BREAK CROP BENEFITS FACT SHEET

GRDC
Grains Research & Development Corporation

MARCH 2011

WESTERN REGION

Why make the break?

Introducing broadleaf crops into the rotation offers a range of benefits, especially in relation to disease and weed control. In mixed farming systems pastures can offer an alternative break crop option.

PHOTO: DAFWA

Lupins are showing positive break crop benefits in crop sequencing trials in WA.

KEY POINTS

- A break crop is any crop sown to provide diversity to help reduce disease, weed and pest levels in a paddock.
- Choice of break crop type is determined by soil type and regional climate; crop sequence is determined by market and agronomic factors.
- Sourcing regional information from research organisations, agronomists, consultants, other farmers and industry bodies is essential when selecting the most suitable crop type and varieties.

Break crops are especially important in the application of integrated disease and weed management. They provide the opportunity to use alternative control options and different timings.

Break crops generally refer to a pulse or oilseed crop grown instead of cereals. The decision not to grow wheat but to grow and choose a break crop is based on many factors including the relative profitability of the crops – yield by price, the cereal disease pressure, herbicide resistance and personal preference.

The decision to grow a break crop is also complicated by many interactions through the cropping sequences including disease and herbicide carryovers and economic issues such as capital investment for new equipment or storage.

The Department of Agriculture and Food (WA) (DAFWA) has collated a database of all the available rotation experiments conducted in WA. Over 10,000 records representing the results of over 160 experiments conducted since 1966 appear in the database. In the experiments conducted to date, continuous wheat was rarely as productive or economically viable as any rotation which includes either a pasture or break crop, regardless of nitrogen fertiliser input.

Indeed continuous wheat appears to be a yield-limiting exercise. Few trials on light soils suited to narrow-leafed lupins reported wheat on wheat yields above 2.5 tonnes per hectare.

Wheat following lupin out-yields wheat following wheat. The average response to lupin is a boost to the following season's wheat crop of 600 kilograms per hectare. In low rainfall areas this response is lower than the rest of WA – approximately 300kg/ha.

The frequency of large responses to lupin increases when wheat on wheat yields less than 1.7t/ha. This indicates the largest responses to lupin occur when there are some factors limiting wheat on wheat production. These factors have been identified to be root diseases (in particular take-all) and, to a lesser extent, weed competition (in particular grass weeds). Where these factors are not issues, response to lupin will invariably be smaller.

Break crops usually provide a boost to following wheat crops but in approximately 10 per cent of instances wheat following lupins or field peas does not produce a higher yield than wheat after wheat. Generally this is due to the failure of adequate weed control in the break crop year or the higher nitrogen level following a legume break crop. This leads to growth in excess of what the season – in particular a dry spring – could support.

Both canola and oats do not provide consistent boosts to following wheat crops. If paddocks have a background level of relatively high cereal root disease then both oats and canola may provide fair to excellent breaks. If the paddock is relatively free from root disease then canola provides only a small boost to a following wheat crop of around 200kg/ha, whilst oats provide no boost to a following wheat crop.

Disease

The inclusion of break crops into the cropping rotation helps the management of cereal diseases in several ways:

- break crops are not hosts of many cereal diseases;
- well grown, weed-free break crops remove the cereal disease green bridge and may remove the disease residue bridge depending on the environment; and
- carryover nitrogen from pulse break crops generally results in higher yields and lower cereal disease levels due to improved cereal plant health and vigour.

Break crops will only be successful in reducing cereal diseases for following cereal crops if all cereal disease hosts (grasses) are controlled and any cereal disease residue (inoculum) is broken down or destroyed.

A weedy grass pasture or grassy break crop will not provide an adequate cereal disease break to sufficiently suppress cereal disease severity.

For many break crops and diseases a minimum time period and distance between consecutive crops has been established (Table 1).

Break crops are just one part of integrated disease management, which also includes fungicide application and timing, crop and variety choice.

Cereal leaf and stem diseases

The majority of leaf and stem diseases in wheat can be simply avoided by removing the disease host. By removing the host and the consequent sources of inoculum, the disease lifestyle is broken and the occurrence of disease reduced.

