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Techniques for improving establishment of maize and soybean on cracking clay soils in the Burdekin River Irrigation Area

M. V. Braunack, W. J. McDonald and A. L. Garside

Department of Primary Industries, PO Box 591, Ayr, Q. 4807, Australia.

Abstract

Emergence of irrigated row crops is a problem on heavy clay soils in the Burdekin River Irrigation Area (BRIA). Two field trials were conducted on laser levelled land to examine the effects of sowing into ridges and beds, using before and after sowing irrigation and different opener-press wheel combinations on the emergence of maize and soybean.

There was no difference between beds and ridges on establishment of both crops. Establishment of maize was a mean of 63.4% and soybean was a mean of 35.4% across all treatments. After sowing irrigation was superior to before sowing irrigation for the establishment of both maize and soybeans. Maize gave 76.5% and 50.2% for after sowing and before sowing irrigations, and soybean 45.2% and 25.5% respectively.

The results suggest that the best option for improving maize and soybean establishment on the heavy clay soils of the BRIA is to use after sowing irrigation with spear point-split steel press wheels on laser levelled ground with a well aggregated seedbed consisting of less than 10% fine (<1 mm) material.

INTRODUCTION

Crop emergence is a major problem on the heavy clay soils of the Burdekin River Irrigation Area (BRIA). Emergence as low as 16% for maize and 30% for soybean has been measured in previous experiments (J. Barnes and R. Brinsmead, unpub. data 1974). Management options to facilitate establishment include timing of initial irrigation application, selection of opener-press wheel combinations and sowing on beds or ridges.

Irrigation options include before and after sowing irrigation. Before sowing irrigation is similar to the dryland situation of sowing after rainfall for which experience and equipment are available. However, poor establishment can occur due to uneven wetting caused by uneven microtopography and soil variability. Sowing can be delayed by the drying period required to avoid causing excessive soil compaction in the furrows by machinery. When the furrows are sufficiently dry the seedbed may be too dry for imbibition of moisture by the crop seeds. Further, before sowing irrigation increases the susceptibility to seed rots and surface crusting in the event of rain before emergence.

After sowing irrigation allows shallower planting compared with before sowing irrigation, and consequently rapid emergence and establishment and less susceptibility to surface crusting due to follow-up rain. Soil compaction of furrows by traffic is reduced and irrigation efficiency is increased. However, the available technology in terms of machinery and weed control are limitations. An uneven soil surface results in uneven sowing depths and poor water control. These problems have recently been minimised by laser levelling. Despite the apparent advantages, the newer technology of after sowing irrigation is not widely practised.

Past research in the BRIA on before and after sowing irrigation has indicated conflicting responses. Smith and McShane (1981) reported benefits for after sowing irrigation, and J. Barnes and R. Brinsmead (pers. comm. 1987) found that compared with before sowing irrigation, after sowing irrigation increased establishment of maize from 16 to 87% and of soybean from 30 to 53%. In contrast W. J. McDonald (unpub. data 1978) found better maize establishment with before sowing irrigation (80%) compared with after sowing irrigation (53%). There was, however, no significant response measured for soybean.

The combination of opener and press wheels has an influence on the establishment of crops under dryland conditions (Nielsen *et al.* 1986; Wurr and Fellows 1985). The opener produces a slot into which the seed is dropped with the most suitable press wheel for a particular opener being one that matches the slot produced by that opener (Schaaf *et al.* 1984). Press wheels improve soil–seed–water contact, reduce the depth for emergence and reduce insect attack due to a decrease in pore sizes and continuity. However, positive pressure rubber press wheels have been shown to be detrimental to soybean emergence (Radford 1983).

Maize and soybean are sown on either 750 mm ridges or 1500 mm beds in the BRIA. This decision is usually based on available equipment and no studies have been reported.

This experiment aimed to further examine the before sowing, after sowing irrigation controversy by postulating that the establishment of maize and soybean will be higher with after sowing irrigation and split steel press wheels because of improved seed–soil–water relationships, but will not be affected by surface configuration (ridges or beds) nor by the type of opener used for seed placement.

MATERIALS AND METHODS

Site details

Trials were conducted at the Millaroo Research Station, north Queensland (20°27′S, 147°165′E). The area is climatically classified as the dry tropics with marked dry and wet seasons.

