CROP SCIENCE SOCIETY
OF SA INCORPORATED

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NEWSLETTER

December 2019

Hello there all,

For many in the industry this year has posed a great deal of challenges. The society lost a great contributor, researcher & friend in John Both earlier in the year. John was actively involved on the committee & as a past President. The society worked hard to see that there was recognition for his contribution to the industry.

Significantly lower annual rainfall, but particularly in spring, has led to below average state grain production, and for some spring frost conditions were the worst experienced in memory. Along with the negatives, growers are continually amazed at the grain production that can be achieved on low growing season rainfall. Accounting for reduced evaporation losses (due to increased stubble loads, improved soil structure & better infiltration), improved fallow efficiency & increased crop outputs (kg achieved per mm of rainfall), there appears to still be exploitable improvements. To see an average or above average season will be a joy for all.

The Crop Science Society has been actively advocating for members & Agricultural science generally. We have provided submissions on the State's planning reforms & provided written & in-person evidence to support abolishing the GM moratorium in SA. With respect to the GM moratorium, the impacts on growers & industry have been well documented with the report tabled by Emeritus Professor Anderson tallying up $33M in lost opportunities. Add to this the lack of research investment in SA and we are sliding backwards rapidly.

In 2020 the Crop Science Society will recognize the newest Life Member & regular contributor, Hugh Wallwork. We will also work actively to promote the awards available to members. The Society will be engaging with the Weed Management Science Society of SA for the 22nd biannual Australasian conference. This event, on the 25-29th October, will bring participants from across Australia & the globe. Committee members Ben Fleet, Dan Peterson & myself are assisting with arrangements for an Adelaide Plains bus trip of delegates with significant time to be spent at the Roseworthy Campus & surrounds. For more details got to http://wmssa.org.au/events/.

Next CSS Monthly Technical Forum: 19th February, 2020 – Crop Establishment Project with Dr Glenn McDonald (Adelaide University) as well as an update on the role of seeding systems Dr Jacky Desboilles (University of SA).

We wish all members & families a safe and Merry Christmas & enjoyable festive season. We look forward to seeing you along at our Technical Forums & events in the new year.

Craig Davis.
President.

History of Australian Agriculture

Here is the first instalment of our series of history of Australian agriculture – tillage to sowing in Principles of Field Crop Production, Jim Pratley (ed), Oxford University Press, 2003

CHAPTER 1
EVOLUTION OF AUSTRALIAN AGRICULTURE: FROM CULTIVATION TO NO-TILL

Jim Pratley and Lewis Rowell

On the Australian landscape, two centuries of trial and error followed by extensive research has resulted in evolved agricultural systems more closely attuned, in the 21st century, to the fragility of the natural resource base and the vagaries of the Australian climate. The history of Australian agriculture is a study in farmer-based innovation as well as natural and man-made disasters. Major agricultural policy over that period occurred in response to such disasters rather than as a proactive process. It was the Australian farmer who tested the limits of the system and the nation is better off for knowing those limits so that the mistakes of the past are not repeated.

This chapter provides a brief account of the development of farming from first European settlement. Any student of agriculture should understand this evolution in order to appreciate the principles and practices now in place. The development of machinery occurred largely through the innovativeness of the Australian farmer whilst the farming systems of today have emerged largely through trial, error and necessity.

There is now heightened awareness of the environmental imperatives associated with rural landscapes as well as the economic imperatives for farmers and their communities. Knowledge is never perfect though and the search for improved understanding and better solutions must continue to underpin the ongoing evolution of Australian agriculture. This chapter traces Australian agriculture from European settlement to the chemical-based agriculture of modern times.

PIONEER TECHNOLOGY

Cultivation in the early days of settlement was done by hand. There were no draught animals or machinery but human labour in the form of convicts was readily available (Jeans, 1977). This situation persisted into the 1820s even though ploughs were substituted for spades, hoes and other crude tools from about 1797. Due to lack of assistance from the British Government, primitive implements were invented and produced in Australia to help in the process of seedbed preparation. For over 100 years, until the 1930s, the horse was the chief source of farm power (Jeans, 1979).

FROM MOULDBOARD TO DISC

Before land could be cultivated, timber had to be cleared. The remaining stumps and roots created great difficulties for the pioneer settlers (Wheelhouse, 1966). English ploughs, such as the light Rotherham plough, which were brought to New South Wales in the early days of settlement, were discarded and replaced by heavy wooden breaking ploughs (Figure 1.1) for use on virgin country (Jeans, 1977; 1979).

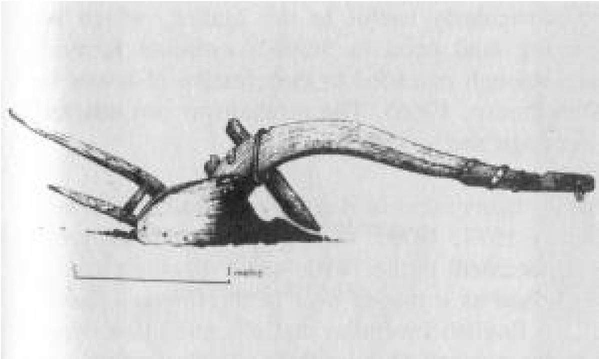


Figure 1.1 Heavy wooden breaking plough used for breaking up virgin country in the early nineteenth century (Photo courtesy of D.N. Jeans)