In many cases the break crop is able to reduce disease as it cannot act as a host. During the break there is the opportunity to control grassy weeds that can host cereal diseases. None of the main leaf or stem diseases of

TABLE 1 Rotation requirements for common break crops to minimise disease carryover within and between paddocks and to prevent contamination between varieties

Crop	Maximum crop frequency (years)	Main disease affecting crop intensity	Distance from last year's stubble and self-sown seedlings of that crop, or similar crop type for the main air-borne diseases	Distance from a different variety of same crop
OILSEEDS				
Canola	1 in 4	Blackleg	500m	Minimum of 5m from all commercial crops of non-GM canola
Brassica juncea	1 in 4	Blackleg	500m	
PULSES				
Faba bean	1 in 3	Ascochyta, cercospora	500m (ascochyta)	400m (out-crossing)
Chickpea	1 in 2	Ascochyta, botrytis grey mould	500m (ascochyta)	
Field pea	1 in 3	Downy mildew, Blackspot	500m (blackspot)	
Lentil	1 in 3	Ascochyta	500m (botrytis grey mould)	
Lupin – narrow leaf	1 in 2	Pleiochaeta root rot, brown leaf spot		
Lupin – albus	1 in 2	Pleiochaeta root rot, brown leaf spot	500m (anthracnose)	
Vetch	1 in 3	Botrytis grey mould, ascochyta	500m (botrytis grey mould)	

Note: information sourced from various trials funded by GRDC and industry.

PHOTO: EMMA LEONARD

Peas and other legume crops provide a valuable way of reducing the inoculum levels of cereal foliar and some root diseases.

wheat can be hosted by canola, lupins, chickpeas, faba beans, lentils or field peas.

The term 'green bridge' describes the plants that survive the summer and autumn, providing a host for disease and inoculating the winter crop with spores. These living plants effectively provide the 'bridge' for disease to survive from one season to the next.

In the case of wheat rusts, volunteer wheat plants and grass weeds carry the disease on living tissue through summer and autumn. Killing the green bridge removes the source of disease inoculum.

Some diseases can survive on both living and dead material. Cereal leaf and stem diseases that survive on dead cereal crop residues are harder to control. These include *Septoria nodorum*, yellow spot, barley yellow dwarf virus and powdery mildew.

Old wheat stubble and leaf material host disease over summer, releasing spores and inoculating developing wheat plants in the autumn. Stubble-borne diseases are prevalent in paddocks where a wheat crop follows a wheat crop (Table 2).

Yellow spot spores are dormant on wheat residue and are dispersed over small distances in moist autumn conditions. This disease is easily managed using a break crop. Growing a break crop allows time for the residue to break down and spores to be released on a non-host crop.

TABLE 2 Leaf disease levels, yellow spot and *Septoria nodorum* measured when wheat was at flowering, indicative of wheat sown into old wheat stubble

Wheat Variety	Disease resistance rating		Year of wheat	% of leaf area disease affected
	Yellow spot	*Septoria nodorum*		
WyalkatchemΦ	Moderately resistant	Moderately susceptible – susceptible	2	37.6
				26.6
Tammarin RockΦ	Susceptible – very susceptible	Moderately susceptible – susceptible	2	69.5
				52.9
YitpiΦ	Susceptible – very susceptible	Moderately resistant – moderately susceptible	3	51.1
MagentaΦ	Moderately susceptible	Moderately resistant – moderately susceptible	3	29.2

SOURCE: Thomas et al., 2011

Root disease

The ability of root disease to cause yield loss in wheat is dependent on the level of disease and seasonal factors. A broad leaf break from cereal does not necessarily reduce the level of some root diseases (Table 3).

Infected root and crown material can decay during the summer and autumn, reducing the inoculum level. However, moist conditions and microbial activity are required for this to happen, making breakdown unlikely during WA's long, dry summers.

A number of root and crown diseases are soil-borne including rhizoctonia and take-all. Soil-borne inoculum for root and crown diseases can survive for long periods in a dormant state. This may require that non-host crops are grown for more than one season to sufficiently reduce disease inoculum levels, however, consecutive crops of the same species should be avoided (Table 1).

Management across the rotation is important to ensure host residues are reduced to levels that will not affect cereal yield. A grassy break crop or pasture will continue to host root disease and inoculum for following wheat crops.