The soil was classified as a 2Ugh (Thompson 1977) or as a Ug5.29 (Northcote 1979). Some physical and chemical properties of the soil are given in Table 1.

Table 1. Physical and chemical properties of the Ug5.29 soil type from a typical soil profile

Depth (mm)	pH 1:5	Ec mS/cm	CS	FS % OD	Si	Cl	OC %	CEC meq/100g	Moisture (%OD)	
									33kPa	1500kPa
0–100	7.5	0.05	8	18	20	51	0.92	34	38	18
200–300	8.6	0.06	6	15	20	52	0.58	35	38	19
500–600	9.0	0.20	8	19	21	54		35	40	19

OC = Organic Carbon; CS = Coarse Sand; FS = Fine Sand.

Site preparation

Site preparation consisted of an initial deep ploughing to 200 mm, followed by a disc-harrowing. Prior to ridging or bedding the area was rotary hoed to a depth of approximately 100 mm.

For the ridged area plots were two rows at 0.75 m spacing by 10 m long, and for the bedded area plots were beds 1.5 m wide by 10 m long. All spacings are furrow to furrow centre.

Trial 1 was sown on 4 September 1984 into an area with no cropping history since being laser levelled in November 1983. Trial 2 was sown on 1 October 1984 into an area which had a rice crop the previous season.

Experimental design and analysis

Two irrigation strategies were used; before sowing and after sowing. Within each irrigation strategy a randomised split plot design with four replicates was imposed. The main plots consisted of two soil management options. These were either 1.5 m beds or 0.75 m ridges. A balanced factorial structure of two test crops by four opener-press wheel combinations formed the subplots. The crops used were maize and soybean, while the opener-press wheel combinations were:

spear point-rubber press wheel;
spear point-split steel press wheel;
runner-split steel press wheel; and
disc-split steel press wheel.

The same design and treatments were used for both trials.

Results were analysed using standard analysis of variance.

Measurements

Depth of sowing was measured by excavation after the crop had been sown and was 20 mm for the after sowing and 50 mm for the before sowing irrigation treatments, respectively. The deeper sowing depth was used to ensure that seed was placed into moist soil. Depth of sowing was not a treatment.

Emerged seedlings were counted 28 days and 24 days after the crop was sown for Trials 1 and 2, respectively. Laboratory tests indicated that germination was maize 85% and soybean 96%. Percentage emergence was expressed as the percentage of viable seed.

A soil sample (150 × 150 × 120 mm deep) was taken from a before and after sowing irrigation treatment on each trial for aggregate size distribution determination by sieving.

Unreplicated measurement of soil water content and soil water potential (Fawcett and Collis-George 1967) at sowing and one day after sowing was made in the 0 to 50 mm layer.

Climatic conditions for the seven days after planting were measured at the Millaroo Research Station and are given in Table 2.

Between sowing and the application of after sowing irrigation 16 mm of rain fell.

Table 2. Mean air temperature, rainfall and class A pan evaporation during the seven day period after planting for Trials 1 and 2

Days after planting	Trial 1			Trial 2		
	Air temp °C	Rainfall mm	Evaporation mm	Air temp °C	Rainfall mm	Evaporation mm
1	23.6	16.0	7.6	20.8	0	6.2
2	18.6	0	4.0	21.8	0	7.2
3	17.9	0	5.0	23.3	0	4.0
4	19.4	0	4.0	23.8	0	4.0
5	20.6	0	4.0	23.5	0	4.6
6	21.2	0	4.0	22.9	5.6	1.0 R
7	21.8	0	4.0	22.4	0	6.8

R = Water removed from pan.

RESULTS

The significance of the main treatments and their interactions on establishment are shown in Table 3. Irrigation and opener-press wheel treatments had a significant effect on establishment, but surface configuration (ridges vs beds) did not (Table 4). These interactions are shown in Figure 1 and 2 for Trials 1 and 2, respectively. The interaction between irrigation and opener-press wheels was consistent across trials. For after sowing irrigation there was no significant difference in emergence among opener-press wheel combinations for maize, but soybean emergence was reduced by the disc-split steel press wheel. For before sowing irrigation the emergence of both crops was reduced with the rubber press wheel.

