dependent on soil moisture status than on soil chemical properties. The four years over which data have been collected have been drier than normal (Figure 2). Regressions of crop yield and total rainfall during the cropping season (May 1 - July 31), showed a high correlation ($r^2 = 0.98$) with first-cut forage yield but a low correlation ($r^2 = 0.28$) with cereal yields.

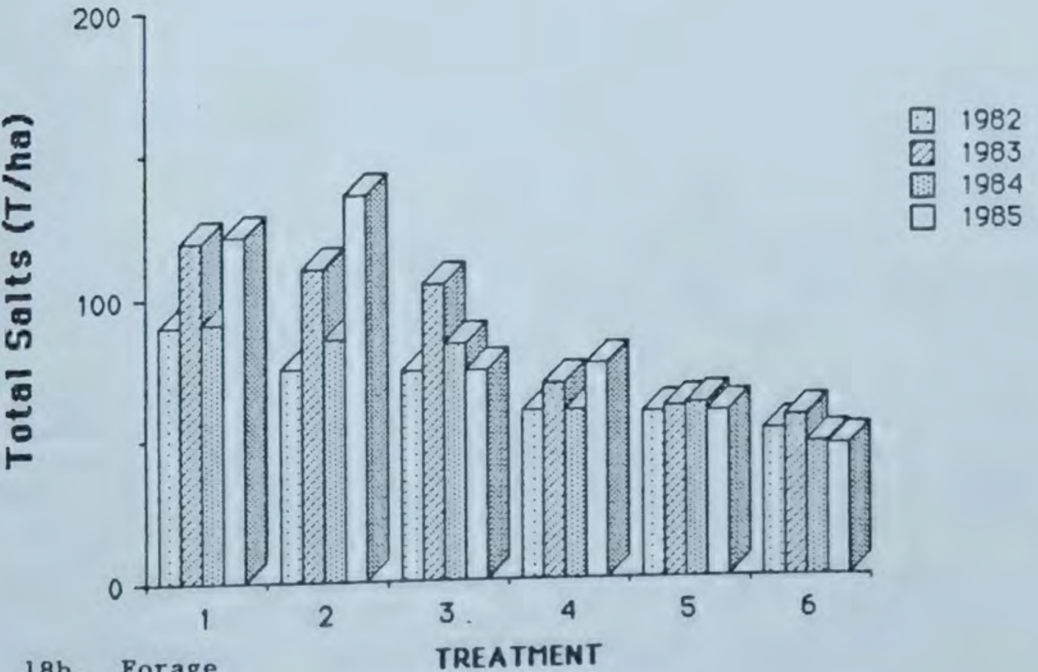
The high correlation of forage yields with rainfall reflects the ability of forage with its extensive rooting system (to greater depth than cereal) to access and therefore extract moisture stored deeper in the soil. Forage yields in every year increased linearly (statistically significant trend) with increased subsoil depth (Figure 3b). This trend is so consistent and strongly expressed it is reflected in long term yields (Figure 4). These yields are relatively independent of distribution of precipitation events which supports the interpretation that forages extract moisture stored in the deeper subsoil layers.

The low correlation of cereal yields to total growing season precipitation appears to reflect the inability of cereals to access soil moisture stored at depth. Since their rooting systems are shallow, yields are responsive to the dynamics of soil moisture status near the surface. Treatment effects on cereal crop yields were not strong nor consistent through the years (Figures 3a and 4) but variations in yield were closely linked to differences between the years in timing of major precipitation events. In 1982 and 1985 precipitation was evenly distributed throughout the growing season allowing good germination in the spring and providing limited moisture during the remainder of the growing season to the shallow rooting system. Consequently, yields were higher in these years than in 1983 and 1984. Although total precipitation during the 1983 growing season was high, the distribution was poor. In early May precipitation was high resulting in excellent germination. Subsequently, a long period with very little rainfall resulted in poor growth and some mortality, indeed the crops never recovered from this early drought. In 1984 the first major rainfall did not occur until

Figure 18: Total Salts (T/ha) in the Rooting Zone (140 cm) Under Forage and Cereal Crops (1982-1985).



18a. Cereal



18b. Forage

mid-June, therefore germination was delayed, uneven, and poorer than in years where rainfall was good in May. As a result yields were lower than in 1982 or 1985 but better than in 1983.

The difference in ability of the two crops to withdraw moisture stored in the soil can be further supported by soil moisture/depth relationships beneath the two crops (Figures 5-7). Trends for soil moisture with depth under the two crops were similar in 1984 and 1985 (Pedology Consultants, 1985;1986). Moisture profiles from three treatments (1, 4 and 6) at the beginning and end of the 1985 growing season are shown in Figures 5-7. Where spoil impedes root development (Treatment 1 - Figure 5) trends for soil moisture are similar for both crops. Where subsoil is 135 cm thick (Treatment 4) the distribution of soil moisture beneath the two crops is different (Figure 6). This difference is most strongly expressed at the end of the growing season. Soil moisture sharply increases below 50 cm under cereal whereas soil moisture remains low to about 140 cm under forage and then sharply increases. These depths (50 and 140 cm) correspond to the depths of rooting observed in the field. Further, the area between the two curves (cereal and forage) likely represents the additional soil water utilized by the forage, but not cereal, crops. A similar phenomenon exists for Treatment 6 (Figure 7). In this case where subsoil thickness is about 330 cm the area between the curves in July is even greater than for Treatment 4.

