GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

GRDC
GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 22
Integration of the sprayer with other farm equipment

Tyre centres, equipment widths and spacings

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Key points

- Increased levels of accuracy and precision provide opportunities for new spray application techniques, including banded and directed spraying and inter-row shielded spraying.
- Whether the measurement system is based on imperial or metric units does not matter, provided the same measurement system is used on all machinery.
- Matching the tyre centres of all equipment can reduce crop damage and minimise trafficked areas in the paddock.
- Selecting seeding and spraying equipment that are multiples of a standard width (e.g. the width of the cutter bar on the harvester) can improve the accuracy of applications and reduce over-dosing or under-dosing on the edges of spray passes.
- Matching nozzle spacing to crop row width may improve spray coverage, stubble penetration and may reduce drift potential.

1. Introduction

The increased levels of precision possible with accurate guidance and autosteer functions has opened up many opportunities for growers to manage seeding operations and traffic within the paddock in ways that were not previously possible. The impact of increased precision and accuracy for spray application has meant that spray operators can now use techniques such as inter-row shielded spraying, banded and directed spraying in-crop, and variable-rate application of liquid fertilisers and other crop inputs.

To maintain the accuracy required to adopt many of the techniques now possible, there are three widths the spray operator should consider before upgrading any of their farm machinery: the width of the tyre centres, the sprayed width of the boom and the width between the nozzles (nozzle spacing).

The width of the tyre centres is one of the most critical factors for maintaining precise steering and to maintain the position of implements. Wherever possible it makes sense to match the tyre centres of the sprayer and the seeding equipment to the largest piece of equipment on the farm, which is the harvester. The width of the boom can then be matched to the width of the seeding equipment, or exact multiples of this, which will reduce the overall level of traffic and reduce under- or over-applications of sprays and can improve the accuracy of each spray application.

2. The starting point – deciding on the unit of measurement

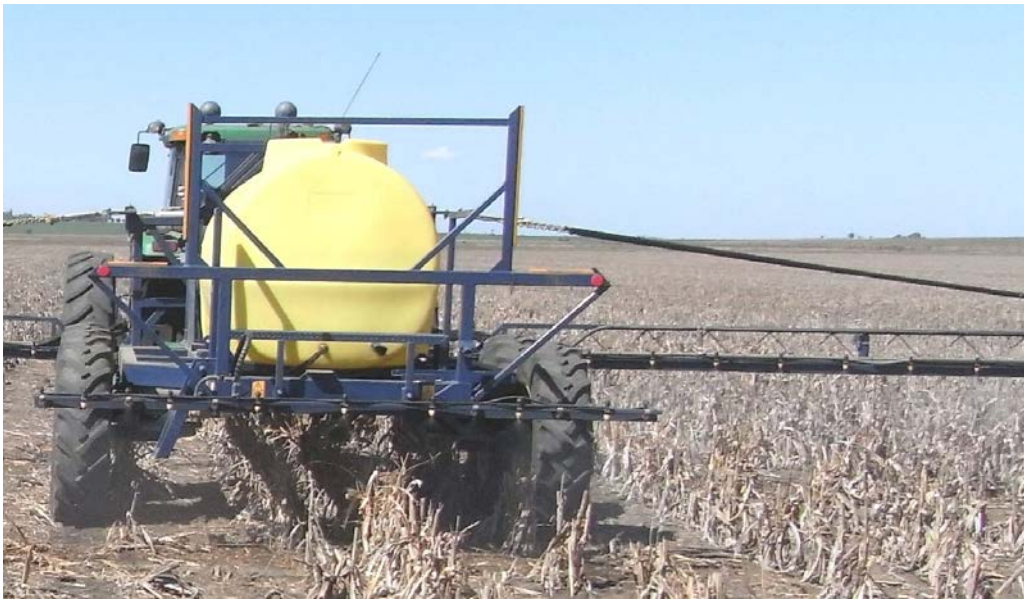
PLAY VIDEO

Tyre tip - aligning tyre centres to improve auto steer function

There isn't a right or wrong unit of measurement to use. However, it is very important to stick to one system, using either all imperial measurements or all metric measurements for each piece of equipment on the farm. It makes sense to match other equipment to the harvester, as this would be the most difficult piece of machinery to try to adjust.

