Paddock Yield and Seeding Depth Optimisation

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Key Points

- Seeding depth uniformity is influenced by both seed placement quality within the furrow and the consistency of added soil cover
- Many machinery design and operating parameters affect the uniformity of seeding depth across a paddock
- Deep sowing (eg. beyond 50-6omm) can significantly affect crop emergence and final grain yield
- Many paddock situations can soon suffer a 5-10% yield loss as a result of inadequate seeding depth, with more extreme situations suggesting possible yield penalties of 15-20% or more.

Introduction

The importance of seeding depth accuracy in maximising crop potential is recognised by most farmers. However, being able to quantify the effect of a poorly set and operated seeding machine on crop response is a useful step to justify efforts and investments to secure an optimum seeding depth.

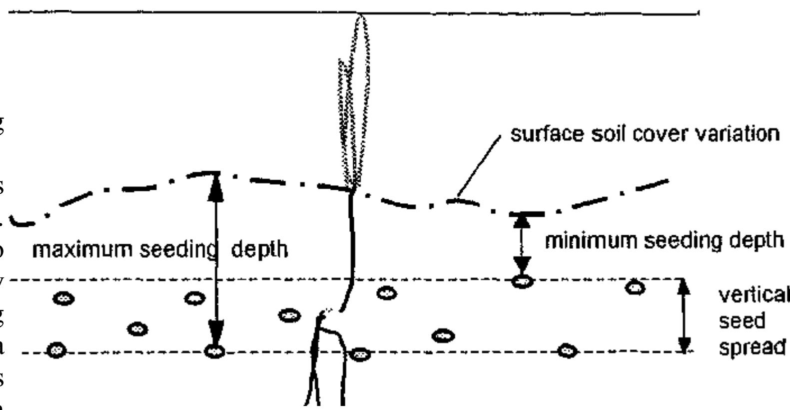

Fig. 1: Seeding depth uniformity reflects the combined accuracies of seed placement and added soil cover

In cereals, the coleoptile length influences how accurate seed placement has to be for optimum crop establishment. As a general rule, the shorter the coleoptile length of a cereal variety, the more accurate the seeding depth needs to be. The coleoptile protects the first leaf while pushing through to the soil surface. When sown deeper than coleoptile length, the emergence of the first leaf is at greater risks of failure and disease. With early sowing in warm soil environment, deeper seed placement significantly delays seedling emergence (equivalent to sowing later) and enables fewer emerging seedlings, which may be weaker and tiller less vigorously. With late sowing into colder topsoils, however, crop emergence and early vigour may conversely be slowed down with too shallow a seeding depth (eg. broadcast seeding technique), while deeper sowing (eg. sing a drilling technique) would comparatively hasten crop establishment.

1. Sources Of Seeding Depth Variation

Seeding depth is influenced by both the seed placement within the furrow and the soil cover subsequently added during the furrow closing operation. Both the vertical seed spread and the uniformity of soil cover will influence the final variation in seeding depth (Fig. 1). The seed boot design, setting and matching to point type dictate the quality of seed placement obtained, however, its performance is only the first half of the equation, as seed covering is another very significant source of variation.

A more uniform seeding depth is typically achieved with press wheels, which minimise variation in soil cover, provided they leave a regular and stable furrow profile, at best centred to the seed row. A rougher surface finish such as that achieved by rotary harrows comparatively contributes to increasing the variation in seeding depth.

At the implement level, significant variation in seeding depth (eg. 20-60mm) can artificially be created with many seeding implements due to lateral soil throw effects between adjacent rows (furrow ridging issue), whereby front mounted openers get additional soil cover from rear mounted openers on adjacent seed rows. The penalty of increased seeding depth on these rows can sometimes add to over-consolidation due to over-pressing by rigid press-wheel gangs. Five options should be considered by the farmer to manage furrow ridging issues:

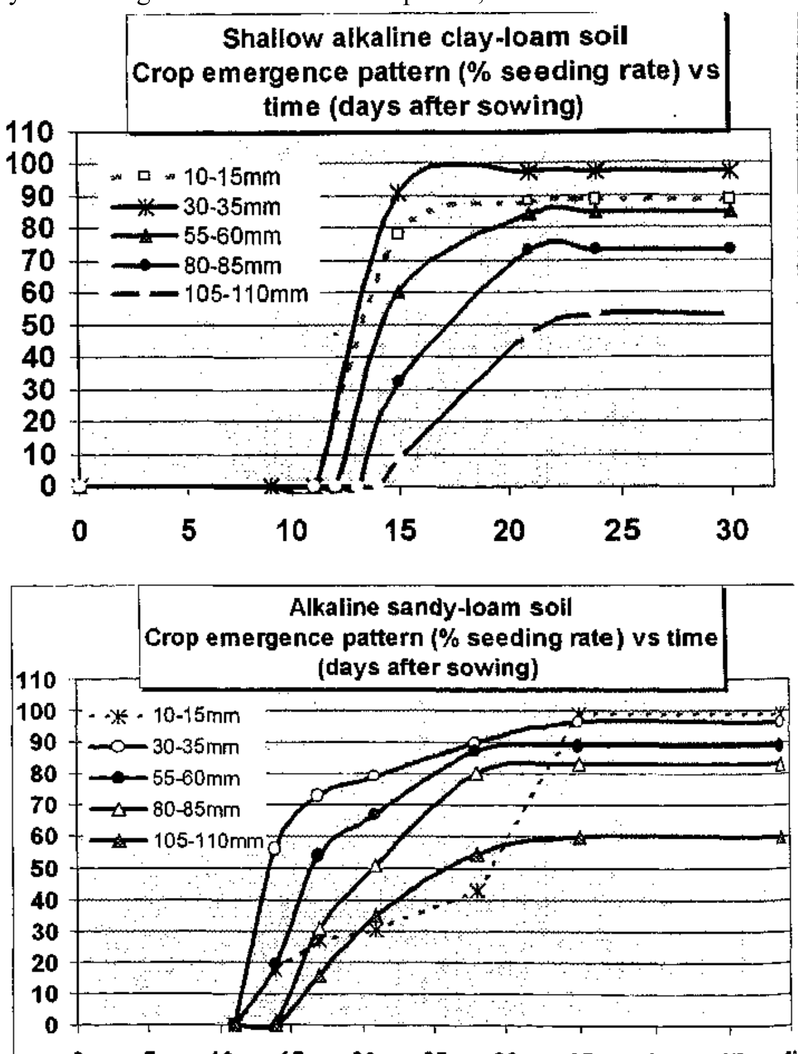

Fig. 2: Seeding depth effect on wheat crop emergence at Minlaton SA (top) and Waikerie SA (bottom)

1. Control: Lateral soil throw typically increases with the square of velocity (ie. it is common to expect soil to reach 4 times as far, at twice the speed), and in most cases can effectively be controlled by adopting low travelling speeds. This option, however, reduces work rates, increases operating costs/ha, with potential timeliness penalties.

2. Minimise: soil throw effects on seeding depth can significantly be reduced by using low disturbance openers (eg. very narrow openers set at a low rake angle), shallow operating depths, narrow and forward leaning tine shanks and wider row spacings. Additionally, the use of disc coulters ahead of tillage points minimises the extent of lateral soil throw. This option may involve specific investment, with likely crop yield opportunity loss occurring at wider row spacings.
3. Compensate: where individual seed boots can be adjusted, seed placement can be optimised on a row by row basis to counter or at least minimise the effects of furrow ridging. This option is not applicable to all seeding technologies and may place the crop at greater risks of poor emergence in marginal moisture conditions or due to toxicity with soil incorporated herbicides (eg. trifluralin).
4. Equalise: ridges can be spread across the soil surface in a levelling operation using full width harrow devices or single ridge dividers (eg. spring finger tines). The increased soil manipulation may further stimulate weed seeds and does not allow the protection and water harvesting benefits of furrows.
5. Contain: Specific technology (eg. floating rolling shields) can be fitted to tine shanks, with the aim to redirect whole or part of the outward soil throw back onto the furrow. Beside the additional cost, cluttering effects within the frame can interfere with the residue handling ability of the machine.

In undulating ground, the lack of contour following ability from the machine can create large local variations in both tillage and seeding depth. Floating hitches, flexible frames and a range of contour following design for openers and seed boot systems can provide partial or full remedial solutions. In soft soil conditions creating sinkage or with leaking hydraulics, variation in implement frame height can be monitored and corrected using depth control sensor technology.

2. Seeding Depth Trials

Two trials were conducted in 2002 at a clay-loam site at Minlaton (Yorke Peninsula, SA) and at a sandy site at Waikerie (Riverland, SA), using intermediate coleoptile length wheat. Five seeding depths within a range of "too shallow" (10mm) to "too deep" (110mm) were implemented in a replicated design, using a low disturbance single shoot spear point opener set at 0.18m row spacing and followed by press-wheels. To eliminate bias, no soil incorporated herbicide was used at sowing, which was conducted at low speed (4kph) to also minimise ridging across rows. 110kg DAPZn fertiliser (16-18-0-3NPKS) was deep banded at 110mm depth in a separate operation prior to sowing.

- At Minlaton, *Krichauff* wheat was sown on 24 June at 78kg/ha, targeting 190 plants/m^2 at 95% field emergence. Sowing was conducted in moist clay-loam soil conditions and significant follow-up rain (50mm) occurred in 3 events at Day 3, 10 and 20 after sowing. Apr-Oct. growing season rainfall was 266mm (77mm below average).

