DESIGNING A SEEDER FOR NO - TILLAGE STUBBLE RETENTION CROPPING ON PERMANENT RAISED BEDS

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Introduction

Most of Western Australia's agricultural topsoils are shallow and dense. For permanent raised beds to work effectively and prevent waterlogging on soils that are essentially structureless, macroporosity has to be created and maintained. This will only occur through the combined effects of prolific numbers of undisturbed roots, active soil biota, gypsum if the soil is sodic and cropping practices which do not cultivate or compact the soil.

To facilitate the rapid development of the required macroporosity, our raised beds are formed by ripping and chisel-ploughing to 20 cm depth, incorporating gypsum in the process, if necessary, and then forming the beds and furrows with a furrower-bed-former. The furrows become the traffic lanes and no farm traffic ever traverses the beds. The beds and furrows form a complete controlled traffic regime. After formation, no-tillage crop establishment practices are imposed and there is no grazing. Total stubble retention is also imposed.

The soil in the beds presents special challenges for the design of a no-tillage seeder with an assured stubble handling capacity. The floor of the furrows is between 25 to 35 cm below the surface of the beds , and the furrows are spaced 1.8 m apart. The soil has a low density and very low load bearing capacity, particularly when moist or wet, placing it at the opposite end of the scale to "normal" no-till seedbeds. "Normal" seedbeds commonly have compact surfaces, and the seeders designed to handle these conditions have high break-out-pressure tines and large disc pressures to allow them to "penetrate" the soil and cut the stubble.

Just to be compatible with the raised beds seeders must:

a) be mounted on a bar with gauge wheels compatible with furrows spaced at 1.8 m centres;
b) be capable of being raised above the beds and still have its openers operate satisfactorily over a 35 cm height range, from furrow floors, up bed shoulders and across bed tops;
c) have openers which can accurately control the depth of seed and fertiliser placement without causing unacceptable compaction of the soft soil in the beds.

In addition, seeders for raised beds must exhibit high performance characteristics of the attributes required of normal seeders, i.e.:

- stubble cutting and/or clearance;
- separation of fertiliser from the seed, either to the side and/or beneath seed;
- mixing some fertiliser with the seed;
- accurate seeding rate settings and even distribution of widely varying seed sizes;
- accurate seed placement in terms of depth and spread within a row;
- good soil coverage and contact without compaction;
- furrow shaping; and
- easily varied opener position to adjust the width of row spacing.

Review of seeder performance in 1997 & 1998

The machine used to seed our raised beds in 1997 and 1998 was a Great Plains 3-point linkage 20 feet double disc seeder (provided by Perkins Machinery, Narrogin). Of the machines available in 1997 this was the only one known to the senior author with compatability attributes a) and b), listed above.

Seeding in 1997 was done in drier than optimum moisture conditions and the crop sown was oats. Establishment was good to excellent at all sites. With the advantage of hindsight, the crop was insensitive to sowing depth and the dry soil provided adequate load bearing capabilities.

Seeding in 1998 involved Canola (as the 2nd crop on most sites), barley, oats and wheat, the last three on new (Quairading, and Toolibin) or renovated (Mt. Barker) sites. Seeding conditions at all sites was done in optimal to wet moisture conditions, and the soil in all the beds, new, renovated and 2nd year was soft and had very little load bearing capacity. In consequence, seeding depth at all sites could not be adequately controlled by press wheels and the seed was sown too deep. Despite the too-deep seeding, the cereal crops in the beds established satisfactorily, but the Canola crops on all the beds and some of the control areas had to be re-sown at three sites (Beverley, Woodanilling and Cranbrook). The Esperance site was sown last, in drier condit. , and with wiser operators. Seeding of the second sowing sites and the Esperance site was accomplished by carrying the seeder totally on the 3-point linkage hydraulics with the double disc openers held just above the soil. The Canola seed was thus dropped on to the surface and lightly pressed by the largely suspended press wheels.

