VG602

Benchmarking the quality of krasnozems under horticulture

L A Sparrow, W E Cotching, J Cooper and W Rowley
TIAR, DPIWE, Tasmania

Know-how for Horticulture™

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Benchmarking the quality of krasnozems under horticulture
(VG602)

FINAL REPORT TO THE HORTICULTURAL RESEARCH AND DEVELOPMENT CORPORATION

L.A. Sparrow, W.E. Cotching, J. Cooper and W Rowley

Tasmanian Institute of Agricultural Research
Department of Primary Industries, Water and Environment

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DEPARTMENT *of* PRIMARY INDUSTRIES, WATER *and* ENVIRONMENT

Tasmania

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Summaries

1(a) Industry Summary

Various attributes of 25 Tasmanian ferrosols (deep red clay loam soils on basalt) under 5 different forms of management (beef-sheep pasture, dairy pasture, intermittent cropping, continuous cropping and pyrethrum) were assessed using field, interview and laboratory techniques. We wanted to see how these attributes changed as the intensity of land management increased. A number of attributes varied significantly with management. Among the most notable were soil organic matter and the amount of microorganisms in the topsoil. Pasture paddocks had about 30% more organic matter and about 60% more microbial mass than did continuously cropped or pyrethrum paddocks. Earthworm numbers showed even greater differences, with virtually no earthworms under pyrethrum. Pasture soils also had better looking soil structure, and could be cultivated without risk of damage to soil structure at higher moisture contents than could cropping paddocks. Despite these differences, the cropping paddocks are still in good physical condition when compared to other cropped ferrosols in Australia and other soil types. This was also the assessment of the farmers themselves, as revealed by individual survey. While cropped paddocks have less organic matter, which is an important reservoir for nutrients, they have also been limed. We think that liming has increased the capacity of the remaining organic matter to hold nutrients so that there is no difference in the total capacity of cropped and pasture soils. We need to know by how much organic matter will continue to decrease under intensive cropping to predict whether such management is likely to lead to serious limitations.

1(b) Technical Summary

Various attributes of 25 Tasmanian ferrosols under 5 different forms of management (low-input pasture, high-input pasture, intermittent cropping, continuous cropping and pyrethrum production) were assessed using field, interview and laboratory techniques. We wanted to see how these attributes changed as the intensity of land management increased. A number of attributes varied significantly with management. Among the most notable were soil organic carbon and microbial biomass C in the top 150 mm, which were about 30% less in cropping and 60% less in pyrethrum paddocks compared to pasture paddocks. Earthworm numbers showed even greater differences, with virtually no earthworms under pyrethrum. Pasture sites also had higher water contents at the liquid limit, higher surface soil shear strength, and more water stable aggregates in the surface soil. Despite these differences, the absolute values of most attributes in cropping paddocks were of a magnitude which suggests that Tasmanian ferrosols under continuous cropping are still in good physical condition. This agreed with the views of the farmers themselves, which were obtained by individual survey. The decrease in organic carbon in the cropped soils has not decreased their effective cation exchange capacity, probably because their higher pH due to liming has compensated to large degree. We need to know by how much organic carbon contents will continue to decrease under intensive cropping to predict whether current practices are likely to lead to serious management limitations.

1(c) Publication schedule

A manuscript has been submitted to the Australian Journal of Soil Research for consideration.

A summary of this work was presented as a poster and abstract to the National Soils Conference in Brisbane in April 1998:

Cotching, W.E., Sparrow, L.A., Cooper, J., Rowley, W. and Doyle, R.B. (1998). An audit of Tasmanian red ferrosol quality under intensive production. In "Environmental Benefits of Soil Management." Proc. ASSSI National Soils Conference, Brisbane 27-29 April 1998 (Ed. P. Mulvey). pp. 385-387.

A summary of the project was published in the notes accompanying the Pyrethrum R&D Technical Seminar held in Ulverstone in July 1997.

An article about the project was published in the Australian Soil Science Society Newsletter "Profile" (Issue 111, July 1997).

2. RECOMMENDATIONS

2.1 Extension/adoption by industry

Articles about the project were published in the Devonport Advocate daily newspaper, Tasmanian Country weekly farm journal and the DPIF's publication 'Agriculture Tasmania'.

In July, public presentations of the project work were given in Devonport (15 farmers, 10 agribusiness, and 4 government persons in attendance), Launceston (1 farmer, 5 agribusiness, 3 students and 12 government) and Scottsdale (16 farmers and 3 agribusiness).

Other presentations were given to dairy farmers at a Property Management Planning course in Preolenna as well as a dairy discussion group at Riana.

Presentations were also given at field days and farmer meetings organised by Botanical Resources Australia Pty Ltd.

Each cooperating farmer received a copy of the results for their paddock(s) compared to the averages for each management history.

2.2 Directions for future research

Further work is needed to better define whether organic carbon concentrations in Tasmanian ferrosols will continue to decrease under intensive cropping, and if so, what the equilibrium concentration is likely to be. This would help determine whether current management is sustainable. An application to the Australian Postgraduate Award (Industry) program has been made for a Ph D. student to work on these aspects.

We restricted the current study to relatively flat sites. We know that erosion is a serious problem on steeper land and feel fairly sure that the quality of surface soils on such land would be less than on the sites we examined in the current study. Studies examining eroded sites are warranted and would help to quantify the losses due to erosion.

Analysis to quantify the changes in pore size distribution and plant available water characteristics between management treatments is considered necessary to determine changes in irrigation management required following intensive cropping.

The application for the APAI to study organic carbon has been supported by Botanical Resources Australia, Tasmanian Alkaloids and GlaxoWellcome. It is disappointing that Tasmanian vegetable and potato growers do not see this work, or work on eroded sites, as high priorities.

An aim of the original proposal was to assess variation in soil quality against variation in the productivity and profitability of farming on these sites. We had hoped to use many sites from the previous Farm Best Practice program which had gathered considerable data on farm costs and production for potato paddocks in northern Tasmania. Unfortunately, most of these paddocks were unsuitable for our study either because they were steep sites, were not on ferrosols, or were known to have produced poor potato crops for reasons unrelated to soil quality (eg poor seed or irrigation). In order to establish a suitable group of sites for comparing soil quality, we selected cropping paddocks which were under a range vegetable production. To limit paddocks on the basis of which vegetable they were to grow in the year of the study would have restricted our choices severely. Farmers still want to equate soil quality to profit but this can only be established through long term, controlled trials which were beyond the scope of this study. The feasibility of such trials in horticulture is the subject of a current HRDC-funded project.

TECHNICAL REPORT:

3. INTRODUCTION

Ferrosols are deep, acidic, heavy textured soils formed on basalt or other basic igneous rocks (Isbell 1994), and have characteristic red colour because of their high content of iron oxides which ranges from 5-20% (Moody 1994). The iron oxides, together with smaller amounts of free aluminium oxides (Moody 1994) and relatively high organic matter contents (Oades 1995), help give ferrosols their strong structure. When nutrient limitations are overcome with fertilizers, ferrosols can be very productive agricultural soils. In eastern Australia, they are used to grow a wide range of crops and animal produce. Intensive horticulture is a common use (Cotching 1995).

Because of their excellent physical characteristics, ferrosols show a resilience which means that their degradation under intensive production can be subtle and go undetected in the short term. Soil erosion has the most obvious immediate effect, but Cotching (1995) also identified soil compaction, less stable aggregation and loss of organic matter as major emerging constraints to long term productivity from these soils. Such constraints can lead to decreased infiltration, more runoff and erosion, less favourable conditions for tillage, and lower nutrient retention. Bridge and Bell (1994) studied the effects of more than 50 years of continuous cropping on physical properties of 3 ferrosols in southern Queensland and showed that, compared to matched uncropped sites, the cropped paddocks had higher bulk densities, and lower infiltration rates, aggregate stability and organic matter contents. These effects were thought to contribute to the low average peanut yield in this area (Bridge and Bell 1994). Moody (1994) showed that the chemical fertility of ferrosols is much more dependent on organic matter than is the case for other clay soils because the clay fraction of ferrosols is dominated by low charge kaolin and sesquioxide minerals. Disturbance through cultivation leads to a much greater relative decrease in chemical fertility in ferrosols than in other soils. After several decades of development, loss of up to 50% of the organic carbon (C) originally present under native vegetation has been measured (Oades 1995).

Previous studies (Wright 1987, Oliver 1992, Lobry deBruyn and Kingston 1997, Doyle and Bailey 1998) have attempted to quantify effects of various land management practices on physical properties of Tasmanian ferrosols. Data from 9 sites suggested that both organic C and wet aggregate stability were less in cropped paddocks than in pasture paddocks (Wright 1987). Oliver (1992) reported significant but weak relationships between organic C and both aggregate stability and mean weight diameter for 54 ferrosols, and concluded that organic C was a poor indicator of ferrosol structure status in Tasmania. Doyle and Baillie (1998) found that, compared to a single uncropped site, two heavily cropped ferrosols had higher surface soil penetration resistance and shear strength and lower organic C, cation exchange capacity and water stable aggregates. Lobry de Bruyn and Kingston (1997) showed that trampling of soil by dairy cows slowed ponded infiltration in ferrosols and decreased earthworm numbers.