Table 3. Significance of main treatments on emergence and their interactions for Trials 1 and 2

Treatment	Trial 1	Trial 2
Irrigation (I)	**	**
Surface Configuration (S)	n.s.	n.s.
Opener-press wheel (OP)	*	**
I × S	n.s.	n.s.
I × OP	**	**
S × OP	n.s.	n.s.
I × S × OP	n.s.	n.s.

n.s. = not significant; * = $P < 0.05$; ** = $P < 0.01$

Table 4. The effect of beds versus ridges on percentage establishment of maize and soybean (mean of before and after-irrigation)

	Trial 1		Trial 2	
	Bed	Ridge	Bed	Ridge
Maize	63	64	71	72
Soybean	36	35	57	61
LSD (P = 0.05)	4.1		4.3	

With both crops after sowing irrigation gave significantly higher emergence than before sowing irrigation for both trials (Figure 3).

Both crops emerged better in Trial 2 compared with Trial 1, where maize emergence increased from 63 to 71% and soybean emergence from 35 to 61% (Table 4).

Plots in Trial 1 contained 49% aggregates greater than 30 mm and 9% aggregates less than 1 mm, while those in Trial 2 contained 28% and 7%, respectively, of the same sizes. This may have affected seed-soil contact and infiltration of water.

DISCUSSION

The difference between before and after sowing irrigation reported above is consistent with previous studies by Smith and McShane (1981) and J. Barnes and R. Brinsmead (pers. comm. 1987). However, the results of the present study conflict with previous studies by W. J. Mcdonald (unpub. data 1978), who found that before sowing irrigation gave greater maize establishment than after sowing irrigation, whereas there was no significant difference in soybean establishment. This result may in part be due to differences in soil conditions between the present study and that of McDonald who sowed shallower on a different soil type that was not laser levelled.

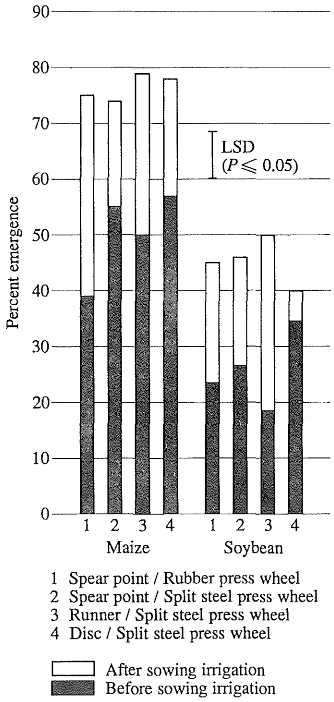

Figure 1. The effect of opener type and press wheel on the establishment of maize and soybean with before and after sowing irrigation with a early sowing date.

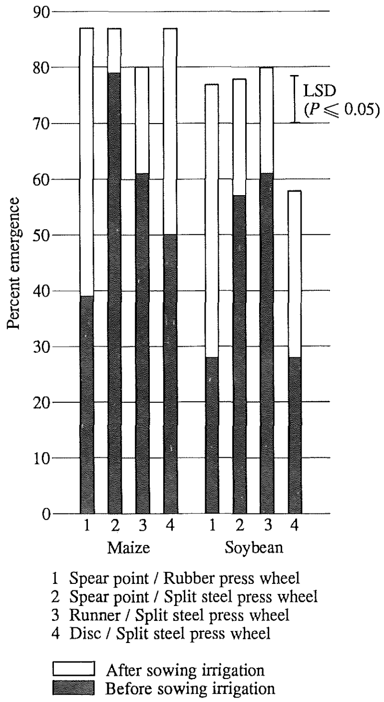

Figure 2. The effect of opener type and press wheel on the establishment of maize and soybean with before and after sowing irrigation with a late sowing date.

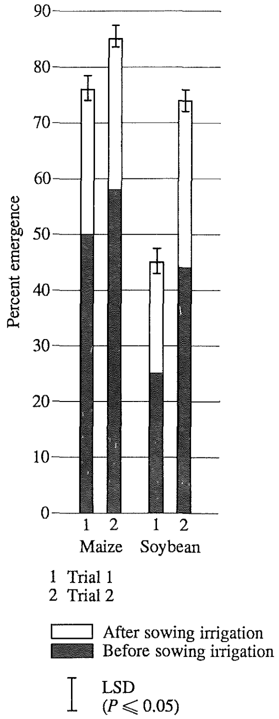

Figure 3. Effect of before and after irrigation on emergence of maize and soybean.