Lessons learned

a) Depth of seeding

The Great Plains seeder, which to the best of our knowledge was the only compatible machine available has been shown to be lacking in depth control capabilities on raised beds. Conventional press wheel mechanisms alone cannot be relied on with soil as soft as it is in raise beds. The stop-gap method used in 1998 to control seeding depth, by way of the tractor driver suspending seeder on the 3-point linkage, places too great a demand on the driver and will not be a viable proposition over large cropping areas.

A easily adjusted mechanism which provides a far greater range of pressures (particularly towards zero pressure) needs to be developed so that seeding depth and the compaction of soil above the seed can be accurately and reliably controlled.

b) Distribution of seed

The distribution of seed across all the openers was effectively uniform with cereals, but not with the small seeds of Canola. There was wide variation in the performance of the seed dispensing mechanisms, with the result that some rows had very little Canola seed dispensed.

A mechanism which reliably delivers a wide range of seed sizes to all openers on a seeder is required.

c) Stubble clearance

Harvesting raised beds requires the harvester to have a very effective straw chopper/spreader. Without a spreader, straw trails tend to fall on to one or two beds, making sowing of the next crop very difficult. Stubble was burned at all but one of the 1997 sites because of this problem. Significantly, the site where it was retained and sown through was the site with the lowest yield of oats in 1997.

Notwithstanding this, the ungrazed, standing stubble at this site presented no problems for the double disc openers on the Great Plains seeder. This was largely due to the standing stubble and the row cropping consequence of bed farming. The double discs parted the stubble easily as they passed down precisely the same row as existed in the previous crop.

Perhaps the stubble cutting capabilities required of seeders used in raised beds will not be stringent because stubble will be standing and openers will pass precisely along previous rows, splitting or pushing the crown and stalks of last year's crop to one side.

Choice of a replacement seeder

The stark realisation that seedbed conditions in raised beds are grossly different from normal soil conditions led us to assemble the following criteria for selection of a replacement seeder:

i) *A disc machine is needed* (rather than a tine machine) because only minimal disturbance is desired in order to leave the maximum possible number of undisturbed roots (to facilitate macropore development and organic matter build-up) and achieve good control of seed placement, particularly for small seeded crops, something which is not possible with the shattering and spraying of soil that occurs with a tine machine.

ii) *A machine that cuts stubble and places fertiliser away from the seed is needed.* Preferably one which also provides the options of either mixing the fertiliser with the soil or placing it as a concentrated band at variable depths relative to seeding depth.

iii) *A machine is needed with an easily adjustable press wheel/seed covering device which is capable of adjusting wheel pressures to close to zero and so controls the depth and compaction of soil above the seed.*

The capabilities and reliability of the triple disc units of Walker's, Merredin came to our notice. These openers satisfy 5 of the 8 performance characteristics required of normal seeder (listed above, Figure 1.). Furthermore, these openers offered the prospect of simple adaptation to satisfy a 6th (easy adjustment of row spacing) and possibly a 7th (good soil coverage and contact without compaction).

In addition, the Walker openers are compatible with mounting on a bar with gauge wheels and brackets that ensure compatibility requirements a) and b) are met (listed above).

Adaptations undertaken

a) Press wheel pressure adjustment

The effects on crop emergence, growth and yield of high soil bulk density and soil strength are well-established (Barley & Greacen, 1967; Collis-George & Williams, 1968; Mc Kyes, 1989; Taylor, 1971). Although the optimum values of bulk density or strength vary with soil type and season, the shape of the relationship shows reductions either side of an optimum density/strength, which itself is not widely varying. In terms of bulk density, the optimum over a wide range of soils, climatic conditions and crops lies within the range of 1.0 to 1.4 t/m^3. In Australian soils densities approaching 1.0 t/m^3 are found only in freshly cultivated soils, and values of settled topsoil are commonly > 1.5 t/m^3. Our challenge is to keep the bulk density of soil $\leq$ 1.4 t/m^3.

