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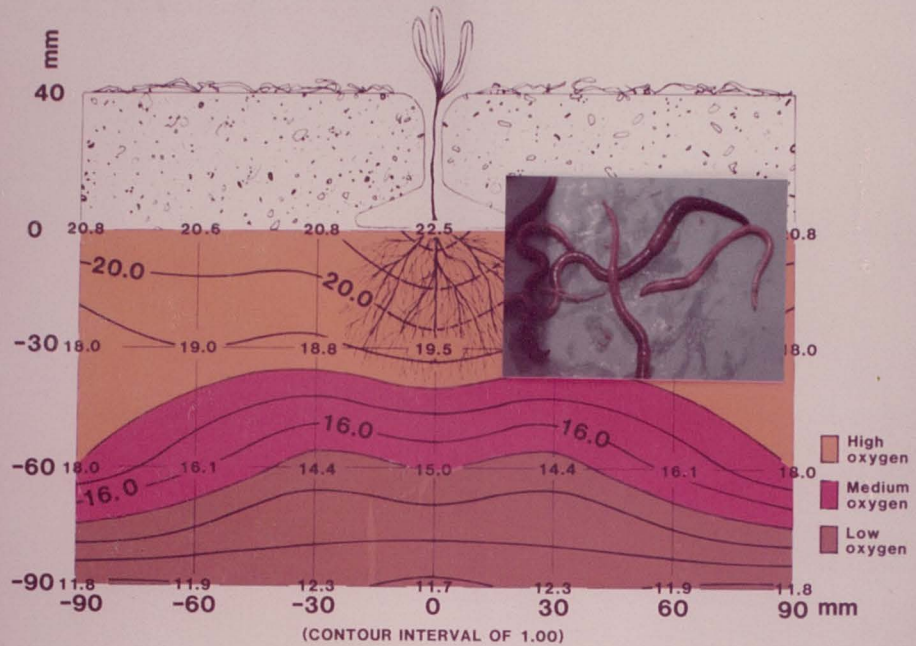
EFFECTS OF DIRECT DRILLING OPENERS, SURFACE
RESIDUE AND EARTHWORMS ON SEED AND SEEDLING
PERFORMANCE IN A WET SOIL

A Thesis presented in partial fulfilment of
the requirements for the degree of
Doctor of Philosophy
at Massey University
Palmerston North
New Zealand

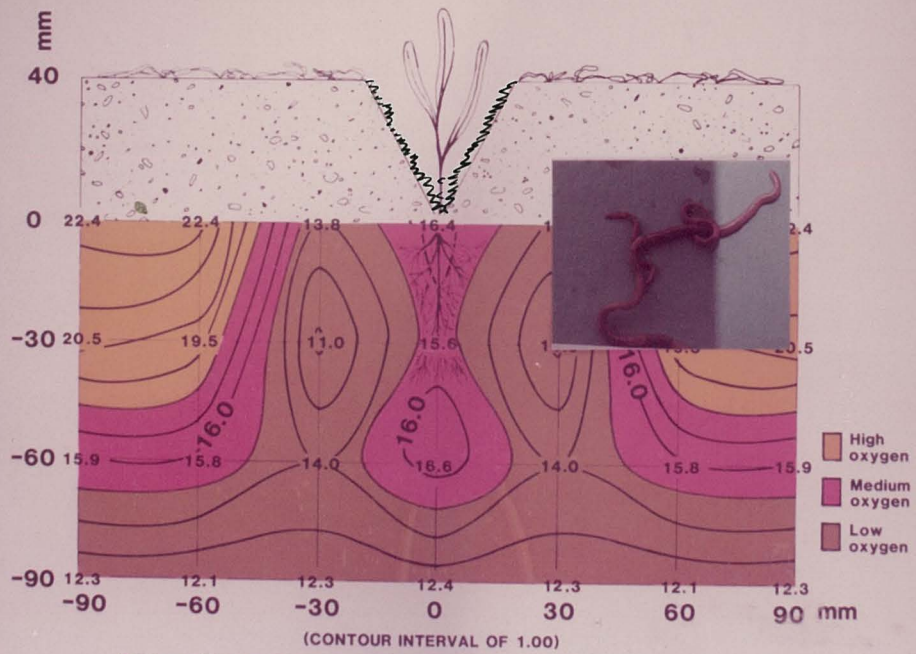
by

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January 1985.



Oxygen diffusion rate ($\text{gm} \times 10^{-8}/\text{cm}^2/\text{min}$): Winged opener in residue.



Oxygen diffusion rate ($\text{gm} \times 10^{-8}/\text{cm}^2/\text{min}$): Triple disc opener in residue.