The difference in emergence between the two trials may reflect differences in climatic conditions and aggreagate size distribution. Air temperature was approximately 2.2°C higher for Trial 2 (Table 2) and this may have been reflected in soil temperature. Further, 16 mm of rain fell immediately after Trial 1 was sown, but prior to after sowing irrigation. This rainfall may have produced excessively wet soil conditions in the before sowing irrigation treatment and promoted surface crust formation on both irrigation treatments. For Trial 2 no rainfall was recorded until six days after the crop was sown, thus rainfall would have had little influence on emergence.

Aggregate size distribution in the seedbed influences the emergence of seedlings (Taylor 1974). The aggregate size distribution in the plots of Trial 2 agrees closely with that found by Tisdall and Adem (1984) to enhance the emergence of maize. They determined that the smaller amount of material less than 1 mm in diameter resulted in better infiltration and aeration in the seedbed. Better aggregation in Trial 2 may have been due to the fact the area had been under rice before the experiment. Smith and McShane (1981) state, 'Rice is an ideal pioneer crop because it promotes . . . and creates temporary friability in the surface soil'. Although there is no direct evidence, soybean may be more sensitive to aggregate size distribution than maize, which may explain the reduced soybean emergence across all treatments. Further work on this topic needs to be undertaken.

In this study, with before sowing irrigation, the spear point-split steel press wheel gave the highest mean emergence for both crops and the spear point-rubber press wheel gave the lowest mean emergence for both maize and soybean. J. Barnes and R. Brinsmead (pers. comm. 1987) have observed similar results. Split steel press wheels are designed to apply pressure to either side of, but not directly above, the slot produced by the opener and also at some point just below the seed. The seed is covered by soil crumbling from the edge of the slot. Hence, seed-soil contact is improved but compaction is avoided.

The lower emergence with the rubber press wheel may be due to surface smearing or more likely compaction over the seed row. Radford (1983) showed that positive pressure rubber press wheels, as used in this study, impeded emergence of soybean whereas zero-pressure press wheels did not. This supports the suggestion that compaction may have been the major problem with the rubber press wheel, at least for soybeans.

The overall difference in emergence between the two crops may be due to a number of factors. Firstly, it has been shown that soybean is more sensitive to low soil water potentials than maize at germination (Hunter and Erickson 1952). Since the drying rate of the seedbeds was rapid (water content/potential of 13.3%/-1.3 MPa on day one and 8.9%/-6.2 MPa on day two), both maize and soybean emergence may have been reduced by a water deficit, but soybean more so due to the higher water potential required for germination.

Secondly, the effect of water deficit may have been further exacerbated by the shape and width of the slot. Choudhary and Baker (1980, 1981*a*, 1981*b*) have shown that rate of drying from different shaped slots affected germination of wheat. In our study under the dry conditions the disc formed a wide slot and the press wheel was unable to cover the seed adequately, resulting in desiccation and failure to germinate, particularly for soybean. This was confirmed by excavation along the sowing line and examination of the seeds.

Thirdly, due to seed shape a larger surface area of the maize seed was in contact with the soil than the soybean seed, which would probably reduce the effect of desiccation on maize. Further experimentation is needed to study the changes in seedbed conditions induced by the action of press wheels and soil-engaging tools.

Fourthly, maize is a monocotyledon whereas soybean is a dicotyledon. Although dicotyledons exert a greater emergence force than monocotyledons (Goyal *et al.* 1980) the critical time to generate that emergence force is approximately twice as long for soybean compared with maize (107h compared with 36–51h). Also, the dicotyledon has two large cotyledons to push through the soil whereas the monocotyledon does not. The faster a seedling is able to exert its maximum emergence force the greater the chance of emergence (Badhoria *et al.* 1977).

The results suggest that the best option for improving maize and soybean establishment on the heavy clay soils of the BRIA is to use after sowing irrigation with spear point-split steel press wheels on lasered ground with a well aggregated seedbed consisting of less than 10% fine (<1 mm) material.

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