A Survey of Soil Invertebrate Diversity under Varying Levels of Tillage Management and Rotations within a Cotton Growing Cycle

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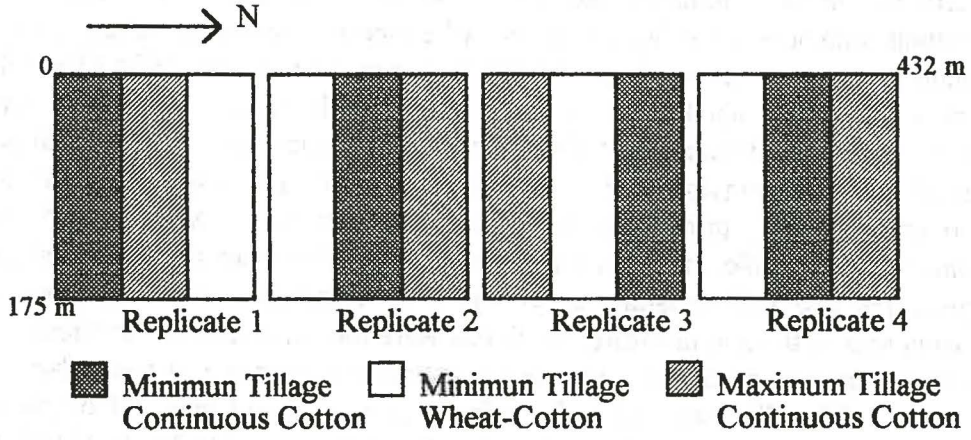
Introduction

The cotton fields are considered to be a biologically 'sterile' environment because of the constant use of pesticides and herbicides, however little work has been done to document the potential benefits of altering crop management practices which may result in less reliance on chemicals, greater soil biodiversity, and improved soil structure. Studies in southern Australia (Haines and Uren 1990, Rovira *et al* 1987) have shown rotations and conservation tillage to double the presence of soil fauna. Haines and Uren (1990) also noted improvements in soil structural properties which was seen to be a consequence of increased soil biological activity.

Research Plan

The experimental design and layout which was used in this experiment has been established by Dr Nilantha Hulugalle, and outlined in CRDC project - DAN83C. I will reiterate the basis of the trial design. It is composed of an experimental trial at the Myall Vale Research Station. There were three treatments (established since 1985) - intensive cultivation with continuous cotton, minimum tillage (retained ridges) with continuous cotton, and minimum tillage with a wheat-cotton rotation (Constable *et al.*, 1992). The three treatment were replicated (four times), and cotton was grown on all plots over the 1994-1996 growing seasons (see Figure 1).

Figure 1: Layout of Experimental site at Myall Vale Research Station 1993-94 (sampling only in cotton rows).

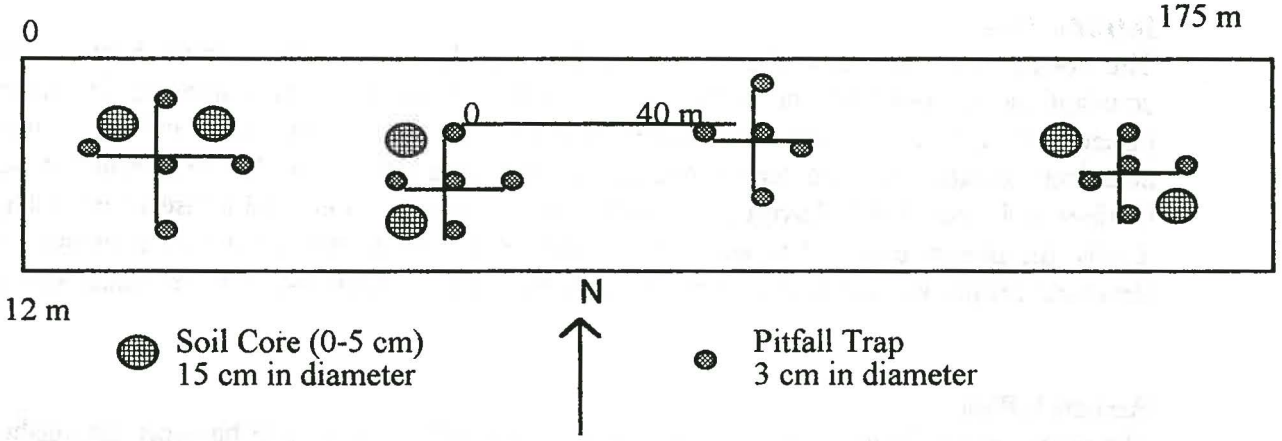


Aims and Methodology

The aims of the project were two-fold. One was to examine the diversity of soil biota, principally soil invertebrates, under different crop rotations on grey cracking clay soils in irrigated cotton crops. The other aim was to examine the spatial and temporal variation of soil biota activity at the early stages of the cotton growing cycle and compare it with the later stages. Both aims were examined by sampling in mid-December and late-March over 1994-95 and 1995-96 seasons using soil cores and pitfall trapping. In each treatment 20 pitfall traps, and six soil cores were placed (see Figure 2 for an example of layout). There was a total number of 240 pitfall traps and 72 soil cores. The pitfall traps were left open for three days

