INTERRELATIONSHIPS BETWEEN PERFORMANCE OF DIRECT DRILLED SEEDS, SOIL MICRO-ENVIRONMENT AND DRILLING EQUIPMENT

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy at

Massey University
Palmerston North

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1979

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ABSTRACT

Stand establishment of crops by direct drilling is a function of seed germination and seedling emergence efficacy and their interactions with the soil physical micro-environment created by direct drill coulters.

Experiments conducted in two contrasting controlled climates using 0.5 tonne undisturbed turf blocks suggested that the three coulter types compared (viz. an experimental chisel coulter, a hoe and a triple disc coulter) performed significantly differently, in terms of wheat seedling emergence, when the seed was direct drilled into a fine sandy loam soil. Overall the chisel coulter promoted highest seedling emergence (63.5%) followed by the hoe coulter (50.6%) and the triple disc coulter (27.0%). When the initial soil moisture potential was close to permanent wilting point, seedling emergence counts between these three coulters were highly significant with the difference between the chisel and triple disc coulters being almost six-fold. When the initial soil moisture level was adequate, seedling emergence counts from the triple disc grooves, were still significantly lower than from the chisel and hoe coulters which themselves performed equally.

When the controlled relative humidity was increased from 60% to 90%, seedling emergence increased but this difference was significant only at a lower level of probability of $P = 0.10$.

Application of pressures (using press wheels) up to 70 kPa over the covered seeds after bar harrowing had no significant effect on seedling emergence at either the low or adequate initial soil moisture levels. When similar pressures were applied directly over the uncovered seeds, seedling emergence significantly increased to 60% in the hoe coulter grooves and to 28% in the triple disc coulter grooves compared to the unpressed seeds. No significant increase was observed from the chisel coulter groove as a result of these pressures because it had already promoted a high seedling emergence count of 58%.

Further experiments, using small undisturbed turf blocks, to examine more closely the poor performance of the triple disc coulter, indicated that smearing had not been the main cause of seedling emergence failure. When the triple disc coulter grooves were modified

using combinations of pressure applications and seed covering techniques, seedling emergence was significantly improved. It appeared that this improvement in seedling emergence was a function of a modified soil physical micro-environment at the seed-soil interface. Based on these results two hypotheses were evolved. The first hypothesis suggested that the transfer of liquid soil moisture to the seed for germination (and perhaps away from the unprotected seedling after germination but prior to emergence) could be altered by the shape of the seed groove and placement and covering of the seed. This was described as "soil moisture diffusion"

The second hypothesis suggested that after the germination, subterranean seedling survival depended on the availability of vapour phase moisture which was also a function of the groove shape and covering medium. This was described as "soil moisture captivity".

A thermo-electric dew point hygrometer was used to measure the in-groove vapour moisture potential within the drilled grooves in the larger turf blocks, in a controlled environment. Significant and repeatable differences in the drying rates of the grooves created by the three coulter types were measured and promised to at least partly explain the underlying causes of their abilities (or lack of abilities in some cases) to promote seedling emergence. Combined counts of seedling emergence and sub-surface seedling survival were moderately correlated ($r = 0.71$) with the corresponding rates of loss of in-groove soil vapour moisture.

It appeared from the data that the important design characteristics for direct drilling coulters were that they must have the ability to both exploit the limited supply of sub-surface liquid moisture for germination and also to retain soil moisture in the vapour form for seedling emergence and/or survival. The latter function appeared to be aided by the creation of minimum surface shattering and maintenance of a high incidence of surface mulch in the form of sod or organic matter.

Field experiments suggested that when the only measured soil moisture data available was at or prior to drilling, the present state of knowledge would not permit accurate seedling emergence data to

be predicted for any given coulter and covering technique. If however, soil moisture data was available for the period between drilling and seedling emergence, reasonable predictions of seedling emergence could be made, given the characteristics of the coulter types and covering techniques used. Examples of mathematical models were constructed for each of the three coulter types used, to predict seedling emergence as a function of these soil moisture data.

The field experiments also confirmed that higher seedling emergence counts could be expected when the chisel coulter was used in dry soils compared with the hoe or triple disc coulters. During a typical spring-summer-autumn period in the Manawatu, when wheat seed was direct-drilled at fortnightly intervals into a "Tokomaru silt loam soil"; from 16% of the drillings the chisel coulter promoted significantly higher seedling emergence counts than either the hoe or triple disc coulters.