BUREAU OF SUGAR EXPERIMENT STATIONS
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FINAL REPORT - SRDC PROJECT BS145S
IMPROVING SETT/SOIL CONTACT TO ENHANCE SUGARCANE ESTABLISHMENT

by

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SUMMARY

Limited information is known about the soil firming requirements of sugarcane required to improve both the rate of emergence and the crop establishment percentage. A survey was conducted of wholestick and billet planting machines to determine current crop establishment practices with respect to soil firming. Survey results showed that commercial sugarcane presswheels can be described as:

- of small wheel diameter (average diameter of 335 mm);
- with light ineffective springs or in several cases no spring at all;
- having very low pressing forces (average force 1.1 kilogram force per centimetre of tyre width);
- of variable tyre width (range 140–300 mm);
- having predominantly pneumatic tyres but several steel wheels are used;
- of light construction with mainly crude, non-lubricated pivots;
- having limited or no provisions for adjustment of spring pre-load to alter pressing forces.

The results from nine field trials were used to define the soil firming requirements of sugarcane planters under most typical planting conditions. The single, over-centre presswheel can effectively improve both the rate of sugarcane germination and percentage of crop establishment. Use of this presswheel always exceeded or, at the least, equalled the germination and establishment of the no presswheel treatment. This recommended presswheel should have:

- a pneumatic tyred wheel with a minimum outside diameter of 400 mm (450 mm or greater is preferred);
- easily adjustable pressing forces in the range of 2-4.5 kg f/cm width of wheel;
- a mounted position close to where the setts are planted to ensure effective pressing of the planted setts;
- a robust frame with pivots capable of withstanding the applied loads.

The twin inclined presswheel was found to produce variable soil cover over the planted sett. The simpler and cheaper single over-centre is recommended for use on sugarcane planters.

Two prototype presswheels were designed to satisfy the abovementioned criteria. The BSES Engineering staff manufactured examples of these presswheels and the presswheel fitted to commercial planting machines. Information on these presswheel designs and suggested modifications to current presswheels has been supplied to manufacturers and planter operators.

1.0 BACKGROUND

Many methods of sett firming have been used when planting the Australian sugarcane crop. Good sett to soil contact ensures setts quickly reach the temperature and moisture conditions required for rapid germination and establishment. Presswheels, post-planting rolling with a tractor wheel and dragging a 'pig' along the furrow have all been used for many years.

However, little is known of the desired levels of soil firming to achieve reliable sugarcane germination and establishment. How different wheel types and presswheel configurations affect plant establishment is also poorly understood.

The cereal growers both in Australia and overseas have enthusiastically embraced the use of presswheels to improve crop establishment. Detailed field-testing has defined optimum pressing forces required for different crops over a range of soil types and soil conditions. Presswheels are described in a Queensland Department of Primary Industries publication (Anon, 1991) as 'the most important modification to upgrade a planter's efficiency and reliability of establishment'.

2.0 OBJECTIVES

This project had three objectives that were achieved in the following order:

1. Quantify the crop establishment practices of canegrowers within the major regions of Queensland and northern New South Wales.
2. Quantify the improvement in crop establishment achieved through the use of selected presswheel types and soil firming forces on the most common soil types. Provide machinery manufacturers and growers with recommendations on use of presswheels.
3. Investigate the suitability of planting aids, such as finger harrows and in-furrow presswheels, for use on soils that exhibit surface crusting, cloddiness, etc.

3.0 METHODOLOGY

3.1 Objective 1

The crop establishment practices, with respect to soil firming, were determined by a survey of current planting machinery. Wholestick and billet planters were examined at various locations within Queensland and New South Wales. Physical dimensions of the various presswheel components were recorded along with the vertical pressing force of the wheel on the soil. Where possible, photographs recorded the various presswheel designs. A set of household bathroom scales was used to measure the pressing force. As the effective pressing width varies considerably between types of presswheel, all pressing forces are quoted as vertical pressing force per unit width (kilogram force per centimetre). The author is aware that centimetres are not preferred scientific or engineering units and Newton is the more appropriate force unit however results are presented in kg f/cm as these units are readily understood by the clients who are the planter operator and the grower. This group is not familiar with the Newton as a force unit and hence it is only used in scientific reporting of the results. Using force per unit width to quantify presswheel efficiency is a standard practice in research trials (Ward *et al.*, 1991) and is well accepted by grain-growers in summer and winter cropping enterprises. This also enables comparisons to be made between presswheels of different widths. Variations in diameter of presswheels used on commercial cane planters were small and hence were ignored in all presswheel comparisons.

3.2 Objective 2

BSES Engineering staff fabricated a simple, single presswheel assembly with the ability to apply a variable pressing force. This unit trailed behind a tractor and different pressing treatments applied to soil containing pre-planted setts. Adding or removing 20 kg cast iron masses varied the presswheel force. The cane setts were planted using a commercial billet planter with the presswheel removed. The initial trial was conducted on the Fairymead Plantation, Bundaberg Sugar Ltd at Bundaberg.

The trial with the simple presswheel assembly showed several operational deficiencies. To overcome these deficiencies, a dedicated planter with attached presswheel was designed and constructed by BSES Engineering staff (see Photo 1). The planter was attached to the tractor via the three-point linkage. The planter frame and components were connected using the agricultural clamp and wedge system and could be disassembled to fit into the back of a utility. The planter used a simple but innovative magazine system to ensure a predetermined number of billets was evenly placed within a trial of a predetermined plot length. The magazine cells were loaded with selected billets for planting. A cord connected the magazine frame to a boss attached to one of the planter depth wheels. As the planter travelled along the trial plot, the magazine loaded with billets was pulled by the cord, across an open slot leading to the planting furrow. Altering the diameter of the boss, gave trial plots of different lengths ie smaller boss diameters produced longer trial plots.

After planting each plot, the magazine was returned to its initial position, refilled with billets and the next plot planted. Marker pegs were placed at the start and end of each plot and a small gap of 0.5–1.0 m was left between plots. In all trials, 25 high quality, double eye setts (50 viable eyes) were planted. Plot length was set at about 8 metres or 6 eyes per metre to allow emerging primary shoots to be easily identified during sequential countings. Because the number of eyes or nodes planted in each trial was known, germination and establishment rates could be accurately determined.

Photo 1 - Magazine planter and presswheel configuration developed for field trials

Two presswheel configurations were used for the trials (see Photo 2). They comprised of:

- a single presswheel using a 5.00 X 8 (6 ply) pneumatic tyre (tyre diameter of 430 mm and effective width of 100 mm)
- a twin inclined presswheel using two 4.00 X 8 (4 ply) pneumatic tyres with an included angle of about 30° (tyre diameter of 380 mm and effective width of 75 mm).