In this paper, we present physical, chemical and biological data from 25 sites in an attempt to better define the magnitude and significance of differences in the properties of ferrosols under a range of management typical in Tasmania. Intensive vegetable cropping is the land use of prime concern, and we sought to assess the condition of soil managed for this purpose against less intensive management in the region. Our aim was to assess a wide range of attributes rather than make intensive measurements of a limited number of properties. This approach is consistent with current broad views of soil quality (Carter 1996).

4. MATERIAL AND METHODS

Site selection

Twenty-five paddocks with red ferrosol soils (Isbell 1996) (Humic eutrodox, Soil Survey Staff 1990) were selected from 5 districts in northern Tasmania (Table 1). Within each district, sites on basalt flows of similar age were selected, and, although not always possible, we tried to select one site from the following five management systems:

1. Low input (beef/sheep) pasture LIP
2. High input (irrigated dairy) pasture HIP
3. Intermittent cropping (2-5 years cropping in 10) IC
4. Continuous cropping (for at least 10 years) CC
5. Pyrethrum (*Tanacetum cinerariifolium*) PY

Table 1. Site locations and management details

Site number	District	Map reference	Management when sampled
111	Sassafras	458500E 5428800N	LIP
112	Sassafras	458700E 5428400N	LIP
121	Sassafras	457800E 5435500N	HIP
131	Moriarty	455300E 5433600N	CC
141	Moriarty	455900E 5433500N	IP
151	Sassafras	457200E 5430200N	PY
152	Sassafras	456300E 5430900N	PY
211	Forth	441800E 5441900N	LIP
231	Forth	441800E 5441700N	CC
241	Forth	441500E 5442400N	IC
251	Forth	439700E 5441400N	PY
311	West Pine	416800E 5442500N	LIP
321	West Pine	415500E 5444200N	HIP
331	West Pine	417200E 5444800N	CC
341	Cuprona	414500E 5445800N	IP
411	Gawler	427300E 5433600N	LIP
421	Gawler	427300E 5440300N	HIP
431	North Motton	425800E 5436500N	CC
441	Gawler	430500E 5440300N	IC
451	North Motton	426800E 5438500N	PY
511	Scottsdale	545500E 5449000N	LIP
521	Scottsdale	538300E 5437600N	HIP
531	Scottsdale	540700E 5447200N	CC
541	Scottsdale	545600E 5448500N	IC
542	Scottsdale	540600E 5448500N	IC

Potatoes, onions, peas, beans, brassica species, carrots, barley and poppies are grown on the cropped sites. Pyrethrum is a perennial crop which has been grown commercially in Tasmania in the last decade. The pyrethrum paddocks in our study had been planted to pyrethrum for 4-9 years, and all had been regularly cropped with vegetables prior to pyrethrum establishment.

All sites were at altitudes less than 200 m, and had slopes less than 10%. These restrictions were put in place to decrease between-site variability and to minimise erosion as a possible confounding influence. We recognise that erosion occurs in northern Tasmania on cropped land (Cotching 1995), but we wanted to see if we could identify other effects of cropping on soil quality by removing erosion as a likely confounding influence.

Profile description and soil sampling

At each site a pit was dug by spade and the soil profile described to a depth of 1.0 m, with soil attributes described as specified by McDonald *et al.* (1990). All data was entered on the Tasmanian Soils Database.

Twenty cores were taken from an area about 80 m by 60 m using a 100 mm diameter augur. Cores were combined for each of two depths, 0-150 mm and 150-300 mm. These soils were dried at 40°C, ground to pass a 2 mm sieve, and stored in air-tight containers for further analysis as described below.

Ten subsamples of soil from 0-75 mm and ten from 200-275 mm depth were taken at random by spade from the 80 m by 60 m sample area and placed in wooden trays to air-dry in preparation for aggregate size and stability measurements (see below).

Physical tests

Aggregate distribution and stability. The air-dry soil from those samples taken by spade was passed through a sample splitter with 40 mm openings to help mix the samples and to remove a few large clods. Subsamples of 300-500 g were then weighed and placed on a nest of sieves of aperture sizes 9.5, 4.75, 2, 1, 0.5 and 0.25 mm. The sieves were shaken on a mechanical shaker for 10 s and the weight of soil on each sieve after this time was determined. The mean weight diameter (MWD) was calculated as $\mu_i w_i$ where μ is the arithmetic mean size for a particular aggregate size range and w is the proportion of the total sample weight left on the corresponding sieve after sieving.

The 2-4.75 mm aggregates from the dry sieving, weighing between 80 and 200 g depending on the sample, were then placed on a nest of 2 and 0.25 mm aperture sieves and sieved under water for 15 minutes on a wet sieving apparatus (Precision Engineering Company, Melbourne), after Yoder (1936). After this time, soil remaining on the sieves was gently washed into trays and dried before weighing. After weighing, the samples were dispersed in sodium tripolyphosphate and the clay and silt particles decanted to allow aggregate stability to be corrected for the proportion of primary particles in the sample. Aggregate stability was calculated as the proportion of the total sample retained on the 2 and 0.25 mm sieves after wet sieving. Mean weight diameter was calculated as above, but for the range of sieve sizes used in the wet sieving.

A 200-300 g sample of air dry whole soil was also sieved under water for 15 minutes on a nest of sieves of aperture size 4.75, 2, 1, and 0.25 mm after the method of Laffan *et al.* (1996). We wanted to compare this technique with the more commonly used method of Yoder (1936). Both Laffan *et al.* (1996) and Prove *et al.* (1990) recommended the use of samples of whole soil in preference to samples of fixed size range.

Infiltration

Ponded infiltration was determined using a disc permeameter placed on either bare soil (IC, CC and PY sites) or on clipped pasture (LIP and HIP sites). Measurements were made at eight randomly chosen places at each site, and at each place readings were made until flow was steady for at least 10 consecutive readings. The measurements were made when soils were at or near field capacity. On cropped paddocks when the surface 20-50 mm was drier than field capacity, comparisons were made between rates measured with this drier layer in place and with it removed. There was no consistent difference in infiltration rate with or without this surface layer.

Atterburg limits. Liquid and plastic limits were measured on the dried and ground core samples from both depths using the Casagrande method (Standards Association of Australia 1991) and the "thread" method (Standards Association of Australia 1995) respectively. Results were expressed on a gravimetric basis.

Shear strength and penetrometer resistance. A shear vane was used to estimate soil shear strength at 0-100 and 100-200 mm depths. Measurements were made at 10 locations within the sample area at each site. Also at these locations, a recording cone penetrometer (RIMIK CP 20) was used to record penetration resistance each 15 mm to a depth of 600 mm. All shear vane and penetrometer measurements were made when the soils were considered to be at or near field capacity.

Bulk density. Stainless steel cylinders, 75 mm long and 75 mm in diameter, were hammered into the soil at ten random locations and cores collected from 0-75 mm and 200-275 mm depths. Cores with soil intact were excavated and trimmed before the contents were emptied into plastic bags, dried, and then weighed.

Moisture content at field capacity. Soil moisture tension was recorded by inserting a "Quickdraw" tensiometer (Soil Moisture Equipment Corporation) to a depth of 200 mm at 3 randomly selected places at each site between 24 and 48 h after spring rain which was judged sufficient to bring the soil at that depth to field capacity. Soil from 180-200mm was collected, weighed, dried at 105 °C and reweighed to determine gravimetric moisture content.

Chemical tests

The core samples taken by auger were analysed for pH (1:5 H_2O), extractable phosphorus (P) (Colwell, 1963), extractable calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) (1M NH_4Cl at pH 7, method 15A1 in Rayment and Higginson 1992), exchangeable acidity (1M KCl, method 15G1 in Rayment and Higginson 1992), organic C (Walkley and Black 1934 (OC_{WB}) and Heanes 1984 (C_{Heanes})), permanganate extractable C (Moody *et al.* 1997 after Blair *et al.* 1995), and total nitrogen (Kjeldahl digest). Effective cation exchange capacity was calculated as the sum of exchangeable Ca, Mg, Na, K and exchange acidity. Carbon fractions from the permanganate and Heanes determinations were calculated according to Moody *et al.* (1997), i.e. Fraction 1 (F1) was equal to the carbon oxidised by 33 mM $KMnO_4$, Fraction 2 (F2) as the difference between the carbon oxidised by 167 mM $KMnO_4$ and 33 mM $KMnO_4$, and Fraction 3 (F3) as C_{Heanes} minus (F1+F2).

Biological assessment

Earthworm counts. In spring when surface soils had been moist for at least 3 months, spade squares of soil were excavated to a depth of 200 mm at 15 randomly chosen places at each site. The excavated soil was broken by hand and earthworms extracted and counted. Juveniles were distinguished from adults by size and the absence of a saddle, and the adults identified. The species noted were *Aporrectodea caliginosa* and *Lubricus rubellus.*

Seed extraction and counts. One hundred gram subsamples of the surface soil collected for aggregate assessment were placed in a hydropneumatic elutriation chamber which blasted the soil with a jet of pressurised water and washed the dispersed soil through a 0.25 mm sieve, leaving coarse organic matter, including seeds, behind (Smucker *et al.* 1982). This residue was collected by washing the sieve contents onto a filter paper in a buchner funnel and then air drying. The presence in the residues of inorganic matter and organic material other than seeds made counting seeds in the residue difficult. Therefore, the entire residue was sprinkled on top of a 10 mm layer of steam sterilised proprietary potting mix in shallow terracotta trays, covered with about 2 mm of fine potting mix, gently tamped, watered, and allowed to stand in a glasshouse. Seedlings were counted regularly after emergence, and identified to the species level.