If the harvester has tyre centres based on imperial measurements, for example 120 inches, while this is close to 3 metres, it is actually 3.048m. Running another piece of machinery with metric 3m tyre centres over the same wheel tracks as a 120-inch harvester leaves little room for variation for autosteer systems. While the accuracy of many GPS systems may be 2 centimetres, it is likely that even this small variation (3.000 versus 3.048m) will cause the autosteer system to work harder to maintain the correct line than it would otherwise have to if the tyre centres on the two pieces of equipment were matched.

An example of having all tyre centres in alignment

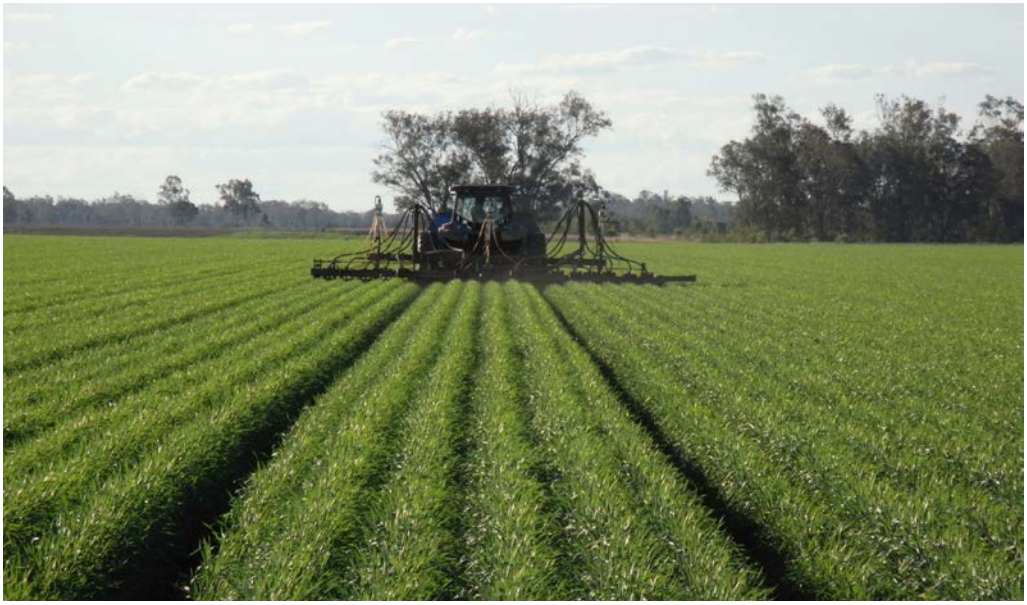


Once all equipment and tyre centres are in alignment, it becomes much simpler to match the nozzle spacing to the crop-row width.

Source: Graham Betts

While the position of the tyres within the wheel track is important for the function of the autosteer, the position of other implements and the tyres in relation to row spacing is also very important for minimising crop damage, compaction and maintaining the position of the nozzle in relation to the crop row. Generally, the narrower the row spacing, the more important the matching of equipment becomes, particularly for operators who plan on inter-row seeding, directed spraying or inter-row shielded spraying.

Inter-row shielded spraying



When the spray equipment aligns with the row spacing, inter-row shielded spraying becomes a possibility.

Source: Graham Betts

3. Equipment widths and tyre centre spacings that work well together

To minimise potential crop damage and maintain the position of the nozzles in relation to the crop row, the following information is provided as a guide to suitable combinations of wheel centres to match particular cutter bar widths on the harvester.

Matching tyre centres to the cutter bar width, imperial examples include:
40-foot cutter bar = 480 inches, tyre centres could be 80 inches or 160 inches with an even number of crop rows, or 120 inches with an uneven number of crop rows.

36-foot cutter bar = 432 inches, tyre centres at 120 inches with an uneven number of crop rows.

30-foot cutter bar = 360 inches, tyre centres could be 120 inches with an uneven number of crop rows.

Matching tyre centres to the cutter bar width, metric examples include:
12-metre cutter bar, tyre centres could be 2m or 4m with an even number of crop rows, or at 3m with an uneven number of crop rows.

11m or 9m cutter bar, tyre centres could be 3.0m with an uneven number of crop rows.

Once the range of possible tyre spacings has been established to match the cutter bar width on the harvester, the operator should determine how to set up the seeding equipment to match the preferred row width and the tyre centre spacings that are possible.