Photo 2 - Single presswheel and twin inclined presswheels used in the trials

The single wheel pressed the centre of the planted row and this is often referred as 'over-centre pressing'. The single presswheel is the simplest and cheapest presswheel unit available. The twin inclined presswheel has wheels inclined towards each other in a 'Vee' configuration. This configuration results in pressing on either side of the planted row with the soil above the sett not being pressed. The twin inclined presswheel is comprised of two separate wheels and therefore is considerably more expensive than the single presswheel. Twin inclined presswheels were initially developed for soil firming when sowing dicotyledon seeds. Most emerging dicotyledons have difficulty emerging through firmed soils. The twin inclined presswheel was included in the trial treatments as little was known of the response of sugarcane to over-centre soil firming.

In the text, SW is used to refer to the single wheel and TW to refer to the twin inclined wheels. The pressing load is quoted in kilogram force per centimetre effective width of wheel. A single wheel with a pressing force of 4.5 kg f/cm is referenced as SW4.5. The presswheels attached to the planter frame by a single pin thus simplifying the changing of presswheel types. Photo 2 also shows the rectangular tray used to carry the cast iron masses. Presswheel loading was varied by adding or removing the masses to obtain the required soil firming.

Data was analysed using the computer program, STATISTIX. All comparisons discussed in this report are at the ≤0.05 probability level.

3.3 Objective 3

Finger harrows and in-furrow presswheels were not tested as part of the trial program. The aim was to test presswheels without these add-on features. These additions would only be trialed if establishment problems were encountered. The treatments of single presswheel (SW) and twin inclined presswheel (TW) with up to three pressing loads were considered sufficient to highlight emergence or establishment problems.

4.0 RESULTS AND DISCUSSION

4.1 Objective 1

Quantify the crop establishment practices of canegrowers within the major regions of Queensland and northern New South Wales.

Planter presswheels

More than 20 planters, wholestick and billet were examined as part of the survey. All planters had been fitted with presswheels as standard equipment. Several growers had undertaken some modification of the commercial presswheel. When operating in either wet or extremely dry soil conditions, growers often experienced problems with the operation of the presswheel and several growers had completely removed the presswheel from their planter.

TABLE 1
Specifications of cane planter presswheels

Planter	Presswheel width x diameter (mm)	Wheel type	Pressing force kg f/cm
A	140 x 360	Pneumatic	1.3
B	140 x 360	Pneumatic	1.5
C*	140 x 360	Pneumatic	2.1
D	250 x 330	Steel	1.7
E	250 x 320	Pneumatic	0.7
F	300 x 320	Pneumatic	1.2
G**	150 x 380	Pneumatic	2.7
H	170 x 300	Pneumatic	0.4

* Grower modified to increase pressing force
** Manufactured by grower

Table 1 is a summary of the tyre dimensions, tyre type and the pressing force of the presswheels surveyed. Several figures are the result of multiple tests on the same model of planter. The brand of planter has been omitted from the table. Most of the presswheels examined were of similar construction and had similar pressing forces. The examined commercial sugarcane presswheels can be described as:

- of small wheel diameter (average diameter of 335 mm);
- with light ineffective springs or in several cases no spring at all;
- having very low pressing forces (average force 1.1 kilogram force per centimetre of tyre width);
- of variable tyre width (range 140–300 mm);
- having predominantly pneumatic tyres but several steel wheels are used;
- of light construction with mainly crude, non-lubricated pivots;
- having limited or no provision for adjustment of spring pre-load to alter pressing forces.

During the survey, discussions were conducted with the planter operators/owners to determine their satisfaction with the operation of the presswheel. Several operators had removed presswheels when planting in wet conditions as wheels would either build up with mud or sink into the soil and cease to turn.

Most operators had never adjusted the pressing force of the presswheel and did not consider this a necessary adjustment as soil types and soil conditions varied. Most mechanisms had no system to allow the operators to adjust the spring pre-load, see Photo 3. The average person could, using one hand, lift most presswheels off the ground without a significant effort. This qualitative, ‘one hand’ test indicated that the pressing forces used were very low. The frames and pivot points on the older presswheel units were often bent and showed signs of significant wear.

Photo 3 - Commercial sugarcane planter presswheel – note small diameter wheel, light springs, poor spring pre-load adjustment and basic pivots

Photo 4 - A wholestalk planter presswheel – note small wheel diameter and the use of bathroom scales for measuring pressing force

Most commercial presswheels appeared to be an 'add-on' extra to the planter. The presswheels configurations were of very basic design with limited effort to optimise the design. A limited analysis of the geometry of several presswheels indicated inefficient utilisation of the spring force. No planter manufacturer could specify the pressing force of their presswheel with most believing the current presswheels were adequate for the role required. Instructions for presswheel operation were either very limited or not provided.

Photo 5 - Steel presswheel used on billet planter – note small diameter solid wheel and lack of spring loading system

While a pressing force generated by the mass of the presswheel frame and added ballast is acceptable for an experimental test rig, this configuration is not preferred for a commercial presswheel. To achieve reasonable pressing forces, the total mass of the unit must be quite high and as the wheel has no spring damping it will have a tendency to bounce if an object is encountered.

Post-plant pressing

Although all manufacturers offer presswheels on the planter, some growers have opted to perform soil firming as a separate operation. Post-plant pressing was often conducted one or more days after planting. Many growers have adopted the unusual practice of firming the newly planted row with the tyres of a small agricultural tractor. This well accepted practice is almost a ‘standard’ field operation in most cane growing regions of Queensland and New South Wales. Estimated tyre loads would be 1000-1500 kg (12-18 kg f/cm). There appears to be no scientific data to support this practice and the practice appears to be unique to the sugar industry (Burgess and Calcino, 1996). Several growers mentioned anecdotal evidence of sett damage after soil firming using a tractor. Insufficient soil cover over the sett compounded by excessive loading of the soil is a possible cause of sett damage and hence reduced crop emergence. The use of tractors as soil firming devices must be considered a high risk practice.

Tractor drawn soil firming machines were examined in the cane growing regions of Meringa and Harwood. The Meringa version firmed three planted rows at once (Photo 6). Wide automotive type tyres were used in an attempt to ensure pressing occurred over the planted sett. The tyres were water-filled for increased soil pressing but the actual pressing force was not known. The tyres were mounted on bush type bearings and have limited sideways movement to assist the wheels to run within the planting furrow. Post-planting pressing with this unit is only possible under the conventional, furrow planting system.

Photo 6 - A grower-built 3-row, post-planting presswheel unit

A low technology example of post-plant pressing was the cast iron presswheel used at the Harwood Mill plantation. This low cost machine has:

- a high labour input;
- a fixed, unadjustable pressing force;
- metal wheel that is unsuitable for moist clay soils.

Post-planting pressing must be questioned as an acceptable practices as:

- alignment of the wheel over the planted row can be difficult to achieve;
- the pressing operation is an additional field operation.

Photo 7 - Cast iron wheel (surplus drive pulley) used as a presswheel at Harwood Mill plantation, NSW

4.2 Objective 2

Quantify the improvement in crop establishment achieved through the use of selected presswheel types and soil firming forces on the most common soil types. Provide machinery manufacturers and growers with recommendations on use of presswheels.