Nematodes

Cereal cyst nematode (*Heterodera avenae*) can cause severe damage when continuous cereal cropping is practiced. Cereal cyst nematode (CCN) only infects cereals and other grasses (particularly wild oat). In WA, CCN is reported frequently in the Northern Agricultural Region around Geraldton and in the Central Agricultural Region but can occur in any area.

Since CCN can only infect cereals and other grasses, rotations incorporating non-cereals and good control of grass weeds are an effective break (Table 3). In infected areas, do not grow more than two consecutive cereal crops following a non-host break crop. However, severe soil infestations may require more than one year of a non-host crop to reduce CCN below yield limiting levels. Growing resistant cereal varieties will also help reduce infestations and tolerant varieties will suffer minimal crop damage.

Root lesion nematodes (RLN) (*Pratylenchus spp.*) inhabit soil and feed on the roots of plants. Several damaging species of Pratylenchus occur in cropping areas of WA including: *Pratylenchus neglectus, P. teres, P. penetrans* and *P. thornei*. Population densities of all RLN species will increase under continuous cereal cropping.

At least 60 per cent of WA's cropping paddocks are infested with one or more species of RLN, and about 40 per cent of these are at levels that may cause yield losses in the order of five to 25 per cent. There have been individual cases of losses as great as 40 per cent.

In WA, *P. neglectus* is the most commonly identified species (detected in 40 per cent of paddocks), followed by *P. teres* (detected in 10 per cent of paddocks). *P. penetrans* has been identified in some crops, including oat and field pea, where it can cause significant root damage. *P. thornei* is rare in WA. More than one species of RLN can occur in a single paddock. Rotations need to be tailored to the predominant RLN species present.

For nematode diseases, particularly RLN, the resistance of a crop species or variety is determined by the plant's ability to inhibit or support nematode reproduction. Resistant varieties can be used to reduce the nematode population over one or more seasons.

However, resistant crops will not eliminate RLN and will still support low nematode levels. For this reason, the nematode population can quickly increase again when a susceptible crop is sown.

Root lesion nematode can be managed with rotations and other cultural practices but cannot be eradicated. The first step towards effective management of nematode diseases is correct identification of the species present.

Crops resistant to *P. neglectus* include field pea, faba bean, narrow-leafed lupin, lentil, rye and triticale. Growing break crops also allows for the control of susceptible weeds such as wild oat, barley grass, brome grass and wild radish and susceptible volunteer cereals to reduce RLN build-up and carryover.

Weeds

The inclusion of break crops into the cropping rotation allows the use of weed control management options unavailable or not suitable in wheat. For example, growing field peas allows the implementation of late herbicide application for weed seed-set control.

Problem weeds may also be targeted with the inclusion of break crops in the cropping rotation. For example, grass weeds are generally more easily controlled in break crops than cereals.

Using break crops to manage herbicide resistance

The inclusion of break crops into the cropping rotation allows the implementation of a number of integrated weed management (IWM) procedures to reduce the onset of herbicide resistance.

These include:

- use of herbicides with different modes of action (MOA) (Table 4). This allows for the control of weeds resistant to one herbicide MOA

TABLE 3 Root diseases and the impact of different break crops on their control

	Canola	Chickpea	Faba bean	Lentil	Lupin Angustifolius	Lupin Albus	Field pea
Take-all	↓	↓	↓	↓	↓	↓	↓
Cereal cyst nematode (CCN)	↓	↓	↓	↓	↓	↓	↓
Pratylenchus neglectus	↑	↑	↓	↓	↓	?	↓
Pratylenchus teres	↓	?	?	?	↓	?	↓
Pratylenchus penetrans	↑	↑	↑	?	↑	↑	↑
Crown rot	↓	↓	↓	↓	↓	↓	↓
Common root rot	↓	↓	↓	↓	↓	↓	↓
Pythium root rot	N	N	N	N	N	N	N
Rhizoctonia (barepatch)	N	N	N	N	N	N	N
Eradu-patch	↓	↓	↓	↓	↑	↓	↓

↓ = reduce levels of disease; ↑ = increase levels of disease; N = no impact; ? = unknown impact

SOURCE: DAFWA

group by herbicides belonging to another MOA group;

- combining or changing herbicide MOA groups and non-herbicide tactics to reduce selection pressure; and
- the implementation of non-herbicide tactics for example delayed sowing, wide row cropping.