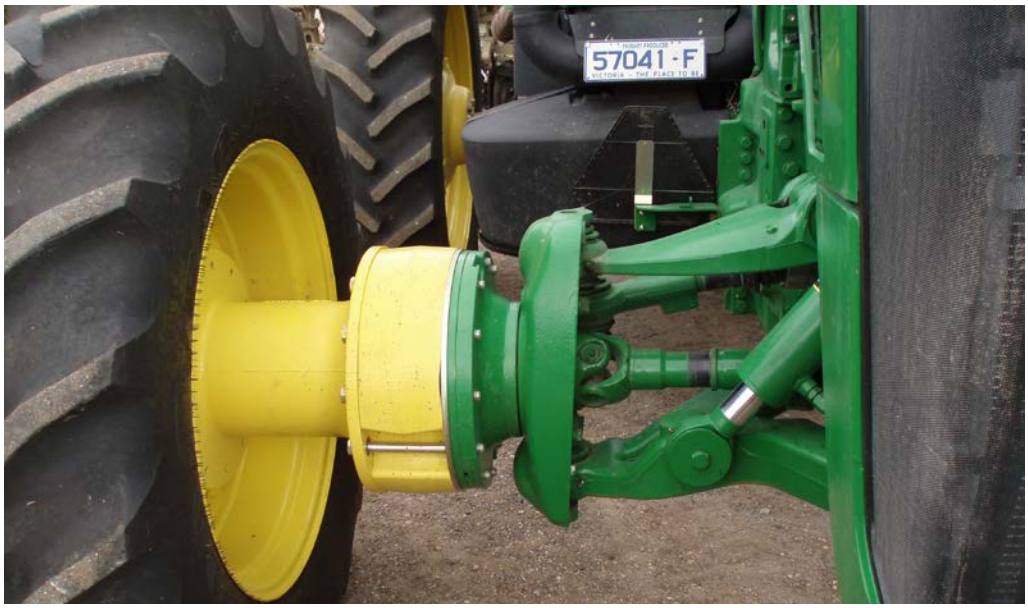
4. Row width and tyre centres – striking the right balance on the seeding equipment to improve the accuracy of spraying operations

The selection of appropriate row spacings for various crops should be driven by agronomic factors, such as yield potential, harvestability, crop competition against weeds and disease management, appropriate for your location and soil type.

Once appropriate row widths have been established, the operator should plan the seeder's width to work with the width of the cutter bar on the harvester (excluding gatherers). The width of the seeding equipment could generally fit in with the cutter bar width in a 1:1 ratio, a 2:1 ratio, or a 3:1 ratio or more in some circumstances.

The number of rows established on the seeding equipment should take into account the spacing between the tyre centres. It is important to consider whether an even number of rows or an odd number of rows on the seeding equipment will work best for your situation. The choice largely depends on whether the operator is happy to drive over planted rows, or would prefer to have the wheel tracks in the inter-row space as much as possible or adjust the crop row width around the tyres.

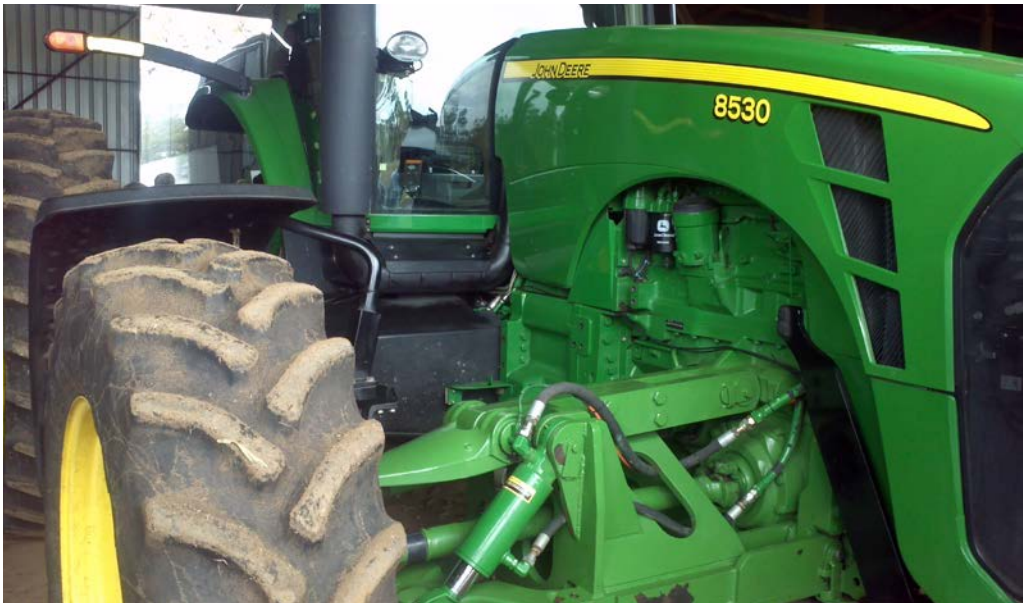
A 3-metre wheel extension on a John Deere tractor