The first trial undertaken used the simple presswheel assembly. While conducting this trial, several operational deficiencies were evident with this configuration. The actual planting rate of sound, viable eyes per metre could not be determined and it was difficult to ensure the soil directly over the planted sett was pressed. The planting output and establishment rate from a billet planter are affected by variables such as billet quality, planter type, planter operation, etc. Along-the-row spatial variation with billet planters is quite high (Robotham and Chappell, 1998). Post-planting pressing requires either accurate guidance or wide presswheels to ensure soil in the planted row is effectively firmed. A wide presswheel requires very high vertical loading to ensure satisfactory pressing forces per unit width of wheel are achieved. Neither the use of billet planted cane nor post-planting pressing is considered an acceptable experimental technique. Establishment of the initial trial was observed but few measurements were taken. The first trial was important as it helped define the testing protocol essential when quantifying presswheel performance.

The results of this and later trials must also question the usefulness of the trial methodology and, hence, the results of furrow compaction undertaken by Burgess and Calcino (1996).

TABLE 2
Trial specifications in chronological order

Trial No.	Date planted	Soil type	Variety	Pressing options
2	28/01/97	Red volcanic	Q141	Control, SW1.5, SW4.5, TW1.5, TW4.5
3	06/02/97	Red volcanic	Q141	Control, SW1.5, SW4.5, TW1.5, TW4.5
4	26/02/97	Red podzolic	Q151	Control, SW1.5, SW4.5, SW6.25, TW1.5, TW4.5, TW6.25
5	04/03/97	Black clay	Q124	Control, SW1.5, SW4.5, SW6.25, TW1.5, TW4.5, TW6.25
6	10/03/97	Black clay loam	Q155	Control, SW1.5, SW4.5, SW6.25, TW1.5, TW4.5, TW6.25
7	14/03/97	Gleyed podzolic	Q124	Control, SW1.5, SW4.5, SW6.25, TW1.5, TW4.5, TW6.25
8	11/04/97	Grey volcanic	Q151	Control, SW1.5, SW4.5, SW6.25, TW1.5, TW4.5, TW6.25
9	25/02/98	Red podzolic	Q124	Control, SW4.5, SW8.5, SW16.5

Data from all trials, excluding trial 1, is included for completeness.

All trials, except for trials 2 and 3, were conducted within the grower's commercial cane planting. Previous field testing has shown that growers are more likely to accept results undertaken in a commercial field. The cane cultivars used in the trials were the same as used by the growers. Planting material was obtained from the same plant source and planting was undertaken within 1-2 days of the commercial planting. The effect of the pressing treatments on the initial emergence is of primary interest as presswheels have been shown to increase both the rate of emergence and percentage of plant established (Anon 1991).

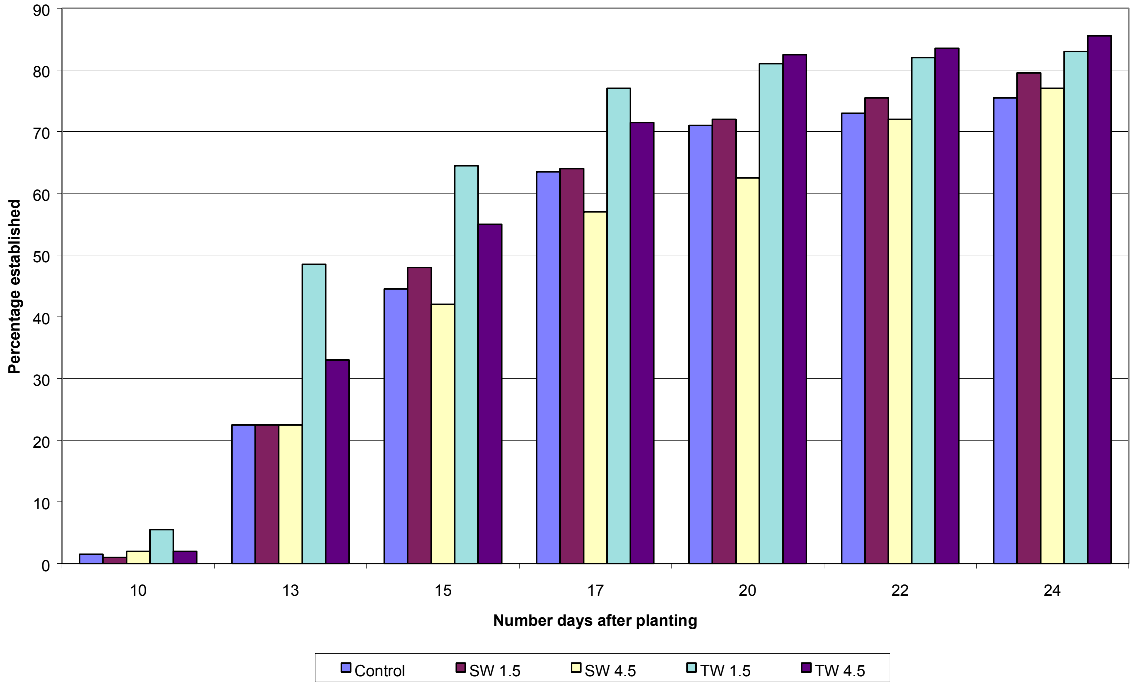

Figure 1 - Establishment rate for 2 SW and 2 TW treatments, Trial 2

Trials 2 and 3 were conducted on the red volcanic soil at the BSES Southern Research Station, Bundaberg. This soil has been farmed for almost 100 years and soil structure has declined markedly. The soil was well drained. Soil moisture and tilth were considered ideal for planting.

The treatment ranking in Trial 2 varied as sequential shoot counts were undertaken. At days 10 and 13, establishment of the TW1.5 treatment was significantly better to all other treatments. When the final count was taken, TW4.5 was significantly different to control (no pressing) but all other treatments were not significantly different to TW4.5.