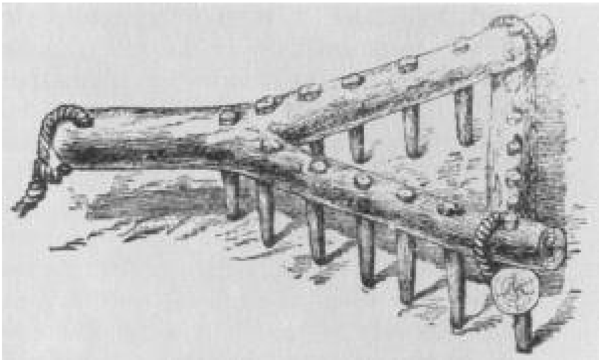


Figure 1.2 Home-made harrow similar to that used for "mullensing" or "Yankee grubbing" in the Mallee in the nineteenth century (Photo courtesy of D.N. Jeans)

These ploughs were equipped with a sharp coulter and sharp mouldboard edge and were pulled by up to twelve oxen through the root mass to a depth of about 25 cm. It was possible to work up to 1.6 ha of land per week. By the middle of the nineteenth century, locally manufactured light ploughs could be bought for ploughing fallow or stubble. However, because of the inherently low fertility of the soil and the lack of fertilisers, Australian farmers continually had to break new ground, a process requiring a heavy plough. Iron ploughs generally replaced the wooden plough in the 1850s and 1860s (Jeans, 1977).

At about this time, 'mullensing' became a form of land preparation in the light scrub and timbered Mallee regions of South Australia and Victoria. A South Australian farmer named Mullens, after whom the method was named, cut trees down to ground level, sold the best timber and burnt the rest. He then used a V-shaped log with spikes driven into the undersurface: a horse was hitched to the pointed end and the crude cultivator was dragged along the ground; burying seed as it loosened the soil (Wheelhouse, 1966). This unique method of tilling the soil was attractive to other farmers because it was a cheap, simple and quick method of producing a grain crop. The method later became known as 'Yankee' grubbing in other States (Figure 1.2).

In 1876, Richard Bruyer Smith of Kalkabury, South Australia, invented the stump-jump plough and received a payment of £500 from the State Government for his efforts (Callaghan and Millington, 1956). The share and mouldboard were hinged so that they rose on meeting an obstruction in the soil. They returned to work again once the root was passed (Figure 1.3). The stump-jump principle was Australia's major contribution to the development of a plough that enabled scrub and stony lands to be profitably tilled. It was particularly useful in the Mallee, which by 1880 constituted most of the suitable wheat-growing land open to South Australian farmers (Jeans, 1977). The contribution of the stump-jump plough extended to the creation of towns in areas previously opened up by this invention (Wheelhouse, 1966). The mechanism was adapted subsequently to almost all implements involved in tillage and sowing.

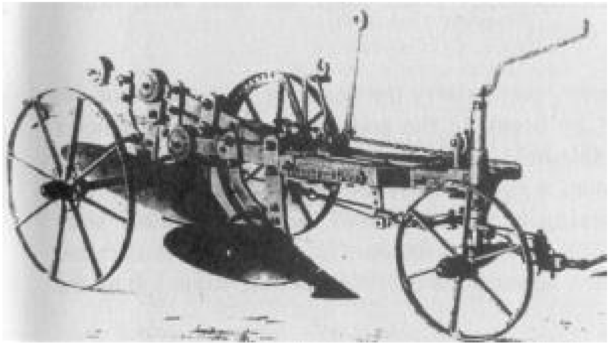


Figure 1.3 Early stump-jump plough invented by R.B. Smith of South Australia in 1876; this implement was especially useful in Mallee country (Photo courtesy of D.N. Jeans)

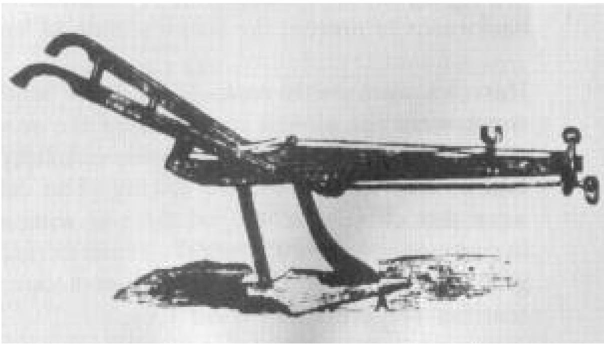


Figure 1.4 Subsoil plough used around the turn of the 20th century (Photo courtesy of D.N. Jeans)

The English mouldboard plough proved unsuitable for many areas in Australia because the turned sods baked to hard clods in the dry conditions (Jeans, 1977; 1979): in England the winter frosts could be relied on to break them up. A common replacement in the 1890s was a digging plough, which had a high short mouldboard to break up the sod as it turned over in the furrow. Heavy subsoils were broken up by a 'subsoiler' plough, an English invention that ploughed to a depth of 30-40 cm without bringing infertile subsoil to the surface (Figure 1.4). This practice was common in the late 1800s and early 1900s.

The problem of clodding in heavy soils was solved most effectively however, by the American principle of the disc plough. The Americans, motivated by the need to reduce plough draught, replaced the sliding friction of the mouldboard and shares by the rolling action of the discs. A few were imported in 1896 and were manufactured locally from about 1903. James Garde of Victoria adapted a stump-jump mechanism to the disc plough to produce the Sundercut stump-jump disc cultivating plough, which was produced from 1906 (Jeans, 1979).