A good starting point is to match tractor and sprayer wheel centres to the harvester.

Source: Graham Betts

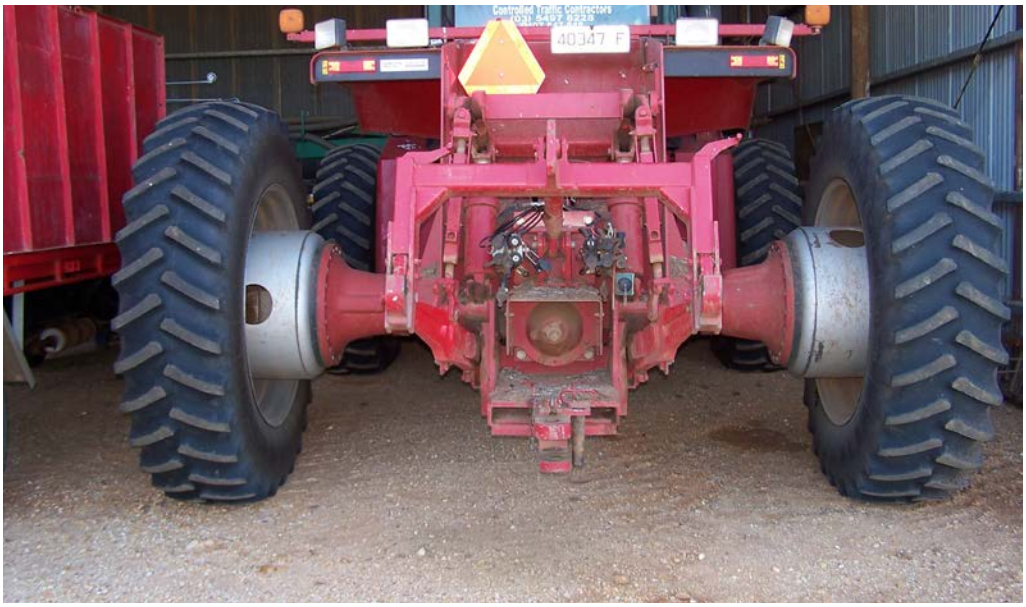
Full front-axle extension on a John Deere tractor



Moving to a full 4-metre system requires careful consideration as movement of equipment on public roads can become very difficult.

Source: Graham Betts

Wheel extensions on a Case tractor



Extending the wheel centres on the tractor is now a relatively simple task.