Soil Chemistry

Results in Figures 8-10 illustrate general trends for soil chemistry by layer and year (no treatment or crop interactions). Values for EC (Figure 8) indicate that in general salinity has increased in the upper and lower subsoil and spoil while it has decreased in the topsoil. Statistical analyses of the difference between upper and lower subsoil, and spoil and lower subsoil, indicate that the rate of increase in salinity is greater in the lower spoil than lower subsoil and greater in the lower than upper subsoil. The significant decrease in EC values for the topsoil should be accepted with caution as a general trend since there is a significant interaction with crop (Figure 11a - discussed later). General trends for SAR (Figure 9) and Na concentration (Figure 10) are similar to those for EC for the topsoil (significant linear decrease) and lower subsoil and spoil (significant linear increase). Only the upper subsoil exhibits no significant linear trend for Na concentration or SAR. The dynamic nature of the subsoil zone (additions and removals of salts/Na from leaching/diffusion and convection) likely accounts for the lack of a consistent linear trend in the upper subsoil.

Although general trend data indicate that salinity and sodicity are on the increase for most materials at depth, and on the decline in the topsoil, significant results at the interaction levels suggest that the rate and nature of these trends vary depending on the treatment (subsoil thickness) and type of crop.

The strongest interaction effects on soil chemistry result from crop influences. Within year values for EC (1983-1985), SAR (1983-1985) and Na concentration (1984, 1985) in the topsoil are significantly lower under forage than under cereal crops (Figure 11). The linear trend for decreasing EC values from 1982 to 1985 (Figure 11a) under forage is highly significant. Although similar trends under forage exist for SAR and Na concentration (Figure 11b,c) they were not shown to be statistically significant.

In 1985 the type of crop also influenced soil chemistry at depth. The differences in EC values between the upper and lower subsoils are significantly greater under forage than under cereal (Figure 12). This may be attributed to a greater decrease in the upper subsoil EC and greater increase in lower subsoil EC relative to baseline conditions, under forage than under cereal crops (Figure 12). Similarly, SAR values of the spoil were significantly higher under forage than under cereal crops (data not shown).

These data (forage - decreasing values in ts, upper ss; increasing values in lower ss, sp) suggest that forage crops tend to produce a leaching environment favouring removal of salts/Na in the upper profile, more so than cereal crops. This may be attributed to differences between the crops rooting systems and their influence on the soil moisture regime. The extensive and deep rooting system of the forage crops when compared to cereal crops maintains drier conditions to a greater depth, for a greater portion of the growing season (Figure 13, 14). The maintenance of dry conditions along with the well established rooting system of the forage crops likely produces a soil structure characterized by numerous voids, cracks and fissures. During the few major rainfall events (common in this region) leaching and removal of salts/Na from the upper to the lower profile is likely favoured under forage over cereal due to greater contact of water with topsoil and subsoil materials. A comparison of soil moisture frequency distribution with depth (Figures 13, 14) with distribution of EC with depth (Figures 15 a,b) further supports this interpretation. In Treatment 3 where rooting depth of the two crops is similar due to impediment to growth by the spoil, trends for EC with depth are similar (Figure 15a) and soil moisture distributions are somewhat similar with forage being slightly drier than cereal at depth (Figure 13). Where more subsoil is present soil conditions are considerably drier under forage than under cereal (Figure 14) and the EC values from 130 to 160 cm depth are lower under forage than under cereal (Figure 15b).

Statistically significant interactions at the treatment level were few and for the most part inconsistent. The only statistically significant and consistent trend was that EC values in the spoil increased at a faster rate than the lower subsoil (Figure 16). The linear trend of the difference between the lower subsoil and spoil was not significant in 1983 but was significant in 1984 and 1985. To discern if improvements in soil chemistry occur in, for example, the rooting zone as a result of increasing subsoil thickness, comparisons should be made at the same depth for the same material across all treatments. In future, this approach should be tested in addition to existing analyses.

Figure 17 illustrates significant differences in saturation %

between years for the four different layers analyzed. Concern arises when differences or trends in means for saturation % mirror those for chemical analyses since results upon which interpretation across years are based may be an artifact of year to year differences in saturation %. Regression analyses of significant means from chemical results with saturation % show that values for EC (upper subsoil, lower subsoil, possibly spoil) and Na concentration (spoil) may co-vary with saturation % (Table 2).