Cotton strip assays. Three strips of cotton burial cloth (Shirley Soil Burial Test Fabric), 100 mm by 300 mm, were inserted to a depth of 200 mm below the soil surface at each site in spring (Anon. 1988). After 21 days the strips were recovered and the strength of 20 mm wide horizontal strips from depths of 80-100 mm and 100-120 mm was assessed relative to new cloth by placing them in an INSTRON Tensile Testing Machine and measuring the force required for them to fail. The average rate of strength loss for the 21 days was determined, and this value used to calculate the number of days to achieve a 50% loss of strength in the cotton strip.

Microbial biomass. Sub samples of the air dried surface (0-150 mm) soil taken by auger were remoistened to field capacity with distilled water and allowed to incubate for 7 days at 23°C ± 2°C before microbial biomass was determined by the fumigation-extraction technique of Vance *et al.* (1987).

Farmer survey

Farmers who managed each site were asked to fill in a soil health scorecard containing 35 questions relating to their perceptions of soil, plant, animal and water properties for that site. The scorecard was based on one developed for Wisconsin farmers in the USA by Romig *et al.* (1995). Farmers scored their answers to each question in healthy, impaired or unhealthy categories and the total number of answers in each category was converted to a percentage of the total number of questions answered.

Statistical analysis

Analysis of variance was conducted using management history as the treatment in a completely randomised design. Analysis of variance could not take account of district because of the non-orthogonal nature of the allocation of treatments across districts. Where examination of the data showed non-normality, transformations were performed and analysis of variance conducted on the transformed data. Least significant differences were calculated when the analysis of variance showed a treatment effect at the 5% level. Correlation matrices and linear regressions were calculated for selected data. For the latter, t-tests were used to test for the significance of regression coefficients. Soil profile description data were subject to chi-square analysis. The residuals from contingency tables of management history by response category (eg different grades of soil structure) were standardised and examined for departure from independence.

5. RESULTS AND DISCUSSION

Morphology

Although changes in soil structure were visible to the naked eye (Fig. 1), these were often difficult to quantify. Analysis of residuals from chi-square analysis (Table 2) indicated that structure in cropping sites tended to be weaker and less granular but more angular than in pasture soils. Residual analysis of other descriptive characteristics (Table 3) did not show significant trends.

Table 2. Significant residuals (absolute value > 2) from chi-square contingency table for structure grade and structure type by management history

History	*Structure grade*				
	Weak	Weak&moderate	Moderate	Strong&moderate	Strong
LIP	*	*	-2.5	3.9	*
HIP	*	*	*	*	3.9
IC	*	2.6	*	*	*
CC	3.0	*	*	*	*
Py	*	*	2.5	*	*

	Structure type					
	Granular	Granular + sub-angular blocky	Sub-angular blocky to granular	Sub-angular blocky	Angular blocky + granular	Angular blocky
LIP	2.6	2.1	*	*	*	*
HIP	*	*	*	*	*	*
IC	*	*	*	*	*	*
CC	*	*	*	*	2.0	4.4
PY	*	*	*	*	*	*

Table 3. Descriptive soil properties

	Low input pasture	High input pasture	Intermittent cropping	Continuous cropping	Pyrethrum
Depth of topsoil (cm)	17 - 21	19 - 24	21 - 30	23 - 30	19 - 20
Structure grade	strongly developed	strongly developed	moderately - weakly developed	weakly - moderately developed	moderately developed
Structure size (mm)	< 2 - 20	< 2 - 20	2 - 100	10 - 100	10 - 100
Structure type	granular + subangular blocky	subangular blocky + granular	subangular blocky + granular or angular blocky	subangular blocky or + subangular blocky or granular	angular blocky or subangular blocky + granular
Resistance of topsoil	firm - soft	firm	firm - stiff loose cultivated	firm - stiff loose cultivated	firm - very stiff
Macropores	many very fine	common - many very fine	few - many very fine to medium	many very fine - none	common - many very fine + fine
Live roots	abundant very fine	abundant very fine	few - abundant very fine	few - many very fine	common - many very fine + fine

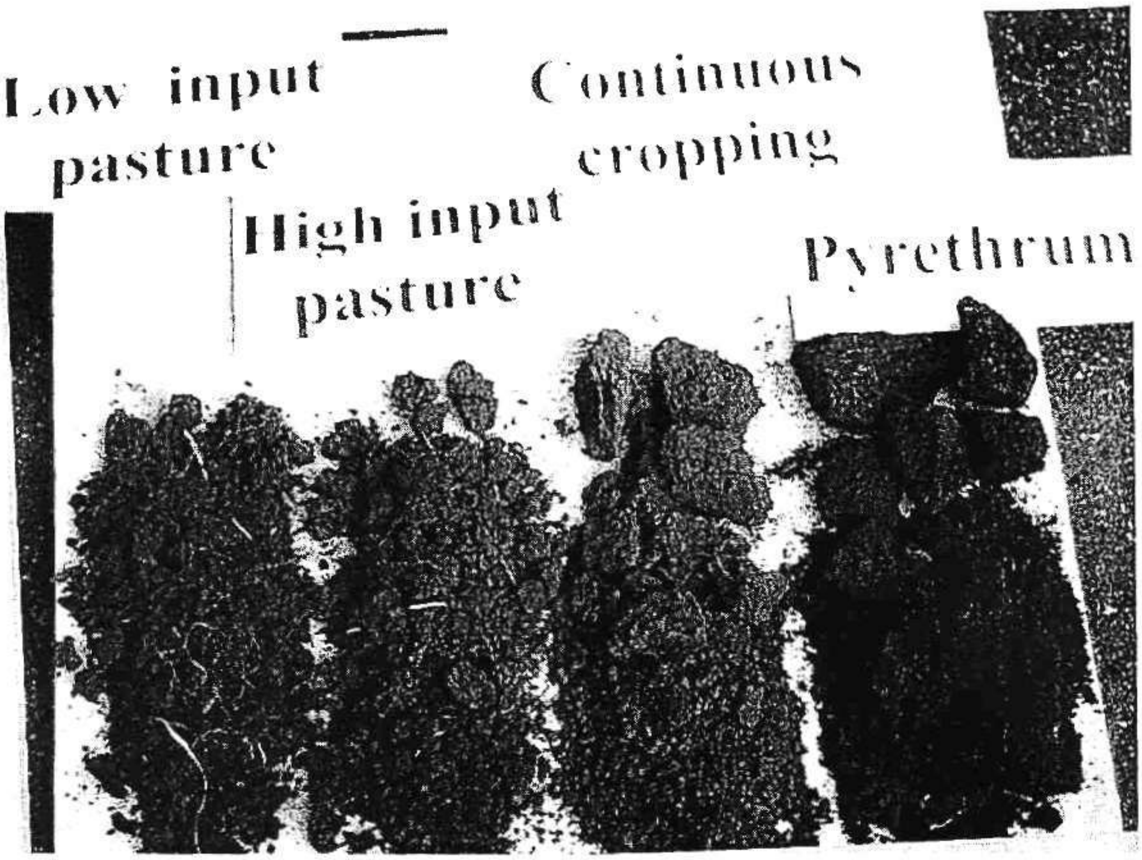

Figure 1. Soil structure under different forms of management.

Chemical tests

A number of chemical measures varied depending on paddock management history (Table 4). Soil pH, extractable P and exchangeable Ca were higher under cropping and pyrethrum than pasture, which probably reflects the greater application of limestone and fertilizer, especially P fertilizer, under cropping. Organic C was about 40% and total N about 50% less under pyrethrum and continuous cropping compared to pasture. Intermittent cropping paddocks gave intermediate values (Table 4). The smaller average organic C and total N concentrations under cropping and pyrethrum are consistent with the greater soil disturbance these paddocks have been subject to (recall that the pyrethrum paddocks were heavily cropped before being planted to pyrethrum). The relative change in organic C of 40% is similar to the change reported for cropped vs. 'native' Queensland ferrosols by Bell *et al.* (1995), but the "equilibrium" organic C concentration in the top 100 mm indicated in Bell *et al.* (1995) for continuously cropped sites was between 1.5 and 2.0 %. In contrast, the average organic C for our continuously cropped paddocks was 3.4% in the surface 150 mm. This is probably due in large part to faster turnover of C at the higher temperatures in Queensland, as Oades (1995) illustrates, although differences in C inputs could also be important. We obtained information from property owners as far back as they could remember about the number of years in which each site had been cultivated. Reliable information dated back only 25 years. Consequently, a plot of organic C versus cultivation frequency (Fig. 2) explained only 1% more of the total variation than did the management history classification (Table 4) (67% c.f. 66%), and also showed no sign that an equilibrium had been reached. Some paddocks with the greatest number of years under cropping had organic C concentrations between 2 and 3 %. Complete histories for all sites may have allowed an equilibrium to have been shown, because anecdotal evidence indicated that some of the continuously cropped and pyrethrum sites have probably been cropped for more than 25 years.