In order to identify what press wheel pressures are required of any adaptation to their adjustment mechanism, the method and standard soil parameter values presented in McKyes (1989; pp224 - 225) were used. This involves the equation:

$$\rho_{dry} = \rho_o + A.\log [N.p (1 + S) / p_o] + B.\log \theta_g$$

where

ρ_{dry}	=	compacted bulk density	(t/m³)
ρ_o	=	initial bulk density	(t/m³)
A,B	=	soil constants	
N	=	number of passes/repeated applications of pressure	
p	=	applied compaction pressure	(kPa)
p_o	=	precompaction soil pressure	(kPa)
S	=	wheelslip (fractional speed)	
θ_g	=	% gravimetric moisture content	(g/100g)

Note: The constant B is the coefficient of a soil's sensitivity to compaction (or its load bearing capacity). It increases to a maximum at the "optimum" compaction moisture content after which it becomes negative.

The analysis used a range of press wheel weights from 1 to 40 kg. (The existing mechanism on the Walker triple disc seeders recorded a weight of 34 kg when the spring producing a downward pressure, to achieve penetration, was taken off.) These weights were then converted to pressures by considering a range of press wheel contact areas (contact angles ranged from 30° to 60°). The pressures generated by this analysis ranged from 0.07 kPa to 5.76 kPa. Two initial bulk density conditions were used, 0.8 t/m^3 and 1.1 t/m^3, which are typical of freshly cultivated soil.

This analysis showed:

- The moisture content at which compaction will be maximised for a given pressure is ~ 15% by weight
- In order to maintain a bulk density $\leq 1.4\ t/m^3$ in soil above the seeds a pressure of ≤ 3 kPa is required.
- Only in soils with $\rho_o > 1.1\ t/m^3$ which are also wetter than 15% by weight will this maximum need to be reduced.

Hence, an adaptation to the Walker triple disc arm which allows the press wheel pressure to be reduced to < 3kPa ought to provide the flotation necessary for good seeding depth control and seed coverage without deleterious compaction above the seed.

The bracket and spring attachment shown in Figure 2. is capable of producing pressures form zero kPa at the lower limit of the seeder arm's 150 mm of vertical travel to 3.2 kPa at the upper limit, assuming the press wheel has a 30° contact angle.

b) Low rolling resistance of discs

One of the consequences of having soft soil in the beds is that pressure cannot be put on the leading coulter or double discs to ensure they turn. Hence, as a means of reducing the rolling resistance the seals in the disc hubs were reduced from two to one.

c) Creation of loose soil and enhanced stubble cutting

There is a need in a complete no-till regime to create some loose soil. This is needed to

- mix and so dilute fertiliser with the soil
- mix soil with herbicides, such as Treflan™ to ensure their efficacy
- disrupt the hyphae of some pathogens, e.g. rhizoctonia, and so assist with its control
- provide some loose soil for covering the seed.

Hence, rippled discs were mounted for the double disc openers and a wavy disc for the leading coulter. The self-sharpening attribute of a wavy or rippled coulter will facilitate stubble cutting and clearance(Figure 3.).

The use of these types of disc also assists in reducing rolling resistance, because of the extra friction caused by the waves and ripples. This extra turning efficiency means their angular velocity will exceed the seeder velocity, further enhancing soil loosening.

Field testing
The specially designed and adapted triple disc openers are to be field tested in the Spring of 1998. The openers are to have the seed and fertiliser delivered to them by way of a Simplicity airseeder.