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1. <u>INTRODUCTION.</u>	1
2. <u>REVIEW OF LITERATURE.</u>	3
2.1 <u>PHYSICAL, BIOLOGICAL AND CHEMICAL INFLUENCE OF</u>	
<u>CROP RESIDUE ON DIRECT DRILLING</u>	3
2.1.1 <u>Physical influence.</u>	3
2.1.2 <u>Biological influence.</u>	7
2.1.3 <u>Chemical influence.</u>	10
2.2 <u>INFLUENCE OF EARTHWORMS ON SOIL FERTILITY AND</u>	
<u>PLANT GROWTH.</u>	13
2.3 <u>SOIL OXYGEN AND PLANT GROWTH.</u>	17
2.4 <u>DESIGN PARAMETERS OF DIRECT DRILLING.</u>	24
2.4.1 <u>Opener functions.</u>	24
2.4.2 <u>Design and modifications of drills for</u>	
<u>direct drilling.</u>	24
2.4.3 <u>Performance of openers and modifications</u>	
<u>for no-tillage.</u>	27
2.4.4 <u>Physical, biological and chemical influence</u>	
<u>of direct drilled grooves.</u>	29
(a) <u>Seed groove micro-environment--physical.</u>	29
(b) <u>Seed groove micro-environment--biological.</u>	33
(c) <u>Seed groove micro-environment--chemical.</u>	35
3. <u>EXPERIMENTS</u>	36
3.1 <u>FIELD COMPARISONS OF DIRECT DRILLING OPENER</u>	
<u>PERFORMANCE (Experiment 1).</u>	36
3.1.1 <u>Introduction.</u>	36
3.1.2 <u>Materials and methods.</u>	36
3.1.3 <u>Measurements.</u>	42
3.1.4 <u>Limitations.</u>	51
3.1.5 <u>Results and discussion.</u>	52
3.1.6 <u>Discussion of Experiment 1.</u>	67

SECTIONPAGE

3.2	<u>EFFECTS OF DIRECT DRILLING OPENERS ON SEED/SEEDLING PERFORMANCE IN THE PRESENCE AND ABSENCE OF CROP RESIDUE, UNDER CONTROLLED CLIMATIC CONDITIONS.</u>	69
3.2.1	<u>Introduction.</u>	69
3.2.2	<u>Materials and methods.</u>	70
3.2.3	<u>Measurements.</u>	76
3.2.4	<u>Experiment 2</u> <u>Seedling emergence under simulated rain conditions.</u>	81
	(a) Introduction.	81
	(b) Results and discussion.	81
3.2.5	<u>Experiment 3</u> <u>Seedling emergence under temporary high water table conditions.</u>	101
	(a) Introduction.	101
	(b) Results and discussion.	101
3.2.6	<u>Discussion of Experiments 2 and 3.</u>	122
3.3	<u>EFFECTS OF CARBARYL ON EARTHWORMS, SEEDS AND SEEDLINGS IN A WET SOIL.</u>	125
3.3.1	<u>Introduction.</u>	125
3.3.2	<u>Effects of carbaryl on the mortality of earthworms.</u> <u>(Pilot experiment, Experiment 4).</u>	125
	(a) Objectives.	125
	(b) Materials and methods.	125
	(c) Results and discussion.	126
3.3.3	<u>Effects of carbaryl on roots and shoots of barley sown in soil.</u> <u>(Pilot experiment, Experiment 5).</u>	128
	(a) Objectives.	128
	(b) Materials and methods.	128
	(c) Results and discussion.	129
3.3.4	<u>Effects of direct seed/carbaryl contact on seed germination and seedling growth</u>	

<u>SECTION</u>	<u>PAGE</u>
(Pilot experiment, Experiment 6).	129
(a) Objectives.	129
(b) Materials and methods.	129
(c) Results and discussion.	129
3.3.5 <u>Discussion of pilot Experiments 4, 5 and 6.</u>	132
3.4 <u>EFFECTS OF OPENER TYPES, RESIDUE AND EARTHWORM ACTIVITY</u> <u>ON SEED/SEEDLING PERFORMANCE.</u>	136
3.4.1 <u>Objectives.</u>	136
3.4.2 <u>Materials and methods.</u>	136
3.4.3 <u>Results and discussion.</u>	136
(a) Experiment 7: (In the absence of earthworms).	139
(b) Experiment 8: (In the presence of earthworms).	151
3.4.4 <u>Discussion of Experiments 7 and 8.</u>	164
3.5 <u>PHYTOTOXIC EFFECTS OF CROP RESIDUE IN THE PRESENCE OF</u> <u>EARTHWORMS, (Experiment 9).</u>	170
3.5.1 <u>Objectives.</u>	170
3.5.2 <u>Materials and methods.</u>	170
3.5.3 <u>Results and discussion.</u>	171
3.5.4 <u>Discussion of Experiment 9.</u>	179
3.5.5 <u>Conclusion of Experiments 7, 8 and 9.</u>	180
3.6 <u>DIRECT DRILLING SEED SOWING TECHNIQUES, EARTHWORMS, AND</u> <u>SURFACE RESIDUE IN A WET SOIL</u> <u>(Experiments 10 and 11).</u>	181
3.6.1 <u>Introduction.</u>	181
3.6.2 <u>Materials and methods.</u>	182
(a) Selection of opener types.	183
(b) Tillage bin technique.	185
(c) Measurements.	185
(d) Experimental design.	186
(e) Constraints.	188
3.6.3 <u>Effects of direct drilling seed sowing techniques</u> <u>and surface residue in the absence of earthworms</u> <u>(Experiment 10).</u>	190
(a) Objectives.	190
(b) Results and discussion.	190
3.6.4 <u>Effects of direct drilling seed sowing techniques</u>	