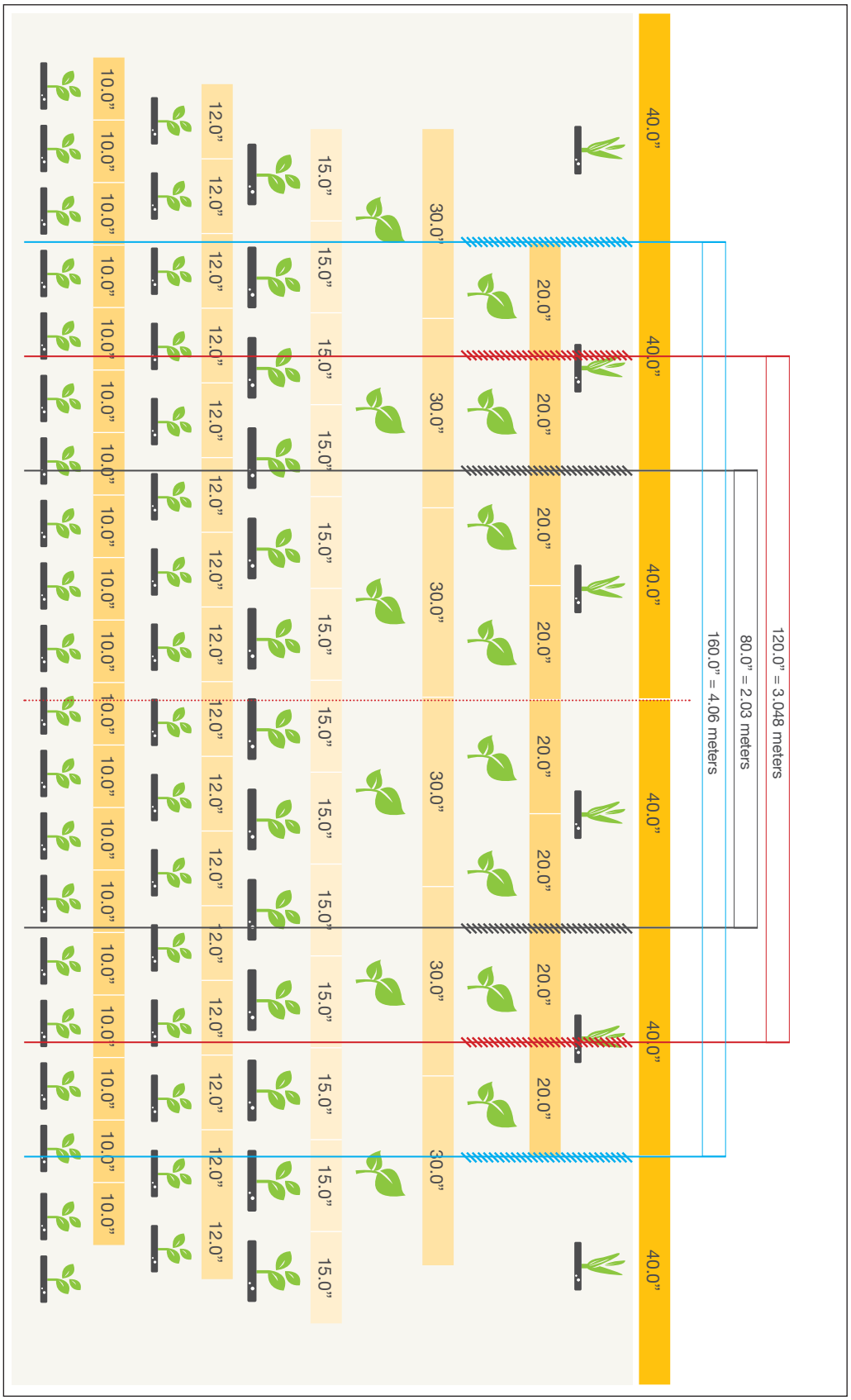
Source: Graham Betts

4.1 Choosing either an even number of planted rows or an uneven number of planted rows

To minimise crop damage, generally using an even number of planted rows will often work better than using an odd number of planted rows.

For example, Figure 1 shows three different spacings for the wheel centres and the position of the crop row for a range of possible row widths, based on an even number of rows planted.

Figure 1 Position of the wheels and traffic in relation to row spacing for an even number of planted rows (based on imperial row spacings).



Using an even number of planted rows (broadacre set-up)

From Figure 1 it can be seen that if the machinery was set up with a 120-inch wheel centre (red), and an even number of rows was planted (a broadacre set-up, with the same number of rows either side of the unplanted centre line of the equipment), this would work for most situations, except for a 40-inch row spacing (as the wheels will travel directly over the planted row).

However, many of the other row spacings illustrated could work well for an even number of planted rows and 120-inch wheel centres, including 20-inch and 10-inch rows. The 30-inch, 15-inch and 12-inch rows would work to a lesser extent, but some compaction and possible crop damage would occur.