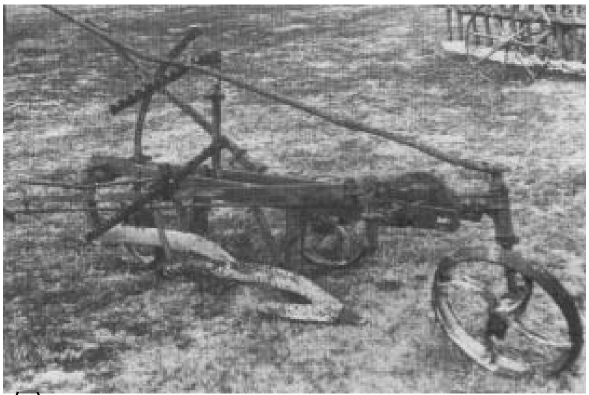
The discs, usually in pairs and set on an angle, turned and pulverised the soil in a way that was suited to dry conditions, particularly on heavy soils. Disc ploughs had been used at Wagga Wagga Experimental Farm since 1898 and, by 1911, the New South Wales Department of Agriculture considered them to be superior to mouldboard ploughs. This was because the disc plough required less draught as well as being faster and better able to break up heavy soils and stubble. The mouldboard plough survived on light soils where the discs pulverised the soils excessively, but between 1900 and the 1970s, however, the disc plough was the main primary tillage implement on Australian farms (Jeans, 1979).

SECONDARY TILLAGE

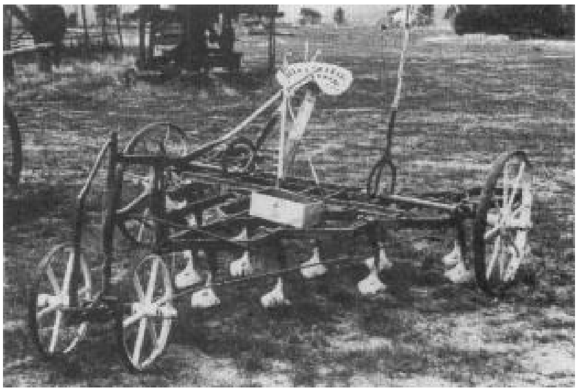
Various forms of harrows were used for the final preparation of seedbeds and to cover broadcast seed. The most primitive forms were spiked logs (as previously described for 'mullensing'), and in some cases tree branches were used to cover the seed. The most common type from the 1870s was the zigzag harrow, which was invented in England in 1839. From 1880, the tines were sloped backwards to prevent the accumulation of weeds (Jeans, 1977).

Harrows were partly replaced by other implements, particularly the scarifier and cultivator, to supplement the plough in preparing the seedbed by breaking the soil down into finer particles (Figure 1.5). The scarifier, a relatively heavy implement with rigid tines, was used to break up fallows and stubbles before sowing. The cultivator, a lighter implement, with spring tines that were less chisel-like, stirred the soil without turning it over. By 1885, these implements were in common use in New South Wales and during 1890 to 1906 were standard implements on Australian grain farms (Jeans, 1977). The skim plough, which appeared after 1900, did the same job as the scarifier (Figure 1.5, Figure 1.6).

The disc principle was adapted to cultivation after 1900. Instead of one or two heavy discs of the plough, the disc cultivator had many lighter discs for scything through surface crusts and breaking up the clods (Figure 1.7).



(a)



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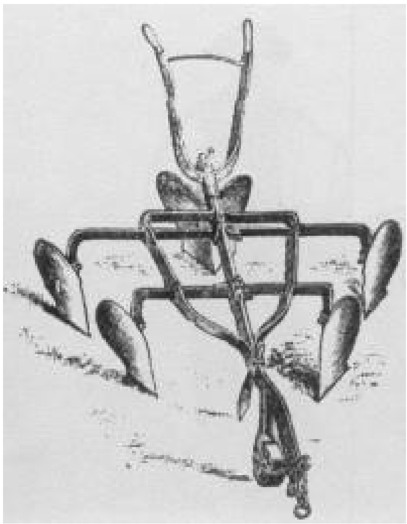


(c)

Figure 1.5 A group of secondary tillage implementsthat completed the mechanisation of the Australian wheat industry in the 1890s:

(a) skim plough
(b) scarifier
(c) plough cultivator

(Photos courtesy of D.N. Jeans)

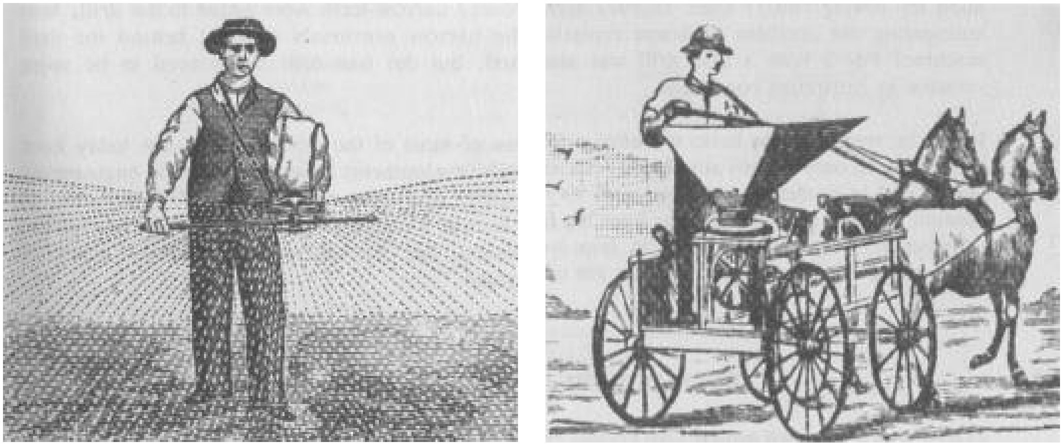
Figure 1.6 Advertisement in *The Scientific Farmer and Agricultural Review*, 1907 for secondary tillage implements and other machinery (Photo courtesy of D.N. Jeans)

Figure 1.7
Advertisement for tandem disc harrows in the early 1900s (Photo courtesy of D.N. Jeans)

SOWING

Inexplicably, the Australian farmer lagged far behind his European counterpart in sowing technology, though not so far behind the North Americans. Attempts had been made over several thousand years to produce a workable seed drill that would plant the seed reliably in rows. The history of this experimentation traces back to Babylon in 2000 BC and to Italy in 1580. It was, however, Jethro Tull in England who first produced a workable drill in 1701. The drill paved the way for better farming by economising on seed, and sowing in rows, which allowed the crop to be kept clean by inter-row cultivation. A higher germination rate (also improved by the use of a roller, which broke up any remaining clods) and greater tillering were also achieved.

