Herbicides in stubble

Improving herbicide effectiveness in stubble retained systems

- **Stubble load**: Higher stubble loads and ground cover increase herbicide interception and results in uneven distribution
- **Chemical Characteristics**: Know the solubility of your herbicide and whether they bind to your stubble
- **Pressure & water rate**: Increase spraying pressure and water rate to increase the amount of pre-emergent herbicide reaching soil surface
- **Speed**: Reduce travel speed to increase herbicide efficiency, reduce bounce and improve application evenness
- **Nozzle spacing**: Nozzles spaced at 25 cm can increase water rate and spray uniformity where crop rows are sown at 25 cm
- **Boom height**: Maintain boom height at 50cm and 80cm above stubble for 110^{0} and 80^{0} nozzles, respectively
- **Spray direction**: Always spray in the direction of the sown row
- **Spray edge**: Add a separate specific AIUB nozzle for applying herbicides to the outside edge of the paddock
- **Emulsifying oils and wetting agents**: these reduce the air inside droplet when using air-induction nozzles, so you need to increase spray pressure
- **Turning**: When applying pre-emergent herbicides into stubble, avoid sharp turns and back up into corners

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Improving herbicide effectiveness in stubble

The use of herbicides to control weeds has increased over the past 25 years with fewer paddocks cultivated and greater adoption in minimum and no-till farming systems. In stubble retained, no-till farming systems where other traditional methods such as burning and grazing have reduced, herbicides are the dominant weed management option. Reduced herbicide efficiency has become an issue in stubble retained farming systems because the stubble acts as a barrier (standing or as ground cover) between the herbicide and the target (soil or plant) when either summer, pre-emergent or in-crop foliar herbicides are applied. The herbicides can be bound to stubble residue and not reach the weed or soil target, significantly reducing efficiency. High stubble loads (>5t/ha) can further compromise the efficiency of the herbicide application.

Stubble and crop interception

Stubble provides a barrier between the target (weed or soil) and the herbicide for summer, pre-emergent and in-crop foliar and soil applied sprays. With increasing stubble loads and increasing ground cover, there is a linear reduction in the proportion of herbicide that reaches the target, and even distribution resulting in potential weed escapes *(Figure 1)*. Reducing ground cover to less than 50% will increase efficacy of pre-emergent herbicides. Similarly, increasing the proportion of stubble standing with stubble loads > 3t/ha will increase efficacy. In a recent spray workshop held by Farmlink Research and CSIRO at Temora Agricultural Innovation Centre, a 1 cm thick layer of stubble lying between the rows intercepted most of the spray. Even when the water rate was increased to 148 L/ha using air-inducted nozzles, only a small amount of herbicide had penetrated to the surface. This has major implications for herbicides that bind tightly to stubble and have low solubility such as trifluralin (Table 1). Understanding the characteristics of your herbicides such as solubility and sorption rating in relation to stubble load and stubble orientation is important, and how these interact with the other characteristics such as volatilization, breakdown and persistence. For a comprehensive summary of pre-emergent herbicide characteristics, refer to www.grdc.com.au/SoilBehaviourPreEmergentHerbicides. Water solubility measures how easy the herbicide dissolves in water, and conversely how easy it moves through the soil and potentially moving off target *(Table 1)*. Products such as chlorsulfuron or even s-metolachlor can move easily into the crop row following rainfall and cause crop damage.

Binding co-efficient (sorption rating) indicates the strength of the bond between the herbicide and organic matter and soil particles. Trifluralin is tightly bound to the stubble so if it is inter-

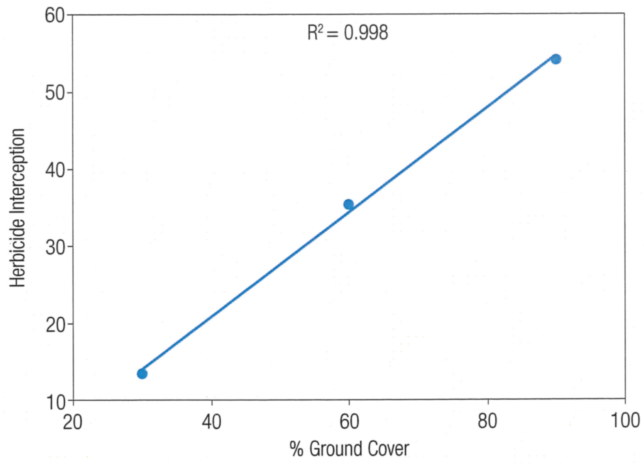

Figure 1: Relationship between groundcover (%) and herbicide interception by crop residue (%) (Shaner, 2013).

cepted by the stubble (standing or flat), it will not be available for weed control and will quickly volatilize unless incorporated within the required timeframe *(Table 1)*. In comparison, 48% of proxasulfone when sprayed onto stubble was washed off 6 days after application with as little as 5 mm of rainfall, and 76% washed off with 20 mm rainfall *(Table 2)*. In a further study, 90% of proxasulfone was washed off wheat stubble after two 12 mm rainfall events 1 and 4 days after spraying. Recently, it was found that 2/3rds of prosulfocarb and 1/3 of the trifluralin was washed off 4t/ha stubble lying flat on the surface with 5mm rainfall (AHRI 2017). However, herbicides that are washed off can then be unevenly distributed onto the soil surface or moved into the sown row resulting in potential damage. Interestingly, prosulfocarb and trifluralin sprayed onto wet stubble was more tightly bound than when sprayed onto dry stubble, but there was no difference in binding with proxasulfone (AHRI 2017).