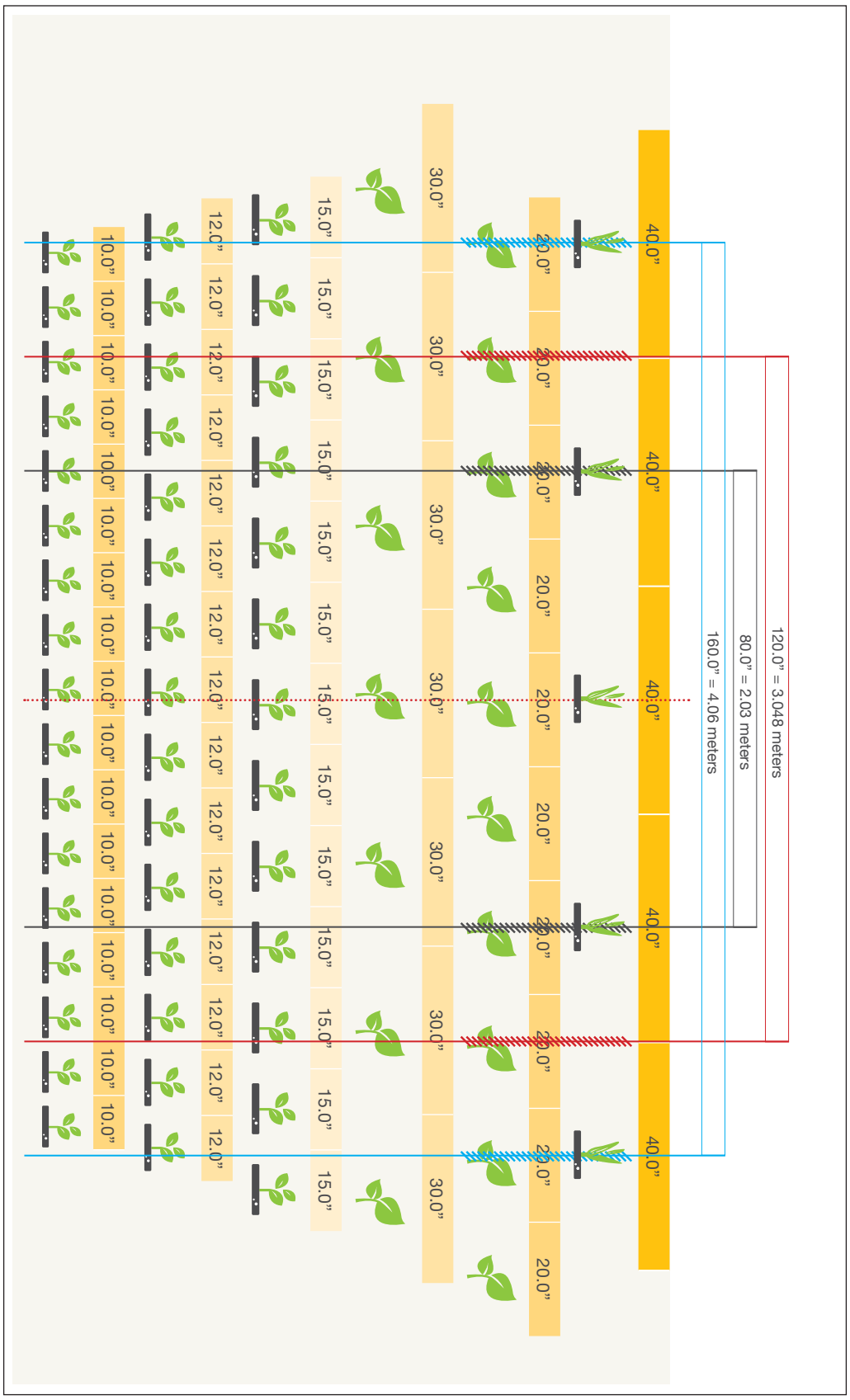
For a 40-inch row spacing, either 80-inch or 160-inch wheel centres would be preferable, which would also work well for 20-inch rows and for 10-inch rows, but would be less suitable for 30-inch, 15-inch and 12-inch row spacings.

Using an uneven number of planted rows (row crop set-up)

A row crop set-up has an uneven number of planted rows, where a row is planted directly in the centre of the equipment, with the same number of rows planted on either side of the centre row (refer to Figure 2 for an example).

There are only a limited number of situations where an uneven number of rows should be the preferred set-up. Figure 2 illustrates that a 120-inch wheel centre may work well for an uneven number of 40-inch row spacings, but does not work well for any of the other crop row spacings shown in this example.

Figure 2 Position of the wheels and traffic in relation to row spacing for an uneven number of planted rows (based on imperial spacings).



Examples of how various tyre centres, row spacings and number of rows may work together

Tables 1 and 2 provide examples of how tyre centres and row spacings may work with either an even number of rows or an uneven number of rows. Where a tick (✓) is present this combination will work, where a cross is indicates (X) this combination will not work.