and nights. The contents were sorted and identified to order. The ants were sorted and identified to species. This data is relevant to the assessment of soil structural properties being conducted by Dr Hulugalle.

Figure 2: Layout of pitfall traps and soil cores for sampling terrestrial invertebrates at Myall Vale Research Station 1993-94 (each pitfall trap cluster of five pitfall traps is randomly allocated to a cotton ridge, and at least 25 m apart from each other).



Results and Discussion

The most abundant invertebrate groups recorded in December 1994, in descending order, were Collembola, ants, beetles, mites and grasshoppers (Table 1). Ant species richness was low, with only two genera recorded which were *Iridomyrmex* and *Pheidole* (with two species each). Earwigs and spiders were not abundant, but at least one specimen was recorded per pitfall trap. There was little difference between the three soil tillage management/cropping rotation treatments in terms of invertebrate foraging activity or presence of soil invertebrates. However, in December of both seasons, there were higher numbers of ants, in particular *Pheidole* sp., in the minimum tillage plots, and lower numbers in the maximum tillage plots. Collembola numbers were highest in the wheat-cotton minimum tillage area and lowest in continuous cotton under maximum tillage, but only in December 1994 (Table 1). In spite of the more favourable habitat/microclimate conditions in March 1995 there was a significant decline (> 90%) in abundance of all surface active invertebrate orders which is probably as a result of pesticide spraying (Table 1). In contrast the soil cores recorded higher levels of invertebrate activity, principally mites and Collembola, in March 1995 compared with December 1994 (Table 2). This result could be attributed to the more ambient surface soil temperatures and soil moisture in March 1995 compared with December 1994. In the following season the soil moisture conditions were the reverse of the previous cropping season with more ambient surface soil temperatures and soil moisture in December 1995 compared with March 1996. This resulted in the highest recorded abundances of Collembola and mites in December 1995 compared with all other sampling periods (Table 2). In March 1996 when soil moisture in the top 5 cm was around 4% (gravimetric) only mites were recorded. Overall, abundance of invertebrates in soil cores was low. Invertebrate activity in the soil seems to be largely controlled by microclimate conditions. Pesticide usage increases through the growing cycle with only herbicide sprays used before sampling in December. Their influence on invertebrate abundance in soil cores seems to be secondary to microclimate conditions but still influential. Surface activity of invertebrates measured in December 1995 has not recovered to the level that was recorded in December 1994 (Table 1). The two groups which were more abundant in December 1995 compared with December 1994 were mites and bugs (Table 1). Ants are still abundant, but were 75% below the numbers recorded in December 1994, with the maximum tillage plots recording the lowest numbers (Table 1). One group which has

remained relatively stable, regardless of season and agronomic practices have been earwigs, and they are the only group to increase in abundance in March 1996 (Table 1). Another group which has shown itself to be resilient to pesticide sprays and less than ambient soil conditions were the mites. The results of this sampling program indicate that there were too many inter-related factors to derive a cause and effect relationship between tillage practices/crop rotations and soil biota. However the influence of soil microclimate conditions and chemical sprays cannot be underestimated. These two factors alone have a greater impact than the reduction of tillage or crop rotations on soil biota abundance and activity patterns. Soil biota activity in the soil, especially for Collembola, is limited to periods when the soil moisture is at field capacity. Surface activity of all invertebrates is severely curtailed by pesticide sprays.

Acknowledgements

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Table 1: Mean abundance of surface active invertebrates/site sampled in December and March over two seasons at Myall Vale, under varying tillage and crop rotations