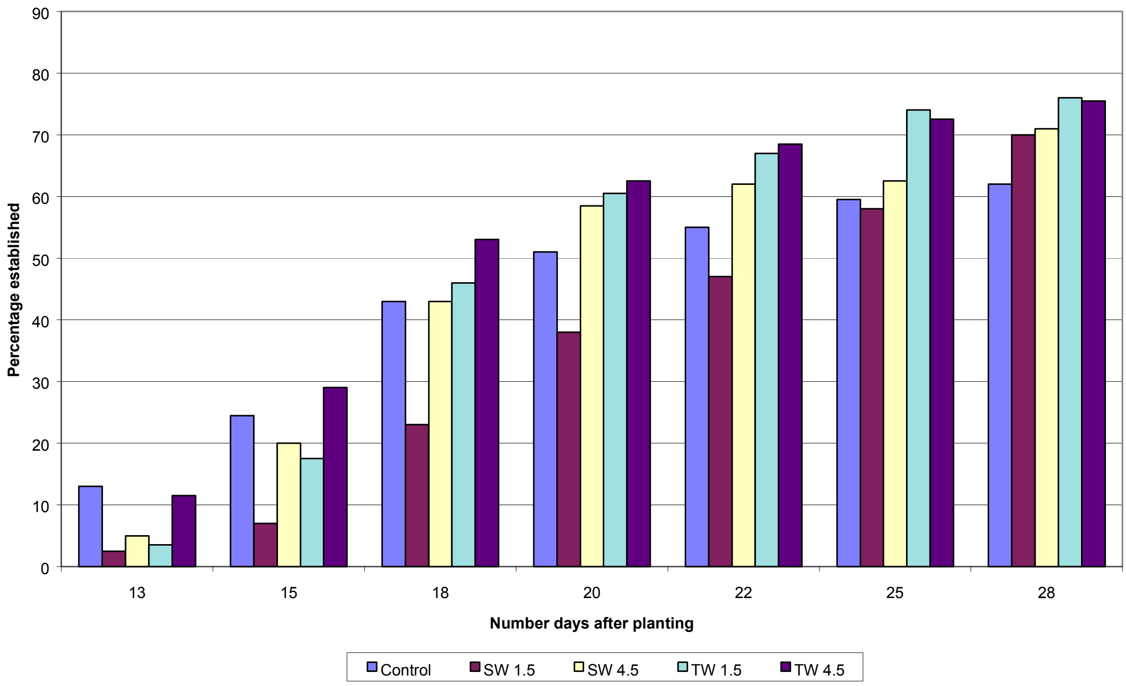

Figure 2 - Establishment rate for 2 SW and 2 TW treatments, Trial 3

Trial 3 showed no significant differences between treatments for days 13, 15, 18 or 28. Both trials were undertaken on one of the 'better soils' of the Bundaberg region where plant establishment is seldom difficult. All pressing treatments performed well but the trials appeared to favour the TW presswheel configuration.

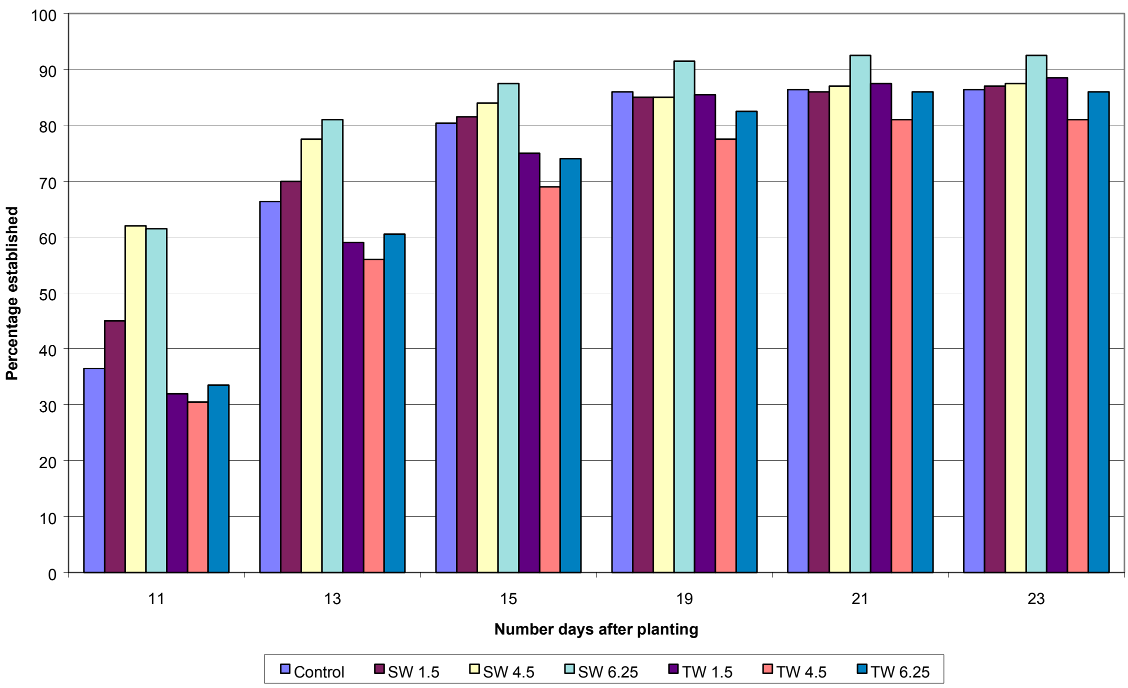

Figure 3 - Establishment rates for 3 SW and 3 TW treatments, Trial 4

The pressing force used in the highest pressing treatment was increased to 6.25 kg f/cm for both the single and twin presswheels. This trial configuration, of SW and TW configurations with three loadings on each presswheel type was used for trials 4, 5, 6, 7 and 8.

The soil type for trial 4 was loose and friable at planting. Ranking of the treatments varied during the trial but all TW treatment performed poorly in this trial. At day 11, establishment from SW4.5 was significantly higher than all TW treatments, SW1.5 and control. This effect continued and at day 13, establishment in SW4.5 and SW6.25 exceeded all TW treatments.

After the shoot counts were completed for days 11 and 13, it was decided to investigate why establishments of the TW treatments were so poor when in the previous trial the TW configuration produced consistently good establishment. The depth of soil covering all setts was measured (see Table 3).

TABLE 3
Depth of soil covering the sett – Trial 4

	Control	SW1.5	SW4.5	SW6.25	TW1.5	TW4.5	TW6.25
Average Cover (mm)	47	49	46	40	68	71	82

All SW treatments showed reducing soil cover as the pressing force was increased. The high pressing forces had compacted and moved a small amount of soil from over the sett. The TW treatments showed the opposite trend, with increasing soil cover as the pressing loading was increased. The twin inclined wheels were moving soil from either side of the sett and placing some soil directly over the planted sett. As the pressing load increased, the amount of soil moved also increased. During this project, the researchers gained an appreciation of how critical the amount of soil cover can be to whether sugarcane plant will establish or fail. The soil cover over the sett was almost doubled by the TW6.25 treatment compared to the control treatment. By comparison, the SW6.25 treatment showed only a minor reduction in soil cover. The variation in soil cover produced by a twin inclined presswheel would be influenced by:

- the load on the wheels;
- the soil type and tilth;
- presswheel configuration (inclination angle, wheel diameter, etc).

The variable soil covering effect of the TW treatments was considered to greatly reduce the potential of this configuration as a useful sugarcane presswheel.

