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DEPARTMENT OF AGRICULTURE
Western Australia

SUMMARY OF EXPERIMENTAL RESULTS 1982

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SOIL PHYSICAL CONDITIONS AND CROP PRODUCTION

1a. DIFFERENCES IN WATER BALANCE AND RESULTANT CROP GROWTH RELATED TO SOIL STRUCTURE : MERREDIN RED BROWN SOLONIZED EARTH

The long term continuous tillage trial at Merredin (77M13) has been monitored for changes in soil structural condition in the surface layer for some years. During 1982 various aspects of the soil structure were assessed on this trial and the adjacent rotational trial (77M56) and related to a water balance and crop growth study to determine the effect of tillage treatment on structural stability and crop water use.

Measurements were made of characteristics of the surfaces of three treatments:

(i) district practice (ploughed, scarified and combine seeded) (DP)

(ii) minimum tilled (sprayed with paraquat-diquat and seeded with a combine. (CDD)

(iii) zero tilled (sprayed with paraquat-diquat and seeded with a Walker disc-drill). (TDD)

The infiltration characteristics of the soil surface were measured with a rainfall simulator, once in March before any tillage operations when stubbles were still standing on the cropped portions of treatments, and once in early July after seeding when 68 mm of rain had already fallen in the growing season. The depth to the natural wetting front resulting from this amount of rain was also determined using a "Bush" recording penetrometer in transects across plots, taking readings every 18cm distance. This method achieved a greater precision than is possible with the neutron meter (minimum resolution > 15 cm) and revealed marked non-uniformity in the depth to wetting associated with the macro-cracking structure of this soil type.

TABLE 1 : Rainfall simulator results

	Surface Condition	Time to Ponding* (mm) DP	CDD	TDD	Av. depth of wetting** (cm) DP	CDD	TDD
Continuous crop							
77M13	Stubble	10.0	10.9	7.6	4.0	6.5	5.0
	Seeded	10.0	15.5	12.5	6.5	7.5	7.0
Rotational							
77M56	Stubble	3.0	3.0	2.0	3.0	7.0	4.5
	Seeded	9.0	8.0	10.0	6.0	7.0	6.0
	Pasture April	2.0	3.2	1.5)	2-15 depending		
	Pasture July	4.0	3.0	3.0)	on cracks		

* Infiltration rate 24 mm h^{-1}. ** 20 minutes at 40 mm h^{-1}.

The time-to-ponding was only significantly different between treatments in the continuous crop seeded situation but there was a highly significant difference ($P < 0.001$) between surface conditions irrespective of treatment or trial. Surfaces which were rough (through tillage) infiltrated faster than flattened surfaces.

When the wetted surface was scraped away the macro-crack structure of the underlying subsoil indicated a minimum unit spacing of 50 cm (horizontal plane) and 30 cm (vertical) (see Table 2).

Water storage in the profile was monitored on three replicates of each treatment from seeding to harvest. The CDD treatment had approximately 16 mm more water in the top 1.3 m at seeding than the other two treatments. No runoff occurs on this site because the slope is < 0.5°. Differences may therefore be wholly ascribed to differences in soil evaporation, resulting from slower infiltration rates in the DP and TDD treatments.

Saturated hydraulic conductivity measurements of the 0-10 cm layers made in 1978, 1979 and 1981 show that there has been an absolute decline in the DP treatment, whereas the TDD and CDD treatments have not changed significantly. (Reported in PRD annual report 1982). The saturated rate occurs where surface ponding results through collapse of the surface soil aggregates.

Stability of the surface soil was tested using the Emerson remould-dispersion test. All treatments on both 77M13 and 77M56 fell into Emerson's category 3, i.e. soils which slake but do not disperse when immersed dry into water, but which subsequently disperse after remoulding and brought to -100 cm matric potential before re-immersion. Using an expanded ranking scale, however, the DP treatment showed significantly more slaking and dispersion than the two direct drilled treatments.

TABLE 3 : Aggregate Stability Index 1982

	DP	CDD	TDD	LSD
<u>77M13</u>				
Slaking	3.50	2.68	2.82	0.40
Remould-dispersion	6.23	5.55	4.50	1.02
<u>77M56</u>				
Slaking	3.72	2.78	2.44	0.29
Remould-dispersion		not yet determined		

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TABLE 2 : Depth in cm to wetting front at seeding (late June) by penetrometer measurement, transects across drill width.