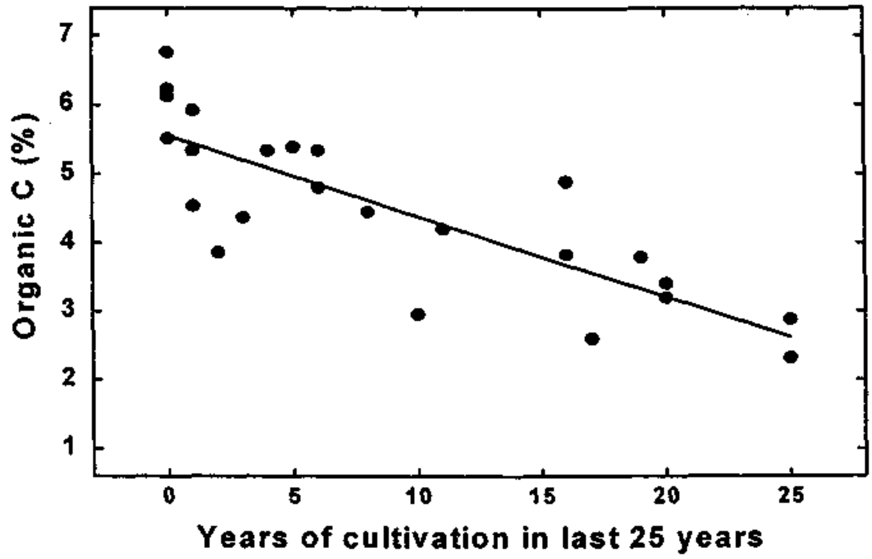

Figure 2. Relationship between Walkley-Black organic C and cultivation history.

The differences in organic C between our sites were not related to the differences in ECEC (*Fprob* of linear regression = 0.276, R^2adj. = 0.01). This contrasts with results comparing developed (cropped or pastured) and undeveloped (forest) ferrosols from various parts of Australia reported by Moody (1994) where developed sites had lower mean ECEC and organic C. The explanation for this may lie in the fact that our developed (cropped) sites had higher soil pH than did our pasture sites (Table 4), whereas the pH of Moody's developed sites was not significantly different to the pH of his undeveloped sites (Moody 1994). Simple linear regression of soil pH against ECEC showed that for our sites soil pH explained 40% of the variation in ECEC (ECEC = -10.46 + 4.19 pH_w, *Fprob* <0.001). Adding organic C to pH in a multiple regression only explained 4% more of the variation. We conclude that the effect on ECEC of the lower organic C concentration in our cropped soils was compensated for by their higher pH due to liming. The importance of organic C as the major source of cation exchange capacity has often been emphasised in ferrosols, where the clay fraction is dominated by sesquioxides and 1:1 minerals of low charge density (Isbell *et al.* 1976, Moody 1994, Moody *et al.* 1997). However, the capacity for lime to compensate for loss of organic C by increasing the ECEC of the remaining C is less recognised and seldom promoted as a way to maintain this component of chemical soil quality (Moody 1994).

The permanganate oxidisable C fractions F1 and F3 were highly correlated with organic C (OC_{WB} and C_{Heanes} Table 5). This agrees with the results of Moody *et al.* (1997) for 32 acidic Queensland topsoils. Because of the high correlation, it is difficult to conclude that these C fractions are any better indicators of soil quality than OC_{WB} and C_{Heanes}. It may be that our soils contain little inert C (Skjemstad 1998 in press), the presence of which might erode the close relationship between organic C and F1, which is the most easily oxidisable C. In contrast to the results of Moody *et al.* (1997), C fraction F2 was less well correlated with either C_{WB} or C_{Heanes}. However, F2 was less well correlated with other soil measures (Table 5), so this difference with the results of

Moody *et al* (1997) does not indicate that F2 is a better measure of soil quality than F1, F3, C_{Heanes} or OC_{WB}.

Biological measures

Pasture soils had the highest microbial biomass C and numbers of earthworms (Table 6). Pyrethrum paddocks had the lowest numbers of germinating seeds, and had almost no earthworms. The effect of management history was similar for both earthworm species recorded, and for juvenile worms (Table 6). There were no significant differences in seed germination for individual plant species (data not shown).

Table 4. Mean values for chemical measures

History	Low input pasture	High input pasture	Intermittent cropping	Continuous cropping	Pyrethrum	ANOVA Fprob
			0-150 mm			
pH_w	5.7ab	5.6a	6.1b	6.5c	6.5c	<0.001
OC_{WB} (%)	5.9b	5.3b	4.3ab	3.4a	3.9a	<0.001
Total nitrogen (%)	0.54b	0.48b	0.35a	0.27a	0.29a	<0.001
C/N ratio	10.9a	11.0a	12.3a	12.6a	13.4a	0.115
C_{Heanes} (%)	6.9c	5.9bc	4.9ab	3.8a	4.2a	<0.001
Carbon fraction F1 (mg/kg)	5.9c	5.0bc	4.1b	3.1a	3.5ab	<0.001
Carbon fraction F2 (mg/kg)	9.4	7.7	7.4	7.2	6.3	0.555*
Carbon fraction F3 (mg/kg)	53.2c	46.5c	37.6b	27.7a	32.1ab	<0.001
Exchangeable Ca (cmol/kg)	9.0a	8.8a	12.8bc	12.0ab	13.3bc	0.030
Exchangeable Mg (cmol/kg)	2.6	2.0	2.0	2.1	2.6	0.216
Exchangeable K (cmol/kg)	1.3	0.8	1.1	1.2	0.9	0.674
Exchangeable Na (cmol/kg)	0.2	0.3	0.2	0.2	0.2	0.124
Exchangeable acidity (cmol/kg)	0.5b	0.5b	0.1a	0.0a	0.1a	0.002*
Exchangeable Al (cmol/kg)	0.38b	0.35b	0.05a	0.00a	0.04a	0.004*
ECEC (cmol/kg)	13.6	12.3	16.1	15.5	17.1	0.078
Colwell P (mg/kg)	512a	78ab	106b	163c	113bc	<0.001
			150-300 mm			
pH_w	5.9ab	5.5a	5.6a	6.4c	6.2bc	<0.001
OC_{WB} (%)	3.7a	3.5a	3.8a	3.4a	3.2a	0.898
Colwell P (mg/kg)	16a	25ab	58c	100d	51bc	<0.001

Within a row, values followed by the same letter are not significantly different (P>0.05); *statistics calculated on transformed data.

Table 5. Correlation matrix for Tasmanian ferrosol properties.

(where Prob = 0.05, r = 0.388; Prob = 0.01, r = 0.496; Prob = 0.001, r = 0.597)

	$OrgC_t$	$OrgC_s$	MWD_tY	$\%WSA_tY$	MWD_sY	$\%WSA_sY$	LL_t	PL_t	LL_s	PL_s	BD_t	BD_s	$Fcap_s$	pH_{wt}	pH_{ws}	ECEC	$C_{Heanes(t)}$	F1	F2	F3	Biomass Ct	Yrlast25
OC_{WBs}	0.490	1.000																				
MWD_tY^B	0.725	0.189	1.000																			
$\%WSA_tY$	0.639	0.213	0.908	1.000																		
MWD_sY	0.675	0.315	0.794	0.769	1.000																	
$\%WSA_sY$	0.527	0.273	0.558	0.695	0.775	1.000																
LL_t	0.790	0.553	0.586	0.525	0.420	0.434	1.000															
PL_t	0.778	0.651	0.502	0.391	0.409	0.389	0.869	1.000														
LL_s	0.657	0.669	0.409	0.422	0.422	0.346	0.573	0.568	1.000													
PL_s	0.625	0.626	0.364	0.367	0.562	0.474	0.533	0.536	0.604	1.000												
BD_t	-0.806	-0.751	-0.591	-0.588	-0.723	-0.583	-0.707	-0.722	-0.694	-0.708	1.000											
BD_s	-0.812	-0.724	-0.585	-0.561	-0.596	-0.556	-0.750	-0.808	-0.808	-0.605	0.811	1.000										
$Fcap_s$	0.488	0.701	0.217	0.140	0.237	0.320	0.606	0.772	0.504	0.557	-0.599	-0.613	1.000									
pH_{wt}	-0.622	-0.267	-0.588	-0.411	-0.434	-0.184	-0.495	-0.506	-0.215	-0.446	0.499	0.345	-0.400	1.000								
pH_{ws}	-0.789	-0.554	-0.680	-0.524	-0.546	-0.266	-0.628	-0.674	-0.605	-0.633	0.666	0.668	-0.527	0.835	1.000							
$ECEC_t$	-0.253	-0.201	-0.574	-0.460	-0.585	-0.263	-0.115	-0.097	-0.127	-0.284	0.358	0.175	-0.113	0.671	0.602	1.000						
$C_{heanes(t)}$	0.976	0.510	0.739	0.657	0.724	0.504	0.730	0.716	0.654	0.669	-0.833	-0.780	0.442	-0.668	-0.824	-0.337	1.000					
$F1_t$	0.962	0.409	0.765	0.663	0.693	0.465	0.726	0.689	0.544	0.588	-0.731	-0.727	0.376	-0.632	-0.776	-0.276	0.970	1.000				
$F2_t$	0.593	0.418	0.380	0.449	0.398	0.341	0.452	0.420	0.602	0.157	-0.587	-0.621	0.216	-0.054	-0.301	0.113	0.611	0.585	1.000			
$F3_t$	0.934	0.459	0.727	0.609	0.710	0.473	0.694	0.692	0.562	0.738	-0.777	-0.697	0.448	-0.771	-0.865	-0.444	0.957	0.925	0.356	1.000		
Biomass C_t	0.543	-0.025	0.646	0.577	0.422	0.308	0.383	0.293	0.179	0.307	-0.220	-0.241	0.064	-0.505	-0.438	-0.247	0.554	0.641	0.189	0.574	1.000	
$Yrlast25_t^C$	-0.768	-0.329	-0.550	-0.516	-0.510	-0.538	-0.504	-0.618	-0.524	-0.470	0.595	0.702	-0.529	-0.525	0.645	0.157	-0.741	-0.701	-0.554	-0.674	-0.400	1.000

[A]The suffixes t and s refer to surface and subsurface soil samples. Refer to the materials and methods for full details. [B]Y=Yoder wet sieving method. [C]years of cultivation in last 25 years.