Some of the problems associated with differences in saturation % and comparing profiles of highly variable composition can be dealt with by taking a mass balance (total salt) approach to assessing soil salinity. Total salts (T/ha) in the rooting zone (140 cm) under cereal and forage crops were calculated for 1982-1985 (Figure 18). These data suggest that regardless of crop type salt fluctuations in the top 140 cm are very strong when the spoil is within 150 cm of the surface. In order to discern more clearly the thickness of subsoil necessary to avoid large fluctuations in salt movement mass balance calculations refined to small depth increments may be required. The variability of these data over the years (especially for treatments 1-3) confirms the necessity of long term monitoring to facilitate valid long term predicition of trends for soil quality.

CONCLUSION

Crop yields at the reconstruction sites are more dependent on soil moisture status than on soil chemical properties. This relationship has been observed during a drier than normal four years over which data have been collected. In every year forage, but not cereal, yields increased linearly with subsoil thickness to more than 3 meters reflecting the ability of the forage's extensive rooting system to draw on stored soil moisture. Variable cereal yields were linked to differences between years in the distribution of major rainfall events.

Annual comparisons of the chemistry of the layers above and below interfaces (topsoil, upper subsoil, lower subsoil, spoil) indicate that, in general, salinity and sodicity is increasing at depth (lower subsoil, spoil) and decreasing in the topsoil. It is surprising that there has been so much salt movement under relatively dry soil conditions (and no shallow water table). Significant results at the interaction levels suggest that the rate and nature of salt movement depends on the treatment (subsoil thickness) and type of crop (cereal versus forage). The strongest interaction effects resulted from crop influences. The data suggest that conditions under forages, but not cereals, are conducive to leaching and removal of salts/Na from the upper into the lower part of the profile. This is attributed to forage rooting systems maintaining drier conditions and producing more fissures, cracks and voids, in the subsoil than do cereal rooting systems. During the few intense rainfall events (common to the area) leaching and downward movement of salts is apparently favoured by relatively rapid percolation of water through the fractured topsoil and upper subsoil. Statistically significant interactions at the treatment level were few and inconsistent through the years. In order to discern if upper profile soil chemistry improved as a result of increasing subsoil thickness additional comparisons should be made at the same depth for the same materials across all treatments, and longer term monitoring is recommended.

Regression analyses of saturation % with soil chemical properties (by interface layers) suggest that care must be taken in accepting annual trends for EC (subsoil, spoil) and Na concentration (spoil) since they could be artifacts of analytical differences from year to year. Some of the problems associated with differences in saturation % and comparing profiles of variable composition can be dealt with by taking a mass balance approach to assessing soil salinity. Preliminary total salt (T/ha) calculations indicate that large fluctuations in salt movement occur in the top 140 cm when the spoil is within 150 cm of the surface.

In the four years of monitoring crop yields and soil properties it is clear the evaluation of reclamation success or sustainability of agricultural production is not a straightforward exercise. Different crops lead to different conclusions; variations in rainfall are very important in affecting salt movement; evaluation of soil EC and SAR should be supplemented by salt balance calculations; and rainfall and moisture supplying ability of the soil play key roles in crop productivity as do management practices. Might the production of cereal crops on the prairies, versus native grasses, result in subsoil salinization even where water tables are deep? In the authors' opinion, more comprehensive long term studies should be undertaken to gain a better understanding of interactions of factors influencing soil development. Land reclamation research appears to be ahead of agricultural research in this regard.

ACKNOWLEDGEMENTS

Pedology Consultants acknowledges all agencies and individuals who have contributed to this research project. Funding for research activities is provided from the Alberta Heritage Savings Trust Fund through the Alberta Land Conservation and Reclamation Council (Plains Coal Reclamation Research Program, PCRRP). Special thanks is expressed to:

The Soil-Crop Subcommittee of the Plains Coal Reclamation Research Program for project supervision. Alberta Power Ltd., Luscar Ltd., and Manalta Coal Ltd. for funding of initial construction and on-going participation on the Soil-Crop Subcommittee. Manalta Coal Ltd. has also assisted with on-site activities and problems over the years.

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ISSN 0705-5927

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FOREWORD

The British Columbia Chapter of the Canadian Land Reclamation Association was formed in 1985 to provide a local public forum for the exchange of information and experience in land rehabilitation. Comprised of professionals from a wide range of backgrounds and interests, this organization pulled together quickly to host the 1986 Annual Meeting. The diverse membership in the B.C. Chapter was realized in a program that expanded the scope of the conference to include many fields that have not been represented in past programs. The quality of presentations and range of topics kept audience participation at a spirited level. It is our hope that we have initiated a trend to widen the scope of the annual meetings so as to not focus on traditional mining or energy development issues.

I wish to thank all speakers and attendees for making this first formal function of the B.C. Chapter a success. The enthusiastic support of chapter members in the planning and administration of the conference demonstrated a strong desire for a quality meeting. This drive bodes well for the future of our chapter.

A great deal of effort went into the publication of the proceedings of the 1986 Annual Meeting. Care was taken to accurately reproducce all papers, however minor errors may have escaped the review process. We hope that this will not detract from the information presented by the authors.

May the CLRA and all local chapters continue to grow and function as a focal point for land rehabilitation.