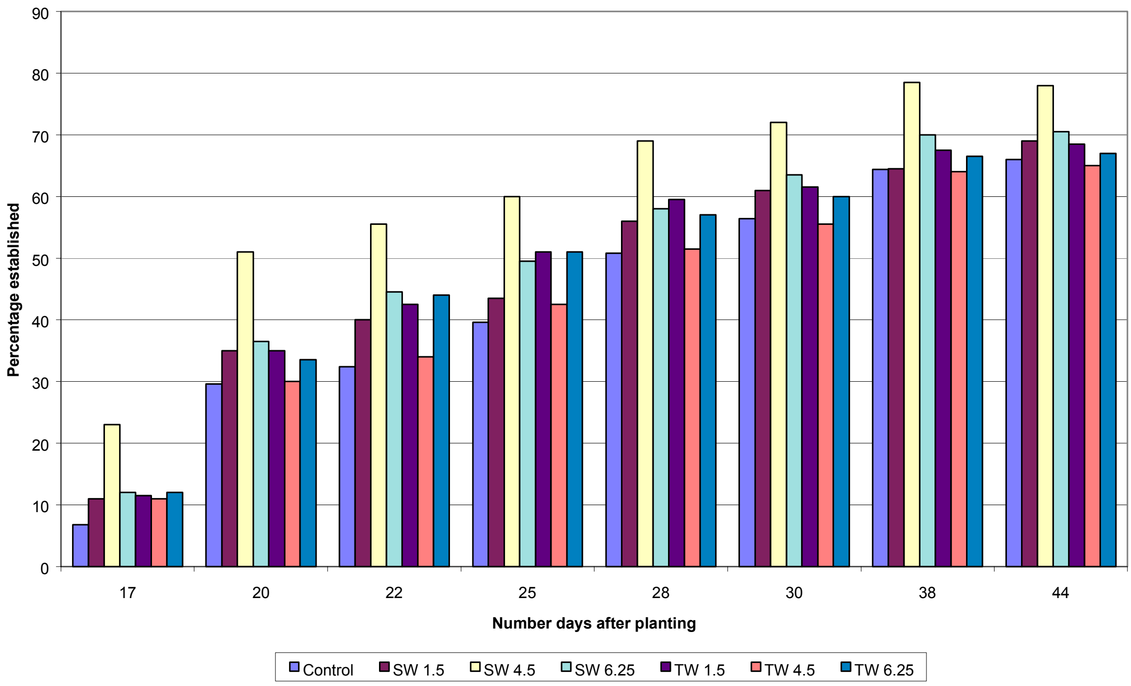

Figure 4 - Establishment rates for 3 SW and 3 TW treatments, Trial 5

Trial 5 was conducted on a heavy black clay soil with a history of establishment failures. Previous experience with the heavy cracking clay soils of the Darling Downs indicated this soil should respond well to soil firming. The SW4.5 showed the greatest establishment and by day 20 was significantly different to all other treatments. By day 44, the SW4.5 treatment had significantly greater shoot establishment than the control and all TW treatments.

The TW treatments exhibited a reduced rate of establishment for all pressing forces. This was most likely due to cumulative effects of increased soil cover over the sett, as previously discussed, and the reduced pressing efficiency of the twin inclined presswheels.

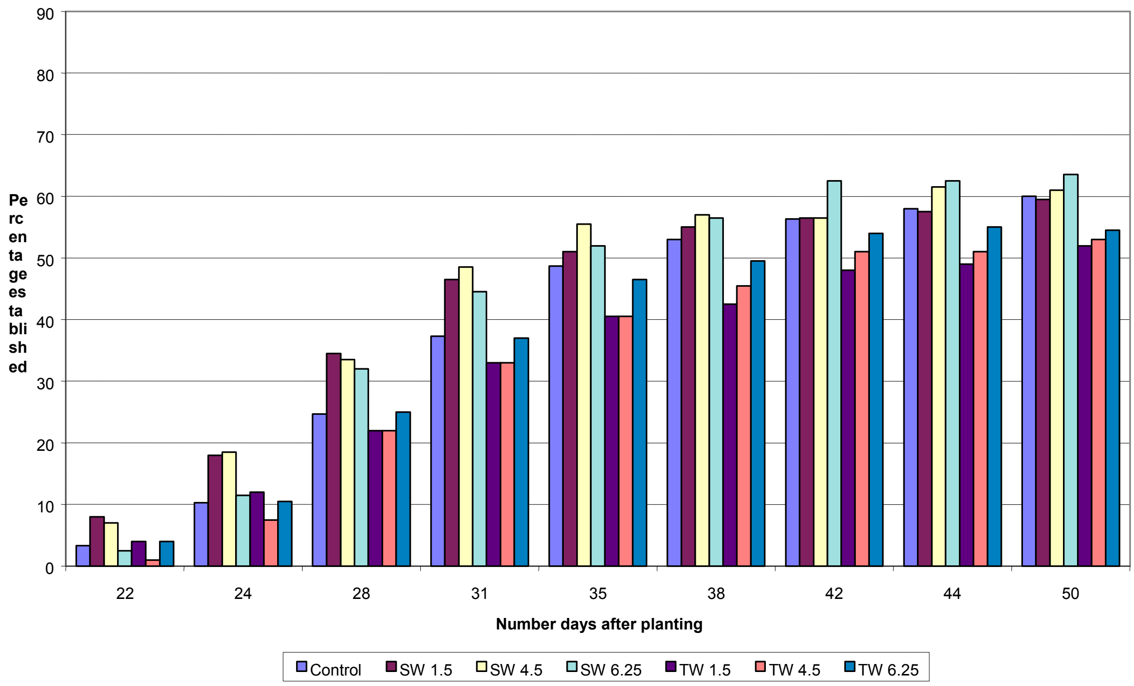

Figure 5 - Establishment rates for 3 SW and 3 TW treatments, Trial 6

Trial 6 was undertaken at a different site to trial 5 and the soil was a more friable black clay loam. The ranking of treatments varied with sequential shoot counts. The SW1.5 and SW4.5 treatments emerged quicker than most other treatments, however this was not always significantly different. At day 24, the establishments of SW1.5 and SW4.5 were significantly greater than TW4.5. This result tended to favour the SW presswheel configuration and particularly in the 1.5 to 4.5 kg f/cm pressing range. Overall crop establishment was quite acceptable at about 60% for all SW and the control treatments.

Trial 7 is discussed in Section 4.3.