The words below the tick (✓) or cross (x) indicate whether an even number of rows or an uneven number of rows is required, or where either an even or uneven number of rows will work.

Table 1 Examples of how imperial tyre centres and row widths may work together with even or uneven row numbers.

Tyre centres in inches	Row width									
	60” (1.52m)	40” (1.016m)	36” (0.914m)	30” (0.762m)	20” (0.508m)	15” (0.381m)	12” (0.305m)	10” (0.254m)	9” (0.229m)	7.5” (0.191m)
160” number of rows	✓ either	✓ even	X	X	✓ even	X	X	✓ even	X	X
132” number of rows	✓ either	✓	X	X	X	X	✓ even	X	X	X
120” number of rows	✓ even	✓ uneven	X	✓ even	✓ even	✓ even	✓ even	✓ even	X	✓ even
80” number of rows	✓ either	✓ even	X	X	✓ even	X	X	✓ even	X	X
72” number of rows	✓ even	X	✓ even	X	X	X	✓ even	X	✓ even	X

Table 2 Examples of how metric tyre centres and row widths may work together with even or uneven row numbers.

Tyre centres in metres	Row width in metres					
	1.5m	1.0m	0.5m	0.33m	0.3m	0.25m
4 metres number of rows	✓ either	✓ even	✓ even	X	X	✓ even
3 metres number of rows	✓ even	✓ uneven	✓ even	✓ even	✓ even	✓ even
2 metres number of rows	✓ either	✓ even	✓ even	X	X	✓ even

5. Boom width, sprayed width and nozzle spacing

In situations where the spray operator would like to have the opportunity to match the position of the nozzles on the boom with the crop row or inter-row, he or she must consider the overall width of the boom, as well as the nozzle spacing, using the same units of measurement as the crop row width on the seeding equipment.

Boom width could be a multiple of the width of the seeding equipment, remembering that the physical width of the boom may not be exactly the same as the sprayed width. Sprayed width is normally determined by the number of nozzles multiplied by the nozzle spacing (where end nozzles on the boom have the same fan angle as other nozzles on the boom).

TIP

- **Do not include additional wheel-track nozzles when considering boom width, these should only be considered when determining the applied rate of product to enter into the rate controller.**

5.1 Nozzle spacing and configuration on the boom

Booms may be plumbed with either a 'broadacre' set-up, or a 'row crop' set-up. Row-crop plumbing (also known as centre-plumbed booms), will have a nozzle outlet in the centre of the sprayer and an equal number of nozzles either side of this (the total number of nozzles is not an even number).

Hence, a metric boom that is physically 36m wide with nozzles at a 0.5m spacing that is centre-plumbed should have 73 nozzles fitted, meaning that the sprayed width would be 36.5m. Whereas a 36m boom plumbed with a broadacre set-up, with a 0.5m nozzle spacing, may be supplied with 72 nozzles producing a sprayed width of 36m. This difference in sprayed width may be very important for obtaining an overlap of spray patterns at the end of the boom between each pass of the sprayer. It is important for the operator to confirm how the boom is to be plumbed and the sprayed width before delivery to ensure it will fit in with their existing or future planting configurations.

TIPS

- **For some applications, such as pre-emergent and residual herbicides, the operator may not want additional overlap at the ends of the boom. Where an overlap is not wanted, the operator may choose to replace the last nozzles with a standard fan pattern at the either end of the boom with offset nozzles (half spray patterns). When doing this the operator should adjust the width of the outer section in the rate controller to reflect the actual sprayed width of that section.**

Centre-plumbed booms can allow for nozzles to be plumbed to match up with the inter-row spacing when an even number of crop rows has been planted, provided the units if measurement for the nozzle spacing matches the units of measurement for the row spacing. Where an uneven number of rows have been planted, the nozzle outlets may line up with the planted row.

Nozzle spacing aligned with the crop row width

When nozzle spacing aligns with crop-row width, directed and banded sprays into the inter-row, or onto the crop itself, become possible.

Source: Graham Betts

5.2 Matching nozzle spacing to crop row width

Growers and spray operators in the northern GRDC region who have traditionally used wider row spacings (e.g. 40 inches or more, or 1.016 metres or more) have matched nozzle spacing to crop-row width, or fractions of the row widths (e.g. one-half or one-quarter), for many decades, even before accurate GPS systems became widely available.