Australian farmers, however, continued to sow seed by broadcasting, the older method of flinging the seed over the land and covering it using a harrow. This was a wasteful procedure in both time and seed. Initially it was done by hand from a bag slung over the shoulder, but later, seed was spread from a hand-held device carried by the sower (Figure 1.8). A revolving mechanism for scattering the seed was activated by means of a bow. These devices remained in use on small properties until well into the twentieth century. In the 1870s a cart implement for broadcasting, the 'Seedsower', was imported from America and it was soon manufactured in South Australia for local use (Jeans, 1977). It employed the same method of seed distribution as the hand-held model, with seed being fed from a hopper to a revolving disc, which was powered by a belt-drive from one of the cart wheels. Regular distribution of the seed up to 16 m in width was claimed for this machine, which was widely used.



(a) (b)

Figure 1.8 Early methods of sowing seed:
(a) hand seed sower showing the bow mechanism for scattering the seed; and
(b) broadcast 'Seedsower' using a ground-driven revolving disc for seed distribution. These were in common use prior to the introduction of the combine drill (Photos courtesy of D.N. Jeans).

In 1782 Englishman James Cook made the first modern drill with a hopper feeding seed down a tube to a 'boot'. This boot placed the seed in a trench made by a tine (Callaghan and Millington, 1956; Jeans, 1977). Even in England the drill was not common until the early part of the nineteenth century.

As late as 1885 Angus MacKay's Elements of Australian Agriculture made no mention of the drill, and it was absent also from his book Introduction to Australian Agricultural Practice in 1890. MacKay was writing chiefly of the less agriculturally advanced State of New South Wales, but there were reports of drills replacing broadcasting in parts of Victoria in the 1870s. It was not until as late as the 1890s that drills began to overtake broadcasting to any significant extent, and not until after 1910 that they were adopted universally, although this varied from State to State. Most grain farms in South Australia had drills by 1910.

The locally manufactured Empire drill of 1895 cost the substantial sum of £35 - farmers objected to paying such a high price! Farming technology then made significant advances, notably in the use of the cultivator. The drill therefore became essential for sowing the crop in rows in order to facilitate inter-row mechanical weed control. The availability of superphosphate also encouraged the rate of adoption of the drill, particularly after 1917 when R.A. Squires of Quirindi, New South Wales, pioneered the 'combine' drill, which sowed seed and fertiliser together (Callaghan and Millington, 1956).

Cultivating tines were added to the combine to prepare the seedbed and bury the seed. The International Harvester combine drill of 1920 had 15 boots for sowing and 31 tines. In 1912 spring-loaded harrow-teeth were added to the drill, thus anticipating the combine drill and replacing the harrow previously dragged behind the drill machine. For a time a disc drill was also used, but the tine drill has proven to be more versatile in Australian conditions.

It can be seen that the basic technical principles of most of the machinery in use today have been changed only slightly since the 1920s, although developments have taken place in engineering design and in modes of operation such as hydraulics and three-point linkage. It is a matter of opinion whether the early designs were the final answer for seedbed preparation and crop sowing or whether the research effort to improve designs has not taken place and the needs of germinating seeds and plant roots are not understood.

Rick Graham (NSW DPI, Tamworth), Leigh Jenkins (NSW DPI, Trangie), Kathi Hertel (NSW DPI, Narrabri), Rohan Brill (NSW DPI, Narrabri), Rod Bombach (NSW DPI, Tamworth), Don McCaffery (NSW DPI, Wagga Wagga) and Neroli Brennan (NSW DPI, Orange) | Feb 2018

Take home messages

- Seed colour change occurs later on the branches of canola plants compared to the primary stem.
- Research examining the partitioning of yield between the primary stem and branches found that branches can contribute up to 80% of total yield.
- Relying solely on seed colour change from the primary stem to determine windrow timing could result in overall seed development being underestimated, potentially impacting seed size, yield potential and oil concentration.
- Results highlight the potential for significant yield and quality penalties associated with early windrow timings, before 40% seed colour change on the primary stem.
- There is potential for yield and oil concentration benefits to be obtained with delayed windrow timings at the upper end of current industry guidelines ≥ 60% seed colour change.
- Given the significance of the proportion of yield contributed by the branches as opposed to the primary stem there appears to be a need to reconsider how windrow timing is determined.

Background

Windrowing is a widely adopted harvest management practice of canola (*Brassica napus* L) in Australia. Its timing has traditionally been based on the seed colour change of seeds taken from pods (siliques) in the middle third of the primary stem (primary racemes). Current industry guidelines based on research undertaken in the 1980s and early 1990s recommend that canola is ready to windrow when 40–60% of seeds on the primary stem change colour from green to red, brown or black (Hocking and Mason, 1993). Over the past decade however, with the introduction of hybrid varieties, improvements in germplasm and developments in farming practices and machinery, there has been increased discussion about what is considered the optimum windrow timing and how best to determine seed colour change (Street, 2014).