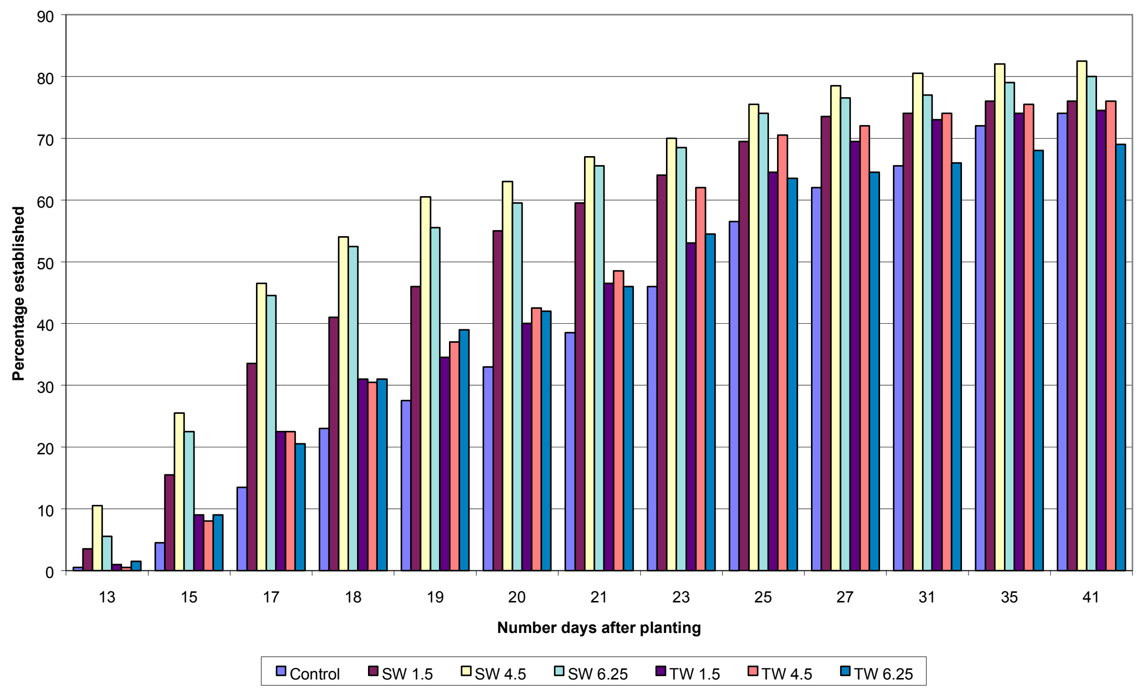

Figure 6 - Establishment rates for 3 SW and 3 TW treatments, Trial 8

The treatment ranking in trial 8 varied with the sequential shoot counts. On day 13, SW4.5 and SW6.25 treatments had significantly more emerged shoots. Although not always statically significant, the SW4.5 treatment had the greatest number of emerged shoots when each shoot count was undertaken. By day 44, all shoot counts had levelled out at about 75% establishment but SW4.5 had significantly more shoots than the TW3 and control treatments.

A valid criticism of the data presentation used for trials 2–9 is the way each primary shoot, irrespective of time of emergence, is given equal ranking. Considering Figure 6, a shoot emerging 13 days after planting will have grown to be significantly bigger than one that has just emerged and was counted for the first time on day 35. Using this method, both plants are given the same final ranking. Plants that emerge with high vigour and establish quickly create the best plant stand. This is not evident in the presented data.

In an attempt to bias the graph towards the early emerging plants, a simple productivity index was derived. The index consist of the number of new plants since the last shoot count multiplied by the number of days growth the plant will have before the final count is taken and the trial ceases. The index is cumulative during the trial. Figure 7 is an example how the data from trial 8 is transformed by using the productivity index. The result is not spectacular but the early growth (left hand side of graph) is favourably amplified. Another method of illustrating the importance of early emergence and establishment would be a system of sequential plant sampling to determine dry matter produced. This destructive method was not allowable as, after the measurements were completed, all trials were grown as part of the commercial cane crop.