<u>SECTION</u>	<u>PAGE</u>
<u>and surface residue in the presence of earthworms</u>	
<u>(Experimernt 11).</u>	204
(a) Objectives.	204
(b) Results and discussion.	204
3.6.5 <u>Discussion of Experiments 10 and 11.</u>	231
3.7 <u>EFFECTS OF SMEARING AND SOIL COMPACTION ON EARTHWORM</u>	
<u>ACTIVITY AND OXYGEN DIFFUSION RATES.</u>	241
3.7.1 <u>Introduction.</u>	241
3.7.2 <u>Effects of soil smearing and compaction on</u>	
<u>earthworm populations and activity</u>	
<u>(Experiment 12).</u>	242
(a) Materials and methods.	242
(b) Results and discussion.	243
3.7.3 <u>Effects of soil smearing and compaction on</u>	
<u>earthworm activity and populations under</u>	
<u>decreasing soil moisture conditions</u>	
<u>(Experiment 13).</u>	254
(a) Materials and methods.	254
(b) Results and discussion.	254
3.7.4 <u>Earthworm behaviour when confronted by a smear</u>	
<u>(Experiment 14).</u>	259
(a) Materials and methods.	259
(b) Results and discussion.	260
3.7.5 <u>Discussion of Experiments 12, 13 and 14.</u>	260
3.8 <u>EFFECTS OF EARTHWORMS ON WATER INFILTRATION RATE</u>	
<u>AROUND THE PROFILES OF DIRECT DRILLED GROOVES.</u>	266
3.8.1 <u>Introduction.</u>	266
3.8.2 <u>Materials and methods.</u>	267
(a) Design of a rectangular infiltrometer.	267
(b) Experimental design.	268
(c) Opener types: selection.	268
(d) Procedure.	268
3.8.3 <u>Results and discussion.</u>	270
(a) Infiltration rate in the presence of earthworms	
and absence of crop residue (Experiment 15).	270
(b) Infiltration rate in the absence of earthworms	
and crop residue (Experiment 16).	273

SECTIONPAGE

(c) Infiltration rate in the presence of earthworms and crop residue (Experiment 17).	275
3.8.4 <u>Discussion of Experiments 15, 16 and 17.</u>	284
3.9 <u>LIMITING FACTORS CAUSING SEEDLING EMERGENCE FAILURE WITH THE TRIPLE DISC OPENER GROOVE (Experiment 18).</u>	286
3.9.1 <u>Introduction.</u>	286
3.9.2 <u>Materials and methods.</u>	286
3.9.3 <u>Results and discussion.</u>	288
3.9.4 <u>Discussion of Experiment 18.</u>	299
4. <u>SUMMARY AND DISCUSSION</u>	303
4.1 <u>OPENERS.</u>	304
4.2 <u>CROP RESIDUE.</u>	315
4.3 <u>EARTHWORMS.</u>	316
4.4 <u>CONCLUSIONS.</u>	319
4.5 <u>RECOMMENDED FURTHER RESEARCH WORK.</u>	320
5. <u>BIBLIOGRAPHY.</u>	322
6. <u>ACKNOWLEDGEMENTS.</u>	336
7. <u>APPENDICES</u>	