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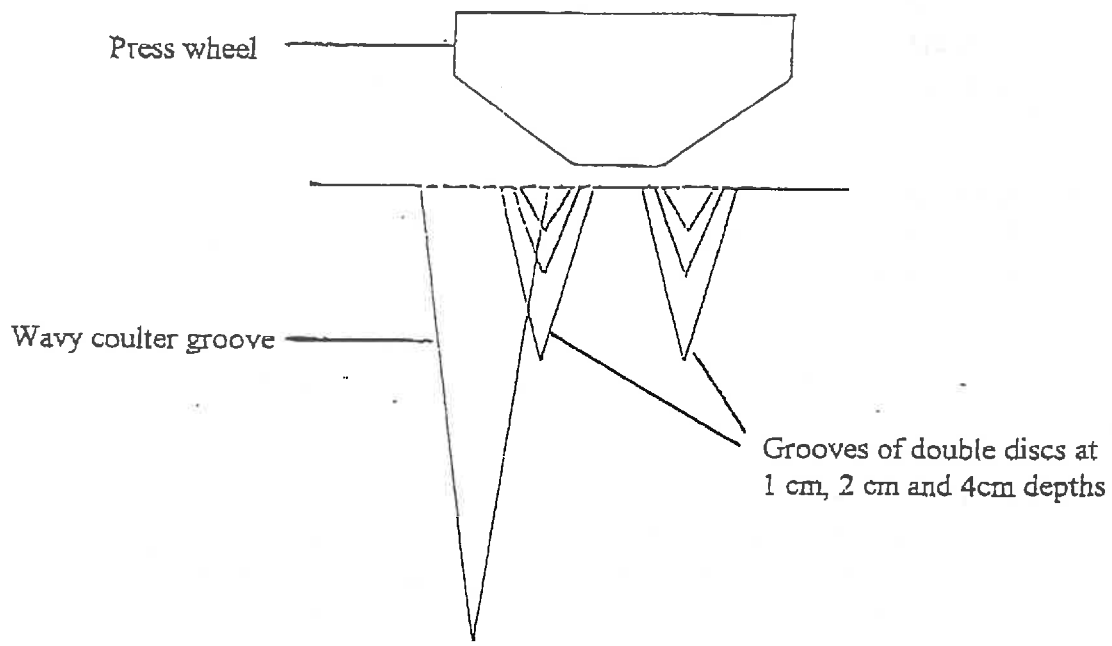

Figure 1. Scale diagram of relative dimensions and juxtaposition of grooves cut by the Walker triple disc seeder when the leading coulter penetrates (a) 10.5 cm & (b) 5.5cm, and the double discs penetrate (c) 3.0 cm & 0.8 cm. Note spoil from the leading coulter passes either side of the double discs and the soft rubber press wheel presses on the shoulders of the double disc cut.