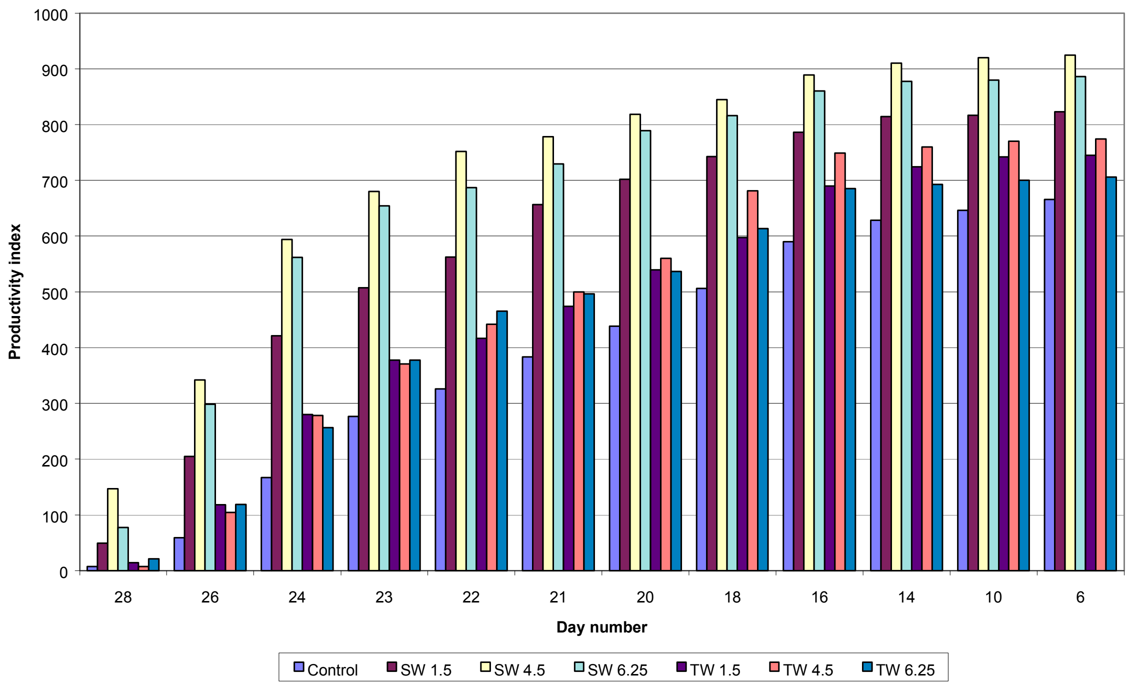

Figure 7 -'Productivity Index' plot for trial 8

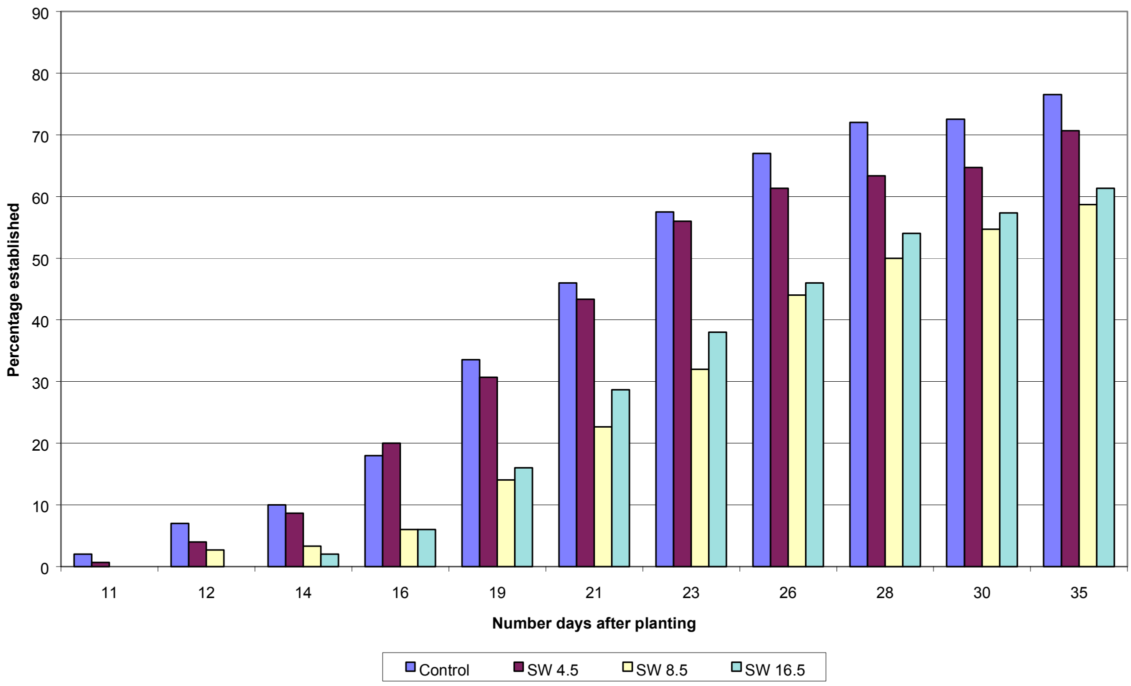

Figure 8 – High pressing force trial, Trial 9

Trial 9 was conducted to examine the effects of very high pressing forces on sugarcane emergence (Figure 8). The maximum force of 16.5 kg f/cm was selected to emulate the loading of the front wheel of a light agricultural tractor. The 8.5 kg f/cm loading was an intermediate pressing but in excess of that produced by most commercial presswheels used in the cereal industry. Planting conditions were very good and rainfall occurred after planting. The ranking of treatments remained the same throughout the trial. Control and SW4.5 treatments produced significantly more shoots than the SW8.5 and SW16.5 treatments. Whilst this was only a single trial on one soil type, the result is consistent with previous findings. When establishment conditions are very good, the correct presswheel, in this case the SW4.5 treatment, may not significantly improve establishment, however excessive soil firming (from a tractor or implement) will be detrimental to plant emergence.

Photo 8 - Trial plot marked by pegs, beside commercial planted cane

During the field trials, growers commented on the superior plant stands produced by the experiment planter (see Photo 8). The early plant vigour was often visually greater than that of the billet planted cane surrounding the trial. Whilst this was not specifically investigated within this project, I believe the improved crop establishment to be a result of the high quality, planting material used, the accurate along-the-row sett spatial distribution and, of course, good sett to soil contact at planting.

4.3 Objective 3

Investigate the suitability of planting aids, such as finger harrows and in-furrow presswheels, for use on soils that exhibit surface crusting, cloddiness, etc.

Trial plantings were conducted in a range of soil types and varied soil tilths (see Table 2). No visible emergence problems occurred on most soil types during the presswheel trial program. At most sites, a limited number of setts were excavated during the emergence phase to examine the coleoptile and determine if soil related factors were limiting progress to the soil surface.

The gleyed podzolic soils that are commonly referred to as the hard setting white sands exhibited reduced emergence due to soil crusting. These soils are low in nutrients and poorly structured. McGarry (1996) conducted trials on this soil type and stated that 'this soil is considered marginal for cropping'. This soil is easily compacted and hence would benefit from controlled traffic and minimum tillage. McGarry also stated that cultivation produced 'no improvement in soil stability as evident in the increased propensity for the cultivated soil to most rapidly slake in the top 0.4 m'.

Because of these structure limitations, this soil was an ideal soil to test for the extreme effects of soil firming on crop emergence. A replicated trial was planted within a field being billet planted by the grower. When the trial was planted the soil was very soft and the top 50 mm of soil was dry and powdery. Under these conditions, the twin inclined wheels again behaved like dished disks and moved additional soil, from each side, onto the planted row (see Trial 3). The extra soil cover significantly reduced emergence for all TW treatments.

The trial was planted into good soil moisture and received about 34 mm of high intensity rainfall 4 days after planting. The grower was well aware of the characteristic of this soil to form a thick surface crust after heavy rain. Crop failures due to poor emergence after heavy rain is common if rain falls before the plant has emerged. It is important to note that the soil crust resulted from high intensity rain and not the pressing action of the presswheel. After the crust had formed, the farmer attempted to use tillage to mechanically alleviate the soil crusting. This process comprised of ploughing with two, edge-on chisel tines either side of the planted row. The tines were spaced at 0.4–0.5 m and the intention of this operation was to shatter the surface crust to ensure the emerging coleoptile had an easy pathway to the soil surface.

The presswheel trial area was not mechanically tilled to alleviate the soil crusting**.** This enabled us to determine if a presswheel or different pressing forces would exacerbate the propensity of this soil to form a surface crust. At day 19 after planting, establishments from SW2 and SW3 were significantly greater than control and all TW treatments.

During subsequent shoot counts the ranking order varied slightly but all SW treatments performed well. By the final shoot count on day 89, the SW2 and SW3 treatments again had significantly greater shoot counts than control and all TW treatments. The SW1 treatment was not significantly different to SW2 treatment.

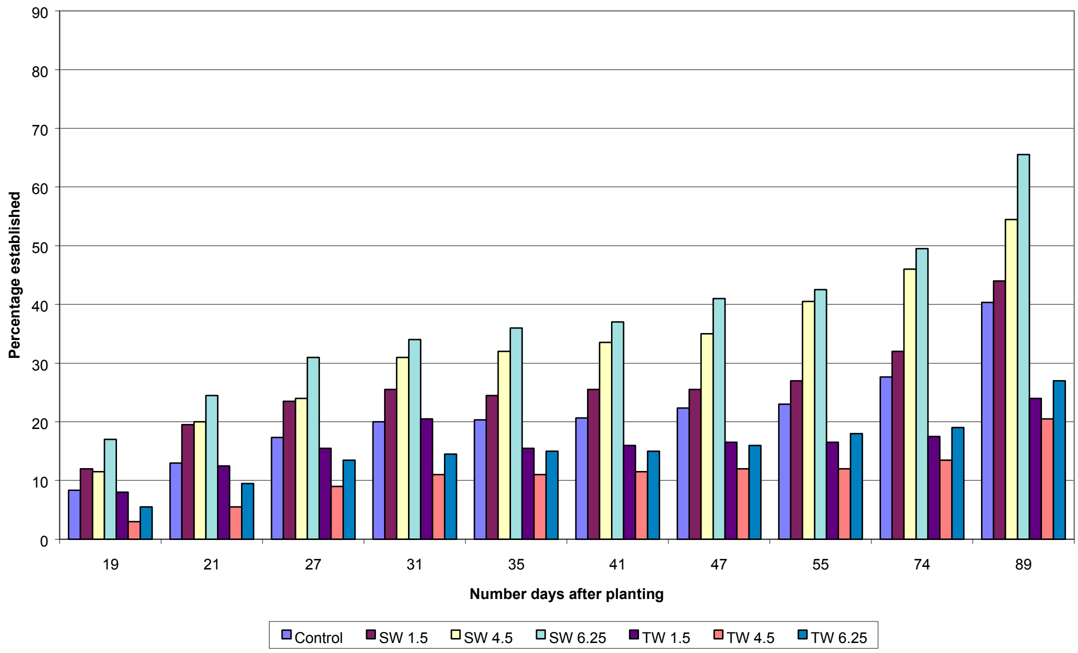

Figure 9 - Establishment with presswheels on gleyed podzolic soil, Trial 7

Final establishment counts of 66% and 55% for SW6.25 and SW4.5 treatments respectively, were significantly greater than establishment for the control treatment (about 40%). This emergence advantage was present at each sequential shoot count. This clearly showed that over-centre pressing actually improved the emergence of sugarcane even after rain induced, soil surface crusting. It is interesting to note that even though this soil with its tendency to form a thick surface after rain, it appears to be responsive to higher levels of soil firming, the 4.5-6.25 kg f/cm range.