LIST OF TABLES

	<u>PAGE</u>
1. Effects of contrasting soil moisture conditions, direct drilling opener types and contrasting crop residue conditions, on the fate of direct drilled barley seeds.	53
2. Effects of contrasting soil moisture conditions, direct drilling opener types and contrasting crop residue conditions, on the root/shoot weights of direct drilled barley seeds.	60
3. Effects of direct drilling opener types and contrasting crop residue conditions, on oxygen diffusion rate at the centre of the grooves, under irrigated conditions.	62
4. Effects of direct drilling opener types and contrasting crop residue conditions, on soil bulk density and soil moisture content, at the centre of the grooves, under irrigated conditions.	65
5. Effects of opener types and contrasting crop residue conditions, on the fate of direct drilled barley seeds, under simulated rain conditions.	82
6. Effects of direct drilling opener types and contrasting crop residue conditions, on oxygen diffusion rate (ODR), under simulated rain conditions.	88
7. Effects of direct drilling opener types and contrasting crop residue conditions, on earthworm populations around the groove profiles, under simulated rain conditions.	95
8. Effects of direct drilling opener types and contrasting crop residue conditions, on in-groove soil temperature, under simulated rain conditions.	95
9. Effects of direct drilling opener types and contrasting crop residue conditions, on soil bulk density around the groove profiles, under simulated rain conditions.	97
10. Effects of direct drilling opener types and contrasting crop residue conditions, on soil moisture content around the groove profiles, under simulated rain conditions.	99
11. Effects of direct drilling opener types and contrasting	

crop residue conditions, on the fate of direct drilled barley seeds, under temporary high water table condition.	102
12. Effects of direct drilling opener types and contrasting crop residue conditions, on oxygen diffusion rate (ODR), under temporary high water table conditions.	109
13. Effects of direct drilling opener types and contrasting crop residue conditions, on earthworm populations around the groove profiles, under temporary high water table conditions.	116
14. Effects of direct drilling opener types and contrasting crop residue conditions, on in-groove soil temperature, under temporary high water table conditions.	116
15. Effects of direct drilling opener types and contrasting crop residue conditions, on soil bulk density around the groove profiles, under temporary high water table conditions.	118
16. Effects of direct drilling opener types and contrasting crop residue conditions, on soil moisture content around the groove profiles, under temporary high water table conditions.	120
17. Earthworm populations in Tokomaru silt-loam soil, 3 days after spraying carbaryl.	127
18. Effect of carbaryl on seed germination and seedling growth of barley seeds, sown in undisturbed soil blocks.	130
19. Effects of concentration of carbaryl solution on seed germination and seedling growth of barley, on germination paper.	133
20. Effects of opener types and contrasting crop residue condition on the fate of direct drilled barley seeds, in the absence earthworms, under simulated rain conditions.	140
21. Effects of direct drilling opener types and contrasting crop residue conditions, on oxygen diffusion rate (ODR), in the absence of earthworms, under simulated rain conditions.	145
22. Effects of direct drilling opener types and contrasting crop residue conditions, on earthworm populations around the groove profiles, under simulated rain conditions, in carbaryl treated pots.	147

23. Effects of direct drilling opener types and contrasting crop residue conditions, on populations of earthworm species in the pots treated with carbaryl, under simulated rain conditions. 148
24. Effects of direct drilling opener types and contrasting crop residue conditions, on matrix soil bulk density, in the absence of earthworms, under simulated rain conditions. 150
25. Effects of direct drilling opener types and contrasting crop residue conditions, on matrix soil moisture content, in the absence of earthworms, under simulated rain conditions. 150
26. Effects of opener types and contrasting crop residue conditions, on the fate of direct drilled barley seeds, in the presence of earthworms, under simulated rain conditions. 152
27. Effects of direct drilling opener types and contrasting crop residue conditions, on oxygen diffusion rate (ODR), in the presence of earthworms, under simulated rain conditions. 157
28. Effects of direct drilling opener types and contrasting crop residue conditions, on earthworm populations around the groove profiles, under simulated rain conditions. 160
29. Effects of direct drilling opener types, and crop residue conditions, on populations of earthworm species, under simulated rain conditions. 161
30. Effects of direct drilling opener types and contrasting crop residue conditions, on matrix soil bulk density, in the presence of earthworms, under simulated rain conditions. 163
31. Effects of direct drilling opener types and contrasting crop residue conditions, on matrix soil moisture content, in the presence of earthworms, under simulated rain conditions. 163
32. Effects of direct drilling opener types and contrasting residue placements, on the fate of direct drilled barley seeds, under simulated rain conditions. 172
33. Effects of direct drilling opener types and contrasting residue placements, on populations of earthworms, under simulated rain conditions. 177