The implementation and/or effectiveness of particular weed management tactics is determined by crop choice. For example, sowing field peas allows delayed sowing, swathing and late herbicide application to be employed.

Crop competitiveness

The impact of weeds on crop yield can be reduced and the effectiveness of weed control tactics increased by improving crop competition. The relative competitive ability of crops can be ranked as:

Oats > Barley > Wheat > Canola > Field pea > Faba bean > Lupin = Chickpea = Lentil

Sowing time, seeding rate, and row spacing impact on the competitive abilities of break crops. The speed at which the canopy of the crop develops influences its ability to compete. Early sowing, greater seeding rate and narrower row spacing all contribute toward a more competitive crop.

Delayed sowing and autumn tickle

Delayed sowing, as a tool to manage weeds, is best used in seasons with an early 'break' and with high soil moisture levels that will allow a later sowing.

As the potential yield of break crops is less than potential yield of wheat, delayed sowing can be less risky with break crops. Shorter season break crop varieties are available such as Mandelup⁽ᶦ⁾ lupin and PBA Twilight⁽ᶦ⁾ field pea.

Early sowing promotes many break crop diseases, so delayed sowing is practised to reduce disease severity, particularly in field peas and chickpeas.

While the benefit from delayed sowing improves weed control, the drawback is a reduction in yield. The average rate of yield decline for all crops is greater in low rainfall areas (less than 325mm) than high rainfall areas (greater than 450mm).

Delayed sowing may benefit weed management in two ways:

- increasing the effectiveness of knockdown herbicides, as the majority of the weed seedbank has germinated and emerged before herbicide application; and
- improving efficacy of soil-active residual herbicides, which have been applied later to moist soils.

Subsequently delayed sowing has a long-term positive impact on herbicide resistance, reducing the weed seedbank and the reliance on selective in-crop herbicides.

To gain the greatest reduction in weed density, delayed sowing should always be used in conjunction with an 'autumn tickle' – a shallow cultivation which stimulates weed seed germination by placing the seed in a better physical position in the soil.

Major weeds effectively controlled by delayed sowing include:

Annual ryegrass – the majority of the annual ryegrass seedbank, nearly 80 per cent, emerges after approximately 20mm of rainfall (Table 5). The inclusion of an autumn tillage with delayed sowing results in substantial reduction of in-crop annual ryegrass.

Barley grass – has low levels of hard seed, and over 99 per cent of seeds germinate in the first year after seed-set. Most of the seed germinates on the autumn break, with little further significant germinations during the year.

Great brome (*Bromus diandrus*) and rigid brome (*Bromus rigidus*) – both species are completely dormant at seed-set but by the end of summer, seeds move out of their dormant phase and many germinate at the autumn break. The release from dormancy in great brome is rapid and almost all of the seed will germinate shortly after the break of the season. However, the release from dormancy is much slower in rigid brome and there are late-emerging seedlings. Seed germination of rigid brome is also inhibited by light (not seen in great brome) so, an autumn tickle to bury seed is required.

Wild radish – plants emerging at the beginning of the season produce greater numbers of seed, with greater dormancy, than second or third cohorts of emerging radish. The use of an autumn tickle greatly increases emergence prior to seeding.

Wide row cropping

Research on the yield impact of growing chickpeas, faba beans and lupins on wide rows (50cm and wider) recorded no yield reduction. Wide row cropping allows shielded spraying, the practice in which shields are used to protect the crop rows while weeds in the inter-row are sprayed with a non-selective herbicide. If using recommended non-selective herbicide

TABLE 4 Herbicide mode of action (MOA) group options in wheat and break crops

Herbicide group	Wheat	Canola	Lupin	Field pea	Chickpea
A	Y	Y	Y	Y	Y
B	Y	Y*	Y	Y	Y
C	Y	Y*	Y	Y	Y
D	Y	Y	Y	Y	Y
E	Y	Y	Y	Y	Y
F	Y	–	Y	Y	Y
G	Y	Y	–	–	–
I	Y	–	–	–	–
K	Y	Y	–	–	–
L	–	–	Y	–	–
M	–	Y*	–	–	–
N	–	–	–	–	–

Y* – only for certain varieties i.e. Triazine tolerant (TT) varieties, Imidazolinone tolerant (IT) varieties and Roundup Ready varieties.
SOURCE: DAFWA

PHOTO: EMMA LEONARD

Break crops can provide opportunities to use herbicides from different modes of action groups and other weed control methods, such as windrowing and late application of herbicides, to control grass weeds before seed-set.

at the correct rate for the size of weed, 90 to 95 per cent of all weeds entering the shield and sprayed by the herbicide will be killed.