- At Waikerie, *Clearfield Jnz* wheat was sown on May 25th at 64kg/ha, targeting 140 plants / m^2 at 95% field emergence. Sandy-loam soil conditions at seeding included suitable moisture below a drying 15-20mm top soil, with a 11mm follow-up rainfall event occurring only 21 days after seeding. Apr-Oct. GSR rainfall was very low at 91mm (72mm below average), which resulted in a serious drought condition.

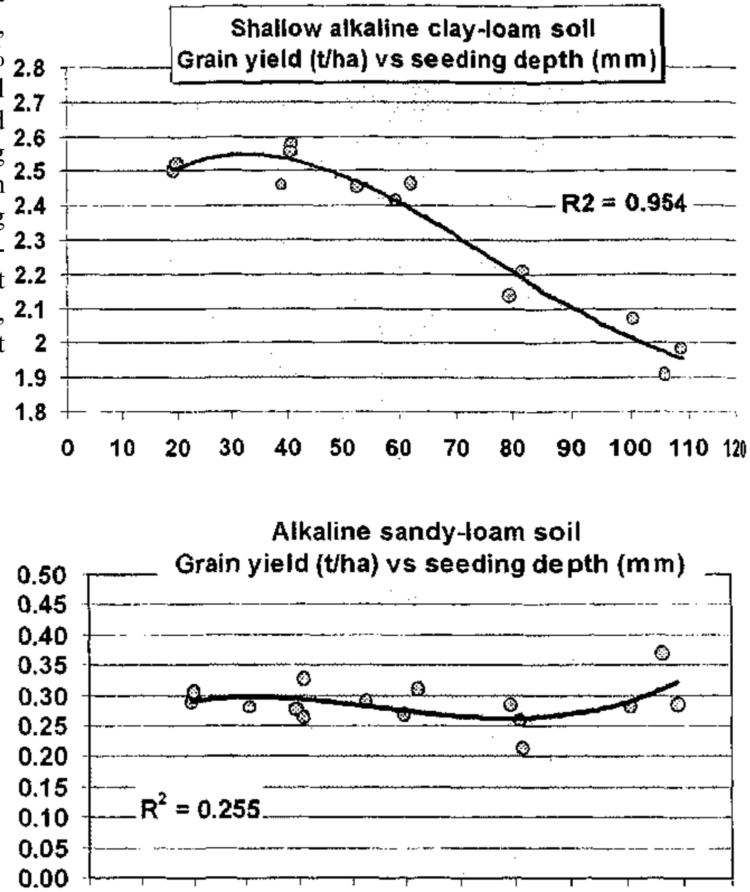

Fig. 3: Crop yield potential was seriously compromised by deep seeding at Minlaton (top) but not at Waikerie (bottom) due to the biasing effect of a very strong drought

3. Crop Establishment and Growth Results

Fig. 2 (top) shows the extent to which wheat emergence was gradually reduced by deeper seeding depth at the Minlaton site, reaching 85%, 73% and 53% of seeding rate, at 60mm, 85mm and 110mm depth respectively. Deeper seeding depth also delayed maximum emergence by up to 6-7 days. An emergence penalty of 12% also occurred at the shallowest seeding depth explained by a proportion of seeds placed in the 0-5mm depth layer, which did not successfully establish and/or were subject to predation. Under these experimental conditions, wheat established best within the 30-35mm layer. At tillering, a trend of fewer tillers/plant and smaller plant size with deeper depth was later observed.

At the Waikerie site (Fig. 2 - bottom), a similar response was achieved with slightly lower penalty levels (eg. 89%, 76% and 59% emergence rate at 60, 85 and 110mm depth), additionally illustrating a situation of staggered emergence at the 10-15mm depth, due to the drying conditions at sowing coupled with late follow-up rains. In this case of marginal soil moisture at sowing, too shallow a seed placement resulted in similar effects to delayed sowing (by up to 3½ weeks).

4. Grain Yield Results

At Minlaton. a head count/m^2 conducted prior to harvest showed significantly reduced numbers at. and below, 80mm depth. However, there was some level of compensation at these deeper depths with slightly heavier head weight (+8 to 16%). The harvested yield data (Fig. 3 - top) showed a significant yield drop beyond an optimum depth of 30-40mm. Deep seeding at 60, 80 and 100mm created yield penalties of 5%, 13% and 21% respectively, below the maximum yield of 2.55t/ha. A trend for a slight yield decrease of 3-4% at the shallowest depth (10-15 mm) is also suggested by the data set. It is anticipated the penalising effects of deeper seeding depth would be greater in above average seasons.