Table 6. Mean values for biological measures

History	Low input pasture	High input pasture	Intermittent cropping	Continuous cropping	Pyrethrum	ANOVA Fprob
Microbial biomass C (mg/kg)[A]	323a	242b	143c	96c	121c	0.004
A. caliginosa m^{-2}	31b	64c	7ab	5ab	0a	0.007*
L.rubellus m^{-2}	75b	45b	11a	8a	1a	0.017*
Juvenile worms m^{-2}	342d	191cd	79bc	44b	1a	<0.001*
Total worms m^{-2}	448c	300c	97b	57b	2a	<0.001*
Days to 50% strength loss of cotton strips	19.5a	20.6a	13.5a	22.6a	20.8a	0.344
Seed germination (counts/tray)	44.8b	30.3b	48.3b	13.0ab	8.8a	0.026*

[A]From 0-150 mm. Within a row, values followed by the same letter are not significantly different (P>0.05); *statistics calculated on transformed data.

Earthworm numbers in high input pastures were consistent with numbers reported by Lobry de Bruyn and Kingston (1997) for ferrosols in north west Tasmania (100-200 *A. caliginosa* m^{-2} and 20-70 *L. rubellus* m^{-2}). There are no reports of earthworm numbers in Tasmanian cropping systems, but Rovira *et al.* (1987) in South Australia and Haines and Uren (1990) in northern Victoria reported total counts of 100-300 m^{-2} in dryland cereal/pasture/grain legume systems. These counts are higher than those we made in cropping paddocks (Table 6).

The lower earthworm numbers in cropping paddocks compared to pasture paddocks can be attributed to less disturbance, higher organic C and lower use of pesticides in pasture paddocks compared to Tasmanian cropping systems. In other studies, all of these factors have been shown to decrease earthworm populations to some extent (Edwards and Lofty 1977, Lee 1985). With the exception of organic C, these factors probably also explain why worm numbers in our cropping paddocks were less than those in the cropping paddocks of Rovira *et al.* (1987) and Haines and Uren (1990). Vegetable cropping paddocks are more frequently and vigorously cultivated and pesticides are used more frequently.

The reason for the near-absence of earthworms in pyrethrum paddocks is not clear, but may be due to low food supply from the relatively small root system of pyrethrum, the fact that under cultural practices used to date, mature pyrethrum only covers about 50% of the soil and so returns limited amounts of residues, and that weed and disease control in pyrethrum necessitate frequent applications of pesticides. It is also possible that pyrethrum itself is affecting earthworms, although the flowers, the main source of pyrethroids, are removed at harvest, and limited toxicity tests (Edwards and Bohlen 1996) have not shown either synthetic or natural pyrethroids to be toxic to earthworms. All of these possibilities are the subject of further study.

Microbial biomass C varied with history in a similar way to both organic C and the permanganate oxidisable C fractions (Table 6). Microbial biomass C was significantly correlated with these other C measures (Table 5). However, the proportional change in microbial biomass C between management histories was greater than for organic C. This supports the view that microbial biomass C is more sensitive than organic C as an indicator of change in soil quality, as has been suggested elsewhere (Jenkinson 1987).

Management history did not explain variations in the loss of strength of buried cotton strips (Table 6), which we think may have been because for sites with the same history the test strips were wet to varying extents over the 3 weeks of burial, depending on % ground cover, stage of crop growth and plant vigour.

Physical measures

Significant effects of management history were measured for surface soil liquid limit (higher in pasture sites), MWD of surface and subsurface dry aggregates (surface MWD greater in high input pasture, subsurface MWD least in both pasture classes), MWD of both surface and subsurface aggregates after Yoder wet sieving (both pasture classes higher in the surface soil, and low input pasture higher in the subsoil), surface (Laffan %WSA) and subsurface (Yoder %WSA) % water stable aggregates (pasture sites more stable than cropped and pyrethrum sites), ponded infiltration (higher in cropped and pyrethrum sites than in pasture sites), and surface soil shear strength (higher in pasture than cropped sites) (Table 7).

While the differences in Laffan %WSA were statistically significant, even the lowest values were still quite high (Table 7). Laffan *et al.* (1996) regarded 70% WSA as indicative of soil with the highest resistance to breakdown. Our mean Laffan % WSA values were all >70%. However, our values for pasture (Table 7) were somewhat lower than the 96-98% reported by Lobry de Bruyn and Kingston (1997). This could reflect the fact that we sampled soils to 150 mm compared to 100 mm by Lobry de Bruyn and Kingston (1997).

The lower ponded infiltration rate for high input pasture may have been the result of grazing and water management on these soils. Stocking rates are generally much higher for dairy grazing than for beef cattle or sheep grazing and the dairy pastures selected were irrigated. Lobry de Bruyn and Kingston (1997) have shown in a controlled experiment that trampling by stock decreased infiltration by about two-thirds compared to untrampled soil, and irrigated soil had infiltration rates about 40% less than non-irrigated plots.

Profiles of penetration resistance showed that below 200-250 mm there was no significant difference between the 5 management histories (Fig. 3), but at more shallow depths there was a tendency to higher resistance in the pasture sites, probably because of the numbers of grass roots at these sites. We think this root density was also the reason for the higher shear strength of the pasture soils at 0-100mm. Penetration resistance was of similar magnitude to that reported by Prove *et al.* (1990).

Table 7. Mean values for physical measures

History	Low input pasture	High input pasture	Intermittent cropping	Continuous cropping	Pyrethrum	ANOVAF prob

			Surface soil samples[A]			
Infiltration (mm hr^{-1})	666ab	246a	1152bc	1723c	808bc	0.006*
Shear strength (kN)	81.6b	89.2b	52.9a	48.7a	68.2ab	0.017
Bulk density (Mgm^{-3})	0.88a	0.95a	0.98a	1.04a	0.99a	0.183
Dry agg MWD (mm)	6.1a	8.3bc	6.5a	5.9a	7.3ab	0.041
Yoder MWD (mm)	2.6b	2.6b	1.7a	1.6a	1.6a	<0.001
Yoder %WSA	86a	84a	80a	82a	82a	0.335
Laffan MWD (mm)	3.2cd	3.8d	2.3ab	1.9a	2.7bc	<0.001
Laffan %WSA	84bc	88c	75a	77ab	81abc	0.014
Liquid limit (%)	59.7c	58.1c	50.0ab	47.8a	47.1a	0.027
Plastic limit (%)	42.3a	50.4a	42.5a	35.4a	34.7a	0.089
Plastic index (%)	17.4a	7.7a	7.5a	12.4a	12.4a	0.063
			Subsurface soil samples[A]			
Field capacity (v/v%)	39.0a	39.0a	39.4a	34.8a	37.7a	0.268
Shear strength (kN)	92.7a	91.8a	83.2a	74.1a	86.6a	0.620
Bulk density (Mgm^{-3})	0.98a	0.93a	1.04a	1.07a	1.04a	0.236
Dry agg MWD (mm)	5.2a	5.5a	8.2c	7.8bc	7.2ab	0.049
Yoder MWD (mm)	2.1b	1.8a	1.5a	1.6a	1.4a	0.01
Yoder %WSA	88b	87b	77a	78a	79a	0.015
Laffan MWD (mm)	7.1a	6.8a	6.5a	6.5a	6.6a	0.160
Laffan %WSA	84a	81a	79a	83a	81a	0.467
Liquid limit (%)	53.9a	54.4a	50.9a	45.9a	49.2a	0.738
Plastic limit (%)	43.7a	37.8a	39.8a	33.2a	40.5a	0.234
Plastic index (%)	10.2a	16.6a	11.1a	12.7a	8.7a	0.738

[A]exact depth varies with attribute, see materials and methods for detail. Within a row, values followed by the same letter are not significantly different (P>0.05); *statistics calculated on transformed data.