Late herbicide application

Late herbicide application (formally known as crop-topping) is the use of a non-selective knockdown herbicide when the crop is nearing maturity, before the majority of weed seeds have reached full viability. This strategy is particularly useful when combating ryegrass and wild radish seed numbers. However, there is often a slight crop yield penalty.

Timing is critical to the success of late herbicide application. Spraying too early will reduce the crop's yield potential, while spraying too late will have little effect on the weed seed-set. Timings differ between crops and between paddocks within crops. It is important to understand the correct timing for your particular situation.

The early maturity of field peas makes them ideally suited to late herbicide application. Once the field pea seeds have reached 30 per cent moisture, or when the lower 75 per cent of the pods are brown, with firm seeds and leathery pods, late herbicide application will not reduce crop yield greatly. In lupins the corresponding timing is at the 80 per cent leaf drop stage.

TABLE 5 Effect of a three-week delay in sowing of various crops on the number of mature annual ryegrass plants in the crop and on the following seedbank

Crop species	Normal sowing		Delayed sowing	
	Annual ryegrass plants per m^2	Annual ryegrass seeds per m^2	Annual ryegrass plants per m^2	Annual ryegrass seeds per m^2
Field Pea	234	15,995	104	12,011
Barley	367	2,240	152	1,060
Wheat	419	5,557	237	5,791

SOURCE: Matthews and Powels, 1996

Used at the correct timing, the late herbicide application will, on average, reduce viable seed-set for annual ryegrass by 75 per cent and wild radish by 45 per cent.

Swathing and windrow burning

Swathing is the mechanical cutting of a crop when it has reached physiological maturity. Swathing is a viable option for break crops – particularly canola and field peas. Some general benefits of swathing include improved quality of harvested grain, reduced harvest losses, and an increased harvest window for the swathed crop.

When controlling weeds, swathing at the correct timing is able to control between 15 and 50 per cent of annual ryegrass seed-set.

Another benefit of swathing is to concentrate all cut material, including weed seeds, into more defined rows. This allows the burning of the windrows. Windrows can also be created by removing the straw spinners on the harvester and replacing them with a chute to create dense, narrow harvester trails. These windrows can be burnt in late summer, or early autumn.

Reductions of up to 98 per cent of annual ryegrass and 75 per cent of wild radish weed seed numbers have been measured by burning windrows.

Hay cutting

Hay cutting conducted earlier than swathing and late herbicide application has a large impact on the set of viable seed, providing cutting is before weed seed maturity. However, in many cases a follow-up application of glyphosate is required to kill the weed regrowth.

Nutrient supply

Crops vary in their use and requirement for nutrients by species, end use and overall bulk of dry matter produced. While pulse crops fix nitrogen, the amount of residual nitrogen also varies by crop type and season. This makes it hard to provide information about break crop choices in relation to nutrition. Growers are encouraged to:

- review local nutrient research for different crop types, including National Variety Trials;
- soil test and tissue test; and
- create nutrient budgets for the whole crop sequence.

Intensive cropping rotations, the use of minimum tillage and retained stubble can result in an increase in available soil nitrogen. This nitrogen is produced by free-living, nitrogen-fixing soil organisms.

Season and soil type are key influences on a crop's nutrient supply and/or removal. Therefore, local research and experience is the best source of information about nutrient supply and removal by different crops.

Water use

Crops differ in their water usage. The total amount of water removed from the soil profile influences water availability to the following crop. A crop's water use efficiency (WUE) influences the overall productivity of the current crop.

Traditionally, WUE has been assessed on an annual basis. However, there is increased interest in considering WUE across the whole crop sequence.

The GRDC's National Water Use Efficiency Initiative commenced in 2009 and is investigating the management factors that most influence WUE, including the role of break crops.

PHOTO: EMMA LEONARD

The inclusion of different break crops across the rotation can influence water use efficiency; shallow rooted crops such as peas that produce less biomass could leave more water in the profile for a following wheat crop.

TABLE 6 Procedures to reduce weed seed-set in break crops.