The main issues of concern relate to the proportion of yield contained on the branches (secondary racemes) versus the primary stem and the effect of the differential rate of seed maturity on yield and seed quality parameters. This is further accentuated when you consider that canola seeds mature progressively up the primary stem and from the lower branches to the upper branches, with changes in seed colour indicative of declining metabolic activity and increasing seed maturity (Hertel, 2012). Based on these observations, there is an obvious need to consider in detail the partitioning of yield (stem *vs.* branches) and rate of seed development when looking at recommendations around seed colour change and optimum windrow timing, particularly in the hotter finishing environments of northern NSW (Hertel 2013).

In 2015, research commenced as a component of the GRDC co-funded 'Optimised Canola Profitability' project (CSP00187) to examine the relationship between seed colour change, seed yield and quality parameters. The objective was to assist growers to make more informed decisions around canola harvest management in northern NSW and potentially across Australia.

Based on these preliminary findings a comprehensive set of experiments were conducted across a range of environments in the northern grains region of NSW in 2016 and 2017. Findings from these experiments are reported in this paper.

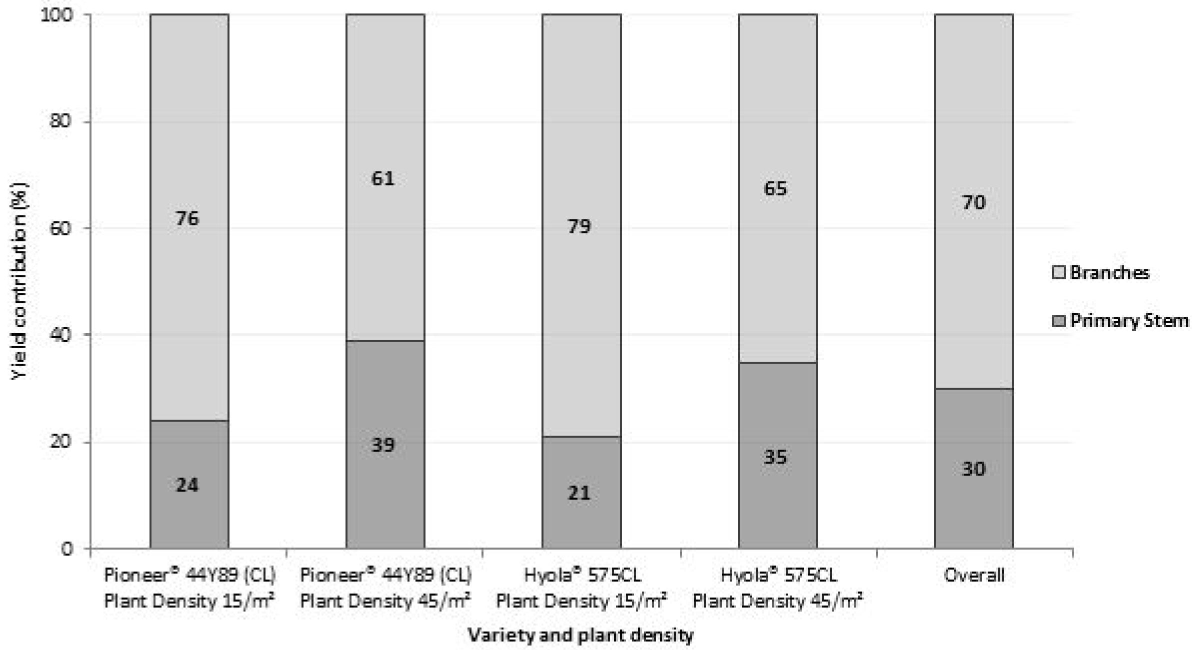


Figure 1. Mean yield contribution (%) of primary stem *vs.* branches for two target plant densities (15 and 45 plants/m^2) at Trangie in 2015.

Research in 2016

Replicated field experiments were conducted at three sites; 'Tarlee' near Edgeroi on the north-west plains of NSW, Tamworth Agricultural Institute on the north-west slopes of NSW and Trangie Agricultural Research Centre on the central-west plains of NSW.

Methodology

Experiments were sown on 6 May at Tamworth and Trangie, and 10 May at Edgeroi, and were managed using best management practices to limit biotic stresses and nutritional constraints. Two hybrid canola varieties, Pioneer® 44Y89 (CL) and Hyola® 575CL with similar flowering times but different maturity ratings, were sown in small plot experiments at Tamworth and Trangie, however only one variety Pioneer® 44Y87 (CL) was sown at the Edgeroi site, which was overlaid in a commercial crop. Windrow timings were conducted at 2 day intervals from the start of seed colour change on the primary stem up until 100% seed colour change on branches, alleviating difficulties associated with trying to target seed colour change and hence simulated windrow timings.

The following results focus on overall effects of windrow timing and seed colour change on canola yield and oil concentration, rather than on varietal differences.

Results

Seed colour change

Seed colour change and windrow timing treatments commenced on 4 October at Edgeroi, 7 October at Trangie and 14 October at Tamworth. Consistent with the 2015 Trangie findings, seed colour change occurred earlier on the primary stem compared to the branches (data not shown). Windrow timing averaged across the two varieties at Tamworth showed that when seed colour change on the stem was at 61%, branches were only at 20% seed colour change (windrow timing 7, Figure 2). Similarly, at Edgeroi and Trangie where seed colour change occurred earlier than Tamworth, the primary stem was more advanced compared to branches at key windrow timings. At Trangie for instance, when the primary stem was at 84% seed colour change (windrow timing 7), branches were only at 43% seed colour change, likewise at Edgeroi when the primary stem was at 80% seed colour change, branches were at 52% seed colour change (data not shown). The results from Tamworth also illustrated how rapidly seed colour change can occur, with seed colour change on the primary stem progressing in a five-day period from 18% to 61% seed colour change (windrow timing 5 to timing 7) (Figure 2).