As the grower's cane was billet planted, the actual planting rate of sound billets and hence the establishment rate could not be determined. Observations by both the researchers and the grower indicated that:

- the single presswheel treatments achieved greater establishment rates than the billet planted cane, even after the tillage pass to reduce the effect of the surface crust on the billet planted cane.
- because the soil crust was caused by the rainfall event after planting, modifying the soil pressing process would have no influence on whether a surface crust formed.

Photo 9 - Plant emerging through the surface crust of a gleyed podzolic soil

If planted when very wet, some of the red volcanic soils can form a surface crust that may crack along the row when drying. Soil conditions at neither red volcanic site were of sufficient moisture to produce a surface crust when planting the trials. Previous experience with presswheels on red volcanic soils indicates soil crusting has a very minor effect on sugarcane emergence. A loop of light chain dragged behind the presswheel can alleviate this problem by placing loose soil over the pressed zone but the issue of increasing the depth of soil cover with this operation must be considered.

5.0 CONCLUSIONS

The use of an effective soil firming presswheel is essential to improve sugarcane establishment. Over the range of soil types trialed, the pneumatic single presswheel (SW) was the best presswheel for sugarcane planters. The twin inclined presswheel (TW) showed promise but the initial results are thought to be influenced more by depth of soil cover than effective pressing of the soil. The single over-centre presswheel is a cheap and robust presswheel configuration and hence must be favoured over the more expensive twin wheeled option. The pneumatic tyre has the added advantage of inflation pressure being altered to suit soil conditions. Under wet conditions, tyre inflation pressure can be reduced and the tyre carcase will 'flex' and shed built-up mud. In average to dry soil conditions, inflation pressures can be increased.

It is of interest to note that with respect to soil firming, sugarcane has similar requirements to common summer crop cereals. The Darling Downs Summer Crop Management Notes 1991-1992 (Anon) recommends presswheel pressures of:

- sorghum – tilled seedbed 4-6 kg f/cm;
- maize 2-4 kg f/cm.

The pressing force for these monocotyledons compares favourably with 2-4.5 kg f/cm pressing recommendation produced from this project. The optimum soil pressing for sugarcane is similar to the sorghum and maize requirements even though sorghum and maize are grown from sown seeds (4 and 12 mm diameter seed respectively) and sugarcane is propagated using setts of about 25-30 mm in diameter and up to 400 mm in length.

5.1 Presswheel designs

Several presswheel options were made available to both cane growers and machinery manufacturers as an additional output of this project. Recommendations were produced for fitting of stronger springs and improved spring adjustment mechanism for current billet planter presswheels. This option was not favoured due to the light construction and small diameter wheel on most commercial presswheels. Increasing the pressing force to the desired range can result in the small diameter wheels being 'buried' under soft soil conditions.

A compact presswheel suitable for retrofitting to the current wholestalk and billet planters was designed (see Photo 10). This design utilised several components, the spring and wheel that were used on an existing sugar industry machine. Pressing force is easily adjustable and forces in excess of 4 kg f/cm can be obtained. A maximum wheel diameter of only 330 mm was possible due to the location of the drawbar and trailer hitch point. A single 5.00 x 6 tyre (105 mm effective tyre width) was well matched to the width of the planting furrow of this machine. This presswheel had most of the features, determined by this project as necessary for a sugarcane planter presswheel.

Photo 10 – Presswheel designed during this project retro-fitted to wholestalk planter

This design was further refined and used on the current high density planters constructed for BSES trial planting's. The layout of this planter enabled the use of the larger diameter 4.00 x 8 tyre (diameter 410 mm and width 80 mm). The narrow tyre width matched the narrow planting slot of the double disk planter and ensured the desired soil firming forces were easily achieved. This presswheel design has also been copied by a planter manufacturer and used on several commercial machines.

Photo 11 - Presswheel design used on HDP planter – note large diameter wheel

A presswheel was designed for retro-fitting to a commercial dual row planter. The presswheel supplied with this planter was of small diameter (330 mm) and of steel construction. When planting into soft soil conditions, the grower had observed the steel wheel would penetrate to below the axle level and the wheel would cease to rotate. Pressing forces were also inadequate.

Photo 12 - Robust presswheel designed to suit commercial dual row planter

The configuration of this planter enabled large diameter, automotive type tyres to be used as presswheels. The large diameter, about 600 mm, ensured the tyre would freely roll under all foreseeable conditions. Tyre width of 200 mm matched the planting furrow width ensuring pressing of all planted billets. The automotive tyres were inflated to seat the bead and the pressure was reduced to low operating pressure of about 60 kPa. The wide pressing width of this presswheel required two compression springs to achieve the required pressing forces. The springs were obtained as spare parts from a Darling Downs machinery manufacturer. Pressing force was easily adjustable using two hairpin cotter clips. The pivot of the presswheel trailing arm was a greaseable bush for long life.

The grower achieved uniform soil cover over the planted setts by fitting adjustable dished disks. The disks were mounted on the trailing arm of the presswheel frame to ensure a ground following capability.

Planter manufacturers and planter operators have been supplied with information about the characteristics of their presswheel and suggestions of how to improve the performance. Acceptance of these results by planter operators has been very good with many presswheels being modified to improve the pressing forces. One planting contractor is using a hydraulic loaded presswheel that can be raised when turning or travelling.

I have attempted to explain the importance of correct geometry to ensure the presswheel mechanism generates adequate pressing forces. Unfortunately due to the lack of engineering competence, one manufacturer produced a presswheel with a large powerful spring, but because of inappropriate pivot geometry, it was unable to produce forces within the acceptable range. This project has created sufficient grower awareness of the requirements of presswheels that the market place will be the final judge of the efficiency of component design.

6.0 RECOMMENDATIONS

Presswheels are an essential component of any sugarcane planter. Most current sugarcane presswheels have:

- wheels that are too small in diameter for operation under the range of planting conditions;
- insufficient soil firming force;
- pressing forces that cannot be easily adjusted;
- a construction that is either too light or inappropriate for the operating conditions.

The results from this series of trials indicated the single, over-centre presswheel can effectively improve sugarcane germination and establishment. This presswheel should have:

- a pneumatic tyred wheel with a minimum outside diameter of 400 mm (450mm or greater is preferred);
- easily adjustable pressing forces in the range of 2-4.5 kg f/cm width of wheel;
- a mounted position close to where the setts are planted to ensure effective pressing of the planted setts;
- a robust frame with pivots capable of withstanding the applied loads.

The presswheel designs developed within this project are readily available to both growers and planter manufacturers. Both presswheel designs from this project use compression springs as a well-designed compression spring can be taken to a coil bound state without over-stressing the spring material. Such a spring should give trouble-free performance in the field. Tension spring could be used with the appropriate design changes.

7.0 PUBLICATIONS

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