Table 1: The solubility and binding ability of some pre-emergent herbicides

Herbicide	Trade Name	Solubility rating	Binding to organic matter		
			Absorption Coefficient (K)	Sorption Rating	Volatility
Trifluralin	Treflan ®	low	15800	not mobile	high
Tri-allate	Avadex Xtra	low	3084	slightly mobile	high
Prosulfocarb	Boxer® Gold	low	1850avg.	slightly mobile	low
Propyzamide	Kerb®, Rustler®	low	840	slightly mobile	low
Diuron	Diuron	med	813	slightly mobile	low
s-metolachlor	Dual®, Boxer® Gold	med	200	mobile	high
Atrazine	Gesaprim	low	100	mod mobile	low
Pyroxasulfone	Sakura	low	95	mod mobile	low
Chlorsulfuron	Glean®	v.high	40	mobile	low

(Source: Congreve and Cameron 2014)

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Effect of water rates, pressure and nozzle type on herbicide efficacy

At a February 2017 spray workshop in Temora, a water rate of 70 L/ha sprayed into ~ 6 t/ha standing cereal stubble using either an air induction or a non-air induction 1100 coarse to very coarse nozzles, was satisfactory to apply knockdown systemic herbicides, but not for pre-emergent herbicides. An increase in water rate to 100 L/ha significantly increased the amount of spray that reached the soil surface between the sown row on the snap card (20% cf 10%). Similar results were found in South Australian research with spray coverage of 9%, 17% and 25% at water rates of 50, 75 and 100 L/ha. In field tests in standing stubble, increasing the pressure from 3 to 5 bar using the TeeJet AIXR 110 red 04 very coarse nozzle increased water rate from 96 L/ha to 120 L/ha which further increased the amount of spray that reached the soil surface (20% cf 29%). The increased coverage from the higher water rate was similar to the spray coverage at 100 L/ha in stubble harvested at 15 cm high (30% cf 29%). In standing stubble sown at 25 cm row spacing, nozzles spaced at 25 cm also provided good penetration into the stubble by both air and non-air inducted nozzles at water rates of 100 L/ha. Nozzles spaced at 25 cm can allow for an increase in water rate and uniformity of application. It is recommended to use a higher water rate (at least 100 L/ha) for all pre-emergent herbicides with coarse to very coarse nozzles to increase the amount that reaches the ground and spray at higher rates (120 L/ha or higher) if spraying trifuralin or contact herbicides such as paraquat or diquat. When spraying contact knock down herbicides such as paraquat, keep water and pressure rates high to increase the number of larger droplets penetrating the stubble and hitting the target weed. Even at these higher water rates, the stubble is intercepting a significant quantity of chemistry.

Boom height

When using an 800 nozzle generally spaced 25 cm apart, the boom height needs to be 80 cm above the top of the stubble, whereas a 1100 nozzle requires a boom height of 50 cm above the stubble. If the boom height is reduced in either nozzle type, there is a reduction in the overlap between each nozzle resulting in strips of low herbicide concentrations and ineffective weed control. In contrast, increasing the boom height from 50 cm to 70 cm and 100 cm led to a 4 and 10 fold increase in drift potential, and a large increase in the number of droplets not hitting the target.

Figure 2—Craig Day of Spray Safe and Save at the FarmLink Making Sprays Work workshop in February 2017

Spray direction

It is always recommended to spray in the direction of the sown row to ensure maximum herbicide reaches the target. In the recent spray workshop at Temora, field studies showed the effect of spray application at 900 to the sown row (such as at the end of a paddock driving into the headland). Using very coarse nozzles at high water rates at 900 to the sowing direction in stubble 40 cm high on row spacings of 300 mm, resulted in a thin strip of soil next to the sown row on the back side of the stubble in direction of travel with little herbicide on the soil surface. This means no weed control in that area. With taller or thicker stubble or with closer row spacing, the area missed by the herbicide would increase. One method to overcome this is to sow 4 runs of a headland (48 m) if sowing on 12 m and spray the headland with a 24 m boom in the direction of the sown row. This would improve the effectiveness of the herbicide in the headlands and reduce the potential for weeds to be missed or only be exposed to half doses of herbicide which may increase herbicide resistant weeds.

Effect of travel speed on penetration

Using the AIM Command at 15 km/hr with a 75% duty cycle compared to 20 km/hr at a 100% duty cycle and water rate of 118 L/ha, there was a 4% increase in the amount of water that reached the soil surface at a stubble height of 40 cm (10.5% cf 14.5%).