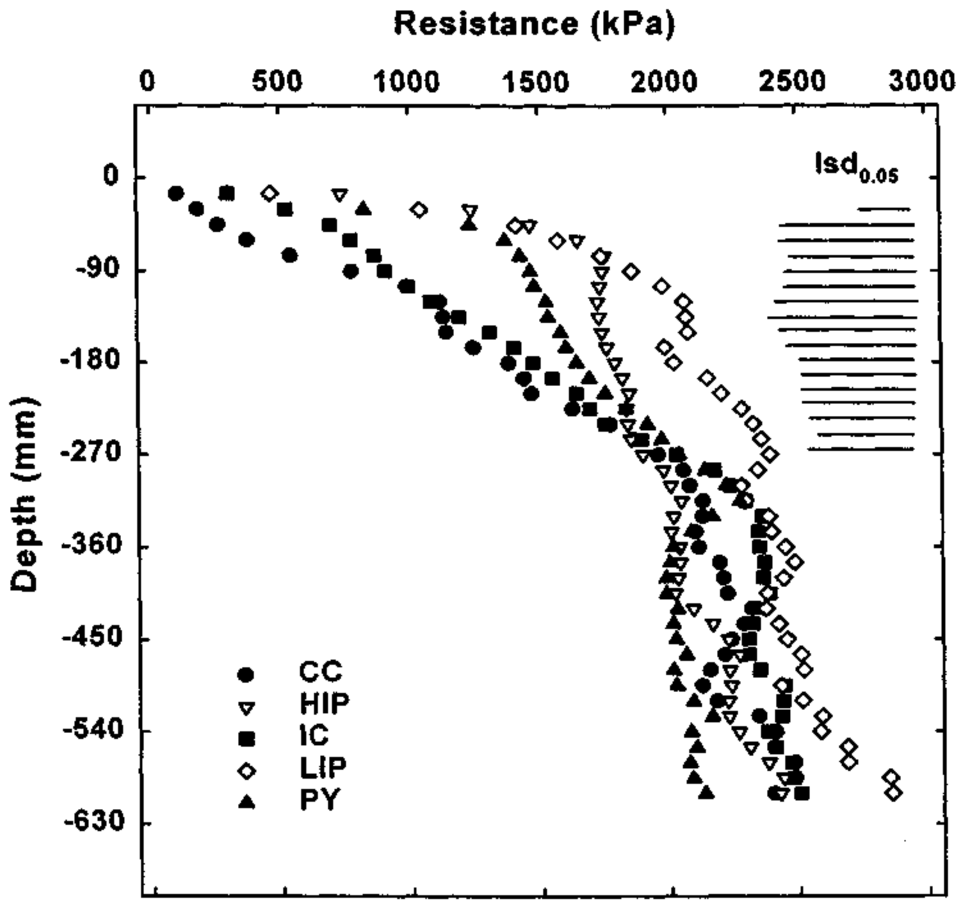

Figure 3. Profiles of average penetration resistance.

Organic C was significantly correlated with a number of soil physical measures (Table 5). The correlation coefficients were mostly positive, except with bulk density, which not surprisingly showed lower values as OC_{WB} increased. Our positive correlation between organic C and Yoder %WSA (Table 5) is in agreement with Hirst *et al.* (1992) but is in contrast to the results for pasture soils of Lobry de Bruyn and Kingston (1997). The latter contrast is probably because our soils spanned greater ranges of both properties.

Management history did not affect a number of the physical measures we made (Table 7). These included surface (0-75 mm) and subsurface (200-275 mm) bulk density, moisture content at field capacity, surface and subsurface plastic limit and plastic index, surface water stable aggregates (Yoder %WSA), and subsurface mean weight diameter (Laffan MWD) and water stable aggregates (Laffan %WSA). Our values for plastic limit were considerably higher than the 22-26% reported by Bridge and Ball (1995) for ferrosols from southern Queensland.

We think that, in spite of the differences in a number of physical properties, even the "worst" soils in this study are still in good physical condition. The changes in some properties (%WSA, dry aggregate MWD) although statistically significant, were still relatively small. Conversely, while mean values for ponded infiltration varied by a relatively large amount, even the lowest value of 246 mm/h in the high input pasture was still high. Although organic C appears to have been lost from the cropping soils, and this appears to have affected many physical properties, the amount of organic C remaining in our continuously cropped soils (3-4%) is still much higher than the concentrations of 1-1.5% reported for heavily cropped ferrosols from Queensland (Coughlan *et al.* 1973, Prove *et al.* 1990, Bridge and Bell 1994), where infiltration rates have decreased, bulk densities have increased and the proportion of fine aggregates after wetting by rain has doubled compared to uncropped sites (Bridge and Bell 1994).

Farmer views

Our view that heavily cropped Tasmanian ferrosols are still in good physical condition is consistent with the views of the farmers themselves (Fig. 4). They generally considered their paddocks to be healthy. There was a tendency for farmers with cropping and pyrethrum paddocks to score more attributes of their paddocks as impaired or unhealthy than did farmers with pasture paddocks (Fig 4), but these differences were not statistically significant (P>0.05). Attributes scored as unhealthy are listed in Table 8.

Table 8. Attributes which farmers scored as unhealthy

Low input pasture	High input pasture	Intermittent cropping	Continuous cropping	Pyrethrum
earthworms	nil	topsoil depth earthworms decomposition of residues	compaction hardness aeration surface crust	organic matter erosion

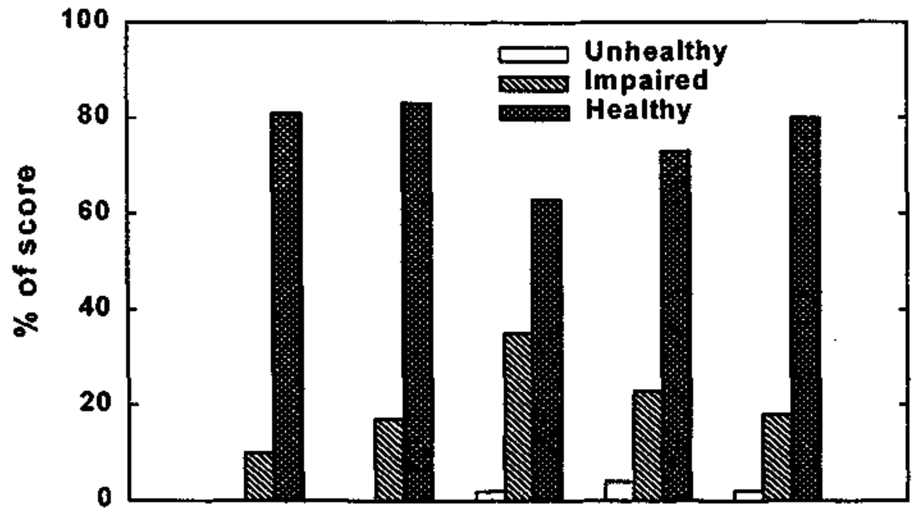

Figure 4. Farmer survey scores in each of 3 categories of soil health. There was no significant effect (P>0.05) of management history on any of the three categories.

6. CONCLUSIONS

The measurements in this study are consistent with the fact that Tasmanian farmers report very few gross limitations to production on ferrosols due to poor soil quality. None of the measures we have made indicate a gross limitation but many significant changes were measured. Any temporary physical and chemical limitations appear to be able to be overcome through current management practices, either tillage to relieve compaction, irrigation, or the application of fertilizers and lime. For some of the measurements we made, particularly the biological measures, the findings are difficult to interpret because we do not have calibration data for them. We think the near lack of earthworms in pyrethrum paddocks is undesirable, but we do not know whether the numbers found in cropping paddocks are adequate. There is an abundance of data such as ours on relative differences in microbial biomass C, but so far there appears to be little information to say just how high or low microbial biomass C should be in certain situations (Duxbury and Nkambule 1994). We are unable to supply that calibration from our study.

We are concerned about the apparent loss of organic C in cropping soils. While the concentrations of organic C in such soils are presently higher than they are in cropped ferrosols in Queensland, and appear to be sufficiently high to generally maintain good soil physical conditions, we are unable from our study to say whether these Tasmanian ferrosols are at equilibrium under continuous cropping, or whether we might expect organic C concentrations in continuously cropped paddocks to continue to decrease in the future. While there is evidence to suggest that considerable change in organic C takes place in the first 10-20 years after cropping begins (Dalal and Mayer 1986, Bell *et al.* 1995), there appears to be far less data to say with confidence how long it might take for a new equilibrium to be reached. However, it would be reasonable to think that any equilibrium in Tasmanian ferrosols would lie above the concentration which would prevail in warmer climates like Queensland, and so would be unlikely to be less than 2% organic C. We are currently planning studies to model C in our soils to verify or refine this prediction. It could be that Tasmanian ferrosols will sustain sufficient C reserves to maintain good physical condition. Gradwell and Arlidge (1971) concluded that, despite a loss of water-stable aggregates, heavily cropped New Zealand volcanic ash soils containing 2-3% organic C were able to sustain vegetable production provided compaction by traffic was minimised. If a similar situation applies in Tasmania, the major soil challenges for our farmers might be to manage soil compaction by tilling and harvesting at the right soil moisture, to manage soil chemistry through judicious use of fertilizers and lime, and to manage soil biology by ensuring sufficient additions and turnover of C and sensible use of pesticides. For research, a major challenge might be to discover whether decreased organic C affects the biodiversity and capacity of the soil for natural pest and disease control.

A final warning relates to our choice of sites with relatively little slope. The loss of topsoil from the many steeper ferrosol paddocks under continuous cultivation in northern Tasmania (Cotching 1995, Richley *et al.* 1997) and elsewhere (Elliott and Cole-Clark 1993) is well documented. Such losses are clearly not sustainable. Studies comparing the quality of eroded soils with those in this paper are warranted.

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8. ACKNOWLEDGEMENTS

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Appendix - press & other articles about the project

Robust reds resilient soils

Seminars to reveal research findings

By BRUCE MOUNSTER

THE impact of present farm-management systems on Tasmania's rich krasnozem (red) soils will be discussed next week at seminars sponsored by the Department of Primary Industry and Fisheries.

DPIF regional land management officer Bill Cotching said the seminars in Devonport, Launceston and Scottsdale would communicate recent Tasmanian research findings to primary producers.

The benefits of applying lime to a variety of Tasmanian soils and the potential for using finely crushed lime would also be discussed.

At krasnozem soil sites between West Pine and Scottsdale, researchers involved in the $40,000 krasnozem study produced evidence suggesting that primary producers could continue common farm practices without destroying the soil — provided soil erosion was kept in check and there was some rotation between crops and pasture.