	Late herbicide application	Swathing	Windrow burning	Hay cutting	Chaff cart
Canola	√	√	√	√	√
Brassica juncea	√	√	√	√	√
Faba Bean	X	√	√	√	√
Chickpea – desi and kabuli	Salvage only – yield loss great	Salvage only – yield loss great	√	X	√
Lentil	√	√	√	√	√
Lupin – narrow leaf	√	√	√	√	√
Lupin – albus	X	√	√	X	√
Field pea	√	√	√	√	√
Vetch	√	√	√	√	√

SOURCE: DAWFA

Other factors to consider

The introduction of a new crop or crop sequence can present logistical and management challenges and opportunities.

- **Time of sowing –** appropriate sowing times need to be achieved for all crops in the rotation, otherwise yield penalties due to frost or short seasons can be experienced. Detailed time of sowing guides are available from DAFWA, Pulse Australia and the Australian Oilseeds Federation.
- **Row spacing –** while constant row spacing for all crops is common, research and farmer experience is suggesting wider row spacing improves pulse yields, especially in drier regions. Details on wide row pulses and stubble systems can be found on the Pulse Australia website. Using a row spacing that is a multiple of existing tyne set-up is becoming more common, for example, 250mm for cereals and 500mm for pulses, lupins and canola. This enables inter-row sowing and easy set-up on most seeding bars. Non-sowing tynes need to be lifted. Spacings up to 750mm are used in pulses, lupins and canola to provide the possibility of using inter-row shielded sprayers.
- **Stubble cover post-harvest –** pulse and oilseed crops, especially lentils and field peas, can provide considerably less stubble cover across the soil surface than a cereal crop. Stubble cover is reduced further when wider row spacing is used. This lack of stubble not only can result in diminished soil protection but also reduced summer stockfeed. Pulses sown into standing cereal stubble leave residual cereal roots and stems even after the pulse is harvested. Spreading chopped pulse stubble at harvest provides better soil protection than leaving stubble in harvester rows.
- **Equipment –** the majority of operations for growing pulses and oilseeds can use the same equipment as for cereals. Canola requires windrowing. Pulses and oilseeds can be damaged in a flight auger, and alternative designs including belt shifters are preferred. Harvester modifications, such as the use of a flexi-front and alternative screens, may be required when harvesting pulses. Some pulse crops may require cleaning after harvest to ensure market grade is delivered.
- **Storage –** on-farm storage may enable growers to chase more lucrative markets for break crops but these crops may require specialised storage. For example oilseeds and pulses are best stored in aerated storage. Pulses and oilseeds are deemed less suitable than cereals to be stored in grain bags, also known as silo, sausage or harvest bags (visit www.pulseaus.com.au).
- **Marketing –** issues that need to be considered include availability of delivery locations, contract specifications, storage requirements and meeting the receival standards to achieve market grade.

Useful resources:

- **Publications available from Ground Cover Direct Bookshop** — **www.grdc.com.au/bookshop**
  - **Integrated Weed Management Manual in Australian Cropping Systems** — **Email ground-cover-direct@canprint.com.au**
  - **Ute Guides – topics include peas, faba beans, lentil, vetch, chickpea disorders and winter pulse disorders** — **Email ground-cover-direct@canprint.com.au**
  - **Grain Legume Handbook 2008** — **www.grdc.com.au/grainlegumehandbook**
  - **Raising the bar publications – various oilseeds** — **Email ground-cover-direct@canprint.com.au**
- **GRDC Research Update papers** — **www.grdc.com.au/researchupdates**
- **Herbicide resistance mode of action groups** — **www.grdc.com.au**
- **Department of Agriculture and Food** — **www.agric.wa.gov.au**
- **Black Spot Manager, information for WA, SA and Victoria** — **www.agric.wa.gov.au/PC_92989.html**
- **Publications available from Pulse Australia** — **www.pulseaus.com.au/Search_Publication.aspx**
  - **Wide row pulses and stubble systems**
  - **Residual herbicides and weed control**
  - **Use care with pulses in grain bags**
- **Australian Oilseeds Federation** — **www.australianoilseeds.com**
- **National Variety Trials and resources** — **www.nvtonline.com.au**

Authors and contributors: Ian Pritchard, Wayne Parker, Abul Hashem and Vivien Vanstone, DAFWA.

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