ORDER	Common Name	1994-1995 Total Mean Abundance n = 4 sites		1994-1995 total of 20 pitfall traps per site		1995-1996 Total Mean Abundance n = 4 sites		1995-1996 total of 20 pitfall traps per site	
		December'94		March'95		December'95		March'96	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
		Maximum Tillage/Continuous Cotton							
ACARINA	Mites	220	18	25	5	335	54	87	12
ARANEAE	Spiders	21	1	1	0	13	3	1	1
COLEOPTERA	Beetles	369	52	2	1	42	9	1.5	1
COLLEMBOLA	Springtails	619	232	231	96	40	11	0	0
DERMAPTERA	Earwigs	19	5	3	0	14	4	25	7
DIPTERA	Flies	12	3	5	1	26	7	13	7
FORMICIDAE	Ants	198	106	5	1	58	23	10	3
HEMIPTERA	Bugs	12	3	33	5	28	6	10	4
HYMENOPTERA	Wasps,Bees	36	7	4	1	14	4	1	1
LEPIDOTERA	Butterflies	4	2	1	0	0.5	0.5	0	0
ORTHOPTERA	Grasshopper	91	15	0	0	7	3	0	0
PSOCOPTERA	Bristletails	0	0	1	0	0.5	0.5	0	0
THYSANOPTERA	Book Lice	3	1	7	2	0	0	3	2
LARVAE		0	0	0	0	0	0	0	0
		Minimum Tillage/Continuous Cotton							
ACARINA	Mites	185	9	23	5	321	53	74	13
ARANEAE	Spiders	28	6	1	1	14	4	0.5	0.5
COLEOPTERA	Beetles	340	16	1	0	50	8	4	2
COLLEMBOLA	Springtails	664	102	113	10	30	6	0	0
DERMAPTERA	Earwigs	28	7	2	1	14	20	25	8
DIPTERA	Flies	12	1	4	1	27	5	35	15
FORMICIDAE	Ants	574	86	13	3	113	28	14	5
HEMIPTERA	Bugs	12	3	30	1	46	12	10	4
HYMENOPTERA	Wasps,Bees	30	3	6	1	12	5	1.5	1
LEPIDOTERA	Butterflies	3	1	1	0	1	1	0.5	0.5
ORTHOPTERA	Grasshopper	91	17	0	0	5	2.5	0	0
PSOCOPTERA	Bristletails	0	0	0	0	0	0	0	0
THYSANOPTERA	Book Lice	1	0	8	2	1	1	0.5	0.5
		Minimum Tillage/Wheat-Cotton Rotation							
ACARINA	Mites	208	42	17	2	324	52	92	16
ARANEAE	Spiders	20	3	1	0	3	3	1	1
COLEOPTERA	Beetles	366	29	3	1	66	10	3	2
COLLEMBOLA	Springtails	930	263	119	16	33	8	0	0
DERMAPTERA	Earwigs	23	3	2	1	18	4	19	6
DIPTERA	Flies	16	4	4	1	36	6	15	9
FORMICIDAE	Ants	461	66	18	6	100	21	13	5
HEMIPTERA	Bugs	17	1	28	1	51	11	11	5
HYMENOPTERA	Wasps,Bees	30	4	6	1	9	4	1	1
LEPIDOTERA	Butterflies	2	1	1	0	1	1	0	0
ORTHOPTERA	Grasshopper	83	15	0	0	0	0	0	0
PSOCOPTERA	Bristletails	0	0	1	1	0	0	0	0
THYSANOPTERA	Book Lice	1	1	3	0	0	0	2	1
LARVAE		0	0	0	0	0	0	0	0

Table 2: Mean abundance of soil invertebrates/soil core sampled in December and March over two seasons at Myall Vale, under varying tillage and crop rotations

ORDER	Common Name	1994-1995 Mean Abundance in Soil Cores n = 6 cores/site				1995-1996 Mean Abundance in Soil Cores n = 6 cores/site			
		December'94		March'95		December'95		March'96	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
		Maximum Tillage/Continuous Cotton							
ACARINA	Mites	33	8	50	26	113	24.2	26.7	3.4
ARANEAE	Spiders	0.1	0.1	0.1	0.1	1.3	0.1	0	0
COLEOPTERA	Beetles	0.4	0.3	0.6	0.2	1.4	0.1	0	0
COLLEMBOLA	Springtails	2	1.5	27	12	48	12.3	0	0
		Minimum Tillage/Continuous Cotton							
ACARINA	Mites	49	35	22	11	134	63.5	14	2.4
ARANEAE	Spiders	0	0	0.2	0.1	1.0	0	0	0
COLEOPTERA	Beetles	0.5	0.5	0.5	0.4	1.8	0.3	0	0
COLLEMBOLA	Springtails	0.2	0.2	15	7	22	4.3	1	0
		Minimum Tillage/Wheat-Cotton Rotation							
ACARINA	Mites	30	11	19	7	73	17	26	3.3
ARANEAE	Spiders	0	0	0.2	0.1	0	0	0	0
COLEOPTERA	Beetles	0.3	0.2	0.3	0.3	1.5	0.2	0	0
COLLEMBOLA	Springtails	0.3	0.2	17	9	20	3.9	0	0