Fig.4: Securing an optimum seed environment across the whole paddock forms part of a precision farming approach

At Waikerie, due to the very dry season (decile 1 rainfall), the wheat crop yielded very poorly (0.34 t/ha overall) with minimal treatment differences being recorded (Fig. 3 - bottom). Head counts conducted at maturity confirmed slightly lower counts of heads/m^2 with deeper depth, which resulted in significantly greater head weight (eg. 20-32% heavier) at 110mm depth. Under the experimental conditions, the yield data resulted in no significant influencing effect of seeding depth, with a slight 'technical' improvement (8% above average yield) at the 110mm depth. The Waikerie results reflect a situation of strong drought, with the main driving factors linked to plant density differences as influenced by seeding depth. Lower than targeted plant densities at 75-85 plants/m^2 providing less competition were better suited to the limited moisture and able to achieve a slightly better grain yield performance.

5. Paddock Yield Optimisation

The above data reinforce the importance of achieving an optimum seeding depth over the whole paddock (Fig. 4), which implies reviewing and optimising all potential factors influencing i) the accuracy and, ii) the uniformity of seed placement and of soil cover. As tillage depth has a great influence over both the furrow characteristics and the amount of soil throw, suitable technologies, which result in improved control over both tillage depth and seed placement at the individual row level, should be considered, including:

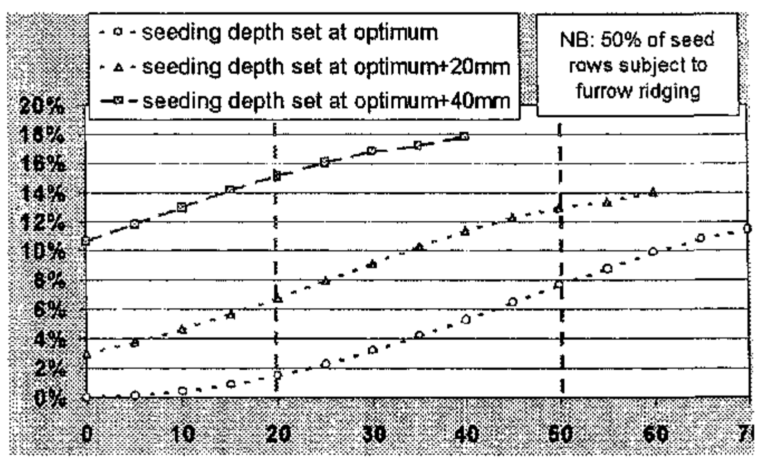

Fig. 5: Anticipated wheat yield penalty (%) as function of additiona seed cover height due to ridging (mm) and implement seeding depth settings (NB: the graph assumes the *Krichauff* yield curve ir Fig. 2 applies individually to each sowing row across the implement)

- Contour following tillage components and/or seed delivery systems

- Automated control of implement frame height
- Effective management of soil throw issues (as reviewed in section 1 - above)

The following example highlights opportunity yield losses expected from the effect of an inadequately set and operated seeding machine. Assuming that the *Krichauff* wheat yield relationship of Fig. 3 holds true for each individual sowing row. the context of a 4 rank implement with a tine layout exposing 50% of seed rows to double sided ridging effects is reviewed in Fig. 5. In the best case scenario (ie. implement successfully set to the optimum seeding depth of 35mm), a 2-8% yield penalty is still expectable from uncorrected ridging effects which may develop at actual sowing speed (eg. 20-50mm typically encountered with many seeding systems). If the implement had instead been set deeper by 20mm and 40mm (ie. 55mm and 75mm seeding depth), intentionally or by accident, the expected penalty range would rise to 7-13% and 15-]9%, respectively.

Seeding depths of 80-100mm were not uncommon in many surveyed paddocks of the Yorke Peninsula and Mallee regions, particularly under levelling harrow systems, likely targeting deeper soil moisture. Farmers should be conscious of the opportunity yield loss attached to deeper sowing, and its effect on profitability.

Crop establishment risks are usually highest in either marginal or excessive moisture conditions. In many cases, tillage and furrow closing technology can selectively be manipulated to minimise risks and optimise results. For instance, as an alternative to deeper sowing into moisture, deep tillage below the seed zone combined with press wheels is a useful technique able to improve the reliability of crop establishment in moisture limiting conditions by combining deeper soil moisture delving and maximised soil/seed contact, while not compromising seeding depth. Research has also shown that some amount of loose soil cover added over press wheel furrows (using snake chains or finger tines) can help minimise water evaporation rates out of consolidated soil and optimise seedling emergence in dry conditions.

Essentially, the above considerations should form part of a precision farming approach to maximising paddock crop yield through securing an optimum seed environment in every furrow over the entire paddock. Other 'precision seed environment' factors include the ability to achieve a uniform spatial distribution of seeds and fertiliser along and across each furrow.

Acknowledgments

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