Tr.	Rep.	18	18	18	18	18	18	18	18	18	18	18	cm	$\bar{x}$	S
CDD	1	25	25	10	28	32	28	25	21	39	35	28	28	27	7.2
	2	25	39	28	46	42	35	35	35	35	28	28	25	33	6.5
	3	32	32	39	28	28	28	35	35	-	-	-	-	32	4.1
	4	21	18	7	28	25	21	28	32	32	39	18	14	24	8.9
	5	14	28	18	32	21	25	7	28	28	21	18	-	22	7.4
	6	18	18	7	21	28	21	21	21	21	21	28	32	21	6.3
														$\bar{x}$ 26.5	
TDD	1	21	21	4	21	28	28	21	18	28	2	28	18	21	6.8
	2	42	42	50	52	52	39	52	39	39	50	40	42	45	5.7
	3	4	4	4	21	25	10	10	14	14	10	10	18	12	6.8
	4	21	4	21	7	28	25	21	18	7	7	7	7	14	8.6
	5	21	11	11	32	28	25	25	25	28	18	18	25	22	6.6
	6	21	21	25	25	28	25	25	28	28	21	18	-	24	3.2
														$\bar{x}$ 23.0	
DP	1	21	21	4	21	25	25	21	18	25	18	25	18	20	5.8
	2	14	32	25	21	18	21	18	25	4	21	11	25	20	7.4
	3	32	4	25	35	25	28	25	32	7	25	21	7	22	10.5
	4	14	32	4	25	25	21	25	7	21	4	25	4	17	10.1
	5	18	25	4	21	21	25	21	25	21	4	21	21	19	7.3
	5	25	25	28	21	21	18	18	21	21	18	25	4	20	6.1
														$\bar{x}$ 19.7	

1b. SOIL STRUCTURE EFFECTS ON CROP GROWTH (MERREDIN)

Grain yields from the two trials have been significantly higher from the direct drilled treatments in 1981 and 1982, whereas in the first three years of the trial (1977-1979) the ploughed treatment yielded better. Infiltration and soil water storage were higher into the well loosened surface of the ploughed treatment in the earlier years, so that in 1978, for example, there was 4% more water at seeding in the ploughed treatment. With the progressive decline in soil structural stability in the DP treatment, because of more frequent tillage operations, the situation is now reversed. In 1981, tillage operations had to be carried out when the soil was plastic rather than friable because of the unusually wet autumn and in 1982 damage from this made it difficult to obtain satisfactory seed bed conditions.

The actual depth of seed placement differed significantly in 1982, despite the fact that the coulters had been set to the same depth for each treatment and sown on the same day.

TABLE 4 : Colyoptile-internode distance (cm) : 1982

Treatment	77M13		77M56	
DP	2.67	LSD:2.01	2.26	LSD:1.70
CDD	6.45		4.50	
TDD	4.60		4.78	

Means of 20 samples randomly collected from each replicate.

As surface soil water contents in 1982 were low after seeding, with only 16 mm rainfall in July, the shallower sown DP seeds emerged patchily with less than half the final number of the direct drilled treatments. Despite the higher average water content of the DP continuous cropped seed bed there was a large number of clods and poor seed-soil contact.

The higher soil strength in the 0-10 cm zone of the TDD treatment compared with the CDD plots has been a persistent feature each year of the trial and has resulted in slower root extension rates which influence nutritional uptake in the first two months.

TABLE 5 : Soil strength (MPa) at seeding 0-10 cm : 77M13, 1977-82

Year	DP	CDD	TDD	
1977	2.07	3.21	4.41	LSD = 0.80
1979	1.48	1.83	2.39	LSD = 0.54
1982	2.81	1.98	3.83	LSD = 1.06

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Dry matter production in the DP treatment was only half that of the direct drilled treatments until near to flowering, but the low plant numbers made available relatively more post anthesis water to each plant so that the final grain yield was 60% of the direct drilled yield.

TABLE 6 : Quadrat dry matters and grain yields (g/m^2)

	DP		CDD		TDD	
Date	77M13	77M56	77M13	77M56	77M13	77M56
29.7.82	2.53	2.25	5.80	2.35	5.58	1.61
9.9.82	65.7	51.5	152.3	77.4	157.1	93.3
28.9.82	163.9	139.7	271.8	182.6	242.0	177.5
21.10.82	241.9	211.2	325.4	286.2	337.9	246.7
23.11.82	226.7	237.7	310.6	297.8	346.3	271.3
Grain	81.4	93.9	108.2	116.7	106.2	101.5
H.I.	0.36	0.39	0.35	0.39	0.31	0.37

The better dry matter production of the continuously cropped trial is an interesting point in this table. The soil water storage at seeding in the first 120 cm of soil was not significantly different between the two trials, and the depth to the wetting front in the 77M56 cropped area averaged 25 cm, no less than that of 77M13, but at the end of the season the rotational crops had withdrawn less water from the profile than the continuous crop.