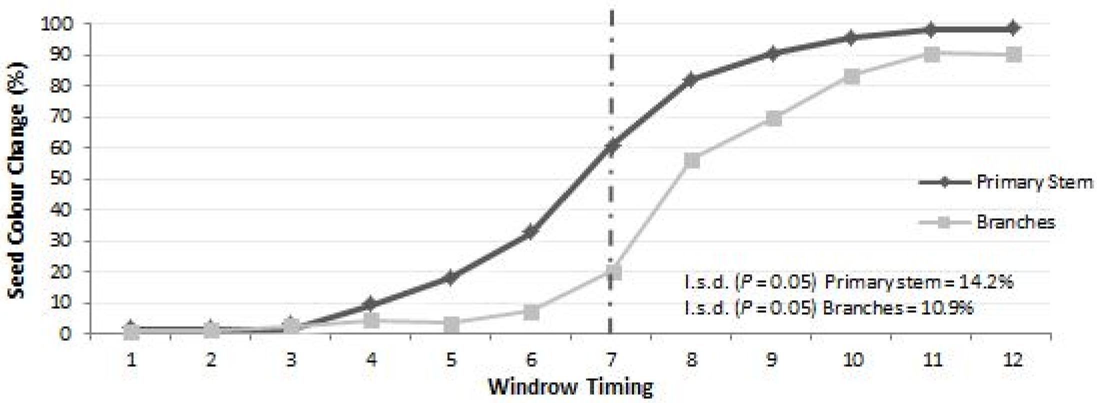


Figure 2. Seed colour change (%) primary stem *vs*. branches over time as determined by windrow timings at Tamworth in 2016. (Vertical line approximates 60% seed colour change on the primary stem ~ windrow timing 7).

Seed size

Changes in seed size (thousand seed weight) across windrow timing can be used as an indicator of both reaching physiological maturity and yield potential over time. At Tamworth (Figure 3a) and Trangie (Figure 3b) differences in thousand seed weight on the primary stem vs. branches was greatest during the earlier windrow timings, reflecting differences in seed colour change and maturity. This would be expected given that seeds mature progressively up the primary stem and from the lower branches to the upper branches, with changes in seed colour indicating declining metabolic activity and increasing seed maturity (Hertel, 2012).

Importantly, the optimum thousand seed weight for branches occurred at a later windrow timing than current industry recommendations which are based solely on seed colour change on the primary stem. This is of relevance given that branches contributed 63% and 78% of potential yield at Trangie and Tamworth respectively. A similar pattern of thousand seed weight development on branches vs. the primary stem was also observed at Edgeroi (data not shown).

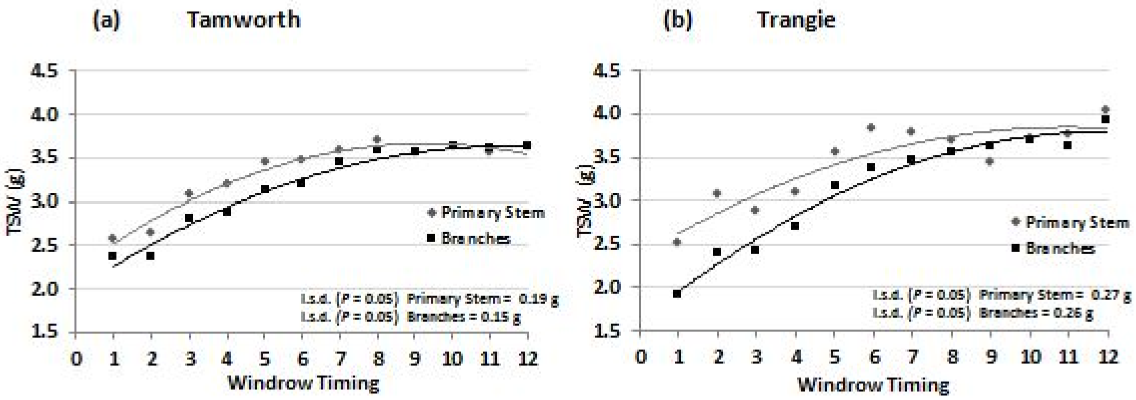


Figure 3. Changes in seed size (thousand seed weight) on primary stem *vs.* branches over time as determined by windrow timing for Tamworth (a) and Trangie (b) in 2016.

Yield

Windrowing at the start of seed colour change of 6% on the primary stem at Trangie resulted in a 1.34 t/ha decline in yield compared to windrowing at ~60% seed colour change, a yield loss of 48% (1.47 t/ha *vs.* 2.81 t/ha) as outlined in Graham *et al* (2017). When looking at the breakdown of yield contribution of the primary stem *vs.* branches, it was observed that stems only contributed 37% of the total yield at Trangie, averaged across windrow timings (data not shown). At Edgeroi, yield based on 40–60% seed colour change on the primary stem ranged from 1.70–2.35 t/ha, with yield peaking at 2.42 t/ha when seed colour change on primary stem was 89% and branches 65%. A yield penalty of 0.6–1.3 t/ha was observed at Edgeroi when windrowing occurred at ~6% seed colour change on the primary stem *vs.* industry guidelines when 40–60% seed colour change on the primary stem, 8-10 days later, resulting in a yield loss of up to 55% (Figure 4). At Tamworth, the penalty for early windrowing at the start of seed colour change versus industry recommendations was 1.20 t/ha, a potential yield loss of 32% (data not shown). In all three experiments delaying windrow timing to where seed colour change on the primary stem was >60% either resulted in significant (P<0.001) increases in yield at Edgeroi and Trangie, or trended towards a yield increase at Tamworth.