However, the increased level of precision that GPS and autosteer capabilities now have available means that these techniques can now be utilised in farming systems with much narrower row spacings. There will be some practical limits to how narrow the nozzle spacing can be.

For more information on inter-row shielded spraying and the application of bands, go to Module 19: Pulse-width modulation

Benefits of matching nozzle spacing to crop row width

To maximise the flexibility of the system, having nozzle spacings at intervals of at least half of the crop-row width opens up several opportunities, including:

- **improved stubble penetration;**
- **reduced boom height, leading to reduced drift potential;**
- **improved overlap of spray patterns for fungicide applications;**
- **the ability to apply banded liquid fertiliser to the inter row;**
- **the ability to apply directed sprays onto the crop row; and**
- **inter-row shielded spraying.**

5.3 Practical limitations of using narrower nozzle spacings

One of the practical limitations of using a narrower spacing is that the flow rates required to deliver the desired application rate (litres per hectare) generally requires that small-orifice nozzles may be required.

Smaller orifice sizes, such as an 01 orifice, can potentially create problems with nozzle blockages (unless mixing is always correct, and the filtration is very good). Additionally, the range of nozzle types and spray qualities available in an 01 orifice size is greatly reduced when compared to larger orifice sizes.

Example using 01 orifice sizes (the smallest practical orifice size available)

On a standard, single line boom fitted with 0.25m nozzle spacings, using an 01 orifice produces an equivalent flow rate to using an 02 orifice at a 0.5m spacing on the boom. At an operating pressure of 3.5 bar (mid-range for a low-pressure air-induction nozzle) this would deliver 85L/ha at 18km/h. To achieve lower total application volumes, the operator would be forced to spray at much higher speeds. For example, with this set-up the sprayer would need to travel at 26km/h to achieve a total application volume of 60L/ha. Spraying at this speed is likely to counteract some of the benefits of matching the nozzle spacing to the crop-row width.

In practical terms, either a 0.25m nozzle spacing for metric units, or a 10-inch spacing for imperial units, is the narrowest nozzle spacing that should be considered for the majority of applications in grain-production systems.

5.4 The impact of mixing imperial and metric units of measurement (row spacing and nozzle spacing)

Where the nozzle spacing is an exact match to the crop-row spacing, or is established at half or one-quarter intervals of this spacing, it allows the operator to use banded and directed spraying, as well as inter-row applications or shielded spraying.

If the measurement units are mixed, e.g. imperial row spacings and metric nozzle spacings (or vice versa), a mismatch will occur. The wider the boom width is, the more out of alignment the nozzle outlets and crop row or inter row will become.

For example, for a boom that has been centre-plumbed (row crop set-up) using an imperial spacing of 20 inches to spray a crop that has been planted using a metric 1-metre row spacing and an even number of planted rows, the centre nozzle of the boom should align with the inter-row space of the 1-metre rows.

Using a 20-inch nozzle spacing, which is actually 0.508m, the next nozzle out from the centre of the boom will be 0.8cm off centre, two nozzles out from the centres will be 1.6cm off centre, 20 nozzles out will be 16cm off centre, and 36 nozzles out from the centre will be 28.8cm off centre from the inter-row.

For ‘over-the-top’ or ‘blanket sprays’ mismatching measurement units is not likely to have a great impact on the result, provided the boom height is set to obtain a double overlap, and the spray patterns from each pass of the sprayer overlap sufficiently. However, mismatched row and nozzle spacing prevents directed spraying onto the crop row or attempts to apply banded applications to the inter-row space.

6. Summary

Matching the widths and tyre centres of equipment can provide many benefits to the farming system, particularly for spray applications. However, matching widths does not require that everything has to been done all at the same time: the process should occur in logical steps.

Matching other equipment with the width of the cutter bar on the harvester is the starting point. If you are considering upgrading the harvester (or the harvester front), it is a good time to consider how all of the machinery works together and plan how they may be integrated.

Most harvesters are supplied with imperial tyre centres, so it is logical to use this measurement system on other equipment.

Aligning the row spacings and tyre centres on the seeding equipment would be the next step, with upgrades to the sprayer (or tractor and spray rig) being one of the last steps to complete the transition.

Once everything is in alignment, the opportunity for greater precision and improved spray-application methods can become a reality.

NEXT MODULE

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 23 Upgrading the sprayer Questions to ask before proceeding

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