34. Effects of direct drilling opener types and contrasting residue placements, on populations of earthworm species, under simulated rain conditions. 178
35. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on seed fate of barley, in the absence of earthworms, under simulated rain conditions. 191
36. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on oxygen diffusion rate (ODR), in the absence of earthworms, under simulated rain conditions. 198
37. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on earthworm populations around the groove profiles, in the absence of earthworms (in carbaryl treated pots), under simulated rain conditions. 201
38. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on soil bulk density and soil moisture content around the groove profiles, in the absence of earthworms, under simulated rain conditions. 202
39. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on seed fate of barley, in the presence of earthworms, under simulated rain conditions. 205
40. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on oxygen diffusion rate (ODR) around the groove profiles, in the presence of earthworms, under simulated rain conditions. 212
41. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on earthworm populations around the groove profiles, in the presence of earthworms, under simulated rain conditions. 224
42. Effect of direct drilling seed sowing techniques and contrasting crop residue conditions, on populations of earthworm species around the groove profiles, in the presence of earthworms, under simulated rain conditions. 225
43. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on area indices of

earthworm activity around the groove surfaces, in the presence of earthworms, under simulated rain conditions.	227
44. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on soil bulk density and soil moisture content around the groove profiles, in the presence of earthworms, under simulated rain conditions.	229
45. Effects of smearing intensity and soil bulk density, on cumulative numbers of earthworm holes, under simulated rain conditions.	244
46. Effects of smearing intensity and soil bulk density, on oxygen diffusion rate (ODR), under simulated rain conditions.	249
47. Effects of smearing intensity and soil bulk density, on earthworm populations, at different depths, under simulated rain conditions.	252
48. Effects of smearing intensity and soil bulk density, on cumulative numbers of earthworm holes, under decreasing soil moisture conditions.	255
49. Effects of smearing intensity and soil bulk density, on earthworm populations, under decreasing soil moisture conditions.	258
50. Effects of direct drilling opener types on infiltration rates and cumulative infiltration around the groove profiles, in the presence of earthworms and absence of surface residue.	271
51. Effects of direct drilling opener types on infiltration rates and cumulative infiltration around the groove profiles, in the absence of earthworms and surface residue .	274
52. Effects of direct drilling opener types on infiltration rates and cumulative infiltration around the groove profiles, in the presence of earthworms and surface residues.	278
53. Effects of "V" shaped groove types and crop residue conditions, on seed fate of barley, under simulated rain conditions.	289
54. Effects of "V" shaped groove types and crop residue conditions, on dry matter weights of roots and shoots of barley, under simulated rain conditions.	293
55. Effects of "V" shaped groove types and crop residue	

conditions, on oxygen diffusion rate (ODR), under simulated rain conditions.	295
56. Effects of "V" shaped groove types and crop residue conditions, on earthworm populations around the groove profiles, under simulated rain conditions.	298
57a Summary of interactive responses of direct drilled barley seeds to opener types, crop residue and earthworms in a saturated soil. (Percentage seedling emergence, in the presence of earthworms)	306
57b Summary of interactive responses of direct drilled barley seeds to opener types, crop residue and earthworms in a saturated soil. (Percentage seedling emergence, in the absence of earthworms)	307
58. Summary of interactive responses of earthworms to direct drilling types and crop residue in a saturated soil. (Earthworm populations around the groove profiles)	308

LIST OF FIGURES

	<u>PAGE</u>
1. Front view of Winged opener assembly.	39
2. Side view of Triple disc opener assembly.	39
3. Side view of Hoe opener assembly.	39a
4. Experimental layout of field experiment (Experiment 1).	41
5. Equipment for measuring oxygen diffusion rate.	44
6. Extraction of samples for root studies with perspex pinboard.	44
7. Effect of direct drilling opener types and contrasting crop residue conditions on rates of seedling emergence of barley in an irrigated soil.	55
8. Effects of direct drilling opener types and contrasting crop residue conditions on rates of seedling emergence of barley in a non- irrigated soil.	56
9. Effects of direct drilling opener types and contrasting crop residue conditions, on cumulative seed fate of direct drilled barley in irrigated and non-irrigated conditions.	59
10. Effects of direct drilling opener types and contrasting crop residue conditions on changes in oxygen diffusion rates (ODR) with time, in an irrigated soil.	64
11. Turf block extraction process. (a) Initiation of turf cutter and bin travel into soil.	72
(b) Tillage bin at full depth.	
(c) Tillage bin after drilling <u>in situ</u> .	
12. Experimental layout of tillage bin experiments (Experiments 2 and 3).	75
13. A grid pattern for measuring oxygen diffusion rates (ODR), soil bulk density and soil moisture content, around direct drilled grooves.	