Using a standard boom spray, comparing the Magno Jet Super Turbo and the TeeJet AIXR 1100 nozzles – both 04 sized nozzles – at:

- 15 km/hr, 4 bar and 148 L/ha,
- 20 km/hr at either 3 or 5 bar and 96 or 120 L/ha,
- 30 km/hr, 4 bar and 74 L/ha.

there was a large reduction in the amount of herbicide that reached the soil surface with increasing speed. The snap card indicated that only 10% of the herbicide would have reached the soil surface at 30 km/hr compared to > 20% when the speed was decreased to 20 km/hr or less, and there was no difference between the air inducted and non-air inducted nozzles. Therefore, excessive speed above 25 km/hr leads to an excessive amount of herbicide being absorbed by stubble. This is a major problem for herbicides, such as trifluralin and tri-allate that bind strongly to organic matter. Speeds less than 16 km/hr reduce forward trajectory of droplets. Using larger booms at higher speeds, especially in undulating paddocks also causes "bounce" resulting in unevenness in spray coverage.

Slow down for greater accuracy and efficacy!

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Differential herbicide application

Pulsation Rate on the AIM command and differential herbicide application when turning using a NON-computer assisted boom.

Pulsation rate on the AIM Command Pro, with turn compensation, will allow for the maintenance of a constant application rate. However, consider what happens to outer wingtip speed when a 36 m boom negotiates a turn at 20 km/hr. The wingtip will reach speeds of 40 km/hr resulting in only 50% of the intended application rate. Further, the herbicide is more likely to be deposited higher on the stubble, as was observed in the increasing ground speed treatments.

For AIM Command Pro to compensate for a turn, the duty cycle would have to be maintained at 50% to allow for the doubling in wingtip speed, which some may argue is too low for the application of pre-emergent herbicides. Higher duty cycles, and the correct selection of exit orifice, create better stubble penetration. Regardless of Aim or standard boom, when applying pre-emergent herbicide into stubble, wherever possible, avoid sharp turns. Instead back into corners to square up headlands. If using the AIM Command Pro in a paddock with lots of trees or contours, setting up for a slower ground speed and 60 – 75% duty cycle will allow the system to compensate for turning.

Spray edge

A major problem when spraying a paddock is the reduction in the amount of herbicide that is applied from the outside nozzle onto the fence line, especially in stubble. The addition of an extra nozzle on a separate solenoid with an AIUB or half nozzle allows the operator to increase the rate at the edge of the boom as it complements the taper of the last nozzle. This will ensure weeds are effectively controlled in the outside strip around each paddock. The outside edge of every paddock sprayed with a tapered flat fan has only received half of the application rate.

Effect of emulsifying oils and wetting agents

The fan angle will be affected by pressure and the nature of the chemistry in the tank mix. A reduction in the fan angle occurs when the pressure in the boom line drops. Avoid operating at 2 bar when spraying over stubble as the reduction in fan angle will further exacerbate unevenness in application if the boom travels closer to the stubble.

Fan angle of an air inducted jet will also be affected when emulsifying concentrates (ECs) are added to the tank mix. Oily material tends to decrease the fan angle, so a combination of low pressure and oily material results in less penetration and unevenness in application if the boom moves closer to the target.

Trifluralin will reduce the air in air-induction jets and will lead to a corresponding collapse in fan angle.

Maintain a 3-4 bar range especially when partnering trifluralin with paraquat or when using emulsifying concentrates to ensure fan angles do not collapse.

References

1. Congreve M and Cameron J (2014). Soil behaviour of pre-emergent herbicides in Australian farming systems. GRDC website: www.grdc.com.au/SoilBehaviourPreEmergentHerbicides
2. McCallum M, (2006). Inter-row and no-till – a good marriage. BCG Crop and pasture manual 2006-2007.
3. Scott BJ, Podmore CM, Burns HM, Bowden PI and McMaster CL (2013). Development in stubble retention in cropping systems in southern Australia on Project DAN 00170. http://www.csu.edu.au/research/grahamcentre/research/Pub_downloads/Developments-in-Stubble-Retention-in-Cropping-Systems-in-Southern-Australia-11Dec2013.pdf [https://grdc.com.au/.../Developments-in-Stubble-Retention-in-Cropping-Systems-in-Southern Australia 11 Dec 2013.
4. *Shaner D (2013). Interactions of herbicides with crop residue. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Interactions-of-herbicides-with-crop-residue*
5. Fence line website references: https://grdc.com.au/Resources/GrowNotes-Technical - homepage https://grdc.com.au/GrowNotesSprayApplication - PDF
6. AHRI 2017: http://ahri.uwa.edu.au/herbicides-and-stubble-some-wash-off-some-dont/
7. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/spray-application-tips-and-tactics
8. https://grdc.com.au/resources-and-publications/grownotes/technical-manuals-national/spray-cation-manual

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