Mr Cotching said work done in the past 12 months by DPIF and the Tasmanian Institute of Agricultural Research scientists showed that continuous cropping regimens on krasnozem soils had reduced organic carbon and nitrogen levels by 40% compared with soils under pasture.

The carbon-nitrogen measurements were an indicator of the humified organic matter content of soils — a key indicator of soil structural stability and nutrient supply power.

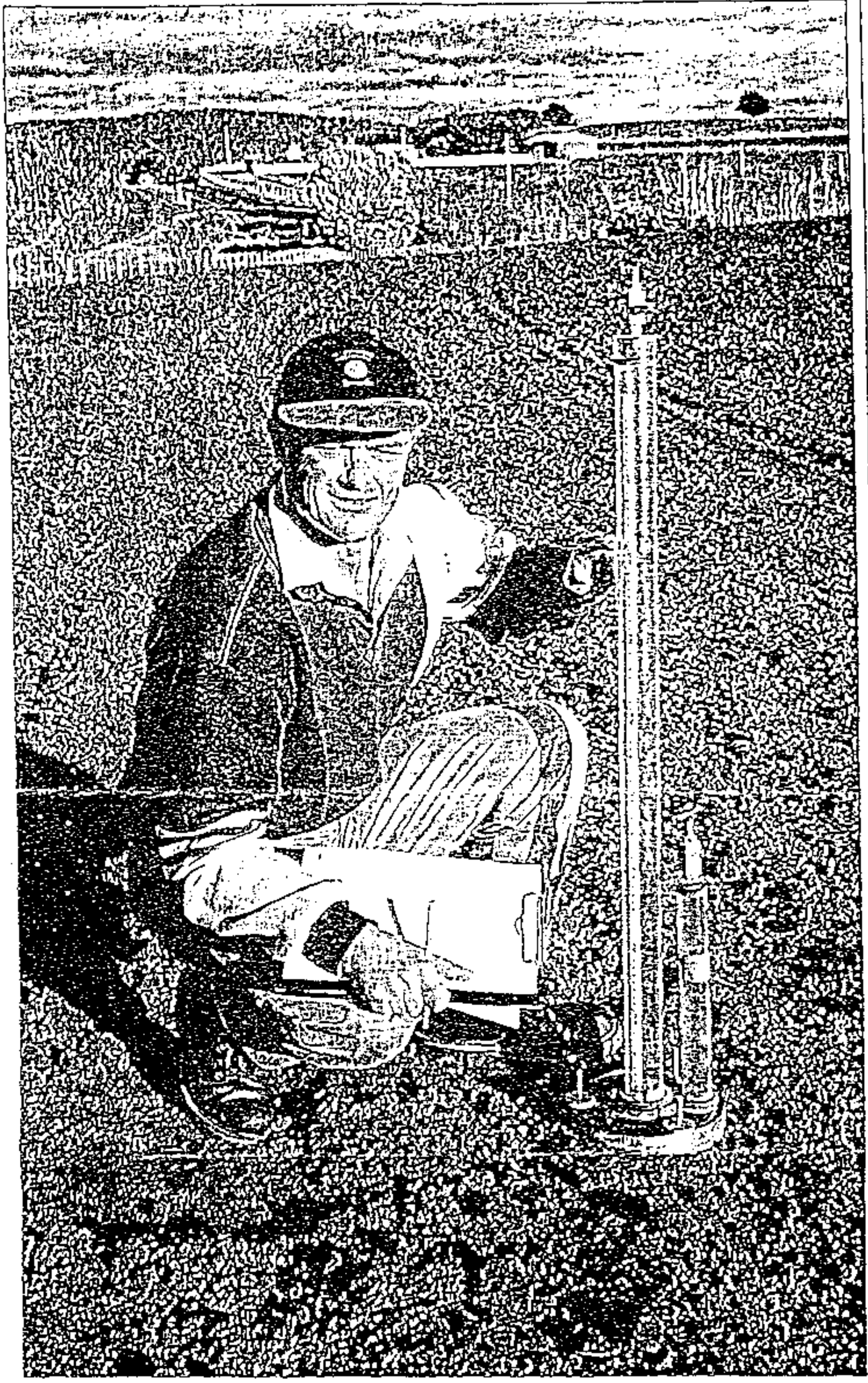
However, the researchers did not detect any significant soil structure decline or yield losses associated with the organic matter deficiencies found in krasnozem soils.

"We are not sure if soil carbon has reached critical levels," he said.

Soil organic matter levels were higher in soils that had supported a mixture of cropping and pasture, compared to levels after continuous cropping.

Mixed cropping and pasture regimens also produced the highest soil microbial activity — another important soil health indicator.

"Earthworm numbers are also significantly less under cropping than pasture," he said.



DPIF officer Bill Cotching using a disk permeameter to measure water-infiltration rates into Tasmania's red krasnozem soils. Picture: TONY CROSS

However Mr Cotching said continuous cropping regimens caused higher chemical fertility in krasnozem soils.

"The pH went up," he said. "Phosphorous and potassium levels also increased, which is good for plant nutrition."

Nobody knew the point at which the positive benefits of extra chemical fertility would be counteracted by the degradation of soil health associated with loss of microbe activity and organic matter.

"Even the degraded krasnozems are still in relatively good condition, compared to most other soil types in Tasmania," he said.

"It is a versatile robust soil, resistant to change."

Water infiltration rates into the soil is a measurement to assess soil structure.

Bulk density tests also suggested that soil compaction was not a significant problem on krasnozem paddocks under intensive cropping.

Mr Cotching said the study indicated that pyrethrum crops produced no positive effects on soil health in terms of structure, microbe and earthworm activity.

Work on pryethrum would continue this year — examining paddocks under crops planted after pyrethrum.

Mr Cotching said researchers also wanted to investigate soil health on eroded sites. All of the sites for the study were flat and not subject to erosion.

It was also unclear if green manure crops boosted soil health indicators to the same extent as pasture rotations.

The seminars will be held in Devonport on July 21 at Stony Rise Government Centre at 7.30pm; Launceston July 22 at Prospect government offices 10.30am and Scottsdale, July 22 at Scottsdale Golf Club 7.30pm. For information contact Bill Cotching on [illegible]

The Primary Producer 2

Coastal soil the subject of study

SOIL STUDY: Bill Cotching, soils officer with the DPIF, talks soil with one krasnozem owner, Robert Addison, of Sassafras.

RICH, red volcanic krasnozem soil, the pride of the North-West, is the subject of a year-long study into sustainability of our soil usage.

Dr Leigh Sparrow, of the Tasmanian Institute of Agricultural Research, and Bill Cotching, of the DPIF, have begun the characterisation of the soils, used for intensive vegetable production and dairying on the North-Coast of Tasmania.

The study aims to investigate the differences between krasnozems, which have been intensively cropped for many years, and those under periodic cropping, irrigated dairy pasture and dryland pasture.

Some paddocks under the perennial crop pyrethrum are also being examined.

The study is the first to be jointly funded by local industry, and the Horticulture, Land and Water and Dairy Research Corporations, soils officer Bill Cotching said.

"Local companies McCain's, Botanical Resources Australia, Tasmanian Alkaloids and Glaxo Wellcome have all provided funding and support for the project because they are concerned to ensure that current farming practices are sustainable," Mr Cotching said.

A range of physical, chemical and biological characteristics of the soils will be investigated with the help of technicians Jamie Cooper and Bill Rowley.

Five paddocks in each of the different management categories will be assessed in each of five districts — Don, North Motton-Gawler, Scottsdale, Sassafras and West Pine.

Diary

June 16: Soup and sandwich lunch, Central Coast group, Tasmanian Women in Agriculture. Red Cross Hall, King Edward St, Ulverstone. Midday.

Central Coast mayor Sue Smith will have lunch then speak (at 1.15 p.m.) on weed eradication in the Central Coast Municipality, after which members may ask questions.

Bring a friend. Cost $5 per person. RSVP to June 6429 1225, or Joy 6425 6512 by June 14.

Forward diary details to: Michelle Paine, Rural Reporter, The Advocate, PO Box 63, Burnie, 7320.

Pivot revamps newsletter

PIVOT HAS launched its revamped, new-look newsletter — with a specific Tasmanian edition — called the Prescription Farmer.

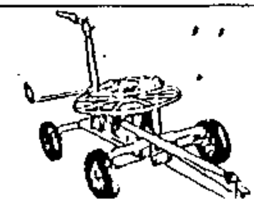
The glossy publication, which was called Pivot Points, has four editions across Australia.

Each edition features national items as well as regional news.

Corporate and agronomic news will be covered.

Featured will be Pivot's Prescription Farming Programme, Site Specific Technologies and stories on local farmers.

THE RURAL



For Sale

ECHO chainsaw, 81DBA, $350 or near offer. Phone 6433 3462.

FENCE DROPPERS, hardwood, $35 per 100. Robinson's Sawmill,

Wanted to Buy

BINTJE POTATOES, good money paid. Phone 6424 9370, if no answer phone 6428 2263 A/hrs.

VEGIE LINK

Bimonthly news and views on the Tasmanian Vegetable Industry

Free Book for Onion Growers

Field Guide to Cream Gold Onion Disorders & their Control in Tasmania.

An industry and HRDC funded project has facilitated the production of this book, with the assistance of DPIF.