	<u>PAGE</u>
(Experiments 2 and 3).	77
14. Core sampler (120mm dia x 100mm length) used for estimating earthworm populations around a direct drilled groove.	79
15. Effects of direct drilling opener types and contrasting crop residue conditions, on seedling emergence rates of barley, under simulated rain conditions.	84
16. Effects of direct drilling opener types and contrasting crop residue conditions, on cumulative seed fate of barley, under simulated rain conditions.	85
17. Effects of direct drilling opener types and contrasting crop residue conditions on changes in oxygen diffusion rates (ODR) with time, under simulated rain conditions.	89
18. (a) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Winged opener, days 5-20), under simulated rain conditions.	91
(b) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Triple disc opener, days 5-20), under simulated rain conditions.	92
(c) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Hoe opener, days 5-20), under simulated rain conditions.	93
19. Effects of direct drilling opener types and contrasting crop residue conditions on seedling emergence rates of barley, under temporary high water table conditions.	104
20. Effects of direct drilling opener types and contrasting crop residue conditions, on cumulative seed fate of barley, under temporary high water table conditions.	107
21. Effects of direct drilling opener types and contrasting crop residue conditions, on changes in oxygen diffusion rates (ODR)	

with time, under temporary high water table conditions.	110
22 (a) Average cumulative oxygen diffusion rate zones, around a direct drilled groove (Winged opener, days 5-20), under temporary high water table conditions.	112
(b) Average cumulative oxygen diffusion rate zones, around a direct drilled groove (Triple disc opener, days 5-20), under temporary high water table conditions.	113
(c) Average cumulative oxygen diffusion rate zones, around a direct drilled groove (Hoe opener, days 5-20), under temporary high water table conditions.	114
23. Effects of different concentrations of carbaryl on root/shoot development of barley.	131
24. The grid pattern for measuring oxygen diffusion rate (ODR) zones, in the absence and presence of earthworms, under simulated rain conditions.	138
25. Effects of direct drilling opener types and contrasting crop residue conditions, on seedling emergence rates of barley, in the absence of earthworms, under simulated rain conditions.	142
26. Effects of direct drilling opener types and contrasting crop residue conditions, on cumulative seed fate of direct drilled barley, in the absence of earthworms, under simulated rain conditions.	143
27. Effects of direct drilling opener types and contrasting crop residue conditions, on changes in oxygen diffusion rates (ODR) with time, in the absence of earthworms, under simulated rain conditions.	146
28. Effects of direct drilling opener types and contrasting crop residue conditions, on seedling emergence rates of barley, in the presence of earthworms, under simulated rain conditions.	153

29. Effects of direct drilling opener types and contrasting crop residue conditions, on cumulative seed fate of direct drilled barley, in the presence of earthworms, under simulated rain conditions. 155
30. Effects of direct drilling opener types and contrasting crop residue conditions, on changes in oxygen diffusion rates (ODR) with time, in the presence of earthworms, under simulated rain conditions. 158
31. Response of barley seedlings to earthworms in direct drilling. 165
32. Effects of direct drilling opener types and earthworms on barley seedlings, under simulated rain conditions. 166
33. The cast soil surface with earthworms (above) and uncast soil surface without earthworms (below). 167
34. Effects of direct drilling opener types and position of crop residue, on seedling emergence rates of barley, in the presence of earthworms, under simulated rain conditions. 173
35. Effects of direct drilling opener types and position of crop residue, on cumulative seed fate of barley, in the presence of earthworms, under simulated rain conditions. 175
36. A garden rotary hoe assembly to create a power-till groove. 184
37. A core sampler (11mm x 40mm) used to make discrete holes to represent a punch planter. 184
38. A quardat used to measure area index of earthworm activity. 187
39. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on seedling emergence of barley, in the absence of earthworms, under simulated rain conditions. 192
40. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on cumulative seed fate of barley, under simulated

	<u>PAGE</u>
rain conditions.	195
41. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on changes in oxygen diffusion rates (ODR) with time, in the absence of earthworms under simulated rain conditions.	199
42. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on seedling emergence rates of barley, in the presence of earthworms, under simulated rain conditions.	206
43. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on cumulative seed fate of barley, in the presence of earthworms, under simulated rain conditions.	210
44. Effects of direct drilling seed sowing techniques and contrasting crop residue conditions, on changes in oxygen diffusion rates (ODR) with time, in the presence of earthworms, under simulated rain conditions.	214
45. (a) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Winged opener, days 7-21), under simulated rain conditions.	216
(b) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Triple disc opener, days 7-21), under simulated rain conditions.	217
(c) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Hoe opener, days 7-21), under simulated rain conditions.	218
(d) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Power-till opener, days 7-21), under simulated rain conditions.	219
(e) Average cumulative oxygen diffusion rate zones, created around a direct drilled groove (Punch planter opener, days 7-21), under simulated rain conditions.	220
(f) Average cumulative oxygen diffusion rate zones, in an undisturbed soil (surface broadcasting, days 7-21), under simulated rain conditions.	221
46. (a,b) Effects of direct drilling seed sowing techniques on barley seedling emergence in the absence of	