Sequential water extraction profiles suggest the rotational crop extended its roots only to 90 cm whereas the continuous crop extracted water to over 110 cm.

2. WATER BALANCE STUDIES UNDER WHEAT ON WONGAN LOAMY SAND

These studies form part of an integrated programme with David Tennant and Michael Perry to provide data sets for crop growth-water balance modelling, to understand the controlling processes on crop water relations in sandy soils, and to put numerical values on the components of the water balance in a range of management practices. During the 1982 season part of the potential yield trial (82WH8) was monitored at an intensive level to test whether root uptake, deep drainage and soil evaporation could be estimated accurately (≅ 5% error terms) from neutron metering and soil sampling. Two dates of planting of Gamenya with 50 kg N ha^{-1} and one "dummy" (drilled without seed) treatments were monitored weekly (4 reps each). Small 'lysimeters', being 9 cm diameter x 30 cm deep metal tubes, were driven into the soil between rows and weighed weekly to estimate soil evaporation without root water extraction (no live roots within the tubes). Surface soil water contents were taken gravimetrically and soil water retention curves, diffusivity, and computed conductivity values for the top soil, were already available.

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While the full results from this experiment are too numerous to present here the method was successful in allowing a reasonable estimate of depth to roots to be made after the first three weeks, and to give first order values for deep drainage beneath the root zone. Soil evaporation between crop rows was significant even at anthesis when the leaf area was over 5 m^2m^{-2}. The unusual degree of uniformity of the soil at this site allowed a detailed water balance to be done with only 4 replicates per treatment. Standard deviations on each depth value of neutron count ratio were less than 0.005. The inclusion of the bare plots allowed checks on each component, by differences.

TABLE 7 : Water balance (mm) 1982 (June 1 - November 24)

Total rainfall: 190 mm

	Crop planted 2.6.82	Crop planted 16.6.82	Bare fallow
Water use	273	277	200
Drainage below roots	65 (24%)	66 (24%)	140 (70%)*
E + T	203 (76%)	229 (70%)	60 (30%)
ΔS	-68	-71	+7

* below 30 cm depth (limit to upward evaporation)

E = evaporation from bare soil

T = plant transpiration

By mid November the crops had dried the soil back to a lower value than the initial May reading (100 mm had fallen in 1982 prior to the start of monitoring).

Although the second crop planted in mid June went into the cooler environment (average max. and min temperatures 14.7° and 5.4°C for the first 14 days after seeding, as against 21.5° and 8.6°C for the first crop) the soil in the top 30 cm was wetter (averaging 45 mm as against 30 mm) and crop development was faster so that mean anthesis dates were less than a week apart. Roots were found to depths of over 2 metres in both crops.

"Water use" (W) does not discriminate between components contributing to changes in soil water storage (ΔS):-

$$W = (\int S_1 + P) - \int S_2/(T_1 - T_2)$$

Where T_1 and T_2 are sequential sampling times and P is the rainfall increment in mm. Soil water storage was measured from 0-3 metres. The drainage time was computed by comparing the fallow and crop profiles at each sampling date so as to identify the depth of root extraction and then substracting sequential water storage values from beneath the rooting depth achieved by t_2, e.g.:-

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cm	24/8/82 P_1 (mm)	24/8/82 Bare	24/8/82 ΔS		1/9/82 P_1 (mm)	1/9/82 Bare	1/9/82 ΔS	
10	18	20	2		11	16	5	
20	15	18	3		12	16	4	
30	19	24	5		17	23	6	
50	26	33	7		24	32	8	
70	30	34	4		28	33	5	
90	30	34	4		29	33	4	
110	31	36	5		29	34	5	
130	33	36	3		32	36	4	
150	31	35	4		30	35	5	
170	27	31	4	Limit of	28	32	4	
190	25	31	6	root	24	28	4	Limit of
- - -	- - -	- - -	- - -					
210	25	25	0	extraction	25	27	2	root
- - -					- - -	- - -	- - -	
230	26	26	0		26	26	0	extraction
250	28	28	0		28	28	0	
270	30	30	0		30	30	0	
290	31	31	0		31	31	0	
	Σ 115 (230-290)		Σ 47 mm		Σ 115 (230-290)		Σ 54 mm	

115-115 = 0 mm drainage for that week under P_1

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