This 48 page pocket book provides a practical reference for the preliminary identification of onion disorders commonly encountered in the field. The book is designed to be used in conjunction with regular crop monitoring, so any disorders can be evaluated on the spot.

Containing over 70 colour photographs, it covers 15 diseases, 10 insects and 16 physiological and environmental disorders including background information and general control strategies where appropriate. A few of the disorders are more easily detected post harvest, but have been included if they arise from conditions in the field.

Specific chemical control recommendations have not been included in this guide as they can change from time to time. Instead, it is recommended growers contact the appropriate field officer or chemical supplier for the most effective current chemical control and any changes to management strategies.

Although written for Tasmanian growers, the book covers most of the main onion disorders that occur throughout Australia. Three diseases in particular are featured; onion white rot, downy mildew and botrytis neck rot. Other disorders with significant contributions include thrips, cutworm, white fringed weevil, nematodes, bacterial soft rot, fusarium rot, pink root, and shape and skin disorders.

One copy, free of charge, will be distributed to all onion growers registered with TFGA. Additional copies will be available at the DPIF's Devonport office. The cost is yet to be determined, but is likely to be $10 each. The book should be available in early July 1997.

Dr Jason Dennis
Principal Plant Pathologist, DPIF
(03) 6421 7695

Local Soil Research

Bill Cotching talks turkey with one krasnozem owner, Robert Addison, of Sassafras

Dr Leigh Sparrow of the Tasmanian Institute of Agricultural Research and Bill Cotching of the Department of Primary Industry and Fisheries have recently begun a 12 month characterisation of Tasmanian krasnozems. These are the rich red volcanic soils used for intensive vegetable production and dairying on the north coast of Tasmania.

The aim is to see what differences exist between krasnozems which have been intensively cropped for many years compared with those under periodic cropping, irrigated dairy pasture and dryland pasture. Some paddocks under pyrethrum, a perennial crop, are also being examined.

The study is the first to be jointly funded by local industry, and the Horticulture, Land and Water and Dairy- Research and Development Corporations. Local companies McCains, Botanical Resources Australia, Tasmanian Alkaloids and Glaxo Wellcome have all provided generous funding support for the project because they want to ensure current farming practices are sustainable.

A range of physical, chemical and biological characteristics of the soils will be investigated with the help of two technicians, Jamie Cooper and Bill Rowley. Five paddocks in each of the different management categories will be assessed in each of five districts - Scottsdale, Sassafras Don, North Motton/Gawler and West Pine.

For more details contact Dr Leigh Sparrow or Bill Cotching on 131368.

Articles for this section are co-ordinated by Nathalie Jarosz, Horticulturalist, Crops Branch, Department of Primary Industry and Fisheries, Devonport. Telephone (03) 6421 7637

Do you know how healthy Tasmania's krasnozem soils are ?

Soil Management Seminar

presenting

Krasnozem soil quality

Dr Leigh Sparrow & Bill Cotching

Liming trials on pastures

Mark Freeman

Use of fine lime

Peter Johnson

Tuesday 21 July, 7.30 -9 pm Devonport
Stoney Rise Government Centre
refreshments provided

Wednesday 22 July, 10.30am -12 noon
Launceston
Prospect Government Offices
Conference room 2

Wednesday 22 July, 7.30 -9 pm
Scottsdale Golf Club
refreshments provided

ALL WELCOME

High profile for krasnozems

Leigh Sparrow of the Tasmanian Institute of Agricultural Research and Bill Cotching of the Department of Primary Industry and Fisheries have recently begun a 12 month characterisation of Tasmanian krasnozems (ferrosols). The aim is to see what differences exist between krasnozems which have been intensively cropped for many years compared with those under periodic cropping, irrigated dairy pasture and dryland pasture. Some paddocks under pyrethrum, a perennial crop, are also being examined.

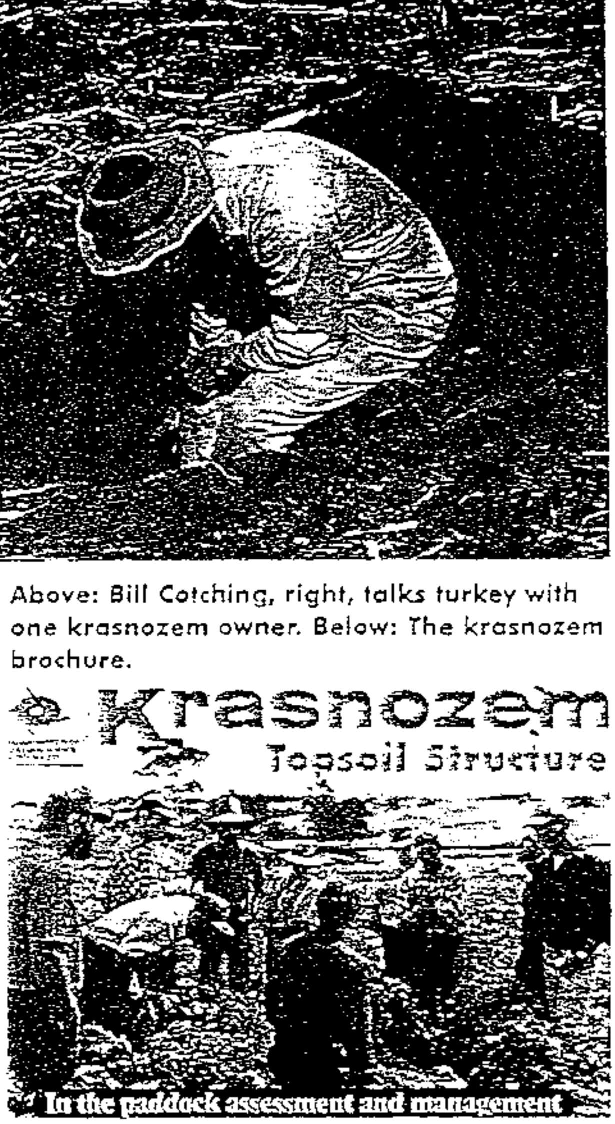
The study, which is the first to be jointly funded by local industry, HRDC, LWRRDC and DRDC, will assess a range of physical, chemical and biological characteristics of the soils. Five paddocks in each of the different management categories will be assessed. For more details contact Leigh on 03 6336 5379, fax 03 6336 5230, or email lsparrow@aries.dpi.tas.gov.au.

Krasnozem brochure

Bill has recently compiled a high quality illustrated brochure on management of krasnozem soils titled *Krasnozem topsoil structure - in the paddock assessment and management*. He compiled it for the Tasmanian zone of the Australian Institute of Agricultural Science using proceeds from the zone's national krasnozem conference in 1994.

The brochure is full of colour photographs showing symptoms of good and bad soil structure. Some symptoms can be recognised by looking at overall paddock conditions such as ponding, patchy crop growth and uneven flowering. Other symptoms require digging a spadeful of soil to look for fine fibrous roots, clods and roots along clod surfaces. Readers will be able to use the brochure to analyse soil aggregates for structure condition.

Above: Bill Cotching, right, talks turkey with one krasnozem owner. Below: The krasnozem brochure.



Also included is a list of recommended management practices to improve soil structure, including growing green manure crops, retaining crop residues and deep ripping compacted areas.

Some 4000 copies of the brochure are being sent to other Australian areas with krasnozem soils. If you'd like a free copy, contact Bill at DPIF, PO Box 303 Devonport 7310, tel 03 6421 7653, fax 03 6424 5142.

Infiltration program

As an aside, Jamie Cooper, a technical officer working on the project, has developed a simple computer program which allows a 286 laptop computer to replace a stopwatch in timing infiltration. This has saved a lot of time previously spent retrieving and manually recording readings stored on the stopwatch. No doubt others have already made this quantum leap but if anybody wants a copy of the program please contact Leigh Sparrow as above.

Media Watch
press clippings

Organic carbon key to maintaining soil condition

By Bill Cotching, DPIF 32

SOIL workability depends on the amount of organic matter in your soil.

Research on Tasmania's rich, red krasnozem soils has found that soils with high organic content remain friable at greater moisture contents than soils with low organic carbon content.

This research, conducted by the Department of Primary Industry and Fisheries and the Tasmanian Institute of Agricultural Research, was the subject of a series of public seminars in July.

Results indicated that soils with carbon content of 6 p.c. remain friable with as much as one and a half times more moisture (53 p.c. moisture by weight). At moisture contents greater than these values, soils become plastic and, therefore, more susceptible to structural damage from trucks and stock.

Paddocks with high organic carbon content can be worked or stocked for more days over the critical winter/spring period without causing damage to soil structure. Organic matter also helps the soil store moisture for plant use.

Research showed that topsoils with 6 p.c. carbon retained one third more moisture at field capacity than topsoils with 3 p.c. carbon. It is this moisture that is stored in the soil for plant use when rainfall stops. The research found long-term pastures had the highest levels of soil carbon — more than 6 p.c. — and heavily cropped paddocks as little as 2 p.c.

Farmers should make sure they include carbon in their soil tests. The results can be monitored over time to see if a farmer's existing rotation is maintaining carbon.

Organic levels do not change rapidly. They can only be built up over a long period — 10 years or more. This is why soil organic carbon is a useful measure of soil health and the sustainability of each farmer's management system.

Levels of organic carbon are critical to maintaining local soils' peak physical condition.

Vigorous pastures in a rotation, or ryegrass green manures over autumn and winter, are probably the only way to maintain organic carbon levels.

For more information, call 6421 7653.

The Advocate, Wednesday, August 19, 1998