	<u>PAGE</u>
earthworms, under simulated rain conditions.	233
(c,d) Effects of direct drilling seed sowing techniques on barley seedling emergence in the presence of earthworms, under simulated rain conditions.	234
(e,f) Typical seedlings from direct drilled grooves and surface broadcasting technique, in the presence of earthworms, under simulated rain conditions.	235
47. Dissections of typical punch planter grooves.	
(a) Without earthworms (b) With earthworms.	237
48. Typical groove created by triple disc opener in the presence and absence of earthworms.	239
49. (a,b,c) Effects of smearing intensity and soil bulk density levels on earthworm activity (cumulative numbers of earthworm holes).	246
50. Effects of soil compaction levels and smearing intensities on cumulative numbers of earthworm holes, under simulated rain conditions.	247
51. Effects of soil compaction levels and smearing intensities on changes in oxygen diffusion rates (ODR) with time, under simulated rain conditions.	250
52. Effects of soil compaction levels and smearing intensities on cumulative numbers of earthworm holes, under decreasing soil moisture conditions.	256
53. (a-d) Effects of smearing on movement and activity of earthworms.	261
54. Effects of soil bulk density levels on earthworm channels.	264
55. Effects of continuously wetting and drying soil conditions on earthworm activity.	264
56. A rectangular infiltrometer used for measuring infiltration rates around the groove profiles created by direct drilling openers.	269
57a Effects of direct drilling opener types and undisturbed soil on infiltration rate to 60 mm, in the presence of earthworms and absence of crop residue.	278
57b Effects of direct drilling opener types and undisturbed soil on infiltration rate to 100 mm, in the presence of earthworms and absence of	

	<u>PAGE</u>
crop residue.	279
58a Effects of direct drilling opener types and undisturbed soil on infiltration rate to 60 mm, in the absence of earthworms and crop residue.	280
58b Effects of direct drilling opener types and undisturbed soil on infiltration rate to 100 mm, in the absence of earthworms and crop residue.	281
59a Effects of direct drilling opener types and undisturbed soil on infiltration rate to 60 mm, in the presence of earthworms and crop residue.	282
59b Effects of direct drilling opener types and undisturbed soil on infiltration rate to 100 mm, in the presence of earthworms and crop residue.	283
60. Effects of different methods of creating "V" shaped grooves and position of crop residue, on seedling emergence rates of barley, under simulated rain conditions.	290
61. Effects of different methods of creating "V" shaped grooves and position of crop residue, on changes in oxygen diffusion rates (ODR) with time, under simulated rain conditions.	296
62. (a,b,c) Effects of different methods of creating "V" shaped groove types and position of crop residue, on root/shoot development of barley.	300

LIST OF APPENDICES

- 1a. The principal characteristics of direct drilling grooves in a silt loam soil at moisture contents, 15%, 20% and 27%.
- 1b. Limits of the effects of direct drilling opener types on soil resistance, from the centre of the grooves.
- 1c
 - i. "Iso-soil-strength" lines on either side of a direct drilled groove (Winged opener).
 - ii. "Iso-soil-strength" lines on either side of a direct drilled groove (Triple disc opener).
 - iii. "Iso-soil-strength" lines on either side of a direct drilled groove (Hoe opener).
- 2a. Manawatu soil and ambient temperatures during December, 1982 and January, 1983.
- 2b. Manawatu rainfall data (December, 1982 and January, 1983).
- 3a. A sample of a week day/night temperature and relative humidity changes inside the glasshouse with a nominally controlled temperature range of 20-25^o C.
- 3b. Thermocouple calibration curve.
- 3c. A sample of a week day/night temperature and relative humidity changes inside the glasshouse with a nominally controlled temperature range of 15-20^o C.

ABSTRACT

Stand establishment of crops by direct drilling is a function of seed germination and seedling emergence and their interactions with the soil physical micro-environment at or near the seed soil interface which itself is influenced by the design of direct drill openers. The main objectives of this project were to study the effects of opener types on seed germination and seedling emergence under continuously wet warm conditions. Experiments were conducted in the field under variable climatic conditions and in a laboratory under controlled conditions.

A field experiment showed that continuously wet soil conditions after drilling, resulted in significantly lower seedling emergence and root/shoot weights than non-irrigated conditions. Both field and laboratory experiments indicated that there were three strong influential variables; opener types, the presence or absence of surface residue, and the presence or absence of earthworms.