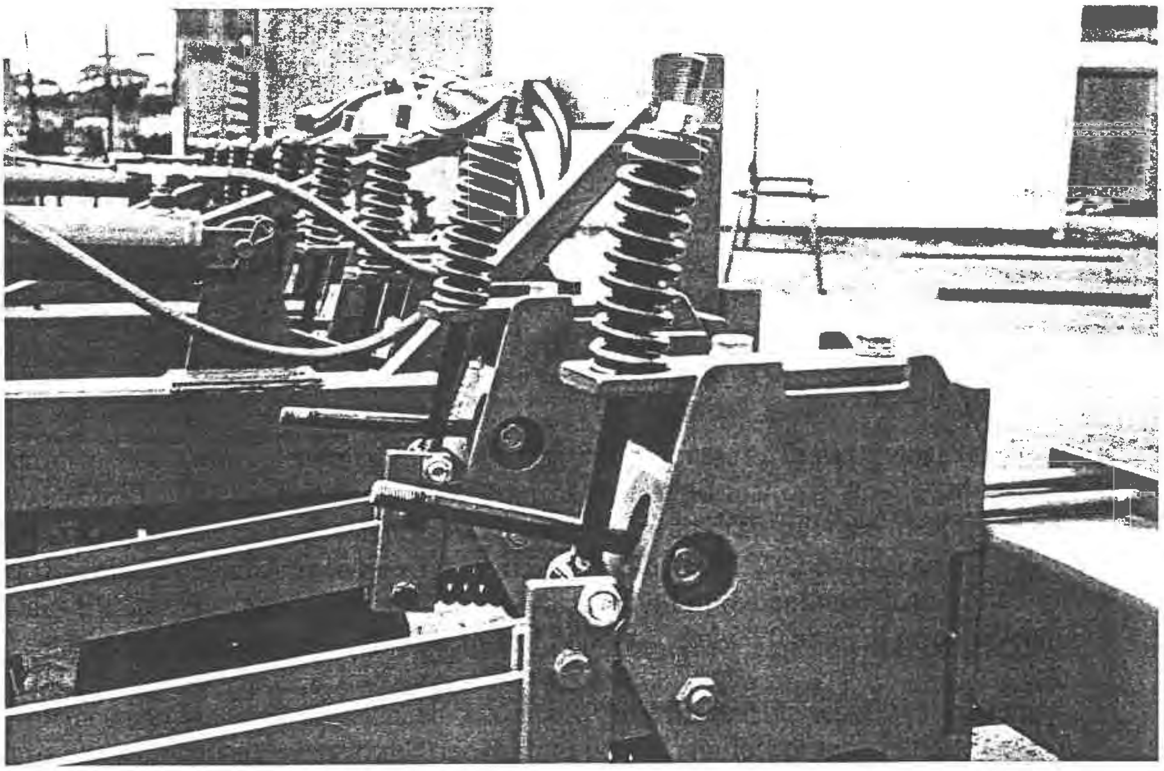

Figure 2. View of the extra bracket and spring added to the opener to adjust the pressure exerted by the press wheel to between 3 kPa and zero kPa. The adjustment is accomplished by tightening the nut above the spring.

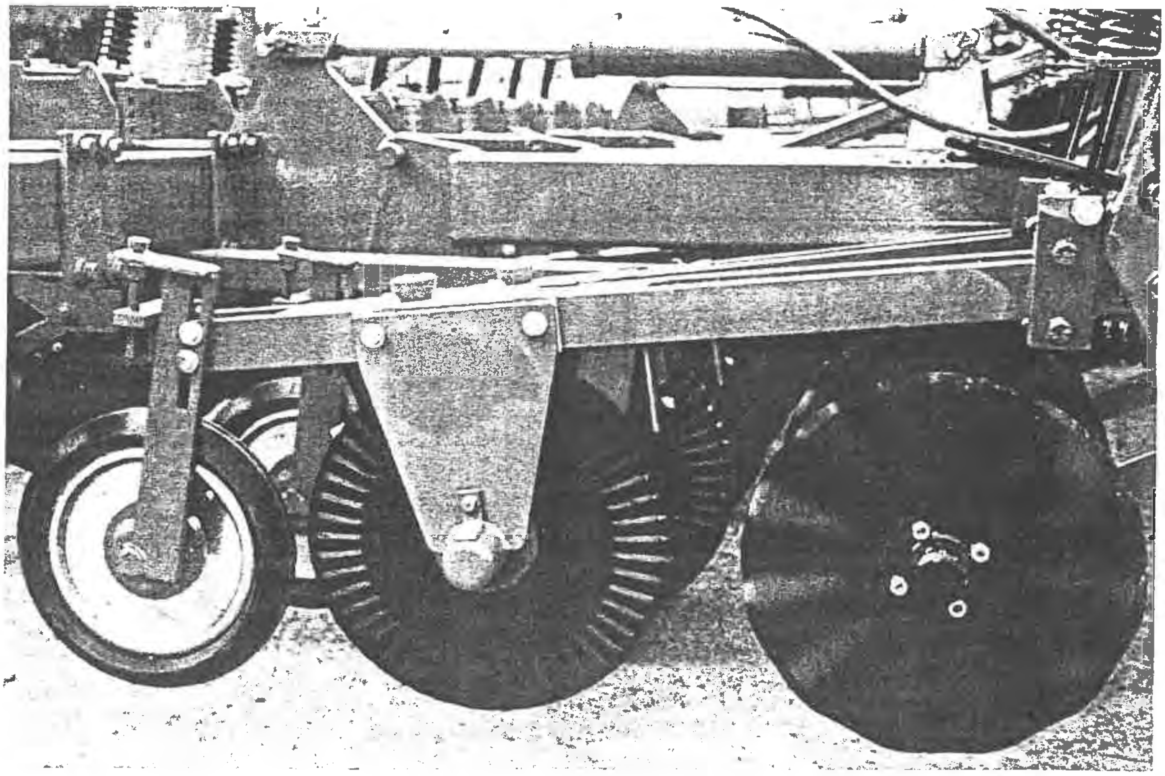

Figure 3. Side view of the triple disc openers mounted on the frame designed for use on the raised beds. Note the wavy leading coulter and the rippled double discs. The bar will be mounted on the 3-point linkage of a tractor and the gauge wheels on the rear of the bar will track in the furrows between the beds.