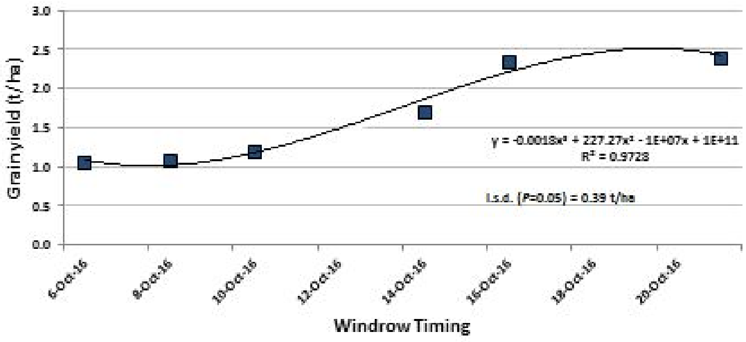


Figure 4. Effect of windrow timing and seed colour change on canola seed yield (t/ha) at Edgeroi 2016

Oil concentration

There were significant ($P \leq 0.001$) oil concentration penalties for windrowing at early stages of seed colour change. At Tamworth, there was a 14% decline or a 6.3% unit reduction in oil concentration (38.9% *vs*. 45.2%) when windrowing at the start of seed colour change versus at ~60% seed colour change on the primary stem (Figure 5). There was also an increase in oil concentration at Tamworth where seed colour change was >60% on the primary stem, with increases in oil concentration of 0.6–2.0% units. At Edgeroi there was a significant (P = 0.001) decrease in oil concentration with early versus >40% seed colour change on the primary stem, with oil concentration declining by 3.9% units (Figure 6). Similarly at Trangie, there was a significant (P<0.001) decline in oil concentration of 4% units, whilst there was an increase of 1.1–1.9% units in oil concentration, with delayed windrow timings of >60% seed colour change (data not shown).

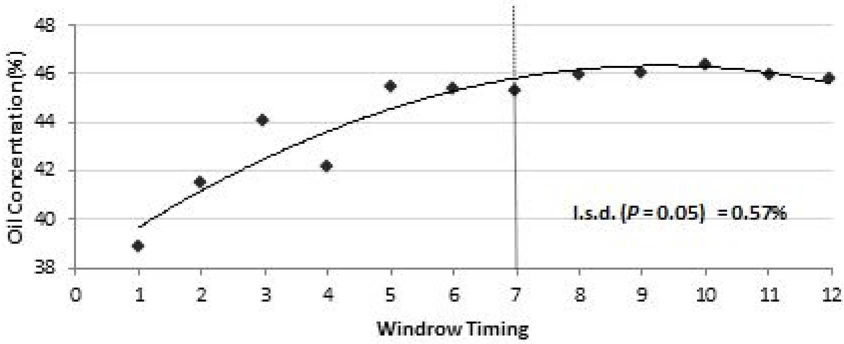


Figure 5. Effect of windrow timing (seed colour change) on oil concentration (%) at Tamworth in 2016 (Vertical line approximates ~60% seed colour change on the primary stem – windrow timing 7)

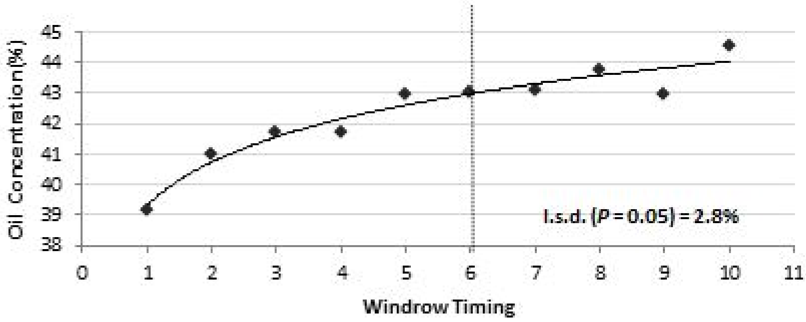


Figure 6. Effect of windrow timing (seed colour change) on oil concentration (%) at Edgeroi in 2016 (Vertical line approximates ~40% seed colour change on the primary stem – windrow timing 6)

Research in 2017

In 2017, experiments were conducted at Tamworth and Trangie. Results from the Tamworth experiment only are outlined in this paper. In keeping with previous years, the Tamworth experiment was sown in the first week of May. In contrast to 2016, which received 543 mm (decile 9) growing season rainfall (April to October), in 2017 the site only received 203 mm (decile 2).

The methodology for the 2017 experiments was as per 2016, the only variation, being the two varieties that were compared. Unlike in 2015 and 2016, where two hybrid canola varieties Pioneer® 44Y89 (CL) and Hyola® 575CL were assessed, in 2017, a hybrid variety Pioneer® 44Y90 (CL) and an open pollinated variety ATR-Bonito were evaluated. This change was made to see if there were any differences in yield components (Stem *vs* Branches), SCC and seed development, between a hybrid CL variety and an open pollinated triazine tolerant (TT) variety.

Results

Seed colour change

The two varieties evaluated had comparable 50% flowering dates but differed in terms of maturity, with Pioneer® 44Y90 (CL) 4 days faster to the end of flowering compared to ATR-Bonito. Windrow timing commencing on the 18 October for both varieties and concluded on the 30 October and 6 November respectively for Pioneer® 44Y90 (CL) (windrow timing 6) and ATR-Bonito (windrow timing 9), reflecting the difference in maturity. Consequently, at any given windrow timing, seed colour change was more advanced for Pioneer® 44Y90 (CL) compared to ATR-Bonito. For example at windrow timing 1, Pioneer® 44Y90 (CL) was at 71% seed colour change on the primary stem, ATR-Bonito was only around 29% seed colour change.