Five opener types and a surface broadcasting treatment were tested. Best results (in terms of barley seedling emergence) came from surface broadcasting on the untilled soil in all residue and earthworm conditions, and a winged (inverted "T" shaped groove) in the presence of both residue and earthworm conditions. A hoe opener ("U" shaped groove) in these latter conditions was marginally inferior to the winged opener in this respect. In the absence of both residue and earthworms there were few opener effects although the increased mechanical disturbance of a power-till opener (100 mm wide "U" shaped groove) gave the highest seedling emergence of all other "true" opener types in these conditions. Worst results involved a punch planter (discontinuous "U" shaped holes) and a triple disc opener ("V" shaped groove) in almost all conditions.

Crop residue conditions resulted in significantly higher numbers of emerged seedlings and greater root/shoot weights than no-residue conditions, under both simulated rain and temporary high water table conditions. Long residue (200 mm) showed a significantly larger number of emerged seedlings than short residue (40 mm) or bare soil (no-residue). Two opener types (winged and hoe) benefitted from the presence of crop residue, whereas with a triple disc opener the presence of crop residue was a disadvantage. This was because the function of the

winged opener kept the residue over the soil surface and the hoe opener swept it aside, whereas the triple disc opener pushed the residue down inside the groove and seed/residue contact appeared to have phytotoxic effects on seeds and seedlings. The performance of the triple disc opener groove was improved when residue was artificially removed from inside of the groove.

The narrow discontinuous "U" shaped holes created by a punch planter opener, the wide "U" shaped groove of a powered power-till opener and a surface broadcasting treatment did not appear to be influenced by the presence or absence of crop residue. Because precipitation was artificially regulated in these experiments, the latter technique was felt to be of limited practical importance, for untilled soils, because of the uncertainty of natural weather conditions following seeding in the field and the otherwise poor potential for seed/soil contact.

In the presence of residue there were higher oxygen diffusion rates (ODR) and lower soil bulk densities, together with increased earthworm populations and activity around the groove profiles of the winged, hoe, power-till and punch planter openers than under no-residue conditions. With the triple disc opener grooves, this trend was reversed, possibly because of compaction and smearing created by this opener.

The presence or absence of earthworms had a marked effect on seed/seedling performance. In the absence of earthworms the contrasting crop residue conditions and opener types had little or no effect on seedling emergence and seed/soil environment were in fact adversely affected by the absence of earthworms. The compacted and smeared groove of the triple disc opener showed lower numbers of earthworms around the groove profile than all other opener types under both residue and no-residue conditions. It was found that a high soil bulk density (1.4 g/cm^3), and to a lesser extent a heavy smear were detrimental to earthworm activity.

The absence of earthworms resulted in 7-9 fold lower cumulative infiltration around the groove profiles than where earthworms were present. Opener effects on infiltration strongly favoured the winged design in the presence of earthworms, but only when infiltration was measured to a depth of 100 mm.

It is therefore recommended that where surface residue and earthworms are present, use of a winged or perhaps hoe or power-till type opener is preferred in soil conditions likely to remain saturated during the germination and emergence phases. A power-till opener is preferred where residue or earthworms are absent. Use of triple disc or punch planter openers in any of these conditions is not recommended.

1. INTRODUCTION

Stand establishment of crops is markedly influenced by the efficacy of seed germination and seedling emergence. The total environment influencing germinating seeds is composed of physical, biological and chemical parameters. Within the broad range of non-limiting biological and chemical conditions, the stress imposed by physical factors in wet soil conditions may become the dominant force which might then limit seed germination and/or seedling emergence in the field. An understanding of soil physical factors and their inter-relationship with seed germination and seedling emergence is therefore fundamental to the precise functioning of seed drills, especially in relation to the design of furrow openers.

Seeds of field crops have been traditionally sown into conventionally tilled seed-beds. Considerable data are available concerning the characteristics of soil tillage profiles in such conventionally tilled seed-beds which have aimed at encouraging consistently optimum responses from seeds and seedlings during germination and emergence. In direct drilling (or no-tillage), because the technique is based on the avoidance of general seed-bed tillage (with or without herbicides), the seed is sown directly into the untilled soil. Most of the comprehensive work to date at Massey University, New Zealand has sought to characterise the micro-environments created by direct drilling openers in dry soils, and has centered on three opener types (winged, triple disc and hoe). Under wet soil conditions, little comparable data exist for untilled seed-beds. If the experience in dry soils is to be followed, extrapolation from tilled seed-beds might be (at best) unwise, and (at worst) distinctly misleading.

Phytotoxic effects of decomposing crop residues under the cool wet soil conditions in the United Kingdom have been described, but no interactions with opener types have been studied. Moreover, little information has been available regarding the comparative performance of opener types in the presence or absence of crop residues and/or earthworms under wet soil conditions. The objective, therefore, of this study was to identify and investigate the salient physical and biological parameters which might be altered by the action of different direct drilling opener designs in wet soils, and in turn to study the effects

that these might have on seed germination and seedling emergence of barley.