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

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by

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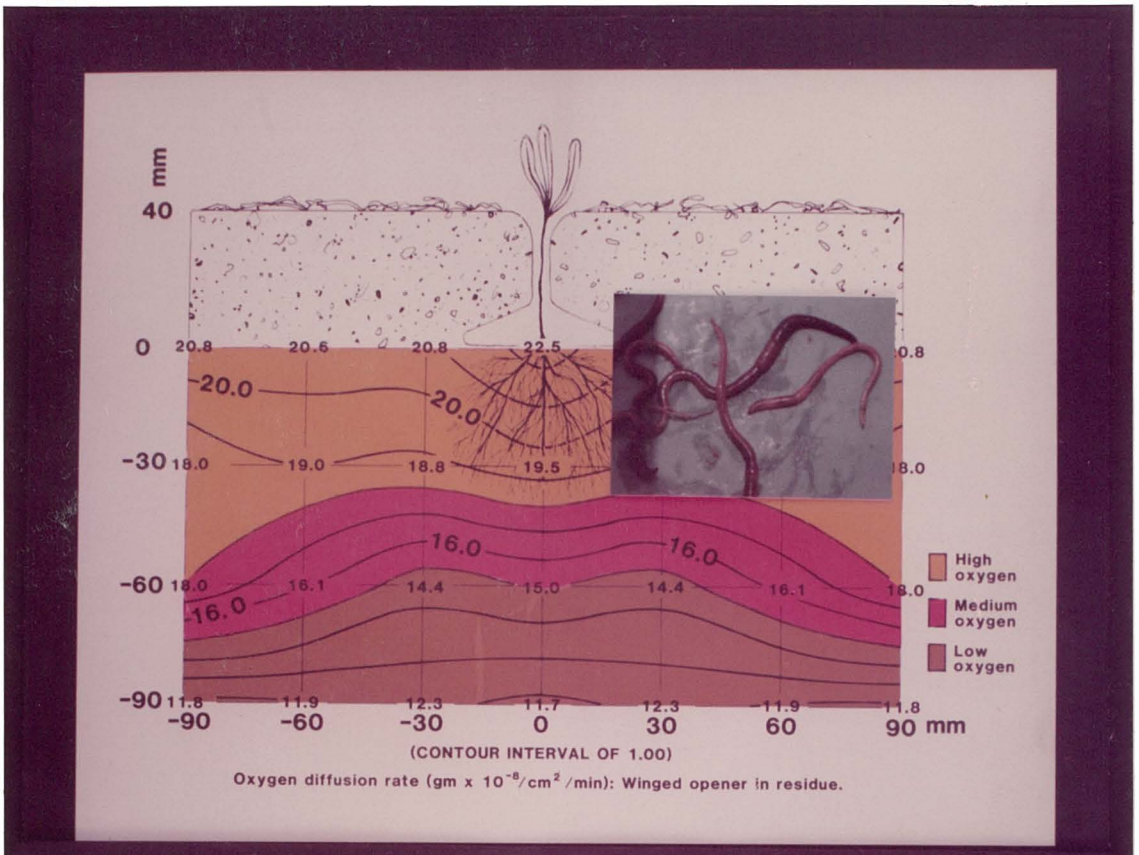

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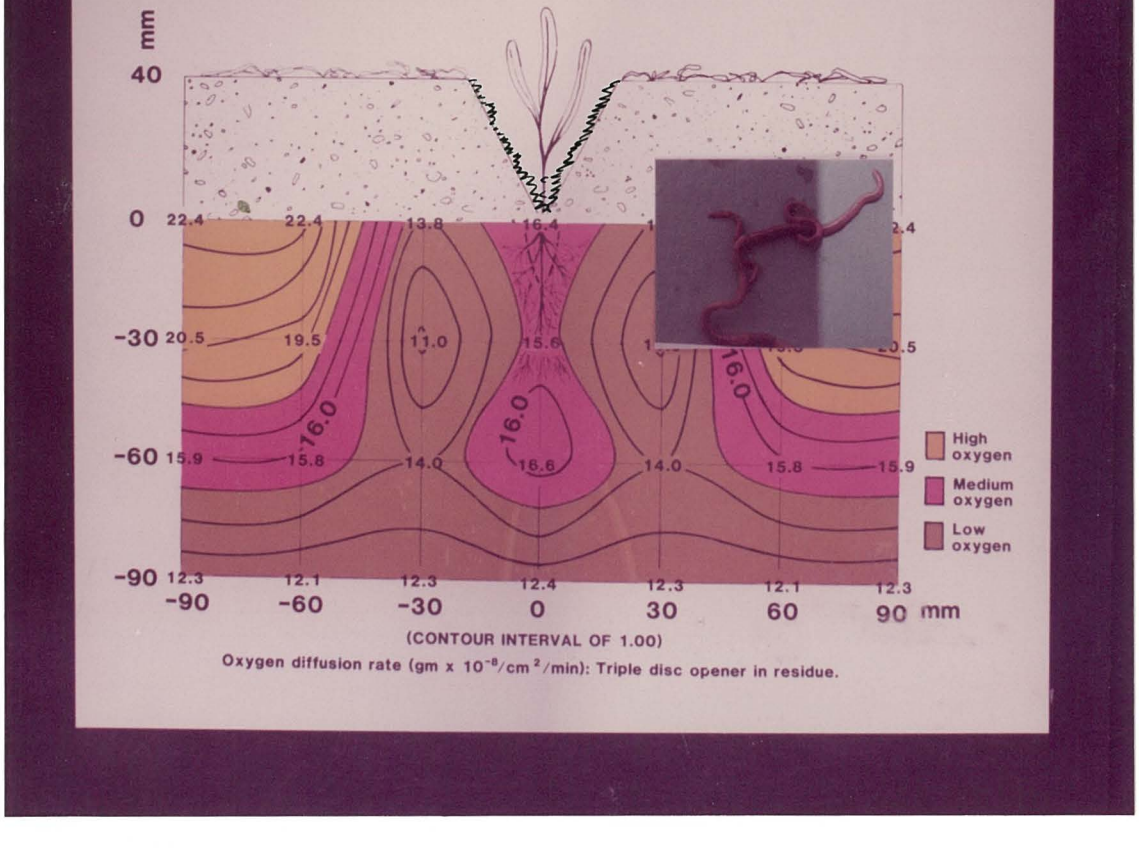
Oxygen diffusion rate (gm x 10^{-8}/cm^2/min): Winged opener in residue.



(CONTOUR INTERVAL OF 1.00)

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

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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.