Consistent with previous findings, seed colour change occurred earlier on the primary stem compared to the branches. In the case of ATR-Bonito when the primary stem was at 29% seed colour change, the branches were only at 6% seed colour change (windrow timing 1) likewise, when the stems were at 99% seed colour change, the branches were only at 65% seed colour change (windrow timing 5). Results from 2017, again reinforced how rapid seed colour change can occur, with seed colour change on the primary stem progressing from 29% to 90% seed colour change in a 5 day period.

Seed size

Seed size expressed as thousand seed weight, is considered an indicator of physiological maturity and yield potential. When looking at changes in thousand seed weight over time as it relates to windrow timing for ATR-Bonito it can be seen that differences in thousand seed weight stem vs. branches are greatest during earlier windrow timing's, reflecting differences in seed colour change and overall maturity (Figure 7). This trend was also observed for Pioneer® 44Y90 (CL) (data not shown). This is of significance given that the branches contributed ~85% and ~87% of potential yield for ATR-Bonito and Pioneer® 44Y90 (CL) respectively, also indicating that yield partitioning did not differ greatly between an open pollinated and a hybrid variety in this case.

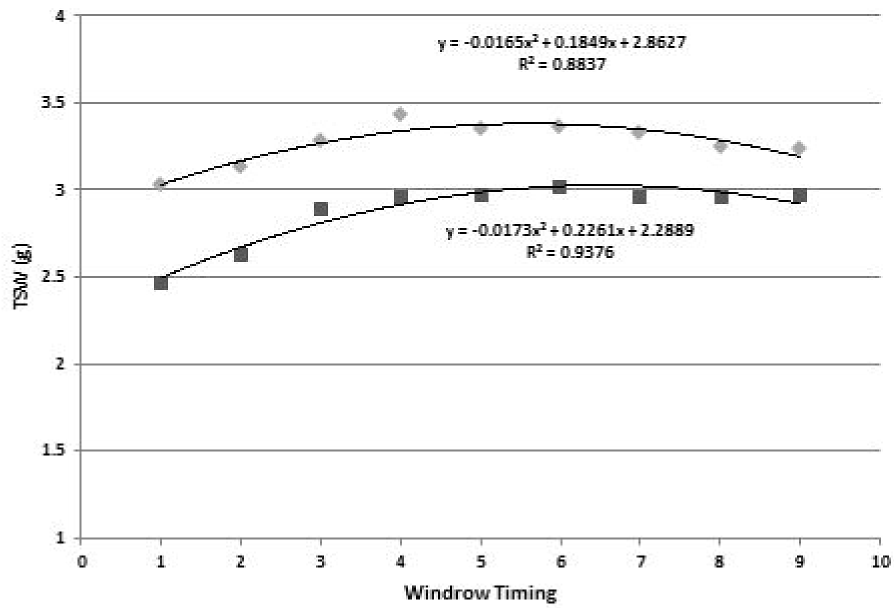


Figure 7. Changes in seed size (TSW - thousand seed weight) on primary stem *vs.* branches over time for ATR-Bonito as determined by windrow timing at Tamworth 2017

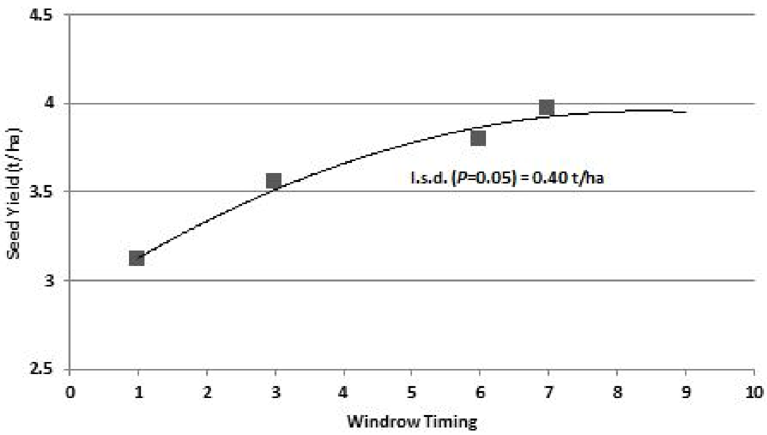


Figure 8. Effect of windrow timing on ATR-Bonito seed yield (t/ha) at Tamworth in 2017

Yield

Early windrow timings before 40% seed colour change on the primary stem, resulted in the potential for a significant yield penalty. When looking at the results for ATR-Bonito it was shown that there was a 13% yield penalty (Figure 8) windrow timing 1 *vs* windrow timing 3 (3.11 t/ha *vs* 3.56 t/ha) and stems were at 29% seed colour change vs 90% seed colour change respectively. Importantly when looking at the breakdown of yield, stem vs branches only ~ 15% of yield was attributed to the stem and that at windrow timing 1 and windrow timing 3, the branches were only at 6% and 38% seed colour change respectively. These results would indicate both a need to consider the breakdown of yield, stem *vs* branches and how rapid seed colour change can occur both of which may be influenced by seasonal conditions.

Summary

Results from these experiments clearly show that seed colour change occurs later on the branches of canola plants compared to the primary stem. This is important when you consider that branches can contribute in excess of 80% of canola yield potential. Relying solely on seed colour change from the primary stem could result in the plants seed development being underestimated, potentially impacting seed size, yield potential and oil concentration.

Findings from this research highlight the potential for significant yield and quality penalties due to early windrow timings (i.e. before 40% seed colour change on the primary stem), with yield losses of up to 55% and decreases in oil concentration of up to 7.7% units observed. This study indicates that seed colour change should ideally be measured on a whole plant basis and not based solely on the assessment of seed from the primary stem when determining windrow timing operations. Furthermore, results demonstrated the potential benefit of delayed windrow timings related to seed colour change, with yields optimised at the upper end of current industry guidelines of ≥60% seed colour change.

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